FOR PROJECTS INITIATED
AFTER MAY 1, 2014
REVISION 4

ITEM 649

WIDE ANGLE PRISMATIC RETROREFLECTIVE SHEETING FOR TRAFFIC CONTROL SIGNS (DIAMOND GRADE)

649.1 Description. This Item shall govern for furnishing and installing sign face material fabricated from flexible, colored, wide angle prismatic retroreflective sheeting and related processing materials to be used for traffic control signs.

649.2 Applicable Documents.

ASTM Standards:

B117 Standard Practice for Operating Salt Spray (Fog) Apparatus

B209 Specification for Aluminum and Aluminum-Alloy Sheet and Plate

D523 Standard Test Method for Specular Gloss

E284 Standard Terminology of Appearance

E308 Computing the Colors of Objects by Using the CIE System

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

E1164 Standard Practice for Obtaining Spectrometric Data for Object-Color Evaluation

CIE Publication Number 39-2 Recommendations for Surface Colors for Visual Signaling

649.3 Requirements. The retroreflective sheeting for sign faces/finished signs shall have a smooth surface with a distinctive interlocking diamond seal pattern and orientation marks visible from the face. The sheeting shall be precoated with a pressure sensitive adhesive backing protected by a removable liner.

The adhesive shall require no heat for proper bonding when applied in accordance with the manufacturer's recommendations to substrates 65^{o}F or above.

649.4 Test Methods.

A. Test Conditions. Unless otherwise specified herein, all applied and unapplied test samples and specimens shall be conditioned at the standard conditions of 73 ± 3 degrees F. (23 ± 3 degrees C.) and 50 ± 5% relative humidity for 24 hours prior to testing.

B. Test Panels. Unless otherwise specified herein, when tests are to be performed using test panels, the specimens of retroreflective material shall be applied to smooth aluminum cut from ASTM B209 alloy 5052-H36, 5052-H38, 5154-H38 or 6061-T6 sheets in 0.020 inch (0.051 cm), 0.040 inch (0.102 cm) or 0.063 inch (0.160 cm) thickness. The aluminum shall be degreased and lightly acid etched before the specimens are applied. The specimens shall be applied to the panels in accordance with the recommendations of the retroreflective sheeting manufacturer.

649.5 Physical Requirements.

A. Color Requirements:

TABLE 1
Color Specification Limits* (Daytime)

	1		2		3		4			
Color	x	y	x	y	x	y	x	y	Min.	Max.
White	0.303	0.300	0.368	0.366	0.340	0.393	0.274	0.329	40.0	--
Yellow	0.498	0.412	0.557	0.442	0.479	0.520	0.438	0.472	24.0	45.0
Red	0.648	0.351	0.735	0.265	0.629	0.281	0.565	0.346	3.0	15.0
Blue	0.078	0.171	0.150	0.220	0.210	0.160	0.137	0.038	1.0	10.0
Green	0.026	0.399	0.166	0.364	0.286	0.446	0.207	0.771	3.0	12.0
Orange	0.558	0.352	0.636	0.364	0.570	0.429	0.506	0.404	12.0	30.0
Brown	0.430	0.340	0.430	0.390	0.518	0.434	0.570	0.382	1.0	6.0
Purple	0.302	0.064	0.310	0.210	0.380	0.255	0.468	0.140	2.0	10.0

*The four pairs of chromaticity coordinates determine the acceptable color in terms of the CIE 1931 standard colorimetric system measured with standard illuminant D65.

TABLE 2
Color Specification Limits* (Nighttime)

	1		2		3		4	
Color	x	y	x	y	x	y	x	y
White	0.475	0.452	0.360	0.415	0.392	0.370	0.515	0.409
Yellow	0.513	0.487	0.500	0.470	0.545	0.425	0.572	0.425
Red	0.650	0.348	0.620	0.348	0.712	0.255	0.735	0.265
Blue	0.033	0.370	0.180	0.370	0.230	0.240	0.091	0.133
Green	0.007	0.570	0.200	0.500	0.322	0.590	0.193	0.782
Orange	0.595	0.405	0.565	0.405	0.613	0.355	0.643	0.355
Brown	0.595	0.405	0.540	0.405	0.570	0.365	0.643	0.355
Purple	0.355	0.088	0.385	0.288	0.500	0.350	0.635	0.221

*The four pairs of chromaticity coordinates determine the acceptable color in terms of the CIE 1931 standard colorimetric system measured with standard illuminant A.

B. Color Test. Conformance to color requirements shall be determined by instrumental method in accordance with ASTM E1164 on sheeting applied to test panels and conditioned as in Section 649.4 A. The values shall be determined on a HunterLab Labscan II 0/45 spectrocolorimeter with option CMR 559. Computations shall be done in accordance with ASTM E308.

C. Coefficient of Retroreflection (R'). The coefficients of retroreflection shall not be less than the minimum values specified in Table 3 and Table 3A. Testing shall be in accordance with ASTM E810 except that the Table 3 values shall be met at 0 degrees and at 90 degrees orientation without averaging and the Table 3A values shall be met using only the 45 degree orientation.

1. Units. Coefficients of retroreflection (R') shall be specified in units of candelas per lux per square meter.

2. The observation angles shall be 0.1, 0.2, 0.5 and 1 degree.

3. The entrance angles shall be -4, 30 and 45 degrees.

4. For screen printed transparent colored areas or transparent colored overlay films on white sheeting, the ratio of coefficients of retroreflection (R') of the white to the other color, when measured at 0.2º observation, -4º entrance, and 0º rotation, shall be 5:1 to 15:1 for red, and not less than 5:1 for all other colors.

TABLE 3
Minimum Coefficient of Retroreflection R'
(Candelas per lux per meter squared)
(0 and 90 degree Orientation)

Observation Angle (Deg.)	Entrance Angle (Deg.)	White	Yellow	Red	Green	Blue
0.1	-4	625	565	165	80	42
0.1	+30	430	315	110	45	22
0.1	+45	120	90	24	12.5	6
0.2	-4	370	300	98	45	22
0.2	+30	225	180	65	28	14
0.2	+45	90	70	26	9.8	4.5
0.5	-4	275	220	70	32	17
0.5	+30	125	100	32	16	8
0.5	+45	35	27	10	3.5	1.5
1.0	-4	75	58	20	9	4.5
1.0	+30	42	35	11	6	3
1.0	+45	10	8.8	3	1.6	.8

80 percent of values listed in Table 3 after 7 years and 70 percent of values listed in Table 3 after ten years must be maintained.

Failure of processing inks or overlay films provided and/or sold for use on recommended sheeting shall constitute a failure of entire sign and shall be replaced under manufacturer's replacement obligation.

TABLE 3A
Minimum Coefficient of Retroreflection R'
(Candelas per lux per meter squared)
(45 degree Orientation)

Observation Angle (Deg.)	Entrance Angle (Deg.)	Yellow
0.2	-4	550
0.2	+30	130
0.5	-4	145
0.5	+30	70

D. Specular Gloss. The retroreflective sheeting shall have an 85 degree specular gloss of not less than 50 when tested in accordance with ASTM D523.

E. Color Processing. The retroreflective sheeting shall permit cutting and color processing with compatible transparent and opaque process colors in accordance with the sheeting manufacturer's recommendations at temperatures of 60 to 100 degrees F. (16 to 38 degrees C.) and relative humidities of 20 to 80 percent. The sheeting shall be heat resistant and permit force curing without staining of applied or unapplied sheeting at temperatures recommended by the sheeting manufacturer.

F. Flexibility. The retroreflective sheeting with the liner removed and conditioned as in Section 649.4 A, shall be sufficiently flexible to show no cracking when slowly bent, in one seconds' time, around a 1/8 inch mandrel, with the adhesive contacting the mandrel, at test conditions. Talcum powder shall be spread on the adhesive to prevent sticking to the mandrel.

G. Adhesive. The protective liner attached to the adhesive shall be removed by peeling without soaking in water or other solutions, without breaking, tearing, or removing any adhesive from the backing. The protective liner shall be easily removed following accelerated storage for 4 hours at 160 degrees F. (71 degrees C.) under a weight of 2.5 pounds per square inch (0.176 kg/cm^2). The adhesive backing of the retroreflective sheeting shall produce a bond to support a 1.75 pound (0.79 kg) weight for 5 minutes without the bond peeling for a distance of more than 2 inches (5.08

cm) when applied to a test panel prepared as in Section 649.4 B. Apply 4 inches (10.16 cm) of a 1 inch x 6 inch (2.54 cm x 15.2 cm) specimen to a test panel. Condition and then position the panel face down horizontally; suspend the weight from the free end of the sample and allow it to hang free at an angle of 90 degrees to the panel surface for 5 minutes.

H. Impact Resistance. The retroreflective sheeting applied according to the sheeting manufacturer's recommendations to a test panel of alloy 6061-T6, 0.040 inch (0.10 cm) by 3 inch (7.6 cm) by 5 inch (12.7cm) and conditioned as in Section 649.4 A, shall show no cracking outside the impact area when the face of the panel is subjected to an impact of a 4 lb. (1.82 kg) weight, with a 5/8 inch (15.8 mm) diameter rounded tip, dropped from a height necessary to generate an impact of 10 in. lb. (1.13 N-m) at test temperatures of 32 degrees F. (0 degrees C.) and 72 degrees F. (22 degrees C.).

I. Resistance to Accelerated Outdoor Weathering. The retroreflective surface of the sheeting shall be weather resistant and show no appreciable cracking, blistering, crazing or dimensional change after 3 years unprotected outdoor exposure, facing the equator and inclined 45 degrees from the vertical. Following weather exposure, panels shall be washed in a 5 percent HCL solution for 45 seconds, rinsed thoroughly with clean water, blotted with a soft clean cloth and brought to equilibrium at standard conditions. After cleaning, the coefficient of retroreflection shall not be less than 70 percent of the values in Table 3.

The sample shall:

1. Show no appreciable evidence of cracking, scaling, pitting, blistering, edge lifting, or curling, or more than 1/32 inch (0.08 cm) shrinkage or expansion;

2. Be measured only at angles of 0.2 degrees observation, -4 degrees entrance and 90 degrees orientation. Where more than one panel of a color is measured, the coefficient of retroreflection shall be the average of all determinations.

J. Resistance to Heat. The retroreflective sheeting, applied to a test panel and conditioned as in Section 649.4 A, shall be measured in accordance with Section 649.5 C at 0.2 degrees observation and -4 degrees entrance angles at both 0 degree and 90 degree orientations and exposed to 170 ± 5 degrees F. (77 ± 3 degrees C.) for 24 hours in an air circulating oven. After heat exposure the sheeting shall retain a minimum of 70 percent of the original coefficient of retroreflection at both orientations when measured at room temperature.

K. Resistance to Corrosion. The retroreflective sheeting applied to a test panel and conditioned as in Section 649.4 A, shall show no loss of adhesion, appreciable discoloration, or corrosion, and after cleaning shall retain a minimum of 80 percent of the original coefficient of retroreflection when measured at 0.2 degrees observation, -4 degrees entrance and 0 degrees and 90 degrees orientation angles only, after 1000 hours exposure to a 5 percent concentration salt spray at 95 degrees F. (35 degrees C.) when tested in accordance with ASTM B117.

L. General Characteristics and Packaging. The faces/finished signs supplied shall be of good appearance, free from ragged edges, cracks, and extraneous materials, and show careful workmanship with the message and border sharply defined.

When furnished as faces the sheeting shall be packaged flat in accordance with commercially accepted standards. Faces shall be interleaved with slipsheets as called for in this Item. The slipsheet glossy side shall be placed against the face with a maximum of 25 faces per carton.

When furnished as finished signs the signs must be protected with slipsheet and foam padding. The slipsheet glossy side shall be placed against the face and sign face padded with closed cell packaging foam. Finished signs shall be packaged in quantities of 10 or less to facilitate handling.

The packaged faces or signs shall include the appropriate number of washers as called for in this Item.

649.6 Performance Requirements and Obligations.

A. Certification. The sheeting manufacturer shall, upon request, submit with each lot or shipment, a certification which states that the material supplied will meet all of the requirements listed herein.

B. Field Performance Requirements: Retroreflective sheeting processed and applied to sign blank materials in accordance with the sheeting manufacturer’s recommendations, shall perform effectively for a minimum of 10 years. The retroreflective sheeting will be considered unsatisfactory if it has deteriorated due to natural causes to the extent that:

1. The sign is ineffective for its intended purpose when viewed from a moving vehicle under normal day and night driving conditions; or
2. The coefficient of retroreflection is less than the minimums specified in Table 3.

C. All measurements shall be made after sign cleaning according to the sheeting manufacturer's recommendations.

D. For screen printed transparent colored areas on white sheeting, the coefficients of retroreflection shall maintain the ratios required by this Item as indicated in Section 649.5 C.

E. Sheeting Manufacturer's Replacement Obligation. Where it can be shown that retroreflective signs with Types A and B sheeting supplied and used according to the sheeting manufacturer's recommendations have not met the performance requirements of Section 649.6 B, the sheeting manufacturer shall cover the restoration costs as follows for sheetings shown to be unsatisfactory during:

1. The entire 10 years: the sheeting manufacturer will replace the sheeting required to restore the sign surface to its original effectiveness.

2. In addition, during the first 7 years the sheeting manufacturer will cover the cost of restoring the sign surface to its original effectiveness at no cost to Harris County for materials and labor.

   Harris County shall require the dating of all signs at the time of application. The date constitutes the start of the field performance obligation period.

649.7 Measurement and Payment. Measurement and payment for wide angle prismatic retroreflective sheeting for traffic control signs shall be incidental to Item 624 "Aluminum Signs".

There are line code(s), description(s), and unit(s) for this Item.

END OF ITEM 649