

SECTION 994 REFLECTIVE SHEETING

994-1 Description.

994-1.1 General: This Section specifies the requirements for reflective sheeting materials consisting of elements embedded or suspended within a transparent, weatherproof outer surface and designed to enhance nighttime visibility of signs. Transparent and opaque process inks for production application to reflective sheeting materials by a direct or reverse silk-screening process are also covered herein.

994-1.2 Classification: Reflective sheeting materials covered herein shall be one of the following seven classifications:

Type II: an engineering grade reflective sheeting which consists of enclosed spherical lens elements embedded within a transparent plastic having a smooth flat outer surface.

Type II-A: a high performance engineering grade reflective sheeting which consists of enclosed spherical lens elements embedded within a transparent plastic having a smooth flat outer surface.

Type III-A: a high performance grade reflective sheeting which consists of encapsulated spherical lens elements embedded within a transparent plastic having a smooth flat outer surface.

Type III-B: a high performance grade reflective sheeting which consists of cube-cornered (prismatic) retro-reflective elements incorporated beneath a transparent plastic having a smooth flat outer surface.

Type III-C: a high performance grade reflective sheeting which consists of cube-cornered (prismatic) retro-reflective elements incorporated beneath a transparent plastic having a smooth flat outer surface.

Type III-D: a high performance grade reflective sheeting which contains prismatic lenses which are formed in a transparent, synthetic resin, sealed, and backed with a pressure-sensitive adhesive and liner.

Type IV: a high performance reflective, vinyl sheeting for temporary and work zone applications.

994-2 Materials.

994-2.1 Testing: The reflective sheeting shall be tested in accordance with this Section and the Florida Test Methods for Reflective Sheeting, available from the Department's Materials Office, using process evaluation test samples and shall meet the minimum requirements as stated herein. Evaluation test samples shall be processed for each color of any production run. The number of samples constituting one test set of samples shall be determined by the Department's Materials Office.

994-2.2 Reflective Intensity: The reflective sheeting shall have minimum initial specific intensity per unit area (SIA) values as shown in Table 1. The SIA shall be measured and determined in accordance with Florida Test Method FM 2-001.

Table 1 Minimum SIA Values for Reflective Sheeting									
Observation Angle (degree)	Entrance Angle (degree)	Minimum SIA (cd/(Foot-candle·ft ²)) [(cd/(lx·m ²))]							
		White	Red	Orange	Brown	Yellow	Green	Blue	Fluorescent Orange at 90 degree
Type II									
0.2	-4	70.0	14.5	25.0	2.0	50.0	9.0	4.0	-
0.2	+30	30	6.0	7.0	1.0	22.0	3.5	1.7	-
0.5	-4	30.0	7.5	13.5	1.0	25.0	4.5	2.0	-
0.5	+30	15.0	3.0	4.0	0.5	13.0	2.2	0.8	-
Type II-A									
0.2	-4	140.0	30.0	60.0	5.0	100.0	30.0	10.0	-
0.2	+30	60.0	12.0	22.0	2.0	36.0	10.0	4.0	-
0.5	-4	50.0	0.0	20.0	2.0	33.0	9.0	3.0	-
0.5	+30	28.0	6.0	12.0	1.0	20.0	6.0	2.0	-
Type III-A									
0.2	-4	250.0	45.0	100.0	-	170.0	45.0	20.0	-
0.2	+30	150.0	25.0	60.0	-	100.0	25.0	11.0	-
0.5	-4	95.0	15.0	30.0	-	62.0	15.0	7.5	-
0.5	+30	65.0	10.0	25.0	-	45.0	10.0	5.0	-
Type III-B									
0.2	-4	250.0	45.0	100.0	-	170.0	45.0	20.0	-
0.2	+30	95.0	13.3	26.0	-	64.0	11.4	7.6	-
0.5	-4	200.0	28.0	56.0	-	136.0	24.0	18.0	-
0.5	+30	65.0	25.0	25.0	-	45.0	10.0	5.0	-
Type III-C									
0.2	-4	250.0	35.0	100.0	7.0	170.0	35.0	20.0	-
0.2	+30	80.0	9.0	34.0	2.0	54.0	9.0	5.0	-
0.5	-4	135.0	17.0	64.0	4.0	100.0	17.0	10.0	-
0.5	+30	55.0	6.5	22.0	1.4	37.0	6.5	3.5	-
Type III-D									
0.2	-4	800		450	-	-	-	-	200
0.2	+30	400		250	-	-	-	-	100
0.5	-4	200		120	-	-	-	-	80
0.5	+30	100		70	-	-	-	-	50
Type IV									
0.2	-4	250.0	35.0	70.0	-	170.0	30.0	20.0	-
0.2	+30	95.0	13.3	26.0	-	64.0	11.4	7.6	-
0.5	-4	200.0	28.0	56.0	-	136.0	24.0	18.0	-
0.5	+30	60.0	17.0	17.0	-	40.0	7.2	7.2	-

994-2.3 Rainfall Performance: The minimum SIA values of the reflective sheeting under simulated rainfall conditions shall not be less than 90% of the respective dry values as shown in Table 1. Wet performance measurements shall be made on unweathered, uncoated sheeting in accordance with Florida Test Method FM 2-001.

994-2.4 Color: The reflective sheeting shall have the same daytime and nighttime color when viewed by reflected light. The diffused daytime color of the reflective sheeting, through instrumental color testing, shall conform to the requirements of ASTM D 4956 and shall be determined in accordance with Florida Test Method FM 3-E097. Geometric characteristics must be confined to:

 Illumination: incident within 10 degrees of, and centered about, a direction of 45 degrees from the perpendicular to the test surface.

 Observation: within 15 degrees of, and centered about, a perpendicular to the test surface.

 Conditions of illumination and observation must not be interchanged. The standards calibrating the test apparatus shall be the Munsell Papers, as indicated in ASTM D 4956. The papers must have been recently calibrated on a spectrophotometer. The test instrument shall be one of the following or an approved equivalent:

1. GARDNER Multipurpose Reflectometer or Model XL 20 Color Difference Meter.
2. GARDNER Model AC-2a Color Difference Meter or Model XL 30 Color Difference Meter.
3. MEECO Model V Colormaster.
4. HUNTERLAB D 25 Color Difference Meter.

The following CIE Chromaticity Coordinate Limits for Type III-D Reflective Sheeting are required:

Color	1		2		3		4		Reflectance Limit Y (%)	
	x	y	x	Y	x	y	x	y	min	max
White	.305	.305	.355	.355	.335	.375	.285	.325	40	-
Orange*	.583	.416	.523	.397	.560	.360	.631	.369	14	30

* Also for Fluorescent Orange

994-2.5 Specular Gloss: The reflective sheeting shall have an 85-degree specular gloss of not less than 40 for Type II material and not less than 50 for Type II-A, Type III and Type IV materials, when tested in accordance with Florida Test Method FM 3-D523.

994-2.6 Colorfastness: The color of a specimen shall be weathered and shall be in conformance with the following requirements for reflective sheeting:

 Accelerated Outdoor Test: Processed and applied in accordance with recommended procedures, the reflective material shall be weather-resistant, resistant to dirt and fungus accumulation and, following cleaning, shall show no appreciable discoloration, cracking, crazing, fading, blistering, or dimensional change and not less than 80% of the specified wet and dry minimum brightness values when exposed to accelerated weathering for two years, south facing, unprotected at 45 degrees, in South Florida.

 Orange sheeting shall meet the above requirements for only one year of exposure, except for barricade (pre-striped) and Type IV sheeting which shall meet the above requirements after six months.

994-2.7 Adhesive Backing:

994-2.7.1 General: The adhesive backing of the reflective sheeting shall be either a pressure sensitive adhesive (Class 1) or a positionable heat activated adhesive (Class 2) that shall be applied to the approved sign surface in a manner compatible with the instructions of the sheeting manufacturer without the necessity of additional adhesive coats on either the reflective sheeting or the application surface.

994-2.7.2 Pressure Sensitive Adhesives: Pressure sensitive adhesives shall be of an aggressive tack type requiring no heat, solvent or other preapplication preparation to the reflective sheeting for adhesion to clean aluminum, fiberglass or other approved surfaces. The reflective sheeting,

after application, shall tightly adhere to the application surface and show no discoloration, cracking, crazing, blistering or dimensional change.

994-2.7.3 Heat Activated Adhesives: Heat activated adhesives shall be positioned under normal working conditions and temperatures up to 100°F [40°C] without damage to the material or application surface. The adhesive shall be activated by applying heat in excess of 175°F [80°C] to the material as in the heat-vacuum process, without additional preapplication preparation to the reflective sheeting for adhesion to clean aluminum or fiberglass surfaces. The reflective sheeting after application shall be tightly adhered to the application surface and show no discoloration, cracking, crazing, blistering or dimensional change.

994-2.7.4 Protective Liner: The protective liner over the adhesive backing shall be removable from the adhesive backing by peeling without soaking in water or other solvents and without breaking, tearing or removing any adhesive from the adhesive backing. The protective liner shall be easily removed after accelerated storage for four hours at a minimum of 150°F [66°C] under a pressure of 2.5 psi [17 kPa].

994-2.8 Film: The exterior film of the reflective sheeting shall be a transparent, flexible, smooth-surfaced, moisture-resisting material and shall have sufficient strength and flexibility to be easily handled, cut to shape, processed and applied without appreciable stretching, tearing or other damage.

994-2.9 Shrinkage Resistance: Following liner removal, the reflective sheeting shall not shrink more than 1/32 inch [0.80 mm] in ten minutes nor more than 1/8 inch [2.8 mm] in 24 hours (in any dimension) per 9 inch [225 mm] square at 75°F [24°C] and 50% relative humidity.

994-2.10 Flexibility: The sheeting, when applied to cleaned and etched 0.020 by 2 by 8 inch [0.5 by 50 by 200 mm] aluminum according to the sheeting manufacturer's recommendations, conditioned 24 hours and tested at 72°F [22°C] and 50% relative humidity, shall be sufficiently flexible to show no cracking when bent around a 3/4 inch [19 mm] mandrel. This will apply only for Type II and Type II-A sheeting.

994-2.11 Tensile Strength: The reflective sheeting shall have sufficient tensile strength so that the sheeting can be handled, processed and applied in accordance with the sheeting manufacturer's recommended procedures without damage to the sheeting.

994-2.12 Workability: The reflective sheeting shall permit preapplication handling, positioning, cutting by hand or die machine, color processing and oven drying.

994-2.13 Solvent Resistance: The processed reflective sheeting shall be solvent resistant so as to permit cleaning with naphtha and mineral spirits.

994-2.14 Color Processibility: The reflective sheeting shall permit color processing with compatible transparent and opaque process inks recommended or furnished by the sheeting manufacturer at temperatures ranging from 60 to 100°F [16 to 38°C] and a relative humidity from 20 to 80%. The sheeting processed in accordance with the sheeting manufacturer's recommendation shall show no loss or cracking of the process inks with normal handling, shop processing, cutting and application.

994-2.15 Heat Resistance: The reflective sheeting shall be heat resistant in order to permit forced oven drying of the transparent or opaque process inks recommended or furnished by the sheeting manufacturer. The Contractor shall submit complete and detailed oven drying instructions for the color processing of transparent and opaque process inks that the manufacturer recommends or furnishes. Such instructions shall be compatible with, and be within the maximum capabilities of, the Department's equipment and normal production procedures. Under no circumstances shall the forced oven drying time exceed nine minutes. The reflective sheeting processed and applied in accordance with the sheeting manufacturer's recommended procedures shall, after normal handling, produce a dry, smooth surface with no staining, discoloration, cracking, crazing, blistering or dimensional change unsuitable to the finished product's intended use. Under no circumstances shall the forced oven drying time exceed two hours for Type III-D Reflective Sheeting.

994-3 Direct and Reverse Silk-Screen Processing.

994-3.1 General: The transparent and opaque process inks furnished for direct and reverse silk-screen processing shall be of a type and quality recommended by the reflective sheeting manufacturer. Silk-screen processing in accordance with the techniques and procedures recommended by the sheeting manufacturer shall produce a uniform legend of continuous stroke width of either transparent or opaque ink, with sharply defined edges and without blemishes on the sign background that will affect the intended sign use. Transparent inks applied by reverse silk-screening over reflective sheeting shall be clear coated if recommended by the manufacturer.

994-3.2 Reverse Silk-Screen Processing:

994-3.2.1 Reflective Intensity: Finished signs produced by the reverse silk-screening process using transparent ink over white reflective sheeting processed in accordance with the techniques and procedures recommended by the sheeting manufacturer shall have minimum SIA values as shown in Table 2. The SIA shall be measured and determined in accordance with Florida Test Method FM 2-001.

Table 2 Minimum SIA Values for Finished Signs (Reverse Silk-Screening Process)					
Observation Angle (degree)	Entrance Angle (degree)	Minimum SIA (cd/(Foot-candle-ft ²)) [(cd/(lx·m ²))]			
		Red	Orange	Green	Blue
Type II					
0.2	-4	8.2	15.0	-	-
0.2	+30	3.5	6.0	-	-
0.5	-4	3.5	7.0	-	-
0.5	+30	2.5	3.0	-	-
Type II-A					
0.2	-4	28.0	31.0	20.0	8.5
0.2	+30	8.0	9.0	6.5	1.0
0.5	-4	7.0	12.0	6.0	2.0
0.5	+30	2.8	3.0	3.0	0.5
Types III-A, III-B, III-C, IV					
0.2	-4	25.0	70.0	-	-
0.2	+30	6.0	23.0	-	-
0.5	-4	11.0	24.0	-	-
0.5	+30	5.0	13.0	-	-
Type III-D					
0.2	-4	160	-	-	-
0.2	+30	80	-	-	-
0.5	-4	40	-	-	-
0.5	+30	20	-	-	-

994-3.2.2 Rainfall Performance: The minimum SIA values of finished signs produced by the reverse silk-screening process using transparent ink over white reflective sheeting, under simulated rainfall conditions, shall not be less than 80% of the respective dry values as shown in Table 2. Wet performance measurements shall be made on unweathered, uncoated signs in accordance with Florida Test Method FM 2-001.

994-3.3 Color: The diffused daytime color of the finished transparent process inks shall conform to the requirements as specified in 994-2.4. Both the finished transparent and opaque process inks shall have colorfastness in accordance with 994-2.6, the same daytime and nighttime color when viewed by reflected light, weather resistance, and a satisfactory performance life equal to or greater than that of the reflective sheeting to which the process colors are applied.

994-4 Quality Assurance.

The Contractor is responsible for the performance of all inspections required by this Section. The Department reserves the right to perform any of these inspections at any time to insure that the materials and processing conform to the requirements of this Section.

994-5 Predicted Performance Life.

994-5.1 General: The material on in-service signs shall be considered as providing the minimum acceptable predicted performance life if the sheeting or process inks have not deteriorated due to natural causes. An unacceptable predicted performance life shall be cause for immediate material rejection and replacement. Sign conditions which shall be considered detrimental to the sign's performance life, and thus unacceptable, shall include, but need not be limited to, the display of:

- (a) bubbles or wrinkles on the sign face greater than 3 inches [75 mm] in length (excluding minor defects around dents or mounting holes), or any cracks, breaks or stress cracks.
- (b) bubbles or wrinkles within the legend or message area (legend or message area shall be defined as the entire area within the limits of the legend or message template).
- (c) a total shrinkage of more than 1/8 inch [3 mm] in the reflective sheeting material in any dimension.
- (d) delamination of the reflective sheeting between the outer surface, optical reflecting system or the adhesive backing.
- (e) a lack of durable adhesive bond between the reflective sheeting and the sign blank.
- (f) a loss of the transparent or opaque ink, processed and applied over the reflective sheeting, due to cracking, crazing, blistering, fading, flaking or chipping.

994-5.2 In-Service Minimum Reflective Intensity: The reflective sheeting and transparent inks processed and applied over white reflective sheeting shall have the minimum SIA values as shown in Table 3, using an observation angle of 0.2 degrees and an entrance angle of -4 degrees. Measurements shall be made on uncoated reflective sheeting. The satisfactory predicted performance life for black process inks shall equal the number of predicted performance life years of the reflective sheeting to which it is applied.

Table 3 End Of Service Values			
Color Reflective Sheeting/Transparent Ink	Minimum SIA	Minimum Predicted	
	Reflective Sheeting	Transparent Ink	Performance Life
	(cd/(Foot-candle·ft ²))	(cd/(Foot-candle·ft ²))	
	[(cd/(lx·m ²))]	[(cd/(lx·m ²))]	(years)
Type II			
White	40.0	-	7
Yellow	20.0	16.0	7
Green	3.0	2.5	7
Blue	2.0	1.5	7
Brown	0.5	0.4	5
Type II-A			
White	50.0	-	10
Yellow	28.0	-	10
Red	14.5	16.0	10
Orange	18.0	18.0	3
Green	11.0	11.5	10
Blue	5.0	5.0	8
Types III-A, III-B, III-C, IV			
White	200.0	-	10
Yellow	136.0	110.0	10
Red	28.0	17.5	10
Orange	80.0	45.0	3
Green	28.0	14.0	10
Blue	16.0	12.5	10
TYPE III-D			
White	640.0	-	7
Orange	360.0	-	3
Fluorescent Orange	160.0	-	3
Red	-	128	7

994-6 Technical Assistance.

In case of material failure, the Contractor shall obtain on-site technical assistance from the manufacturer at no cost to the Department. The corrective action shall be completed to the satisfaction of the Department.

994-7 Material Rejection and Replacement.

The Department reserves the right to approve, reject, or request replacement of any or all material failing to satisfactorily meet all requirements of this Section.

Any or all rejected material which has been documented by written notification from the Department shall be removed within ten calendar days and replaced in full quantity within 30 days at no expense to the Department.

994-8 Contractor's Liability.

The Contractor shall be liable for the replacement of all reflective sheeting or all sheeting processed with transparent or opaque process inks over reflective sheeting furnished by the Contractor which fails to meet the requirements of this Section. The Contractor shall also be liable to the Department for a pro rata portion (based on the minimum predicted performance life shown in 994-5.2 and the actual life) of those additional costs to the Department (as determined by the Department) as may be incurred in manufacturing signs, sign processing, sign refurbishment, and field force removal and replacement of signs directly associated with the material failure.

After final acceptance of the Contract, the Contractor's liability for the minimum predicted performance life shall be assumed by the Reflective Sheeting Manufacturer and such responsibility for liability shall be contained in the manufacturer's certification.

994-9 Certification.

The Contractor shall be required to furnish to the Department's State Materials Engineer six certified copies of a test report from the reflective sheeting manufacturer that the reflective sheeting meets the requirements of this Section. Each certification shall cover only one type of reflective sheeting. Due to the wide range of applications of the products within some types, the certification shall additionally state that this product is recommended for use on this specific project.

994-10 Qualified Products List.

The reflective sheeting material used for any of the applications described in 700-2.5 shall be a product included on the Qualified Products List. Any marked variation from the original test values for a material below the established limits or evidence of inadequate field performance of a material will be considered to be sufficient evidence that the properties of the material have changed, and the material will be removed from the Qualified Products List.

Manufacturers seeking approval of reflective sheeting shall submit to the Department's Materials Office two 2 by 2 foot [600 by 600 mm] samples of each color and adhesive type, test data showing compliance with the requirements of this Section and a certifying statement of compliance.

Manufacturers seeking approval of process color products shall submit to the Department's Materials Office prescreened samples on the sheeting on which it is to be used. These samples are to be mounted on four 6 by 6 inch [150 by 150 mm] aluminum panels of a minimum thickness of 0.04 inches [1.0 mm]. The manufacturer shall include with his submittal test data showing compliance with the requirements of this Section and a certifying statement of compliance.

Product changes will require new samples and repeat tests.