1. SCOPE AND CLASSIFICATION

1.1 Scope. This specification covers flexible, non-exposed glass bead lens and microprismatic, retroreflective sheeting designed for use on traffic control signs, delineators, barricades and other devices. 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 seven 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.

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" (200 mm x 200 mm). 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 lux per square meter (cd·lx⁻¹·m⁻²), shall meet or exceed the minimum requirements in the most current edition of ASTM D 4956 at the specified 0.2°, 0.5° and 1.0° observation angles, or as indicated in Sections 2.2.1 and 2.2.2 for the additional colors. The coefficient of retroreflection shall be measured and determined by the method detailed in ASTM E 810. The coefficient of retroreflection in any rotation, e.g., 0° and 90°, shall satisfy the minimum specification value. (Note, the Department will not measure materials at the 1° observation angle except for the Type IX material.)
2.2.1 **Fluorescent Type III Material.**

<table>
<thead>
<tr>
<th>Observation Angle</th>
<th>Entrance Angle</th>
<th>Fluorescent Orange</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2°</td>
<td>-4°</td>
<td>105</td>
</tr>
<tr>
<td>0.2°</td>
<td>30</td>
<td>50</td>
</tr>
<tr>
<td>0.5°</td>
<td>-4°</td>
<td>45</td>
</tr>
<tr>
<td>0.5°</td>
<td>30°</td>
<td>22</td>
</tr>
</tbody>
</table>

2.2.2 **Fluorescent Type VI Material.**

<table>
<thead>
<tr>
<th>Observation Angle</th>
<th>Entrance Angle</th>
<th>Fluorescent Pink</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2°</td>
<td>-4°</td>
<td>135</td>
</tr>
<tr>
<td>0.2°</td>
<td>30</td>
<td>60</td>
</tr>
<tr>
<td>0.5°</td>
<td>-4°</td>
<td>60</td>
</tr>
<tr>
<td>0.5°</td>
<td>30°</td>
<td>25</td>
</tr>
</tbody>
</table>

2.3 **Color Requirements.** Sheet ing shall have the same daytime and nighttime color when viewed by reflective light. The values shall be determined on a HunterLab Color Quest 0/45 Spectrocolorimeter with option CMR 559. 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.) The diffused day color, through instrumental color testing, shall conform to the requirements of ASTM D 4956 for color specification limits and daylight luminance factors.

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.

2.6 **Abrasion Resistance for Type V Materials.** In order to duplicate the abrasive environment for roadside delineators, Type V retroreflective sheeting materials shall be tested in accordance with Section 3.6. At the conclusion of the test, the sample shall have a minimum of 60 percent of the retroreflectivity requirements for new material, and shall show no appreciable discoloration.
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 (71.1°C) under a weight of 2.5 pounds per square inch (17.24 kPa).

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).

3.3.2 **Heat-Activated Adhesives.** Heat-activated (HA) adhesives shall be positioned under normal working conditions and temperatures up to 100°F (37.8°C) without damage to the material or application surface. The adhesive shall be activated by applying heat in excess of 175°F (79.4°C) and vacuum pressure in excess of 25 psi (172 kPa) to the material as in the heat-vacuum process, without additional pre-application preparation to the reflective sheeting for adhesion to clean aluminum or plywood surfaces.

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 (15.6°C) to 100°F (37.8°C) 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 (37.8°C) to 300°F (148.9°C). 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.

3.6 **Abrasion Resistance Test for Type V Materials.** Mask off a 2-inch by 2-inch (50 mm x 50 mm) area to be tested. Clamp or hold the sample inside the chamber of a Ventura type, bench-top sandblaster (Buffalo Dental Manufacturing Company, or equivalent) at a distance of 5.5 to 6.25 inches (140 to 160 mm) from the Ventura tip, so that the retroreflective face of the sample is perpendicular to the axis of the particle cone and the test area is centered within the particle cone. Sandblast the unit with 60-grit aluminum oxide for 20 seconds with a continuous air pressure of 450 kPa (65 psi). Remove the test unit from the chamber, clean off any abrasive medium, examine the surface for damage or color loss, and read the retroreflectivity at the 0.2° observation angle and -4° entrance angle.

3.7 **Outdoor Weathering.** All sheeting shall be subject to outdoor weathering on NTPEP test decks in Arizona, Louisiana and Virginia, in accordance with Section 6.4 and Table 14 of ASTM D 4956. At the end of the exposure period, the samples from all three 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, RA,” as included in Table 14 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 only be clear coated when recommended by the retroreflective sheeting manufacturer. Inks shall not consist of more than one part.

3.8.1 **Coefficient of Retroreflexion 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 5:1 to 15:1 for red and not less than 5:1 for blue 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 (3.18 mm) shall be scratched over an area of at least 1 square inch (645 mm²) 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 like 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 (75 mm) 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 (3.18 mm) 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.

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°. Measurements shall be made on coated sheeting when recommended by the manufacturer. 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.

<table>
<thead>
<tr>
<th>Sheet Type</th>
<th>Color</th>
<th>Minimum Satisfactory Performance Life (Years)</th>
<th>Minimum Final Coefficient of Retroreflection (% of Section 2.2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>III &amp; IV</td>
<td>all, except orange</td>
<td>10</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td>orange</td>
<td>3</td>
<td>80</td>
</tr>
<tr>
<td>V</td>
<td>all</td>
<td>10</td>
<td>80</td>
</tr>
<tr>
<td>VI</td>
<td>all</td>
<td>3</td>
<td>50</td>
</tr>
<tr>
<td>VII, VIII &amp; IX</td>
<td>all, except orange &amp; fluorescent orange</td>
<td>10</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td>orange &amp; fluorescent orange</td>
<td>3</td>
<td>80</td>
</tr>
</tbody>
</table>

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 anyone 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.** Sheet 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 (45.71 m) of material. All splices shall be overlapped and the maximum overlap shall be 3/8" (9.5 mm). 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" (25 mm x 25 mm) 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 Sheet.** 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). The form should be sent to Chief, Traffic Engineering and Operations Division, P.O. Box 2047, 400 North Street, Harrisburg, PA 17105-2047, and include the following.

4.1.1 **NTPEP Testing.** NTPEP outdoor weathering data for each type and color of material from test facilities in Arizona (Phoenix test deck), Louisiana, and Virginia 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 12 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 Division (MTD) will generally ask the manufacturer to submit two 36”x36” (900 mm x 900 mm) or four 24”x24” (600 mm x 600 mm) samples. If the manufacturer is requesting approval of a white sheeting, one 36”x36” (900 mm x 900 mm) or two 24”x24” (600 mm x 600 mm) samples of white sheeting will generally be requested with reverse screened red, orange, green and blue transparent inks, and black opaque ink, for each color.

/s/ Glenn C. Rowe

Glenn C. Rowe, P.E., P.T.O.E., Chief
Traffic Engineering and Operations Division
NOTES:

- The 5/21/99 specification included changes in table in Section 3.9.2.
- 6/18/99 changes included the addition of red sheeting in Table VIIA and the reference to Type VIIA in Section 3.7.1.
- The 8/9/99 specification eliminated Type VIII sheeting. Approved Type VIII materials will be reinstated as either Type III or Type VII.
- The 12/6/99 specification included a new Table 2.2.2 for Type III fluorescent orange and renumbering old Tables 2.2.2 and 2.2.3. In addition, last sentence added to Section 2.3.2 and Section 2.3.3 split into two subsections.
- The 2/9/00 specification included reinstating the red values in Table 2.2.4.
- The 4/1/02 specification included the adoption of the new Type VIII sheeting as included in ASTM D 4956-01, and the conversion of Type VII-A to Type IX sheeting. In addition, Types V and VI materials, which previously were included in separate specifications, were added to this specification. Finally, NTPEP testing is now required instead of accelerated weathering.
- The 5/1/02 specification (1) revised Section 3.3.3 to eliminate the need for adhesion to stripped and cleaned sign blanks and to fiberglass sign blanks; and (2) revised the Department’s approval process in Section 4.
- The 11/19/04 specification (1) deleted Type I and II materials; (2) corrected the observation angle identified for Type IX sheeting in Section 1.2; (3) revised Section 2.2 regarding retro values at different rotations; (4) added fluorescent pink to Table 2.2.3 and Section 4.1.1; and (5) clarified the flexibility test in Section 3.4.2.
- The 2/16/06 specification deleted fluorescent color retroreflectivity (except for Tables 2.2.1 and 2.2.2) requirements since they are now contained in ASTM 4956.