Commonwealth of Pennsylvania
Department of Transportation

SPECIFICATION FOR RETROREFLECTIVE SHEETING MATERIALS AND PROCESS INKS

November 14, 2013

1. SCOPE AND CLASSIFICATION

1.1 Scope. This specification covers flexible, microprismatic, retroreflective sheeting designed for use on traffic control signs, delineators, barricades and other devices. Transparent and opaque process inks for application to sheeting are also covered herein. All references to other specifications shall imply the current edition.

1.2 Classification. Retroreflective sheeting materials covered herein shall be one of the following classifications:

Type III – A high-intensity retroreflective sheeting, that is typically encapsulated glass-bead retroreflective material. This classification includes fluorescent sheeting types. This sheeting is typically used for permanent highway signing and construction zone devices.

Type IV – A high-intensity retroreflective sheeting, typically using an unmetallized microprismatic material. This sheeting is typically used for permanent highway signing and construction zone devices.

Type V – A super-high-intensity retroreflective sheeting, that is typically a metallized microprismatic retroreflective element material. This sheeting is typically used for delineators.

Type VI – An elastomeric high-intensity retroreflective sheeting without adhesive, which is typically a vinyl microprismatic retroreflective material. This sheeting is typically used for temporary roll-up warning signs, traffic cone collars, and post bands. This classification includes fluorescent sheeting types.

Type VII – A super-high-intensity retroreflective sheeting having highest retroreflectivity characteristics at long and medium road distances as determined by the R_A values at the 0.1° and 0.2° observation angle. This sheeting is typically an unmetallized microprismatic retroreflective element material. This classification includes fluorescent sheeting types. This sheeting is typically used for permanent highway signing and construction zone devices.

Type VIII – A super-high-intensity retroreflective sheeting having highest retroreflectivity characteristics at long and medium road distances as determined by the R_A values at the 0.1° and 0.2° observation angle. This sheeting is typically an unmetallized microprismatic retroreflective element material. This classification includes fluorescent sheeting types. This sheeting is typically used for permanent highway signing and construction zone devices.

Type IX – A very-high-intensity retroreflective sheeting having superior retroreflectivity characteristics at short road distances as determined by the R_A values at 1.0° observation angle. This sheeting is typically an unmetallized microprismatic retroreflective element material. This classification includes fluorescent sheeting types. This sheeting is typically used for permanent highway signing and construction zone devices.

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

1.3 Reboundable Sheeting Requirements. In order to be approved as a "reboundable sheeting material," the material shall satisfy the requirements of Section "S2" of the supplemental requirements included with ASTM D 4956, which in some cases will supersede other requirements.

2. MATERIAL REQUIREMENTS, TESTS, TEST METHODS

2.1 Sampling. The retroreflective sheeting shall be tested according to the following testing procedures using process evaluation test samples. Unless otherwise noted in the test procedures, all test samples shall have a minimum dimension of 8"x8". Three evaluation test samples shall be processed from each color of each shipment of any production run, and the average of the three samples will be reported. The number of samples constituting one set of samples, for any required test procedure shall be determined by the Engineer.

2.2 Coefficient of Retroreflection. The coefficient of retroreflection, expressed as candelas per foot-candle per square foot ($cd \cdot fc^{-1} \cdot ft^{-2}$), shall meet or exceed the minimum requirements in the most current edition of ASTM D 4956 at the specified 0.2º, 0.5º and 1.0º observation angles, or as indicated in Sections 2.2.1, 2.2.2 and 2.2.3 for the additional colors. The coefficient of retroreflection shall be measured and determined by the method detailed in ASTM E 810

2.2.1 Fluorescent Type III Material.

Observation Angle	Entrance Angle	Fluorescent Orange
0.2°	-4°	105
0.2°	30	50
0.5°	-4°	45
0.5°	30°	22

2.2.2 Fluorescent Type VI Material.

Observation Angle	Entrance Angle	Fluorescent Pink
0.2°	-4°	160
0.2°	30	60
0.5°	-4°	68
0.5°	30°	25

2.2.3 Purple Material.

Observation Angle	Entrance Angle	Type III/IV	Type VIII	Type XI
0.2°	-4°	14	28	23
0.2°	30	7	13	9
0.5°	-4°	6	10	17
0.5°	30°	3	5	6

2.3 Color Requirements. Sheeting shall have the same daytime and nighttime color when viewed by reflective light. The values shall be determined on a HunterLab ColorFlex Spectrocolorimeter. Computations shall be done in accordance with ASTM E 308 for the 2° observer. The four pairs of chromaticity coordinates shall define the acceptable color in terms of the CIE 1931 standard colorimetric system measured with standard illuminant D65. (Geometric characteristics must be confined to illumination incident within 10° of, and centered about, a direction of 45° from the perpendicular to the test surface. Conditions of illumination and observation must not be interchanged.) After outdoor weathering the color shall conform to the most current requirements of ASTM D 4956 for color specification limits and daylight luminance factors or as indicated in 2.3.1 below.

The nighttime color values shall be determined on a Gamma Scientific RadOMA spectroradiometer. Nighttime chromaticity shall be determined in accordance with ASTM E811 and evaluated using the CIE 1931 system in ASTM E308. Measure nighttime color using CIE Illuminant A, at an observation angle of 0.33 degrees, and at an entrance angle of +5 degrees. The source and receiver apertures are not to exceed 10 minutes of arc, at the 2 degree observer using the CIE 1931 system. The colors listed in 2.3.1 are excluded from the nighttime color values.

2.3.1 Color Spcification Limits.

Color	Chromaticity Coordinates								Cap Y	
	1		2		3		4		Min	Max
Purple	0.302	0.064	0.310	0.210	0.380	0.255	0.468	0.140	2.0	15
Pink	0.600	0.340	0.450	0.322	0.430	0.275	0.536	0.230	25	None

2.4 Specular Gloss. All materials shall have a minimum specular gloss of 40.

2.5 Colorfastness. The color of a specimen weathered in accordance with Section 3.7 shall conform to the requirements of Section 2.3.

3. QUALITY ASSURANCE PROVISIONS

3.1 Responsibility for Inspection. Unless specified otherwise, the supplier shall perform all inspection requirements as specified hereinafter. The Department reserves the right to perform any of the inspections set forth on an annual or random basis where such inspections are deemed necessary to assure that materials and processing conform to the prescribed provisions.

3.2 Protective Liner. Protective liners 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 following accelerated storage for 4 hours at 160°F under a weight of 2.5 pounds per square inch.

3.3 Adhesive Backing. The adhesive backing shall be either a pressure-sensitive (PS) or a positionable heat-activated (HA) adhesive, as specified by the Department, applied to the approved sign surface according to the instructions of the sheeting manufacturer without the necessity of additional adhesive coats on either the reflective sheeting or application surface. After application, the sheeting shall tightly adhere to the application surface, and show no discoloration, cracking, crazing, blistering, or dimensional change.

3.3.1 Pressure-Sensitive Adhesives. Pressure-sensitive (PS) adhesives shall be of an aggressive tack type requiring no heat, solvent or other pre-application preparation to the reflective sheeting for adhesion to clean, treated aluminum, painted plywood, or plywood with either a medium density overlay (MDO) or a high density overlay (HDO).

3.3.3 Adhesive Bond. The adhesive shall form a durable bond to clean surfaces in accordance with the current Department specifications for Aluminum Sign Blanks.

3.3.4 Adhesive. In accordance with Section 6.9 of ASTM D 4956.

3.3.5 Impact Resistance. In accordance with Section 6.10 of ASTM D 4956.

3.4 Sheeting Film. The exterior film of the 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.

3.4.1 Shrinkage. In accordance with Section 7.8 of ASTM D 4956.

3.4.2 Flexibility. In accordance with Section 7.9 of ASTM D 4956 and as follows: With the adhesive side of the sheeting against the mandrel, place a thumb and forefinger on the reflective side and within 1 second bend the sheeting around the mandrel to form a 180-degree bend.

3.4.3 Tensile Strength. The sheeting shall have adequate characteristics, not limited to tensile strength and flexibility, so that the sheeting can be handled, processed, and applied in accordance with the manufacturer's recommended procedures without damage to the sheeting.

3.5 Pre-application, Handling and Cutting. The sheeting shall permit pre-application handling; cutting by hand or die machine; color processing; and oven drying.

3.5.1 Solvent Resistance. The processed sheeting shall be solvent resistant permitting cleaning with VM&P Naphtha and mineral spirits.

3.5.2 Color Processing. The sheeting shall permit color processing with

compatible transparent and opaque process inks as recommended by the manufacturer at temperatures of 60°F to 100°F and relative humidity at 20 to 80 percent. The sheeting processed in accordance with the manufacturer's recommendation shall show no loss or cracking of the process inks with normal handling, shop processing, cutting and application. The processed color on the sheeting after screening will cover the full surface area. Inks recommended by the manufacturer must be capable of providing permanent full surface coverage without any separation or incomplete coverage of the color. Any minor bubbling of the process color should be capable of flowing out in the first 8 minutes of the dry time.

3.5.3 Oven Drying. The sheeting shall be heat resistant in order to permit forced oven drying of the recommended transparent or opaque process inks at temperatures compatible with the Department's Sign Shop equipment. The vendor shall submit complete and detailed oven drying instructions for the color processing of recommended transparent and opaque process inks. Such instructions shall be compatible with, and be within the maximum capabilities of the Department's Sign Shop equipment and normal production procedures. Process inks recommended by the sheeting manufacturer must be capable of conveyor oven drying within 10 minutes or less at temperatures in the range of 100°F to 300°F. The sheeting processed and applied in accordance with the manufacturer's recommended procedures, with normal handling, and following the vendor's oven drying instructions shall produce a dry, smooth surface, showing no staining or discoloration, cracking, crazing, blistering or dimensional change unsuitable to the finished product's intended use.

3.7 Outdoor Weathering. All sheeting, except Type VI, shall be subject to outdoor weathering on NTPEP test decks in Arizona, Louisiana and Virginia, in accordance with Section 6.4 and Table 12 of ASTM D 4956. Type VI sheeting shall be subject to outdoor weathering on the NTPEP test decks in, Arizona and Louisiana. At the end of the exposure period, the samples from the applicable test decks shall show no appreciable discoloration, cracking, crazing, blistering, scaling, pitting, delamination, edge lifting or curling, or dimensional change. The samples shall also retain the specified "minimum coefficient of retroreflection, R_A," as included in Table 12 of ASTM D 4956 as a percent of the referenced values in Section 2.2.

3.8 Direct/Reverse Screen Processing. The transparent and opaque process inks shall be of a type and quality recommended by the retroreflective sheeting manufacturer. 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 screening over reflective sheeting shall not require clear coating. Inks shall not consist of more than one part.

3.8.1 Coefficient of Retroreflection for Reverse Screened Signs. The coefficient of retroreflection for screen-printed transparent colors on white sheeting processed according to the techniques and procedures recommended by the sheeting manufacturer, shall be not less than 70 percent (55 percent for blue) of the coefficient of retroreflection values in Section 2.2. The ratios of the reflective intensity for the white to the reflective intensity for the color, when measured at 0.2° observation, -4° entrance and a 90° orientation, shall be 3:1 to 15:1 for red and not less than 5:1 for blue and green when processed according to the sheeting manufacturer's recommendations.

3.8.2 Color Requirements. The diffused day color of the finished transparent process inks, through instrumental color testing, shall conform to Section 2.3.

3.8.3 Color Processing. The finished transparent and opaque process inks shall have the same daytime and nighttime appearance when viewed by reflected light. The inks when processed and applied to the sheeting in accordance with the manufacturer's recommendations shall be weather resistant, have color and/or transparency retention, and shall provide an effective satisfactory performance life equal to the sheeting to which the process colors are applied. The finished transparent or opaque process inks processed and applied in accordance with the sheeting manufacturer's recommendations shall show no appreciable discoloration, cracking, crazing, blistering, flaking, dimensional change, and/or loss of the process inks which would affect the sign's intended use.

3.8.4 Scratch Test. A 90° cross hatch pattern of parallel lines spaced at 1/8-inch shall be scratched over an area of at least 1 square inch through the process color surface. Cellophane tape shall be applied over the scratched area. When the tape is removed in one quick motion, no process color shall be transferred to the cellophane tape.

3.9 Satisfactory Performance Life. Transparent and opaque process inks processed, applied and cleaned, in accordance with the sheeting manufacturer's recommended procedures, shall be considered as providing the minimum acceptable satisfactory performance life required by the specification.

3.9.1 Unacceptable Performance. Unacceptable performance life conditions shall be cause for immediate material rejection and replacement. Unacceptable performance includes, but need not be limited to, the display of:

(a) bubbles or wrinkles on the sign face greater than 3 inches in length (excluding minor defects around dents or mounting holes), or any cracks or breaks or stress cracks.

(b) bubbles or wrinkles within the legend/message area (legend/message shall be defined as the entire area within the limits of the legend/message

template.)

(c) a total shrinkage of more than 1/8-inch in the sheeting in any dimension.

(d) delamination of the sheeting between the outer surface, optical reflecting system or the adhesive backing.

(e) a lack of durable adhesive bond between the sheeting and sign blank.

(f) a loss of the transparent or opaque ink applied over sheeting, due to cracking, crazing, blistering, flaking, chipping, fading, etc.

(g) an inappropriate color of the transparent or opaque ink applied over sheeting, or a daytime luminance factor outside the ranges specified in Section 2.3.

(h) a loss in the coefficient of retroreflection for either the sheeting or the transparent process ink at values less than those specified in Section 3.8.1 or 2.2..

3.9.2 Minimum Coefficient of Retroreflection. Transparent inks processed and applied over white sheeting shall have the following minimum percentage of the coefficient of retroreflection values specified in Section 2.2 at a divergence angle of 0.2° and an incidence angle of –4°. The satisfactory performance life for black process inks shall equal the number of performance life years of the retroreflective sheeting over which it is applied.

Sheeting Type	Color	Minimum Satisfactory Performance Life (Years)	Minimum Final Coefficient of Retroreflection (% of Section 2.2)
III & IV	all, except orange	10	80
	orange	3	80
V	all	10	80
VI	all	3	50
VII, VIII & IX	all, except orange & fluorescent orange	10	80
	orange & fluorescent orange	3	80

3.10 Technical Assistance.

3.10.1 Material Failure. The vendor furnishing reflective sheeting and inks shall be responsible for the performance and production specified. Upon receipt in writing of notification of material failure, the vendor shall furnish on-site technical assistance within 48 hours to the Department's Sign Shop at no cost to the Department. This technical assistance shall be maintained, at no additional cost to the Department, until corrective action is completed to the satisfaction of the Department.

3.10.2 Training and Service. The vendor shall, at no cost to the Department, provide the services of a qualified technician to the Sign Shop for the purpose of assisting Department personnel in the proper application of material, silk screening techniques, storage, packaging and other sign shop practices as they pertain to the sheeting supplied by the manufacturer. Service will also include information and assistance on screen printing problems with the inks furnished or recommended by the sheeting manufacturer.

3.11 Cause for Material Rejection and Replacement. The Department reserves the right to approve, reject, or cause to be replaced any or all material failing to satisfactorily meet all sections of the specification, including the Department's Sign Shop production and/or performance requirements.

3.12 Material Replacement. Any or all rejected material, which has been documented by written notification from the Department, shall be removed and replaced in full quantity within 30 calendar days at no expense to the Department. Failure of the vendor to comply with the conditions regarding material replacement shall constitute grounds for the revocation of the bid award and the award to the next low bidder. The Department also reserves the right to remove the offending vendor from the "approved bidders" listing for any or all of the retroreflective sheeting colors.

3.13 Vendor's Liability. The vendor shall be liable for the replacement of all sheeting or all sheeting processed with transparent or opaque process ink furnished by the vendor, which fail to meet this specification. The vendor shall also be liable to the Department for all costs associated with sheeting failures (based on the minimum satisfactory performance life in Section 3.9 and the actual life) as may be incurred in manufacturing signs, sign processing, sign refurbishment, and field force removal and replacement of signs directly associated with the failure.

3.14 General Characteristics and Packaging. Sheeting as supplied shall be of good appearance, free from ragged edges, cracks and extraneous materials, and shall be furnished in either rolls or sheets as specified. When furnished in continuous rolls, the average number of splices or patches on a roll shall not be more than a total of two per 50 yards of material. All splices shall be overlapped and the maximum overlap shall be 3/8". Splices shall be suitable for continuous application as furnished. Patches on a roll which

designate defective areas will be considered and counted in the same way as a splice. Patches shall be not more than 1"x1" in size. When furnished as cut retroreflective sheeting or sign faces, the sheeting shall be packaged flat between pressed composition board or corrugated pads of the same dimensions in accordance with commercially accepted standards. Each carton shall clearly stipulate the classification, color and type adhesive. Stored under normal conditions, the sheeting shall be suitable for use for a minimum of 12 months.

3.15 Slip Sheeting. Slip sheeting paper, if recommended by the sheeting manufacturer for sheeting surface protection during heat vacuum application or for use in packaging, storing or shipping finished signs, shall be furnished in rolls by the manufacturer at no additional charge, in at least equal area and in the same widths as the sheeting. If different slip sheeting materials are recommended for heat vacuum application from packing, storage and shipping of pressure sensitive sheeting, the different slip sheeting materials shall be furnished in at least equal area and in the same widths as the type of sheeting supplied.

4. DEPARTMENT APPROVAL

4.1 Application for Approval. Manufacturers should submit a Product Evaluation Qualification (PEQ) form for each type of the material to be evaluated (available at ftp://ftp.dot.state.pa.us/public/pdf/NPETapplication.pdf).

4.1.1 NTPEP Testing. NTPEP outdoor weathering data for each type and color of material from test facilities identified in section 3.7 for the period of time specified in Section 6 of ASTM D 4956 (fluorescent materials to be weathered for a minimum of 36 months, except fluorescent orange and pink materials to be weathered only 6 months). It will be the manufacturer's responsibility to provide copies of all test results with any request for approval.

4.1.2 Fluorescent Sheeting Materials. If requesting approval of fluorescent sheeting materials, it will be the manufacturer's responsibility to provide independent laboratory tests documenting that the material satisfies the color requirements in Section 2.3 of this specification.

4.2 Samples. At the appropriate time, the Materials and Testing Lab will ask the manufacturer to submit four 24"x24" samples. If the manufacturer is requesting approval of a white sheeting, two 24"x24" samples of white sheeting will be requested with two additional 24"x24" samples for each reverse screened color of red, orange, green and blue transparent inks, and black opaque ink.

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NOTES:

- Eliminated all references to metric units.
- Added a definition for Type XI Sheeting.
- Revised the coefficient of retroreflection values for fluorescent pink material. Added coefficient of retroreflection values for purple material and color specification limits for fluorescent pink and purple.
- Eliminated section 2.6 for Abrasion Resistance for Type V Material
- Eliminated sections 3.3.2 and 3.6 for heat activated adhesives.
- Revised section 3.7 and the outdoor weathering requirements for Type VI Material.