

1 **SECTION 750 – TRAFFIC CONTROL SIGN AND MARKER MATERIALS**2
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4 **750.01 Signs.**5
6 **(A) General.**7
8 **(1) Retroreflectorization.** The following shall be
9 retroreflectorized:10
11 **(a)** Background for illuminated guide signs and exit number
12 panels ("E" designation) with Type III or IV retroreflective
13 sheeting.14
15 **(b)** Background for non-illuminated guide signs and exit
16 number panels ("D" designation) with Type III or IV
17 retroreflective sheeting;18
19 **(b)** Messages, arrows, and borders of guide signs and exit
20 number panels ("D" and "E" designations) with Type III or IV
21 retroreflective sheeting or with acrylic plastic reflex reflectors
22 on porcelain enameled aluminum cut-outs.23
24 **(c)** Regulatory and warning signs, directional signs ("DIR"
25 designation), route and auxiliary markers, shield symbols,
26 yellow "EXIT ONLY" panels, construction warning signs, and
27 barricade rails, completely, with Type III, IV, or IX
28 retroreflective sheeting.29
30 **(d)** Pedestrian, school, bicycle crossing series, completely
31 with Type IX fluorescent yellow green retroreflective sheeting.32
33 **(2) Embossing.** Details from background shall be embossed
34 more than 0.10 inch and less than 0.125 inch. Finished embossing
35 shall be clear and even in outline, and free from cracks or tears.
36 Entire sign shall be free from twist or buckle, or both. Background
37 shall be on plane surface.38
39 Standard warehouse blank shall be kept free from dust and
40 grease and shall be provided with Alodine coating. Standard
41 warehouse blank shall be wiped clean before applying film message.
42 Metal surfaces shall be furnished free of fabrication defects.43
44 Mill finish blanks shall be treated by the following process
45 before applying message film:
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- 47 (a) Vapor degreasing by total immersion of sign panel in
- 48 saturated vapor of trichloroethylene for minimum of one
- 49 minute.
- 50
- 51 (b) Etching by immersion for five minutes in 8 percent
- 52 solution of phosphoric acid at 120 degrees F.
- 53
- 54 (c) Rinsing by spraying with cold running water, followed by
- 55 immersion for one minute in circulating hot water at
- 56 temperature between 160 and 200 degrees F.
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- 58 (d) Placing in forced warm-air drying tank for one minute.
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60 (B) Backing.

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62 (1) **Sheet Aluminum.** Sheet aluminum for signs shall have

63 minimum thickness as follows:

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- 65 (a) 0.063 inch for signs 3 square feet or less.
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- 67 (b) 0.080 inch for signs 3 square feet to 6.25 square feet.
- 68
- 69 (c) 0.100 inch for signs over 6.25 square feet and R1-2
- 70 "Yield" signs.
- 71

72 Aluminum sheet shall conform to ASTM B 209, alloy 6061-T6

73 flat sheet.

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75 Signs 4 feet by 6 feet or smaller shall have backing made out of

76 one sheet.

77

78 (2) **Extruded Aluminum Panels.** Bolted-type extruded aluminum

79 panels used for destination and guide signs shall conform to

80 ASTM B 221, alloy 6063-T6 (Chemical composition only).

81

82 Flat and straight panels shall meet tolerances indicated in

83 ASTM B 221. Panels shall be fastened with the following:

- 84
- 85 (a) Bolts conforming to ASTM B 211, alloy 2024-T4.
- 86
- 87 (b) Nuts conforming to ASTM B 211, alloy 6061-T6.
- 88
- 89 (c) Flat washers conforming to ASTM B 209, alloy Alclad
- 90 2024-T4.
- 91

92 Structural shapes for sign brackets shall conform to

93 ASTM B 308, alloy 6061-T6.

94

95 Twelve-inch-wide sections shall weigh between 2.690 to 2.707
96 pounds per linear foot. Six-inch-wide sections shall weigh between
97 1.103 to 1.115 pounds per linear foot. Six-inch-wide sections shall be
98 used at tops or bottoms of signs to fill in for signs not conforming to 1-
99 foot modulus.

100
101 **(3) Laminated Panels.** Laminated panel sections for destination
102 and guide signs shall include two aluminum sheets as follows:

103
104 **(a)** Laminated to phenolic-impregnated cellulose
105 honeycomb core.

106
107 **(b)** Include extruded aluminum perimeter frame.

108
109 **(c)** Produce flat, rigid panels 1 inch or 2-1/2 inches thick, as
110 required.

111
112 Panels shall be smaller than 24 feet long by 5 feet wide. Signs
113 over 15 feet long in vertical panels will be allowed only if indicated in
114 the contract documents. Panels shall have minimum width of 2 feet.

115
116 One-inch-thick panels shall have maximum span between
117 supports not exceeding 9 feet and overhangs not exceeding 3 feet.
118 Two and one-half-inch-thick panels shall have maximum span
119 between supports not exceeding 14 feet 6 inches and overhangs not
120 exceeding 4 feet 9 inches.

121
122 Laminated panels shall conform to the following requirements:

123
124 **(a)** Panel face sheet shall be in one piece per panel from
125 0.063-inch aluminum porcelain enameling sheet of 6061 or
126 6111 alloy, ASTM B 209.

127
128 **(b)** Core material shall be of phenolic-impregnated cellulose
129 honeycomb conforming to AMS3720 standards. Core material
130 shall be 1 inch or 2-1/2 inches thick. Tolerance of + 0.010 inch
131 for core material thickness shall be met. Federal Specifications
132 MIL-D-5272C for core material resistance to fungus shall be
133 met.

134
135 **(c)** Back sheet shall be assembled from 0.040-inch sheet
136 aluminum alloy 3003-H14, ASTM B 209, in one piece. Surface
137 shall be treated with amorphous chromate conversion coating
138 conforming to Federal Specifications MIL-C-5541B.

139
140 **(d)** Laminating adhesive shall have thermoplastic, neoprene
141 rubber base, solvent-type, exhibiting resilient, oil- and water-
142 resistant bond. Laminating adhesive shall have solids content

143 suitable for automatic spray application, yielding minimum
144 adhesive dry weight of 4.5 grams per square foot. Uniform
145 adhesive film (scotch grain appearance) shall be applied to
146 each surface by automatic spray application. Laminated
147 panels shall be force-dried at minimum temperature of 180
148 degrees F. Final bond shall be made while glue-line
149 temperature is at minimum 180 degrees F. Sufficient pressure
150 shall be applied to ensure intimate mating of surfaces. Tensile
151 strength of Type 1 or 6061 aluminum sheets and honeycomb-
152 type laminate construction shall be 35 to 38 pounds per square
153 inch. Tensile test shall be performed on Dillon Dynamometer
154 at room temperature with 2-inch by 2-inch square test
155 specimen. Bond obtained after 48-hour aging period shall be
156 tested to withstand six complete cycles of the Forest Products
157 Laboratory Weathering Test, ASTM D 1037.

158
159 **(e)** On face and back of every panel, a 1/8-inch,
160 self-plugging rivet to secure the sheets shall be used at each
161 corner of perimeter frame. Rivets shall be used for mounting of
162 letters.

163
164 **(f)** Flat units within measured ± 0.040 -inch per foot shall be
165 used across plane of each panel from opposite corners.
166 Perimeter edges shall be routed flush and smooth. Straight
167 edges shall be within tolerance of $\pm 1/16$ inch.

168
169 **(g)** For panel alignment extrusion, closure and alignment
170 aluminum extrusions shall be provided between panels for
171 multiple-panel signs. Extrusions shall be 0.062-inch thick and
172 shall fit snugly into perimeter channel.

173
174 If field-joining of panels is necessary, and a letter
175 overlaps field joint, holes shall be pre-drilled in panel to
176 facilitate letter installation. Letters shall be shipped with
177 necessary rivets required for field installation.

178
179 **(h)** One-inch-thick panel units shall be framed with 1-inch
180 by 1-inch by 1/16-inch perimeter frame conforming to ASTM
181 B 221, alloy 6063-T6 extruded aluminum channel, heliarc.
182 Corners and locations where attachment of panels for support
183 is required shall be welded.

184
185 **(i)** Two and one-half-inch-thick panel units shall be framed
186 with 1-inch by 2-1/2-inch by 0.080-inch perimeter frame
187 conforming to ASTM B 221, alloy 6063-T6 extruded aluminum
188 channel, heliarc. Corners and locations where attachment of
189 panels for support is required shall be welded.

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191 (4) **Splicing.** Backing for signs 4 feet by 6 feet or less shall be of
192 one sheet.

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(C) **Finishing.**

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(1) **Enamel.** Enamel paint used for metal sign background and details shall be of type, quality, and character to permit baking. Paint shall produce true color tone and surface that is smooth, tough, and without cracks or other blemishes. Yellow color tone, shown by reflected white light, shall conform to the following requirements:

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(a) Dominant wave length of more than 580 millimicrons or less than 588 millimicrons.

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(b) Purity of more than 80 percent.

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(c) Integral pigment reflection of more than 35 percent.

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Metal signs shall conform to the following requirements:

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(a) One prime coat by dipping or spraying.

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(b) One coat of background paint on back.

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215

(c) Two coats of background paint on face.

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Each background coat shall be baked separately. Final coat shall be brushed or sprayed. After application of final background coat, sign shall be baked in accordance with manufacturer's recommendations. Tough, flexible coating shall be produced, not darkened visibly, and entirely free of blemishes.

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Details of signs shall be painted with at least two coats of required paint, in accordance with manufacturer's recommendations. Paint shall then be baked as required for background color.

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Finish design shall be clear-cut and sharp. Lines of letters and details shall be made true, regular, free from waviness, unevenness, furry or fuzzy edges or lines, and free from cracks, scales, pits, blisters, and blemishes.

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Two bolt holes for fastening sign shall be drilled before applying finishing coat of paint.

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(2) **Porcelain Enamel.** Porcelain enamel shall have properties required to enable firing and fusing to metal at manufacturer's

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750.01

237 recommended temperatures. Enamel shall produce true color tone
238 and surface that is smooth and without cracks, blisters, and
239 blemishes.

240
241 Metal signs shall be coated on face and back with minimum
242 one ground coat and one cover coat of porcelain enamel, separately
243 fired, and fused to metal at manufacturer's recommended
244 temperatures. Succeeding coats shall be applied, as recommended
245 by manufacturer, over coatings. Coats shall be fused to produce
246 single, integral coat of porcelain of desired colors and designs in
247 finished plate. During enamel coating and fusing, sign plates shall be
248 hung by hooks through punched hole such that no point marks, scars,
249 and other imperfections appear on face of sign plates. Signs shall
250 have no surface defects.

251
252 Porcelain enamel color samples shall be submitted and
253 accepted by the Engineer before manufacture. Color shall conform to
254 the National Bureau of Standards (N.B.S.) Procedure C429, using
255 NES S-reflectance Standards No. SCR-11 as primary references.
256 Porcelain enamel shall have gloss reading of 50-70 units at angle of
257 45 degrees when measured on Photovolt meter, in accordance with
258 ASTM C 346. Porcelain enamel coating applied to face of sign shall
259 be more than 0.002 inch thick and less than 0.0051 inch thick.
260 Thickness shall be established in accordance with ASTM D 1005 or
261 ASTM D 1400.

262
263 Before enameling, aluminum sheets shall be treated with metal
264 treatment designed to produce maximum adherence of porcelain
265 enamel coating. Face of sign shall have required color. Sign back
266 shall be free from over-spray or discoloration, or both. To ensure
267 uniformity, porcelain enamel shall be applied by automatic spray
268 equipment conforming to P.E.I. Specifications ALS-105(57).
269 Noticeable color difference on one sign shall be +0.01 when
270 measured in accordance with N.B.S. Procedure C429.

271
272 Adherence shall be checked by accelerated spall test, in
273 accordance with P.E.I. Process Bulletin A1-1a, Section 6, dated
274 March 24, 1959. Samples 12 inches by 12 inches, processed with
275 production run, shall be tested. Test samples shall be run for every
276 1,000 square feet of production cycle or total order, whichever occurs
277 first. Samples that have undergone spall testing shall be used as
278 parts of project signs. Porcelain enamel shall have acid resistance of
279 Class B or better when tested in accordance with ASTM C 282.
280 Porcelain enamel need only pass blurring-highlight test. Porcelain
281 enamel shall have weight loss of more than 20 milligram per square
282 inch. Porcelain enamel shall have subsurface abrasion volume index
283 of less than 7.0 when tested in accordance with P.E.I. Bulletin T-2
284 (Part IV Sub-Surface Abrasion). Standard index shall be divided by

285 density of porcelain enamel, as defined in P.E.I. Bulletin A1-1a
286 (Section 2 Abrasion Resistance), to obtain volume index.
287

288 Porcelain enamel coating surface exposed to weathering shall
289 be free of blemishes that may impair serviceability or detract from
290 general appearance of sign when viewed from distance of 25 feet.
291

292 **(3) Type I (Engineering Grade) or Type II (Super Engineering**
293 **Grade).** Retroreflective sheeting shall include either of the following:
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295 **(a)** Glass spheres embedded beneath flexible transparent
296 plastic that forms smooth flat outer surface.
297

298 **(b)** Plastic sheeting with minute lenses that are integral part
299 of and uniformly distributed over entire surface of sheeting,
300 forming smooth flat outer surface.
301

302 Visible color of retroreflective sheeting surface and of light
303 reflected shall conform to MUTCD or to color samples furnished by
304 the Engineer.
305

306 Colors, except black, shall be reflectorized.
307

308 Retroreflective sheeting and adhesive backing required for
309 retroreflective sheeting shall conform to AASHTO M 268.
310

311 Durable adhesive bond shall be formed on well-painted
312 surfaces, on unpainted steel and aluminum, and on porcelain enamel.
313

314 Retroreflective sheeting, when ordered separately, shall be
315 shipped in sheets or rolls. Dimensions of sheets shall be specified in
316 purchase order. Material in boxes shall be protected from damage or
317 defacement during transportation. Each shipment shall include
318 quantity of suitable adhesive necessary to attach material to surface.
319

320 Signs made of retroreflective sheeting shall not be embossed.
321

322 Type I retroreflective sheeting shall retain 50 percent of
323 coefficient of retroreflection, in accordance with Table 750.01-1 - Type
324 I Sheeting Minimum Coefficient of Retroreflection, after 7 years from
325 date of installation.
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TABLE 750.01-1 - TYPE I SHEETING MINIMUM COEFFICIENT OF RETROREFLECTION (CD/LUX/M²)				
Color	Observation Angles (Degrees)	Entrance Angle (Degrees)		
		-4.0	30.0	45.0
White	0.1	75	35	9
	0.2	70	30	8
	0.5	30	15	7
	1.0	12	9	4
Yellow	0.1	53	23	5
	0.2	50	22	4.5
	0.5	25	13	4
	1.0	8.5	5.5	2
Red	0.1	15	6.2	1
	0.2	14	6	0.6
	0.5	7.5	3	0.5
	1.0	2.4	1	0.4
Green	0.1	10	5	2
	0.2	9	3.5	1.5
	0.5	4.5	2.2	0.5
	1.0	1.8	1.6	0.4
Blue	0.1	4.2	2	0.8
	0.2	4	1.7	0.6
	0.5	2	0.8	0.5
	1.0	0.7	0.6	0.2
Brown	0.1	1.1	0.5	0.3
	0.2	1	0.3	0.2
	0.5	0.3	0.2	0.1
	1.0	0.2	0.1	0.1

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(4) Type III or IV Retroreflective Sheeting (High Intensity). High intensity retroreflective sheeting shall be encapsulated glass-bead retroreflective material or unmetallized microprismatic retroreflective element material. Sheeting shall have pre-coated adhesive or backside protected by removable liner.

(a) Color Requirements. Color shall conform to AASHTO M 268.

(b) Intended Use. Retroreflective sheeting specified on surfaces of highway signs, traffic delineators, and barricade rails shall be used.

(c) General.

1. Test Conditions. Applied or unapplied test samples and specimens shall be conditioned at 72 degrees F \pm 2 degrees F and 50 percent relative humidity \pm 4 percent for 24 hours before testing.

2. Embossing. Signs made with retroreflective sheeting shall not be embossed.

(d) Retained Reflectivity. Type III retroreflective sheeting shall retain 80 percent of coefficient of retroreflection, in accordance with Table 750.01-2 - Type III Sheeting Minimum Coefficient of Retroreflection, after 10 years from date of installation.

TABLE 750.01-2 - TYPE III SHEETING MINIMUM COEFFICIENT OF RETROREFLECTION (CD/LUX/M²)				
Color	Observation Angle (Degrees)	Entrance Angle (Degrees)		
		-4.0	30.0	45.0
White	0.1	300	225	100
	0.2	250	175	95
	0.5	95	70	55
	1.0	10	9.5	9.0
Yellow	0.1	200	150	60
	0.2	170	135	50
	0.5	62	60	40
	1.0	9.0	8.5	8.0
Red	0.1	54	40	15
	0.2	45	30	12
	0.5	15	12	10
	1.0	2.0	1.5	1.0
Green	0.1	54	40	15
	0.2	45	30	12
	0.5	15	12	10
	1.0	1.0	0.8	0.5
Blue	0.1	24	14	7.0
	0.2	20	11	6.0
	0.5	7.5	5.0	4.0
	1.0	0.5	0.3	0.1
Brown	0.1	14	10	30
	0.2	12	8.5	2.8
	0.5	5.0	3.5	2.5
	1.0	0.5	0.3	0.1

357 **(5) Hardened Aluminum-Backed Retroreflective Sheeting.**

358 Retroreflective sheeting used for manufacture of this product shall
359 conform to Subsection 750.01(C)(4) - Type III or IV Retroreflective
360 Sheeting (High Intensity). Hardened aluminum backing substrate
361 shall be 0.005 inch to 0.010 inch thick. Aluminum shall be cleaned
362 and degreased in accordance with sheeting manufacturer's
363 recommendations.

364
365 Hardened aluminum-backed retroreflective sheeting includes
366 precoated pressure sensitive adhesive backing (Class I) that may be
367 applied to properly prepared smooth surface without necessity of
368 additional adhesive coats on either sheeting or application surface.

369
370 Class I adhesive shall be pressure sensitive adhesive of
371 aggressive tack-type, requiring no heat, solvent, or other preparation
372 for adhesion to smooth, clean surfaces. Surface primer for application
373 to rough surfaces may be required.

374
375 Adhesive on aluminum backing of sheeting shall be subject to
376 adhesion test as follows:

377
378 **(a)** Two 2-inch by 6-inch pieces of hardened aluminum-
379 backed retroreflective sheeting shall be subjected to
380 temperature of 160 degrees F and pressure of 2.5 pounds per
381 square inch for 4 hours.

382
383 **(b)** Materials shall be brought to equilibrium at 72 degrees
384 F, ± 2 degrees F, and, 50 percent, ± 4 percent relative humidity
385 for 24 hours.

386
387 **(c)** One 1-inch by 6-inch adhesion specimen shall be cut
388 from each piece. Liner shall be removed by hand without use
389 of water or other solvents. During removal of liner, if liner
390 adhesive breaks or tears from backing, the specimen fails.
391 Failure of one specimen constitutes failure of test.

392
393 **(d)** Four inches of one end of each specimen shall be
394 applied to a smooth aluminum test panel of 6061-T6 or
395 5052-H38 alloy that is 0.020, 0.040, or 0.063 inch thick. Panel
396 shall be prepared in accordance with ASTM B 449, Class 2 or
397 degreased and etched lightly.

398
399 **(e)** Test panels shall be suspended in horizontal position
400 with specimen facing downward.

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402 **(f)** Four-pound weight shall be attached to free end of each
403 specimen. Specimen shall be allowed to hang free at angle of
404 90 degrees to panel surface for 5 minutes.

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(g) At end of 5-minute period, distance of peeling shall be less than 2 inches.

(h) Failure of one specimen constitutes failure of test.

(6) Type IX Yellow Wide-Angle Prismatic Fluorescent Retroreflective Sheeting. Sheeting shall be wide-angle retroreflective sheeting with optimized performance over broad range of observation and entrance angles. Retroreflective sheeting shall provide high sign brightness at all viewing distances, especially at short distance, and shall conform to the following applicable ASTM Standards:

TABLE 750.01-3 - TYPE IX YELLOW RETROREFLECTIVE SHEETING STANDARDS	
ASTM Designation	Title
B 117	Standard Practice for Operating Salt Spray (Fog) Apparatus
B 209	Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
D 523	Standard Test Method for Specular Gloss
E 284	Standard Terminology of Appearance
E 308	Standard Practice for Computing the Colors of Objects by Using the CIE System
E 810	Standard Test Method for Coefficient of Retroreflection of Retroreflective Sheeting Utilizing the Coplanar Geometry
E 811	Standard Practice for Measuring Colorimetric Characteristics of Retroreflectors Under Nighttime Conditions
E 991	Standard Practice for Color Measurement of Fluorescent Specimens
E 1164	Standard Practice for Obtaining Spectrophotometric Data for Object-Color Evaluation
E 1247	Standard Practice for Detecting Fluorescence in Object-Color Specimens by Spectrophotometry

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(a) **Description.** Retroreflective sheeting shall have smooth surface with distinctive interlocking diamond seal

422 pattern and datum orientation marks visible from the face.
423 Sheeting shall be precoated with pressure sensitive adhesive
424 backing protected by removable liner.
425

426 **(b) Test Methods.**
427

428 **1. Test Conditions.** Unless otherwise specified
429 herein, applied and unapplied test samples and
430 specimens shall be conditioned at standard conditions
431 of 73 degrees \pm 3 degrees F and 50 \pm 5 percent relative
432 humidity for 24 hours prior to testing.
433

434 **2. Test Panels.** Unless otherwise specified herein,
435 when tests are to be performed using test panels,
436 specimens of retroreflective material shall be applied to
437 smooth aluminum cut from ASTM B-209 Alloy 5052-
438 H36, 5052-H38, 5154-H38 or 6061-T6 sheets in 0.020-
439 inch, 0.040-inch or 0.063-inch thickness. Aluminum
440 shall be degreased and lightly acid etched before
441 specimens are applied. Specimens shall be applied to
442 panels in accordance with recommendations of
443 retroreflective sheeting manufacturer.
444

445 **(c) Physical Requirements.** Retroreflective sheeting shall
446 conform to Table 750.01-4 - CIE Daytime Chromaticity
447 Coordinate Limits and Total Luminance Factor. Daytime color
448 shall be determined instrumentally on sheeting applied to
449 aluminum test panels, using two monochromator
450 spectrophotometers employing annular 45/0 (or equivalent
451 0.45) illuminating and viewing geometry. Total chromaticity
452 coordinates and total luminance factor shall be calculated from
453 total spectral radiance factors computed for CIE illuminant D65
454 in accordance with ASTM E-308, for CIE 1931 (2-degree)
455 standard colorimetric observer. Measurements shall be made
456 on Labsphere BFC-450 Bispectral Fluorescence Colorimeter or
457 equivalent.
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TABLE 750.01-4 - CIE DAYTIME CHROMATICITY COORDINATE LIMITS AND TOTAL LUMINANCE FACTOR									
Color	Chromaticity Coordinate 1		Chromaticity Coordinate 2		Chromaticity Coordinate 3		Chromaticity Coordinate 4		Total Luminance Factor Y (Percent, min.)
	x	y	x	y	x	y	x	y	
Fluorescent Yellow	0.521	0.424	0.557	0.442	0.479	0.520	0.454	0.491	40

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(d) Fluorescence Requirements. Retroreflective sheeting shall conform to fluorescence luminance factor requirements in Table 750.01-5 - Fluorescence Luminance Factor Y_F and Table 750.01-8 - Coefficient of Retroreflection and Fluorescence Luminance Factor. Fluorescence luminance shall be determined instrumentally, on sheeting applied to aluminum test panels, using two monochromator spectrophotometers employing annular 45/0 (or equivalent 0.45) illuminating and viewing geometry. Fluorescence luminance factor shall be calculated from fluorescence spectral radiance factors computed for CIE illuminant D65 in accordance with ASTM E 308, for CIE 1931 (2-degree) standard colorimetric observer. Measurements shall be made on Labsphere BFC-450 Bispectral Fluorescence Colorimeter or equivalent.

TABLE 750.01-5 - FLUORESCENCE LUMINANCE FACTOR Y_F	
Color	Y_F (Percent, minimum)
Fluorescent Yellow	25

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(e) Coefficient of Retroreflection, R_A . Coefficients of retroreflection shall not be less than minimum values specified in Table 750.01-6 - Minimum Coefficient of Retroreflection R_A and Table 750.01-8 - Coefficient of Retroreflection and Fluorescence Luminance Factor. Testing shall be performed in accordance with ASTM E 810 and values of 0-degree rotation and 90-degree rotation shall be averaged to determine R_A .

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1. Units. Coefficients of retroreflection R_A shall be specified in units of candelas per lux per square meter.

2. Datum Mark. Datum mark (arrow) imprinted on face of sheeting shall be datum mark for test purposes. For 0-degree rotation angle, direction of datum mark shall be parallel to entrance plane. For 90-degree rotation angle, datum mark is perpendicular to entrance plane.

TABLE 750.01-6 - MINIMUM COEFFICIENT OF RETROREFLECTION R_A (CD/LUX/M²)			
Observation Angle (Degrees)	Entrance Angle (Degrees)		
	-4	30	45
0.1	400	250	70
0.2	250	150	55
0.5	165	75	15
1.0	45	24	6

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(f) Nighttime Color (x,y). Chromaticity coordinates of retroreflective sheeting shall conform to Table 750.01-7 - CIE Nighttime Chromaticity Coordinate Limits.

1. Nighttime Color Test. Conformance to nighttime color requirements of Table 750.01-7 - CIE Nighttime Chromaticity Coordinate Limits shall be determined instrumentally on sheeting applied to aluminum test panels. Testing shall be performed in accordance with ASTM E 811. Total chromaticity coordinates shall be calculated from total spectral radiance factors computed for CIE illuminant A in accordance with ASTM E 308, for CIE 1931 (2-degree) standard colorimetric observer.

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TABLE 750.01-7 - CIE NIGHTTIME CHROMATICITY COORDINATE LIMITS								
Color	Chromaticity Coordinate 1		Chromaticity Coordinate 2		Chromaticity Coordinate 3		Chromaticity Coordinate 4	
	x	y	x	y	x	y	x	y
Fluo- rescent Yellow	0.554	0.445	0.610	0.390	0.569	0.394	0.527	0.436

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(g) Gloss. Retroreflective sheeting shall have an 85-degree specular gloss of not less than 50 when tested in accordance with ASTM D 523.

(h) Color Processing. Retroreflective sheeting shall permit cutting and color processing with compatible transparent and opaque process colors in accordance with sheeting manufacturer's recommendations at temperatures of 59 degrees F to 100 degrees F, and relative humidities of 20 percent to 80 percent. Sheeting shall be heat resistant and permit force curing without staining of applied or unapplied sheeting at temperatures recommended by sheeting manufacturer.

(i) Flexibility. Retroreflective sheeting with liner removed and conditioned as in Subsection 750.01(C)(6)(b)1. - Test Conditions shall be sufficiently flexible to show no cracking when slowly bent, in one second's time, around 1/8-inch mandrel, with adhesive contacting mandrel, at test conditions. Talcum powder shall be spread on adhesive to prevent sticking to mandrel.

(j) Adhesive. Protective liner attached to adhesive shall be removed by peeling without soaking in water or other solutions, without breaking, tearing, or removing any adhesive from the backing. Protective liner shall be easily removed following accelerated storage for 4 hours at 158 degrees F under weight of 2.5 pounds per square inch. Adhesive backing of retroreflective sheeting shall produce bond to support 1.75 pound-weight for 5 minutes without bond peeling for distance of more than 2.0 inches when applied to test panel as described in Subsection 750.01(C)(6)(b)2. - Test Panels. Apply 4 inches of 1-inch by 6-inch specimen to test panel.

544 Condition and then position panel face down horizontally,
545 suspend weight from free end of sample, and allow it to hang
546 free at angle of 90 degrees to panel surface for 5 minutes.
547

548 **(k) Impact Resistance.** Retroreflective sheeting applied in
549 accordance with sheeting manufacturer's recommendations to
550 test panel of alloy 6061-T6, 0.040 inch by 3 inches by 6 inches,
551 and conditioned as in Subsection 750.01(C)(6)(b)1. - Test
552 Conditions, shall show no cracking outside impact area when
553 face of panel is subjected to impact of 50 inch-pounds using
554 weight with 5/8-inch diameter rounded tip dropped from height
555 necessary to generate impact of 50 inch-pounds, at test
556 temperatures of both 32 degrees F and 72 degrees F.
557

558 **(l) Resistance to Accelerated Outdoor Weathering.**
559 Retroreflective surface of sheeting shall be weather resistant
560 and show no appreciable cracking, blistering, crazing, or
561 dimensional change after 3 years unprotected outdoor
562 exposure, facing equator and inclined 45 degrees from vertical.
563 Following weather exposure, panels shall be washed in 5
564 percent HCL solution for 45 seconds, rinsed thoroughly with
565 clean water, blotted with soft clean cloth, and brought to
566 equilibrium at standard conditions. After cleaning, coefficient of
567 retroreflection and fluorescence luminance factor shall not be
568 less than values of Table 750.01-8 - Coefficient of
569 Retroreflection and Fluorescence Luminance Factor. Color
570 shall conform to Table 750.01-4 - CIE Daytime Chromaticity
571 Coordinate Limits and Total Luminance Factor and 750.01-7 -
572 CIE Nighttime Chromaticity Coordinate Limits. Sample shall
573 show no appreciable evidence of cracking, scaling, pitting,
574 blistering, edge lifting or curling more than 1/32 inch, or
575 shrinkage or expansion, or combination thereof.
576

577 Where more than one panel of color is measured,
578 coefficient of retroreflection shall be average of all
579 determinations.
580

TABLE 750.01-8 - COEFFICIENT OF RETROREFLECTION AND FLUORESCENCE LUMINANCE FACTOR					
Color	Warranty Period	Minimum Coefficient of Retroreflection at -4.0 Degrees Entrance Angle (cd/lux/m ²)		Minimum Fluorescence Luminance Factor (Percent)	Minimum Total Luminance Factor (Percent)
		Observation Angle (Degrees)	R _A	Y _F	Y
Fluorescent Yellow	7 Years	0.2	165	20	35
		1.0	30		

Note: All measurements shall be made after cleaning, in accordance with manufacturer's recommendations.

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(m) Optical Stability. Three pieces of retroreflective sheeting applied to test panels and conditioned as in Subsection 750.01(C)(6)(b)1. - Test Conditions shall each first have photometric properties characterized by measuring coefficients of retroreflection in accordance with provisions in Subsection 750.01(C)(6)(e) - Coefficient of Retroreflection, R_A at all test geometries shown in Table C. Panels shall then be exposed in air circulating oven at 170 ± 5 degrees F for a period of 24 hours. After exposure, panels shall be allowed to condition in accordance with provisions of Subsection 750.01(C)(6)(b)2. - Test Panels. Panels will again be characterized for photometric properties by measuring coefficients of retroreflection in accordance with to provisions of Subsection 750.01(C)(6)(e) - Coefficient of Retroreflection, R_A at all test geometries measured before exposure.

Coefficients of retroreflection measured after exposure shall be between 85 percent and 115 percent of values measured before exposure for each of three samples.

(n) Resistance to Corrosion. Retroreflective sheeting applied to test panel and conditioned as in Subsection 750.01(C)(6)(b)1. - Test Conditions, shall show no loss of adhesion, appreciable discoloration or corrosion and after cleaning shall retain minimum of 80 percent of original coefficient of retroreflection when measured at 0.2 degree

608 observation, -4 degrees entrance and 0-degree rotation angles
 609 after 1,000 hours exposure to 5 percent concentration salt
 610 spray at 95 degrees F when tested in accordance with ASTM B
 611 117.

612
 613 **(o) Sheeting Manufacturer's Warranty.** Sheeting
 614 manufacturer shall, upon request, submit with each lot or
 615 shipment, certification stating that material supplied shall meet
 616 requirements indicated by the contract documents.

617
 618 The Engineer will request certification if sign deteriorates
 619 due to natural causes such that any of the following conditions
 620 are met:

- 621
 622 1. Sign is ineffective for its intended purpose when
 623 viewed from moving vehicle under normal day and night
 624 driving conditions by driver with normal vision.
 625
 626 2. Coefficient of retroreflection and fluorescence
 627 luminance factor, after cleaning, are less than values
 628 indicated in Table 750.01-8 - Coefficient of
 629 Retroreflection and Fluorescence Luminance Factor.
 630
 631 3. Daytime chromaticity, after cleaning, falls outside
 632 limits indicated in Table 750.01-4 - CIE Daytime
 633 Chromaticity Coordinate Limits and Total Luminance
 634 Factor.
 635
 636 4. Nighttime chromaticity, after cleaning, falls
 637 outside limits indicated in Table 750.01 -7 - CIE
 638 Nighttime Chromaticity Coordinate Limits.
 639

640 Natural causes include effects of exposure to weather.
 641 Natural causes exclude (without limitation) damage from
 642 exposure to chemicals, abrasion, mechanical damage from
 643 fasteners used to mount sign, collisions, or mishandling.
 644

645 **(p) Sheeting Manufacturer's Replacement Obligation.**
 646 Where it can be shown that retroreflective sheeting fails to
 647 conform to performance requirements of Subsection
 648 750.01(C)(6)(o) - Sheeting Manufacturer's Warranty, sheeting
 649 manufacturer shall:

- 650
 651 1. Restore sign surface to its original effectiveness
 652 if failure occurs within first five years from date of
 653 fabrication.
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2. Furnish necessary amount of sheeting to restore sign surface to its original effectiveness if failure occurs from 6 or 7 year from date of fabrication.

Replacement sheeting shall carry unexpired warranty of sheeting it replaces.

(7) Type IX Yellow-Green Wide Angle Prismatic Fluorescent Retroreflective Sheeting. Sheeting shall be visible-activated fluorescent retroreflector providing higher daytime brightness than ordinary colored sheetings of similar chromaticity.

Sheeting shall be wide-angle retroreflective sheeting with optimized performance over broad range of observation and entrance angles. Retroreflective sheeting shall provide high sign brightness at viewing distances, especially at short distance, and shall conform to the following applicable ASTM Standard Documents:

TABLE 750.01-9 - TYPE IX YELLOW-GREEN RETROREFLECTIVE SHEETING STANDARDS	
ASTM Designation	Title
B 117	Standard Practice for Operating Salt Spray (Fog) Apparatus
B 209	Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate
D 523	Standard Test Method for Specular Gloss
E 284	Standard Terminology of Appearance
E 308	Standard Practice for Computing the Colors of Objects by Using the CIE System
E 810	Standard Test Method for Coefficient of Retroreflection of Retroreflective Sheeting Utilizing the Coplanar Geometry
E 991	Standard Practice for Color Measurement of Fluorescent Specimens
E 1164	Standard Practice for Obtaining Spectrophotometric Data for Object-Color Evaluation

673
674

674 (a) **Description.** Retroreflective sheeting shall have
675 smooth surface with distinctive interlocking diamond seal
676 pattern and datum orientation marks visible from the face.
677 Sheeting shall be precoated with pressure sensitive adhesive
678 backing protected by removable liner.

679
680 (b) **Test Methods.**

681 1. **Test Conditions.** Unless otherwise specified
682 herein, applied and unapplied test samples and
683 specimens shall be conditioned at standard conditions
684 of 73 degrees \pm 3 degrees F and 50 \pm 5 percent relative
685 humidity for 24 hours prior to testing.

686
687 2. **Test Panels.** Unless otherwise specified herein,
688 when tests are to be performed using test panels,
689 specimens of retroreflective material shall be applied to
690 smooth aluminum cut from ASTM B 209 Alloy 5052-
691 H36, 5052-H38, 5154-H38 or 6061-T6 sheets in 0.020-
692 inch, 0.040-inch, or 0.063-inch thickness. Aluminum
693 shall be degreased and lightly acid etched before
694 specimens are applied. Specimens shall be applied to
695 panels in accordance with recommendations of
696 retroreflective sheeting manufacturer.

697
698 (c) **Physical Requirements.** Daytime Color Test shall
699 conform to requirements of Table 750.01-10 - CIE Daytime
700 Chromaticity Coordinate Limit and Total Luminance Factor.
701 Test shall be conducted instrumentally, on sheeting applied to
702 aluminum test panels, using 2-monochromator
703 spectrophotometer employing annular 45/0 (or equivalent 0.45)
704 illuminating and viewing geometry. Total chromaticity
705 coordinates and total luminance factor shall be calculated from
706 total spectral radiance factors computed for CIE illuminant D65,
707 in accordance with ASTM E 308, for CIE 1931 (2-degree)
708 standard colorimetric observer. Measurements shall be made
709 on Labsphere BFC-450 Bispectral Fluorescence Colorimeter or
710 equivalent.

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711

TABLE 750.01-10 - CIE DAYTIME CHROMATICITY COORDINATE LIMIT AND TOTAL LUMINANCE FACTOR									
Color	Chromaticity Coordinate 1		Chromaticity Coordinate 2		Chromaticity Coordinate 3		Chromaticity Coordinate 4		Total Luminance Factor Y (Percent, min.)
	x	y	x	y	x	y	x	y	
Fluorescent Yellow-Green	0.387	0.610	0.460	0.540	0.421	0.486	0.368	0.539	60

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(d) Fluorescence Requirements. Fluorescence shall conform to requirements in Table 750.01-11 - Fluorescence Luminance Factor and Table 750.01-13 - Minimum Coefficient of Retroreflection R_A (Cd/Lux/M²) and Fluorescence Luminance Factor Y_F , After Accelerated Outdoor Weathering. Conformance shall be determined instrumentally, on sheeting applied to aluminum test panels, using a 2-monochromator spectrophotometer employing annular 45/0 (or equivalent 0.45) illuminating and viewing geometry. Fluorescence luminance factor shall be calculated from fluorescence spectral radiance factors computed for CIE illuminant D65 in accordance with ASTM E 308, for CIE 1931 (2 degrees) standard colorimetric observer. Measurements shall be made on Labsphere BFC-450 Bispectral Fluorescence Colorimeter or equivalent.

TABLE 750.01-11 - FLUORESCENCE LUMINANCE FACTOR	
Color	Y_F (Percent, min.)
Fluorescent Yellow-Green	35

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(e) Coefficient of Retroreflection, R_A . Coefficients of retroreflection shall not be less than minimum values specified in Table 750.01-12 - Minimum Coefficient of Retroreflection R_A and Table 750.01-13 - Minimum Coefficient of Retroreflection R_A (Cd/Lux/M²) and Fluorescence Luminance Factor Y_F After Accelerated Outdoor Weathering. Testing shall be in accordance with ASTM E 810, except that angle of rotation shall be specified.

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1. **Units.** Coefficients of retroreflection R_A shall be specified in units of candelas per lux per square meter.

2. **Datum Mark.** Datum mark (arrow) imprinted on face of sheeting shall be datum mark for test purposes. Testing shall be performed at 0 degree rotation and 90 degrees rotation in accordance with tables below. For the 0-degree rotation angle, direction of datum mark shall be parallel to entrance plane. For 90-degree rotation, angle datum mark is perpendicular to entrance plane.

TABLE 750.01-12 - MINIMUM COEFFICIENT OF RETROREFLECTION R_A (CD/LUX/M ²)				
Observation Angle (Degrees)	Rotation Angle (Degrees)	Entrance Angle		
		-4 Degrees	30 Degrees	45 Degrees
0.1	0	560	465	30
0.1	90	525	300	160
0.2	0	375	225	25
0.2	90	275	180	125
0.5	0	225	145	70
0.5	90	250	70	40
1.0	0	75	45	4
1.0	90	50	25	12

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(f) **Gloss.** Retroreflective sheeting shall have 85 degrees specular gloss of not less than 50 when tested in accordance with ASTM D 523.

(g) **Color Processing.** Retroreflective sheeting shall permit cutting and color processing with compatible transparent and opaque process colors in accordance with sheeting manufacturer's recommendations at temperatures of 59 degrees F to 100 degrees F, and relative humidities of 20 percent to 80 percent. Sheeting shall be heat resistant and

761 permit force curing without staining of applied or unapplied
762 sheeting at temperatures recommended by sheeting
763 manufacturer.

764
765 **(h) Flexibility.** Retroreflective sheeting with liner removed
766 and conditioned as in Subsection 750.01(C)(7)(b)1. - Test
767 Conditions shall be sufficiently flexible to show no cracking
768 when slowly bent, in one second's time, around 1/8 inch
769 mandrel, with adhesive contacting mandrel, at test conditions.
770 Talcum powder shall be spread on adhesive to prevent sticking
771 to mandrel.

772
773 **(i) Adhesive.** Protective liner attached to adhesive shall
774 be removed by peeling without soaking in water or other
775 solutions, without breaking, tearing, or removing any adhesive
776 from backing. Protective liner shall be easily removed following
777 accelerated storage for 4 hours at 158 degrees F under weight
778 of 2.5 pounds per square inch. Adhesive backing of
779 retroreflective sheeting shall produce bond to support 1.75
780 pound-weight for 5 minutes without bond peeling for distance
781 of more than 2.0 inches when applied to test panel as
782 described in Subsection 750.01(C)(7)(b)(2) - Test Panels.
783 Apply 4 inches of 1-inch by 6-inch specimen to test panel.
784 Condition and then position panel face down horizontally,
785 suspend weight from free end of sample and allow it to hang
786 free at angle of 90 degrees to panel surface for 5 minutes.

787
788 **(j) Impact Resistance.** Retroreflective sheeting applied in
789 accordance with sheeting manufacturer's recommendations to
790 test panel of alloy 6061-T6, 0.040 inch by 3 inches by 5 inches
791 and conditioned as in Subsection 750.01(C)(7)(b)(1) - Test
792 Conditions, shall show no cracking outside impact area when
793 face of panel is subjected to impact of 100 inch-pounds using
794 weight with 5/8-inch diameter rounded tip dropped from height
795 necessary to generate impact of 100 inch-pounds, at test
796 temperatures of both 32 degrees F and 72 degrees F.

797
798 **(k) Resistance to Accelerated Outdoor Weathering.**
799 Retroreflective surface of sheeting shall be weather resistant
800 and show no appreciable cracking, blistering, crazing, or
801 dimensional change after 3 years unprotected outdoor
802 exposure, facing equator and inclined 45 degrees from vertical.
803 Following weather exposure, panels shall be washed in 5
804 percent HCL solution for 45 seconds, rinsed thoroughly with
805 clean water, blotted with soft clean cloth and brought to
806 equilibrium at standard conditions. After cleaning, coefficient of
807 retroreflection and fluorescence luminance factor shall not be
808 less than values indicated in Table 750.01-13 - Minimum

809 Coefficient of Retroreflection R_A (Cd/Lux/M²) and Fluorescence
 810 Luminance Factor Y_F , After Accelerated Outdoor Weathering.
 811 Color shall conform to Table 750.01-10 - CIE Daytime
 812 Chromaticity Coordinate Limit and Total Luminance Factor.
 813 Sample shall conform to the following:

- 814
- 815 1. Show no appreciable evidence of cracking,
 816 scaling, pitting, blistering, edge lifting or curling of more
 817 than 1/32 inch shrinkage or expansion.
 - 818
 - 819 2. Where more than one panel of color is
 820 measured, coefficient of retroreflection shall be average
 821 of all determinations.
 - 822

TABLE 750.01-13- MINIMUM COEFFICIENT OF RETROREFLECTION R_A (CD/LUX/M²) AND FLUORESCENCE LUMINANCE FACTOR Y_F, AFTER ACCELERATED OUTDOOR WEATHERING					
Color	Warranty Period	Observation Angle (Degrees)	Rotation Angle (Degrees)	-4 Entrance Angle (Degrees)	Fluorescence Luminance Factor Y_F (Percent min.)
Fluorescent Yellow- Green	7 Years	0.2	0	190	20
		0.2	90	140	20
		1.0	0	40	20
		1.0	90	25	20

823

824 **(l) Optical Stability.** Three pieces of retroreflective
 825 sheeting applied to test panels and conditioned as in
 826 Subsection 750.01(C)(7)(b)(1) - Test Conditions shall first have
 827 each of their photometric properties characterized by
 828 measuring coefficients of retroreflection in accordance with
 829 provisions in Subsection 750.01(C)(7)(e) - Coefficient of
 830 Retroreflection, R_A at test geometries indicated in Table
 831 750.01-12 - Minimum Coefficient of Retroreflection R_A
 832 (Cd/Lux/M²). Panels shall then be exposed in air-circulating
 833 oven at 170 ± 5 degrees F for a period of 24 hours. After
 834 exposure, panels shall be allowed to condition in accordance
 835 with provisions of Subsection 750.01(C)(7)(b)(1) - Test
 836 Conditions. Panels will again be characterized for photometric
 837 properties by measuring coefficients of retroreflection in
 838 accordance with provisions of Subsection 750.01(C)(7)(e) -

839 Coefficient of Retroreflection, R_A at test geometries measured
840 before exposure.

841

842 Coefficients of retroreflection measured after exposure
843 shall be between 85 percent and 115 percent of values
844 measured before exposure for each of three samples.

845

846 **(m) Resistance to Corrosion.** Retroreflective sheeting
847 applied to test panel and conditioned as in Subsection
848 750.01(C)(7)(b)(1) - Test Conditions shall show no loss of
849 adhesion, appreciable discoloration, or corrosion. Resistance
850 to corrosion shall be measured after 1,000 hours exposure to 5
851 percent concentration salt spray at 95 degrees F. After
852 cleaning and when tested in accordance with ASTM B 117,
853 retroreflective sheeting shall retain minimum 80 percent of
854 original coefficient of retroreflection, measured at 0.2 degree
855 observation, -4 degrees entrance, and 0 degree rotation
856 angles.

857

858 **(n) Sheeting Manufacturer's Warranty.** Sheeting
859 manufacturer shall submit with each lot or shipment,
860 certification stating that material supplied shall meet
861 requirements indicated by the contract documents.

862

863 If any of the following conditions are met, sheeting
864 manufacturer shall comply with Subsection 750.01(C)(7)(o) -
865 Sheeting Manufacturer's Replacement Obligation.

866

867 **1.** Coefficient of retroreflection and fluorescence
868 luminance factor, after cleaning, are less than values
869 indicated in Table 750.01-13 - Minimum Coefficient of
870 Retroreflection R_A (Cd/Lux/M²) and Fluorescence
871 Luminance Factor Y_F , After Accelerated Outdoor
872 Weathering.

873

874 **2.** Daytime chromaticity, after cleaning, falls outside
875 limits indicated in Table 750.01-10 - CIE Daytime
876 Chromaticity Coordinate Limit and Total Luminance
877 Factor.

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879 Natural causes include effects of exposure to weather.
880 Natural causes exclude (without limitation) damage from
881 exposure to chemicals, abrasion, mechanical damage from
882 fasteners used to mount sign, collisions, or mishandling.

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(o) Sheeting Manufacturer's Replacement Obligation.

Where it can be shown that retroreflective sheeting fails to conform to performance requirements of Subsection 750.01(C)(7)(n) - Sheeting Manufacturer's Warranty, sheeting manufacturer shall do the following:

1. Restore sign surface to its original effectiveness if failure occurs within first 60 months from date of fabrication.
2. Furnish necessary amount of sheeting to restore sign surface to its original effectiveness if failure occurs from 61 to 84 month from date of fabrication.

Replacement sheeting shall carry unexpired warranty of sheeting it replaces.

(8) Type VII Fluorescent Orange Wide Angle Prismatic Retroreflective Sheeting. Fluorescent orange wide angle prismatic retroreflective sheeting shall be specifically designed for use on rigid substrate work zone signs to provide high visual impact under nighttime and daytime driving conditions, including low visibility periods such as dawn, dusk, and overcast days.

(a) Description. Sheeting shall consist of prismatic lenses formed in transparent fluorescent orange synthetic resin, sealed and backed with aggressive pressure sensitive adhesive protected by removable liner. Retroreflective sheeting shall have smooth surface with distinctive interlocking diamond seal pattern and orientation marks visible from face.

(b) Coefficient of Retroreflection, R_A . Sheeting applied on aluminum test panels shall be measured in accordance with ASTM E 810, and shall have minimum coefficient of retroreflection values as indicated in Table 750.01-14 - Minimum Coefficient of Retroreflection R_A (Cd/Lux/M²), 90 Degree Rotation Angle. Rotation angle shall be 90 degrees, observation angles shall be 0.2 degree and 0.5 degree, entrance angles (component β_1) shall be -4 degrees, +30 degrees, and +50 degrees, and entrance angle (component β_2) shall be 0 degree.

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TABLE 750.01-14 - MINIMUM COEFFICIENT OF RETROREFLECTION R_A (CD/LUX/M ²), 90 DEGREE ROTATION ANGLE		
Observation Angle (Degrees)	Entrance Angle (Degrees)	Orange
0.2	-4	200
0.2	+30	120
0.2	+50	50
0.5	-4	80
0.5	+30	50
0.5	+50	20

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Datum mark (arrow) imprinted on face of sheeting shall be datum mark for test purposes. For specified 90-degree rotation angle, sheeting shall be positioned on goniometer so that direction of datum mark is perpendicular to observation plane (geometry is equivalent to a 90-degree orientation angle with presentation angle of 0-degree in measurement geometry described in Federal Test Method Standard 370).

(c) Daytime Color. Daytime color shall conform to Table 750.01-15 - Color Specification Limits (Daytime). Daytime color and maximum spectral radiance factor (peak reflectance) of sheeting mounted on aluminum test panels shall be determined instrumentally in accordance with ASTM E 991. Values shall be determined on HunterLab Labscan 6000 0/45 Spectrocolorimeter with option CMR 559 [or approved equal 0/45 (45/0) instrument with circumferential viewing (illumination)]. Computations shall be done in accordance with ASTM E 308 for 2 degrees observer.

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TABLE 750.01-15- COLOR SPECIFICATION LIMITS (DAYTIME)										
Color	Chromaticity Coordinate 1		Chromaticity Coordinate 2		Chromaticity Coordinate 3		Chromaticity Coordinate 4		Reflectance Limit, Y (Percent)	
	x	y	x	y	x	y	x	y	min.	max.
Fluorescent Orange (New)	0.583	0.416	0.523	0.397	0.560	0.360	0.631	0.369	30	-
Fluorescent Orange (Weathered)	0.583	0.416	0.523	0.397	0.560	0.360	0.631	0.369	20	45

Note:
Maximum spectral radiance factor (new): 110 percent min.
Maximum spectral radiance factor (weathered): 60 percent min.

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(d) Nighttime Color. Nighttime color of sheeting applied to aluminum test panels shall be determined instrumentally in accordance with ASTM E 811 and calculated in u^1 , v^1 coordinate system in accordance with ASTM E 308. Shheeting shall be measured at 0.33 degree observation and -4 degrees entrance at 90 degrees rotation. Color shall conform to Table 750.01-16 - Color Specification Limits (Nighttime).

TABLE 750.01-16- COLOR SPECIFICATION LIMITS (NIGHTTIME)								
Color	Chromaticity Coordinate 1		Chromaticity Coordinate 2		Chromaticity Coordinate 3		Chromaticity Coordinate 4	
	u^1	v^1	u^1	v^1	u^1	v^1	u^1	v^1
Fluorescent Orange (New and Weathered)	0.400	0.540	0.475	0.529	0.448	0.522	0.372	0.534

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(e) Resistance to Accelerated Weathering. Retroreflective surface of sheeting shall be weather-resistant and show no appreciable cracking, blistering, crazing, or dimensional change after one-year, unprotected outdoor exposure, facing equator and inclined 45 degrees from vertical, or after 1,500 hours exposure in xenon arc weatherometer in

962 accordance with ASTM G 155, Type B, Method A. Following
963 weather exposure, panels shall be washed in 5 percent HCL
964 solution for 45 seconds, rinsed thoroughly with clean water,
965 blotted with soft clean cloth and brought to equilibrium at
966 standard conditions. After cleaning, coefficient of
967 retroreflection shall not be less than 100 when measured as
968 prescribed in Subsection 750.01(C)(8)(e)2.; and color shall
969 conform to Table 750.01-15 - Color Specification Limits
970 (Daytime) and Table 750.01-16 - Color Specification Limits
971 (Nighttime) for weathered sheeting. Sample shall conform to
972 the following:

- 973
974 1. Show no appreciable evidence of cracking,
975 scaling, pitting, blistering, edge lifting or curling of
976 more than 1/32 inch shrinkage or expansion.
- 977
978 2. Be measured only at angles of 0.2 degree
979 observation, -4 degrees entrance and 90 degrees
980 rotation. Where more than one panel of color is
981 measured, coefficient of retroreflection shall be average
982 of all determinations.

983
984 **(f) Impact Resistance.** Retroreflective sheeting applied in
985 accordance with sheeting manufacturer's recommendations to
986 test panel of alloy 6061-T6, 0.040 inch by 3 inches by 5 inches,
987 and conditioned for 24 hours, shall show no cracking outside
988 impact area when face of panel is subjected to impact of 100
989 inch-pounds using weight with 5/8-inch diameter rounded tip
990 dropped from height necessary to generate an impact of 100
991 inch-pounds, at test temperatures of both 32 degrees F and 72
992 degrees F.

993
994 **(g) Resistance to Heat.** Retroreflective sheeting, applied
995 to test panel as in Subsection 750.01(C)(8)(e)2., and
996 conditioned for 24 hours, shall be measured in accordance with
997 Table 750.01-14 - Minimum Coefficient of Retroreflection R_A
998 (Cd/Lux/M²), 90 Degree Rotation Angle. at 0.2 degree
999 observation and -4 degrees entrance angles at 90 degrees
1000 rotation and exposed to 170 + 5 degrees F for 24 hours in air
1001 circulating oven. After heat exposure, sheeting shall retain
1002 minimum of 70 percent of original coefficient of retroreflection.

1003
1004 **(h) Field Performance.** Retroreflective sheeting processed
1005 and applied to sign blank materials in accordance with sheeting
1006 manufacturer's recommendations shall be expected to perform
1007 effectively for minimum of 3 years. Retroreflective

1008 sheeting shall be considered unsatisfactory if it has
 1009 deteriorated due to natural causes such that the following
 1010 condition is met: coefficient of retroreflection is less than 100
 1011 when measured at 0.2-degree observation angle and
 1012 -4-degree entrance angle at 90-degree rotation.
 1013

1014 Measurements shall be made after sign cleaning in
 1015 accordance with sheeting manufacturer's recommendations.
 1016

1017 **(D) Sign Message and Accessories.** White letters, numerals, symbols,
 1018 and borders from retroreflective sheeting shall be used on individual
 1019 aluminum cut-outs, or individually embossed porcelain enameled aluminum
 1020 cut-outs containing reflex reflectors, or hardened aluminum-backed
 1021 retroreflective sheeting.
 1022

1023 **(1) Aluminum Cut-Outs With Retroreflective Sheeting.** Size
 1024 and design of letters, symbols, numerals, and borders shall conform to
 1025 FHWA's *Standard Alphabets for Highway Signs*.
 1026

1027 Letters, numerals, and symbols shall be 0.040-inch-thick
 1028 aluminum sheet of ASTM B 209, 3003-H14 alloy. Borders shall be
 1029 0.032-inch-thick aluminum sheet of ASTM B 209, 6061-T6 alloy.
 1030 Aluminum shall be degreased and etched, or treated with light, tight,
 1031 amorphous chromate-type coating.
 1032

1033 Each letter, numeral, symbol, and border shall be supplied with
 1034 mounting holes and secured to sign surface with aluminum blind
 1035 rivets. Blind rivets shall be self-plugging type with 1/8-inch minimum
 1036 diameter shank and 5/16-inch minimum grip range.
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1038 Letters, numerals, symbols, and borders shall be finished to be
 1039 clean cut and sharp and shall have plane surfaces.
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1041 Certificated of compliance shall be submitted in accordance
 1042 with Subsection 106.07 - Certificate of Compliance for furnished
 1043 letters, numerals, symbols, and borders
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1045 Letters, numerals, symbols, and borders shall be packaged to
 1046 ensure arrival at their destination undamaged and shall be protected
 1047 from exposure to moisture during shipment and storage.
 1048

1049 **(2) Porcelain Enameled Aluminum Cut-Outs With Acrylic
 1050 Plastic Reflectors, Letters, Symbols And Borders.** Size and
 1051 design of porcelain enameled aluminum cut-outs with acrylic plastic
 1052 reflectors, letters, symbols, and borders shall conform to FHWA's
 1053 *Standard Alphabets for Highways Signs*.
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Aluminum cut-outs with acrylic plastic reflex reflectors shall include embossed metal frames. Prismatic reflectors may be installed. Tape or adhesive will not be allowed. Metal frames shall be sheet aluminum more than 0.040-inch thick conforming to ASTM B 209, alloy 3003-T6. Sheet shall be cleaned thoroughly after fabrication and treated for corrosion protection. Frames shall be finished neatly and have embossed edges.

Frames shall have white porcelain enamel finish. Metal parts of letters, digits, symbols, and borders shall be capable of withstanding 50 hours of salt spray, with no evidence of pinholing, when tested in accordance with ASTM B 117. Frames shall be fastened to panel background with aluminum, self-plugging blind rivets.

Round reflectors shall include clear, transparent face (lens) and plastic back of identical material. Plastic back shall be fused to lens, under heat and pressure, around perimeter to form a homogeneous unit. Plastic back shall be sealed permanently against dust, water, or water vapor. Reflector units assembled with gaskets will not be allowed.

Lenses shall include smooth front surface free of projections or indentations, other than those required for identification. Lenses having rear surface bearing configuration shall affect internal reflection of light without aid of plating or separate reflector.

The following values for specific brightness of reflex reflectors shall be met or exceeded:

TABLE 750.01-17 - SPECIFIC BRIGHTNESS OF REFLEX REFLECTORS		
Entrance Angle (Degrees)	Divergence Angle (Degrees)	Specific Brightness (Candlepower/Square Inch/Foot-Candle)
0	1/6	3.6
10	1/6	3.0
20	1/6	1.6
0	1/3	3.0
10	1/3	2.3
20	1/3	1.0

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For testing optical performance, the following definitions shall be used:

(a) Entrance Angle. Angle at reflector between direction of light incident on reflector and direction of reflector axis.

(b) Divergence Angle. Angle at reflector between observer's line of sight and direction of light incident on reflector.

(c) Specific Brightness. Candlepower returned at chosen divergence angle, per square inch of reflecting surface for each foot-candle of illumination at reflector.

(3) Hardened Aluminum-Backed Retroreflective Sheeting. Size and design of letters, symbols, numerals, and borders shall conform to FHWA's *Standard Alphabets for Highway Signs*.

Sheeting finish shall conform to Subsection 750.01(C)(5) - Hardened Aluminum-Backed Retroreflective Sheeting.

Sheeting shall be fabricated in accordance with manufacturer's instructions.

Letters, numerals, symbols, and borders shall be clean cut and sharp, and shall have plane surfaces.

Certificate of compliance shall be submitted in accordance with Subsection 106.07 - Certificate of Compliance for furnished letters, numerals, symbols, and borders.

Letters, numerals, symbols, and borders shall be delivered undamaged and shall be protected from exposure to moisture, oil, and solvents during storage and shipment.

Same material shall be used for background and sign legend. Background shall be made smooth, clean, and dry before application of sign legend. Sign legend shall be installed in accordance with manufacturer's instructions.

(E) Retroreflective Sheeting Materials. Retroreflective sheeting includes white or colored sheeting having smooth outer surface.

Retroreflective sheeting shall be classified in accordance with AASHTO M 268, with addition of 1-degree observation angle and 45-degree entrance angle.

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1133 General and minimum performance requirements for each type of
1134 retroreflective sheeting shall conform to AASHTO M 268.

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1136 Test methods and procedures shall be in accordance with
1137 AASHTO M 268.

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1139 750.02 Sign Posts.

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1141 **(A) Pipe Posts.** Pipe posts of zinc-coated, standard weight, steel pipe
1142 shall conform to ASTM A 53. Portion of post that will be embedded below
1143 finish grade shall be equipped with device accepted by the Engineer to resist
1144 turning of post after installation. Post shall be made of one-piece pipe of
1145 required length. Pipe posts with one welded joint may be used if joint is
1146 located below finished grade. Pipe post shall have two 3/8-inch-diameter
1147 holes, located to match sign holes, or adjustable band brackets accepted by
1148 the Engineer.

1149

1150 **(B) Channel Posts.** Channel posts of uniform flanged channel section
1151 produced from high strength rail steel shall conform to ASTM A 499, grade
1152 60 and shall be zinc coated in accordance with AASHTO M 111.

1153

1154 Weight of each anchor base post and sign post, before holes are
1155 punched, shall be 2-1/2 or 4 pounds per foot as indicated in the contract
1156 documents. Weight tolerance shall be \pm 3-1/2 percent.

1157

1158 Anchor base post shall be punched with minimum of ten 7/16-inch
1159 diameter holes, centered in web. Holes shall be spaced 1 inch on centers,
1160 except that first and fifth holes shall be 7/16-inch by 1/2-inch slots. First hole
1161 shall be made 1 inch from top. Anchor bases shall have tapered bottoms in
1162 accordance with the contract documents.

1163

1164 Sign post shall be punched with 7/16-inch diameter holes centered in
1165 web and spaced 1 inch on centers, full length. First and last holes shall be
1166 made 1 inch from the ends.

1167

1168 **(C) Square Tube Posts.** Square and other tube posts shall conform to
1169 ASTM A 653 for cold-rolled, carbon steel sheet, commercial quality; ASTM
1170 A 1011 for hot-rolled carbon steel sheet, structural quality; or ASTM A 787 for
1171 electric-resistance-welded, metallic-coated carbon steel mechanical tubing.
1172 Posts shall be hot-dip, zinc-coated in accordance with ASTM A 653.

1173

1174 Corner welds shall be made by high frequency, resistance welding,
1175 externally scarfed, and zinc-coated after scarfing. Four sides of square tube
1176 post shall be made with 7/16-inch diameter holes spaced 1 inch on centers
1177 along entire length of post. Permissible tolerances are indicated in Table
1178 750.02-1 - 14-Gage Square Tube Post Tolerance, 750.02-2 - 12-Gage
1179 Square Tube Post Tolerance, and 750.02-3 - 10-Gage Square Tube Post
1180 Tolerance. Posts shall be acceptable to FHWA and meet crashworthiness

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requirements for use in both standard soil and weak soil, as defined in NCHRP Report 350.

Single square tube post to support signs shall be equipped with device accepted by the Engineer to resist turning after installation.

TABLE 750.02-1 - 14-GAGE SQUARE TUBE POST TOLERANCE			
Physical Property	Nominal Outside Size (Inch)		
	1.75 Square	2 Square	2.25 Square
U.S. Standard Gage	14		
Wall Thickness (Inch)	0.083, +0.002, -0.008		
Minimum Yield Strength (Pounds/Square Inch)	60,000		
Minimum Weight (Pounds/Foot)	1.8	2.1	2.4
Outside Dimension (Inch)	± 0.010	± 0.010	± 0.010
Side Squareness (Inch)	± 0.010	± 0.012	± 0.014
Twist Permitted (Inch/Foot)	0.062/3	0.062/3	0.062/3
Straightness	1/16 Inch in 3 Feet		
Telescoping	Consecutive Size Tubes Shall Telescope Freely For 10 Feet		
Hole Size (Inch)	$\pm 1/64$		
Hole Spacing	$\pm 1/8$ in 20 Feet		

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TABLE 750.02-2 - 12-GAGE SQUARE TUBE POST TOLERANCE					
Physical Property	Nominal Outside Size (Inch)				
	1.5 Square	1.25 Square	2 Square	2.25 Square	2.5 Square
U.S. Standard Gage	12				
Wall Thickness (Inch)	0.105, +0.011, -0.008				
Minimum Yield Strength (Pounds Per Square Inch)	40,000				
Minimum Weight (Pounds/Foot)	1.7	2.0	2.4	2.7	3.1
Outside Dimension (Inch)	±0.008	±0.008	±0.008	±0.010	±0.010
Side Squareness (Inch)	±0.008	±0.010	±0.012	±0.014	±0.016
Twist Permitted (Inch/Foot)	0.062/3	0.062/3	0.062/3	0.062/3	0.062/3
Straightness	1/16 Inch in 3 Feet				
Telescoping	Consecutive Size Tubes Shall Telescope Freely For 10 Feet				
Hole Size (Inch)	±1/64				
Hole Spacing (Inch)	±1/8 in 20 Feet				

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TABLE 750.02-3 — 10 GAGE SQUARE TUBE POST TOLERANCE		
Physical Property	Nominal Outside Size (Inch)	
	2.187 Square	2.5 Square
U.S. Standard Gage	10	
Wall Thickness (Inch)	0.135, +0.011, -0.008	
Minimum Yield Strength, (Pounds Per Square Inch)	40,000	
Minimum Weight (Pounds/Foot)	3.4	4.0
Outside Dimension (Inch)	±0.010	±0.010
Side Squareness (Inch)	±0.014	±0.015
Twist Permitted (Inch/Foot)	0.062/3	0.075/3
Straightness	1/16 Inch in 3 Feet	
Telescoping	Consecutive Size Tubes Shall Telescope Freely For 10 Feet	
Hole size (Inch)	+1/64	
Hole Spacing (Inch)	+1/8 In 20 Feet	

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750.03 Fasteners for Signs and Route Markers.

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(A) Regulatory signs, warning signs, and route marker assemblies, mounted on pipe posts, shall be secured in position by using stainless steel washers with neoprene gasket or nylon washers installed between post and sign and under bolt head on sign surface. Bolts and metal washers shall be zinc-coated by hot-dip process in accordance with AASHTO M 232.

(B) Post clips for extruded aluminum sign panels shall be of aluminum conforming to ASTM B 108, alloy 356-T6. Post clip bolt assemblies shall include the following:

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- 1204 (1) Aluminum bolts conforming to ASTM B 211, alloy 2024-T4
1205
1206 (2) Aluminum lock nuts conforming to ASTM B 211, alloy 2017-T4,
1207 (0.0002-inch minimum anodic coating thickness with dichromate or
1208 boiling water seal).
1209
1210 (3) Aluminum-alloy Alclad 2024-T4 flat washers conforming to
1211 ASTM B 209.
1212

750.04 Ground Mounted Destination and Expressway Sign Supports.

1213 Structural steel members and anchor bolts shall conform to ASTM A 283, AASHTO
1214 M 227, or AASHTO M 255. Structural steel members and upper 10 inches of
1215 anchor bolts shall be hot-dip zinc-coated in accordance with AASHTO M 111.
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750.05 Overhead Expressway Sign Supports.

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(A) Steel Supports.

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- 1222 (1) **Tapered Posts And Cross Arms.** Sheet steel shall conform
1223 to ASTM A 1011, Grade 40 or ASTM A 1008, Grade D. Sheet steel
1224 may be of weldable grade with minimum yield point of 40,000 pounds
1225 per square inch.
1226

1227 Posts and arms shall be tubular with constant taper, unless
1228 otherwise indicated in the contract documents.
1229

1230 Tubular section shall be fabricated with only one continuous
1231 longitudinal weld to each section. Tubular section shall be welded by
1232 submerged arc welding process accepted by the Engineer. Tubular
1233 sections shall be fabricated from full-length sheets or from sheets at
1234 least 10 feet in length. Only one transverse joint per post and per arm
1235 will be allowed. Butt-welded transverse joints shall be reinforced by
1236 inserting metal sleeve at each joint. Sleeves shall be of No. 10 U.S.
1237 gage or thicker steel and of same chemical composition as metal
1238 joined. Metal sleeves shall conform to the following:
1239

- 1240 (a) Be at least 1 inch long.
1241
1242 (b) Be centered at joint.
1243
1244 (c) Have same taper as section joined.
1245
1246 (d) Be in full contact throughout length and circumference.
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1248 Variation of centerline of post or arm shall not exceed 3/4 inch,
1249 measured at mid-length, from straight line drawn from centers of ends

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of theoretically straight post of similar length. Diameter of tubular section shall not vary more than ± 1 percent from theoretical diameter at cross sections of cross arm and post.

Two-ply post tubes shall be constructed separately, as prescribed herein, except transverse joints will not be allowed. Tubes shall then be telescoped together and rerolled as a unit on a hardened steel mandrel.

Gage thickness shall be as specified in Table 750.05-1 - Gage Thickness.

TABLE 750.05-1 - GAGE THICKNESS	
No. 7 gage	0.1793 inch
No. 3 gage	0.2500 inch
No. 0 gage	0.3125 inch

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(2) Uniform Tubes, Posts, and Cross Arms. Poles shall be seamless welded black and hot-dipped zinc-coated steel, conforming to ASTM A 53 Grade B, Type S (Seamless) or Type E (Electrical-resistance Weld).

Structural shapes shall conform to ASTM A 36. Hot-dipped zinc-coated components shall conform to AASHTO M 111.

High-strength bolts, nuts, and washers shall conform to AASHTO M 164 and shall be zinc-coated in accordance with AASHTO M 232.

Design shall conform to AASHTO *Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signs*.

(3) Base Plate. Steel for base plates shall conform to ASTM A 36. Exposed edges shall be finished smooth, and exposed corners rounded, unless otherwise indicated by the contract documents.

(4) Structural Steel and Anchor Bolts. Structural steel and anchor bolts shall conform to ASTM A 36 and ASTM A 193. Anchor bolts shall be furnished with two nuts, one lock washer, and one plain washer. Nuts shall conform to ASTM A 194.

(5) Fastenings. Fastenings used at locations other than in sign panels shall be zinc-coated wrought iron.

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High-strength bolts and nuts shall conform to AASHTO M 164, except that Rockwell C hardness of bolts shall not exceed 32 after heat treating and prior to zinc coating. Bolts shall be certified with inspection test report in accordance with AASHTO M 164.

(B) Aluminum Supports.

(1) General. Every span assembly shall be checked for alignment and sound welds. Every span at factory shall be drop-load tested before delivery.

Welding shall conform to Section 7.14.4.5 of AASHTO LRFD Bridge Design Specifications.

Certified proof of qualifications for welders shall be submitted at time of submission of shop drawings. Certification shall be furnished from commercial or public testing laboratory.

Field erection connections shall be made in a manner that ensures integrity of truss and span design. If field welding is required to complete erection, same controls on field welding will be imposed as are imposed on shop fabrication.

Welding shall be performed with consumable electrodes using Aluminum Alloy 4043 as filler.

Basic components required in sign fabrication and erection shall conform to requirements indicated in Table 750.05-2 - Sign Structural Components.

TABLE 750.05-2 - SIGN STRUCTURAL COMPONENTS		
Item	Alloy¹	Temper¹
Structural shapes, including 1 beam post	6061	T-6
Tubular members including tubular posts	6061	T-6
Castings	356	T-6
¹ If the Contractor elects to substitute alloy or temper, request shall be included with submittal of shop drawing.		

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(2) Truss Section. Truss sections shall be fabricated as all-welded, one-piece units with braces welded to main chords. Braces shall be cut and trimmed for proper fit. Welders shall be certified. Sections shall be joined by cast aluminum flanges, welded

1325 to chords with double weld, and bolted together. Two or more span
 1326 sections bolted together and suitably fastened to supporting frames
 1327 shall comprise complete structure. Chords of end sections shall be
 1328 capped. Span shall have sufficient camber to overcome dead-load
 1329 deflection and illusion of sag.

1330
 1331 **(3) Frame.** Rectangular frame supporting span structure shall
 1332 consist of two tapered shafts joined by braces welded between shafts.
 1333 Frame shall be constructed such that lower chords of span ends shall
 1334 be supported by frame platforms and fastened to platforms by
 1335 stainless steel U-bolts. Upper chords of span shall be fastened
 1336 directly to frame shafts by stainless steel U-bolts. Sizes of structural
 1337 members shall be as indicated by the contract documents.

1338
 1339 Shafts shall be seamless, tapered tubes of sufficient diameters
 1340 and wall thicknesses to withstand full design loads. Bottom end of
 1341 shaft shall be double-welded to shoe base. Top of shaft shall be
 1342 provided with pole cap. Frames shall be mounted on footings by
 1343 fastening shoe bases on embedded anchor bolts. Base shall have not
 1344 less than four holes (90 degrees apart) on bolt circle to accept anchor
 1345 bolts, with proper clearance. Under side of base shall be coated with
 1346 bituminous paint.

1347
 1348 **(4) Fastenings.** Fastenings required for fabrication and erection
 1349 of sign posts, frames, spans, signs, and items shall conform to the
 1350 following requirements:

1351
 1352 **(a)** Stainless steel bolts shall be of size, alloy, and temper
 1353 to provide structural strength required in completed connection.
 1354 Stainless steel bolts shall be furnished with stainless steel flat
 1355 washers, stainless steel lock washers, where required, and hex
 1356 head, elastic stop stainless steel nuts.

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 1358 **(b)** Aluminum bolts, including J-bolts, shall be of Alloy
 1359 2024-T4, 5/16 inch in diameter and 8 inches in length.
 1360 Aluminum bolts shall be furnished with aluminum flat washers,
 1361 aluminum lock washers, where required, and hex head nuts.
 1362 Bolts, washers, and nuts shall be finished with alumilite finish
 1363 204.

1364
 1365 **(c)** Anchor bolts shall be of size that meets structural
 1366 strength required in completed connection. Anchor bolts shall
 1367 have proper right angle hook to develop structurally sound
 1368 bond when transferring loads to concrete foundation. Anchor
 1369 rod material shall have minimum tensile yield strength of
 1370 50,000 pounds per square inch. Threaded ends, hex head
 1371 leveling nut, hex head securing nut, flat washer, and lock
 1372 washer shall be hot-dipped and zinc-coated.

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1373 **750.06 Expressway Sign Luminaire Brackets.** Expressway sign luminaire
1374 brackets shall be fabricated from structural steel or aluminum beams of sizes and
1375 types indicated in the contract documents. After fabrication, steel brackets shall be
1376 hot-dip zinc-coated in accordance with AASHTO M 111. On work site, steel or
1377 aluminum brackets shall be painted with one coat of zinc-coated metal primer
1378 accepted by the Engineer and three coats of weatherproof dark green enamel
1379 conforming to Subsection 708.03 - Dark Green Enamel Paint.

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1381 **750.07 Reflector Marker.**

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1383 **(A) Glass Sphere Reflector Marker.** Glass sphere reflector marker shall
1384 include amber, red, or clear retroreflective sheeting. Glass sphere reflector
1385 marker shall have glass spheres embedded in weatherproof, synthetic sheet
1386 resin. Retroreflective face shall be a plastic, sealed optical system.
1387 Complete housing shall be made of anodized aluminum alloy 5052-H34,
1388 0.060 inch thick, conforming to ASTM 209. Plastic face units shall be
1389 removable only by removal of one housing and cap. End caps shall not be
1390 removed without proper tools. End caps shall be interchangeable between
1391 housing sizes. Mounting holes shall fit 1/4-inch carriage bolts and shall fit
1392 posts having holes 1 inch on centers.

1393

1394 **(B) Plastic Prismatic Reflector Marker.** Plastic prismatic reflector
1395 marker shall include amber, red, or clear transparent acrylic plastic face
1396 (lens). Opaque back shall be fused to lens, under heat and pressure, around
1397 the perimeter, forming a unit permanently sealed against dust, water, and
1398 water vapor. Lens shall have smooth front surface, free from projections or
1399 indentations other than those required for identification. Markers shall have
1400 rear surface lens of prismatic configuration capable of reflecting light. Methyl
1401 methacrylate shall conform to Federal Specifications L-P-380C, Type I, Class
1402 3. Prismatic reflector marker shall be 3 inches in diameter.

1403

1404 Reflector shall be housed in anodized aluminum alloy 5052-H34,
1405 0.060 inch thick, conforming to ASTM B 209, with separate back plate
1406 attached with four vandal resistant nuts. Mounting holes shall fit 1/4-inch
1407 carriage bolts and shall fit posts having holes 1 inch on centers.

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1409 **(C) Sheet Reflecting Material Marker.** Sheet reflecting material marker
1410 shall include sheet reflecting material on 0.063-inch sheet aluminum backing.
1411 Sheet reflecting material shall conform to Subsection 750.01(C)(4) - Type III
1412 or IV Retroreflective Sheeting (High Intensity). Backing shall conform to
1413 Subsection 750.01(B)(1) - Sheet Aluminum. Mounting holes shall fit 1/4-inch
1414 carriage bolts and shall fit posts having holes 1 inch on centers.

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1416 **(D) Acrylic Resin Reflector Marker.** Acrylic resin reflector marker shall
1417 include microprism sheeting made of clear or transparent colored (amber or
1418 red) ultraviolet stabilized acrylic resin. Reflector thickness shall be minimum
1419 0.005 inch and maximum 0.025 inch. Reflectors shall have smooth outer
1420 surface and specular gloss of 175 minimum, as specified in ASTM D 523.

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Sheeting shall contain minimum of 40,000 retroreflective elements per square inch. Retroreflective elements shall have cube corner prisms made of acrylic resin. Prism surface shall be coated with deposition of aluminum to protect against loss of reflectivity due to dust, water, water vapor, or penetration of front surface of reflector.

Back surface of reflector shall include pressure sensitive adhesive coating protected by removable release paper. Minimum application pressure shall be 25 pounds per square inch. Minimum shear stress of 10 pounds per square inch at 70 degrees F after 24 hours of curing time shall be exceeded. Shelf life of one year shall be exceeded.

Reflector shall have 50 percent retention of minimum intensity values indicated in Table 750.07-1 - Minimum Specific Intensity of Acrylic Resin Reflector Marker, after 10 years of continuous outdoor exposure.

Values of specific intensity of each reflector, when tested at 0.1 degree-angle of divergence, shall meet or exceed values indicated in Table 750.07-1 - Minimum Specific Intensity of Acrylic Resin Reflector Marker.

TABLE 750.07-1 - MINIMUM SPECIFIC INTENSITY OF ACRYLIC RESIN REFLECTOR MARKER			
Incidence Angle	Specific Intensity per Unit Area Candles per Foot-Candle per Square Foot		
	White	Yellow	Red
-4 degrees	1472	946	315
30 degrees	660	424	140

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750.08 Flexible Delineator Posts and Reflectors.

(A) General. Post material shall be flexible and durable, resistant to impact, ultra violet light, ozone, hydrocarbons, and stiffening with age. Post shall be free of burns, discoloration, contamination, and other marks or defects that affect appearance and serviceability.

Posts shall be opaque white or opaque yellow. Opaque yellow post shall have yellowness index within green and red tolerance limits when compared to the FHWA Standard Color Chips For Highway Signs. Opaque white post with yellowness index shall not exceed 12 when tested in accordance with E 313. Post materials shall be exposed for 1,000 hours in Atlas Type B and BH Xenon Arc Weatherometer in accordance with ASTM G 155, with no significant fading or darkening.

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Post shall be conditioned minimum of 2 hours in oven at 140 degrees F \pm 3 degrees F. Conditioned post shall be capable of straightening itself within 30 seconds when bent 180 degrees at midpoint for four bends. Test shall be completed on each sample post within 2-1/2 minutes of removal from oven. Post shall be sufficiently rigid to resist wilting after conditioning for 2 hours minimum at 180 degrees F \pm 3 degrees F.

Posts shall be NCHRP Report 350 compliant. Posts shall cause little or no damage to impacting vehicle during impact test series and shall exhibit no splitting or delaminating damage due to impacts. Posts shall be sufficiently rigidity to remain upright in high wind conditions.

Posts shall be furnished complete with attached reflectors and special tools or accessories, or both necessary for installation. Posts shall be installed in accordance with manufacturer's recommendations.

(B) Type A Delineator. Type A delineator shall be designed for installation on paved areas. Anchor shall be designed to bond to pavement. Detailed installation instructions shall be provided by manufacturer.

(C) Type B Delineator. Type B delineator shall be designed for installation on unpaved areas. Post shall be designed for anchoring depth of less than 24 inches. Detailed installation instructions shall be provided by manufacturer.

(D) Reflectors. Reflectors shall be impact-resistant with dimensions as indicated in the contract documents. White or yellow reflectors shall conform to Subsection 750.07 - Reflector Marker.

Reflector shall be mounted on top 14 inches of post with reflector facing in direction of oncoming traffic. Reflector shall be mounted by method that prevent loss of reflector during life of post. Reflectors shall be free of scratches, abrasions, and other physical damage.

(E) Packaging. Each carton shall be marked with manufacturer's code or lot number, quantity in carton, and type of post in carton.

(F) Prerequisite for Acceptance. Certified test report with test data, developed by independent testing laboratory, attesting that marker posts comply with these requirements and the contract documents, shall be submitted. Test data submitted by manufacturer will be subject to verification by suitable tests conducted by the Engineer before acceptance.

1503 (G) **Sampling and Acceptance.**

1504

1505 (1) **Sampling.** The Engineer will require minimum of six samples
1506 for testing and acceptance.

1507

1508 (2) **Acceptance.** At least five of six samples shall pass test.

1509

1510 **750.09 Traffic Delineators.**

1511

1512 (A) **Delineator Tube.** Delineator tube shall include medium density
1513 flexible polyethylene or polyvinyl tubing and shall be fluorescent orange-red
1514 in color. Delineator tube shall have the following characteristics:

1515

1516 (1) Forty-two inches in height.

1517

1518 (2) Four inches in diameter.

1519

1520 (3) Greater than 0.085-inch wall thickness.

1521

1522 (4) Approximately 1-1/2 pounds in weight.

1523

1524 (5) 360-degree retroreflectorization.

1525

1526 Two 4-inch strips of yellow-amber wide angle high retroreflective
1527 sheeting shall be used that consist of optical lens elements adhered to
1528 synthetic resin and encapsulated by flexible transparent plastic that has
1529 smooth outer surface with adhesive that is intended for use on reboundable
1530 plastic polyethylene post and tube traffic devices, or molded-prism reflecting
1531 material spaced about 1-5/8 inches apart. Strips shall be arranged one
1532 above the other with upper edge of top strip one inch from tube top. Strips
1533 shall be attached firmly to tube so that no slippage of strips occurs.

1534

1535 Delineator tube shall have smooth continuous surface free from
1536 cracks, seams, blisters, and shall be damage resistant.

1537

1538 (B) **Delineator Base.** Delineator base shall be interlocked securely to
1539 tube. Delineator base shall be at least 1 inch in height, shall weigh more than
1540 13 pounds, and shall be at least 15 inches in width. Delineator base shall be
1541 sufficiently stable to keep tube in upright position under normal wind
1542 conditions. Base shall include heavy rubber components with added paraffin
1543 preservatives for weather protection.

1544

1545

1546

END OF SECTION 750