(i) **Pavement Interlayer:** Paving geosynthetics shall be used as an interlayer between pavement layers. Specific application of these paving interlayers shall be determined by the Engineer.

1. **Paving Fabric:** The geotextile shall conform to the requirements of AASHTO M288 Paving Fabric Property Requirements, Section 10.

2. **Paving Mat:** The paving mat shall meet the requirements of ASTM D7239 Geosynthetic Paving Mat, Type 1.

(j) **Low Permeability Liners for Stormwater Management Facilities:** SWM liner soil shall be classified as CL, CH or MH in accordance with ASTM D2487 and shall have a maximum coefficient of permeability of $1 \times 10^{-9}$ cm/sec in accordance with ASTM D5084, after compaction. The maximum particle size shall be three inches in its largest dimension. Natural soils, which do not meet these specifications, may be blended with bentonite to provide the specified permeability characteristics.

Geosynthetic Clay Liner shall have a maximum coefficient of permeability of $1 \times 10^{-9}$ cm/sec in accordance with ASTM D5887.

This specification is not intended for dam embankment material or clay core cut-off trench material.

### SECTION 246—PAVEMENT MARKING

#### 246.01—Description

These specifications cover material for use in various retroreflective pavement-marking applications.

#### 246.02—Detail Requirements

Materials that must be heated for application shall not exude fumes that are toxic or injurious to persons or property when heated to the application temperature.

The marking material (including primers and adhesives) shall not be formulated with any compounds of the heavy metals listed in 40 CFR 261.24, Table 1, except that barium sulfate is allowed. Total heavy metal levels, with the exception of barium sulfate, shall not exceed 20 times the specified regulatory limits.

The marking material (including primers and adhesives) shall meet the Virginia Department of Environmental Quality (VDEQ) regulations (9 VAC 5-45, Articles 5 and 6) for Volatile Organic Compounds (VOC).

Materials shall withstand air and roadway temperature variations from 0 - 140 degrees F without deforming, bleeding, staining, or discoloring and shall maintain their original dimensions and placement without excessive chipping, spalling, cracking, or loss of adhesion. Material shall not deteriorate because of contact with snow and ice control materials or oil and gasoline drippings from vehicles.

Pavement marking materials shall produce a retroreflective line, message, legend or symbol of specified thickness, width or design in accordance with the latest edition of the Manual on Uniform Traffic Control Devices for Streets and Highways and the Contract requirements.
Pavement marking material shall have the pigment, glass beads, and filler well dispersed in the resin and shall be free from skins, dirt, and foreign objects.

Glass Beads shall conform to Section 234.

The amount and type of yellow pigment and inert filler for yellow material shall be at the discretion of the manufacturer provided the material complies with this specification.

All marking materials shall be suitable for use up to 1 year after the date of manufacture when stored in accordance with manufacturer’s instructions. Pavement marking and pavement marker materials shall conform to the specific requirements for the individual types as indicated hereinafter:

(a) **Approval of Pavement Markings**

The Department will evaluate and approve pavement markings by reviewing performance test data from one or both of the following testing programs:

- AASHTO’s National Transportation Product Evaluation Program (AASHTO/NTPEP) Testing

  Test data values used for approval will be based upon the data generated per the NTPEP, Pavement Marking Material Work Plan. Testing and evaluations shall be performed on a Northern Region test deck unless otherwise approved by the Materials Division.

- VDOT Test Facility – VDOT may evaluate pavement marking performance from data generated at its own test facility. Test data values used for approval will be based upon the data generated by following the testing requirements in VTM-125, Evaluation of Pavement Markings on Road Surfaces.

When pavement markings are installed on the NTPEP test deck or the VDOT facility, the material’s thickness, beads/reflective optic types, and formulation shall be documented to ensure the equivalent thickness, beads/reflective optic types and formulation are installed on VDOT roadways following approval.

Approved pavement marking products later found not meeting the batch testing requirements will be removed from the Materials Division’s Approved Products List.

Black contrast pavement markings of paint, thermoplastic, epoxy, and polyurea shall be accepted based upon batch testing requirements listed herein (as applicable). Retroreflectivity, color, luminance(Y%), and road testing are not required for the black portion of the pavement markings. Black contrast tape requirements are listed in the applicable section below.

**Initial Approval**

Pavement marking products will be included on the Materials Division’s Approved Products List after the Department determines conformance to the specifications on both asphalt and hydraulic cement concrete roadway surfaces. Determination of conformance will include, but not be limited to, the evaluation of test data from AASHTO’s/NTPEP or other VDOT Test Facilities in accordance with the requirements for the respective pavement marking material types.
(b) **Certifications**

The pavement marking material manufacturer shall certify each batch or lot of material supplied and installed is the same product (thickness, reflective optic package and formulation) that was tested and approved on the AASHTO/NTPEP or VDOT test facility in accordance with the Materials Division, Manual of Instructions for Certification I and II Materials. The certification shall include the NTPEP test number from the Materials Division’s Approved Products List. The Contractor shall retain the manufacturer’s certifications.

(c) **Warranty Requirements**

Pavement marking products shall carry the warranties as supplied by the manufacturer of the individual marking types (classes) for the specific timeframes per type and class and the material requirements for reflectance, durability, color, and adhesion as referenced herein. Warranties shall be those commercially supplied or those unique to the Commonwealth in the case of certain products, such as Type B, Class VI preformed pavement marking tape as detailed herein. Manufacturers’ warranties shall be obtained by the Contractor and assigned to the Department in writing prior to final acceptance. Warranty periods shall begin on the date of receipt at the project as verified by delivery tickets signed by the Engineer.

Type B, Class VI pavement marking tape shall be warranted for six years against failure resulting from material defects regardless of method of manufacturer’s prescribed application or pavement type. The material shall be warranted to retain its Retroreflectivity, Day and Nighttime Color and Luminance (Y%) and durability including adherence to the pavement and shall be free of other obvious defects or failures. All Type B Class VI pavement marking tape that has failed to meet the warranty conditions shall be replaced at no additional cost to the Department. The warranty shall cover all pavement striping materials (regardless of method of installation), labor, equipment, mobilization/demobilization, tools, incidentals required to remove (eradicate) and replace the pavement striping including maintenance of traffic during eradication and reinstallation operations.

246.03—Pavement Marking Materials

Pavement marking and pavement marker materials shall conform to the specific requirements for the individual types as indicated hereinafter:

(a) **Paint Pavement Marking Material (Type A)**

Paint material shall be a fast-drying, waterborne, nonleaded, acrylic or modified acrylic resin paint suitable for use on both asphalt and hydraulic cement concrete pavement surfaces and shall be selected from the Materials Division’s Approved Products List No. 20.

1. **Initial Approval**—Maintained retroreflectivity, color (including luminance), and durability shall conform to the following requirements after the material has been installed on the test deck for 1 year:

a. **Maintained Retroreflectivity**: The photometric quantity to be measured is the coefficient of retroreflected luminance (R_a) in accordance with ASTM E1710 for 30-meter geometry. R_a shall be expressed in millicandela per square foot per foot-candle when measured in the skipline or centerline areas:
Coefficient of Retroreflected Luminance (RL) (mcd/ft²/ft²) Paint

<table>
<thead>
<tr>
<th>Color</th>
<th>Initial</th>
<th>1 Year In-Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>200</td>
<td>100</td>
</tr>
<tr>
<td>Yellow</td>
<td>150</td>
<td>100</td>
</tr>
</tbody>
</table>

b. **Day and Nighttime Color and Luminance (Y%)**: Measured according to ASTM D6628

c. **Durability**: Paint shall have a durability rating of at least 6 when determined in the wheel path area when tested in accordance with the NTPEP Work Plan.

d. **Skid Resistance**: The initial skid resistance shall be at least 45 BPN when tested according to ASTM E303, if available.

e. **IR Scan from NTPEP**, if available.

2. **Batch Testing**

Paint batch testing shall be performed by the Department on samples obtained from the point of manufacture or from the field in accordance with the Materials Division’s Manual of Instructions. The test results shall be compared against NTPEP lab test results and the Specifications. Testing shall be performed to determine the following physical requirements and properties:

a. **Solids, (% weight)** according to ASTM D2369: Acceptable range from NTPEP results (+/- 2 %).

b. **Pigment (% weight)** according to ASTM D3723: Acceptable range from NTPEP results (+/- 2 %).

c. **Density (wt/gal.)** according to ASTM D1475: Acceptable range from NTPEP results (+/-0.3 lbs/gal).

d. **Viscosity (KU)** according to ASTM D562: Acceptable range from NTPEP results (+/-5KU).

e. **Contrast Ratio** according to ASTM D2805 (2°,D 65): Paint shall show a dry hiding quality that will give a contrast ratio of at least 0.96 at (15 mil) wet film thickness.

f. **Day Color, Luminance (Y%) - (without Drop-on Beads)**:

Color testing results shall conform to the chromaticity coordinate limits that follow. Color determination for paint materials will be made without drop-on beads at least 24 hours after application in accordance with ASTM D6628.

**Day Color, Chromaticity Coordinates (Without Drop-on Beads), Paint**

<table>
<thead>
<tr>
<th></th>
<th>x</th>
<th>y</th>
<th>x</th>
<th>y</th>
<th>x</th>
<th>y</th>
<th>x</th>
<th>y</th>
<th>Y%</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>0.355</td>
<td>0.355</td>
<td>0.305</td>
<td>0.305</td>
<td>0.285</td>
<td>0.325</td>
<td>0.335</td>
<td>0.375</td>
<td>80.0 Min</td>
</tr>
<tr>
<td>Yellow</td>
<td>0.493</td>
<td>0.473</td>
<td>0.518</td>
<td>0.464</td>
<td>0.486</td>
<td>0.428</td>
<td>0.469</td>
<td>0.452</td>
<td>50.0-60.0</td>
</tr>
</tbody>
</table>
g. **Settling properties:** Settling shall be no less than a rating of 8 when tested in accordance with the NTPEP Work Plan.

h. **Freeze-thaw and heat stability:** Paint shall show no coagulation or change in viscosity greater than +/- 5 KU when tested in accordance with the NTPEP Work Plan.

i. **Water resistance:** Paint shall show no blistering, peeling, wrinkling, softening, or loss of adhesion when tested in accordance with the NTPEP Work Plan.

j. **VOC:** The VOC content shall be no greater than 150 grams/liter when tested in accordance with EPA Method 24.

k. **Flash point:** Paint shall have a flash point of at least 201 degrees F when tested in accordance with ASTM D93, Pensky-Martens Closed Cup.

l. **No-track time:** Paint shall have a 60-second maximum vehicle no-track time when measured in accordance with the NTPEP Work Plan.

m. **IR Scan:** Should match IR scan from NTPEP.

(b) **Thermoplastic Pavement Marking Material (Type B, Class I)**

Thermoplastic material shall be suitable for use on asphalt and hydraulic cement concrete pavement surfaces and shall be selected from the Materials Division's Approved Products List No. 43.

The binder shall be either alkyd or hydrocarbon based. If an alkyd thermoplastic is used, the binder shall consist of synthetic resins, at least one of which is solid at room temperature, and high-boiling plasticizers. At least one-half of the binder composition shall be a maleic-modified glycerol ester of resin and shall be at least 10 percent by weight of the entire material formulation.

Thermoplastic marking materials shall be capable of application at pavement surface temperatures of 50 degrees Fahrenheit and above on all asphalt and hydraulic cement concrete pavement surfaces. Thermoplastic material shall be capable of successfully fusing to itself and previously applied thermoplastic pavement markings.

1. **Initial Approval** - Maintained retroreflectivity, color (including luminance, Y%), and durability shall conform to the following requirements after the material has been installed on the test deck for 1 year:

   a. **Maintained Retroreflectivity:** The photometric quantity to be measured is the coefficient of retroreflected luminance (R<sub>L</sub>) in accordance with ASTM E1710 for 30-meter geometry when measured in the skip line or centerline areas.

<table>
<thead>
<tr>
<th>Coefficient of Retroreflected Luminance (R&lt;sub&gt;L&lt;/sub&gt;) (med/ft&lt;sup&gt;2&lt;/sup&gt;/fc) Thermoplastic</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Color</strong></td>
</tr>
<tr>
<td>White</td>
</tr>
<tr>
<td>Yellow</td>
</tr>
</tbody>
</table>
b. **Day and Nighttime Color and Luminance (Y%)**: According to ASTM D6628

c. **Durability**: Thermoplastic shall have a durability rating of at least 8 as determined in the wheel path area when tested in accordance with the NTPEP Work Plan.

d. **Skid Resistance**: The initial skid resistance shall be at least 45 BPN when tested per ASTM E303, if available.

2. **Batch Testing**:

Thermoplastic batch testing will be performed by the Department on samples obtained from the point of manufacture or from the field in accordance with the Materials Division’s Manual of Instructions. The tests results will be compared against the following specifications and requirements:

a. **Pigment and Glass Bead (% Weight)** according to ASTM D4451: 82.0% Max

b. **Glass Bead Content (% Weight)** according to AASHTO T250 and ASTM D4797: 25.0% Min

c. **TiO2 (%)** according to ASTM D1394 or equivalent method: 8.0% Min

d. **Binder (%)** according to AASHTO T250/ASTM D4451: 18.0% Min

e. **Calcium Carbonate and Inert Fillers**: 49.0 % Max

f. **Day Color, Luminance (Y%) (Without Drop-on Beads)**: Color testing results shall conform to the chromaticity coordinate limits that follow. Color determination for thermoplastic materials will be made without drop-on beads after cooling in accordance with AASHTO T250 and ASTM D6628.

<table>
<thead>
<tr>
<th>Day Color, Chromaticity Coordinates (Without Drop-on Beads), Thermoplastic</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
</tr>
<tr>
<td>White</td>
</tr>
<tr>
<td>Yellow</td>
</tr>
</tbody>
</table>

g. **Nighttime Yellow Color (with Drop-on Beads)**: The initial nighttime color of yellow thermoplastic pavement marking material shall conform to the following CIE chromaticity coordinate requirements when tested in accordance with ASTM D6628 and VTM-111:

<table>
<thead>
<tr>
<th>Night Time Color, Chromaticity Coordinates (with Drop-on Beads), Thermoplastic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color</td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>x</td>
</tr>
<tr>
<td>Yellow</td>
</tr>
</tbody>
</table>
h. **Water absorption:** Materials shall not have more than 0.5 percent retained water by weight when tested in accordance with ASTM D570, Procedure A.

i. **Softening point:** Materials shall have a softening point of at least 194 degrees F as determined in accordance with ASTM E28.

j. **Specific gravity:** The specific gravity of the thermoplastic compound at 77 degrees F shall be from 1.7 to 2.2.

k. **Impact resistance:** The impact resistance shall be at least 10 inch-pounds at 77 degrees F after the material has been heated for 4 hours at 400 degrees F and cast into bars of 1-inch cross-sectional area, 3 inches long, and placed with 1 inch extending above the vise in a cantilever beam, Izod-type tester conforming to ASTM D256 using the 25 inch-pound scale.

l. **No-Track Time:** Material shall set to bear traffic in not more than 2 minutes when the road temperature is 50 degrees F or above.

m. **Intermixed Glass beads:** Glass beads shall conform to Section 234.

n. **Flashpoint:** The material flashpoint shall be no less than 500 degrees F when tested in accordance with ASTM D92.

(c) **Preformed Thermoplastic Pavement Marking Material (Type B, Class II):**

Preformed thermoplastic material shall be suitable for use on asphalt and hydraulic cement concrete pavement surfaces, and shall be selected from the Materials Division's Approved Products List No. 73.

Preformed thermoplastic shall be installed in strict accordance with the manufacturer's installation instructions. Upon cooling to normal pavement temperatures, these materials shall produce an adherent, retroreflective pavement marking capable of resisting deformation by traffic.

Preformed thermoplastic shall be supplied at a minimum of 30% (by weight) of intermixed glass beads.

During application (when molten) all preformed thermoplastic shall be flooded with additional glass beads. Additional retroreflective optics shall also be added to the surface in quantities and types that match what was used for initial approval of these individual products.

Preformed thermoplastic material shall be supplied at 125 mils thickness.

Reversible arrows shall have a minimum of 30% by weight intermixed beads only. During application, surface beads for reversible arrows shall be applied to the thermoplastic material when it is molten.

Preformed thermoplastic may be either of the following types:

- **Type A** where the manufacturer requires preheating of the roadway surface to a specified temperature prior to installation of the preformed thermoplastic material.
• **Type B** where the manufacturer requires preheating of the roadway surface prior to installation of the preformed thermoplastic material to only remove moisture when necessary.

1. **Initial Approval** - Maintained retroreflectivity, color (including luminance), and durability shall conform to the following requirements after the material has been installed on the test deck for 1 year:

   a. **Retroreflectivity**: Photometric quantity to be measured is coefficient of retroreflected luminance ($R_v$) in accordance with ASTM E1710. $R_v$ shall be expressed in milli-candela per square foot per foot per foot-candle and shall be at least the following values when measured in the skip line area.

<table>
<thead>
<tr>
<th>Color</th>
<th>Initial</th>
<th>1 Year In-Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>300</td>
<td>250</td>
</tr>
<tr>
<td>Yellow</td>
<td>250</td>
<td>200</td>
</tr>
</tbody>
</table>

   b. **Day and Nighttime Color and Luminance ($Y\%$)**: According to ASTM D6628.

c. **Thickness**: 120-130 Mils

d. **Durability Rating**: The marking shall have a durability rating of at least 8 as determined in the wheel path area after 1 year when tested in accordance with NTPEP Work Plan.

e. **Skid Resistance**: The surface of the installed marking shall provide an initial average skid resistance value of 45 BPN when tested according to of ASTM E303, if available.

f. **No Track Time**: When installed with glass beads or other reflective media, the markings shall reach a no-track condition in less than 3 minutes.

2. **Batch Testing**:

   Preformed thermoplastic batch testing will be performed by the Department on samples obtained from the point of manufacture or from the field in accordance with the Materials Division’s Manual of Instructions. Testing results shall be compared against the following specifications and requirements:

   a. **Day and Nighttime Color and Luminance ($Y\%$)**: Refer to initial requirements

   b. **Thickness**: Refer to initial requirements

   c. **Nighttime Yellow Color (with Drop-on Beads)**: The initial night time color of yellow preformed thermoplastic pavement marking material shall conform to the following CIE chromaticity coordinate requirements when tested in accordance with ASTM D6628 and VTM-111:
<table>
<thead>
<tr>
<th>Color</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yellow</td>
<td>0.486</td>
<td>0.439</td>
<td>0.520</td>
<td>0.480</td>
</tr>
</tbody>
</table>

(d) **Epoxy-Resin Pavement Marking Material (Type B, Class III)**

Epoxy-resin is a two-component pavement marking material, suitable for use on both asphalt and hydraulic cement concrete pavement surfaces and shall be selected from the Materials Division's Approved Products List No. 75. The ratio of resin to hardner shall be 2:1 respectively.

1. **Initial Approval** - Maintained retroreflectivity, color (including luminance), and durability shall conform to the following requirements after the material has been installed on the test deck for 1 year:

   a. **Retroreflectivity**: The photometric quantity to be measured is the coefficient of retroreflected luminance (R<sub>L</sub>) in accordance with ASTM E1710 for 30-meter geometry when measured in the skipline or centerline areas.

   | Coefficient of Retroreflected Luminance (R<sub>L</sub>) (mcd/ft<sup>2</sup>/fc) Epoxy |
   |---------------------------------|-------------------------------------------------|
   | Color                           | Initial | 1 Year In-Service |
   | White                           | 300     | 250               |
   | Yellow                          | 250     | 200               |

   b. **Day and Nighttime Color and Luminance (Y%)**: According to ASTM D6628

   c. **Durability**: Epoxy shall have a durability rating of at least 8 as determined in the wheel path area.

   d. **Skid Resistance**: The initial skid resistance shall be at least 45 BPN, if available.

2. **Batch Testing**:

   Epoxy batch testing will be performed by the Department on samples obtained from the point of manufacture or from the field in accordance with the Materials Division's Manual of Instructions. Tests results shall be compared against the following specifications and requirements:

   a. **Pigment (% Weight)** according to ASTM D2371

   b. **Epoxy Content** according to ASTM D2371 White, 82.0% Max; Yellow, 77.0% Max

   c. **Contrast Ratio (Hiding Power)** according to ASTM D2805 (at 15 Mils wet):
Readings will be determined in accordance with ASTM E1349 using CIE 1931 (2 degrees standard observer and CIE standard Illuminant D65).

d. **TiO2 (%)**, White conforming to ASTM D476, Type IV according to ASTM D1394 or equivalent

18.0 Min.

e. **Total Amine, Hardener (ASTM D 2074 ERF)** shall be within +/- 50 of the value obtained when tested by NTPEP.

f. **Day Color, Luminance (Y%) (Without Drop-on Beads)**

Color testing results shall conform to the International Commission on Illumination (CIE) chromaticity coordinate limits that follow. Color determination for epoxy materials will be made without drop-on beads at least 24 hours after application in accordance with ASTM D6628.

| Day Color, Chromaticity Coordinates (Without Drop-on Beads), Epoxy |
|------------------------|---|---|---|---|---|---|---|---|---|
| x         | y         | x         | y         | x         | y         | x         | y         | Y%         |
| White     | 0.355     | 0.355     | 0.305     | 0.305     | 0.285     | 0.325     | 0.335     | 0.375     | 80.0 Min   |
| Yellow    | 0.493     | 0.473     | 0.518     | 0.464     | 0.486     | 0.428     | 0.469     | 0.452     | 50.0-60.0  |

g. **Nighttime Yellow Color (with Drop-on Beads):** The initial nighttime color of yellow epoxy pavement marking material shall conform to the following CIE chromaticity coordinate requirements when tested in accordance with ASTM D6628 and VTM-111:

<table>
<thead>
<tr>
<th>Night Time Color, Chromaticity Coordinates (with Drop-on Beads)</th>
</tr>
</thead>
<tbody>
<tr>
<td>epoxy</td>
</tr>
<tr>
<td>Color</td>
</tr>
<tr>
<td>x</td>
</tr>
<tr>
<td>Yellow</td>
</tr>
</tbody>
</table>

h. **Hardness:** Hardness, Shore D determined in accordance with ASTM D2240 shall be 75 to 100.

i. **Tensile strength:** Tensile strength, determined in accordance with ASTM D638, shall be at least 6,000 pounds per square inch after the material has cured for 72 hours at 73 \pm 4 degrees F.

j. **Compressive strength:** Compressive strength, determined in accordance with ASTM D695, shall be at least 12,000 pounds per square inch after the material has cured for 72 hours at 73 \pm 4 degrees F.

k. **Adhesion to concrete:** Adhesion of markings shall achieve at minimum, a rating of Substrate Failure B when tested in accordance with ASTM D7234 after the material
has cured for 72 hours at 73 ± 4 degrees F. Concrete used for the test shall have a tensile strength of at least 300 pounds per square inch.

l. **No-Pick-Up:** Epoxy marking materials when mixed in proper ratio and applied at a wet film thickness of 15 +/- 1 mils with surface, ambient, and material temperatures being 73.5 +/- 3.0 degrees Fahrenheit, shall reach a no-pick-up time in less than 10 minutes when tested in accordance with ASTM D711.

m. **Weight per epoxy equivalent:** The weight per epoxy equivalent of Part A of the epoxy pavement marking material shall be within ±50 of the target value provided by the manufacturer when tested in accordance with ASTM D1652.

n. **Abrasion resistance:** The wear index shall be no greater than 80 gm/cycle when tested in accordance with ASTM D4060.

(e) **Polyurea Pavement Marking Material (Type B, Class VII):** Polyurea is a two-component pavement marking material suitable for use on both asphalt and hydraulic cement concrete pavement surfaces. Polyurea pavement marking material shall be selected from the Materials Division's Approved Products List No. 74. The components shall be formulated such that the complete cure occurs when they are mixed at the time of application.

1. **Initial Approval** - Maintained retroreflectivity, color (including luminance), and durability shall conform to the following requirements after the material has been installed on the test deck for 1 year:

   a. **Retroreflectivity:** The photometric quantity to be measured is the coefficient of retroreflected luminance (R<sub>L</sub>) in accordance with ASTM E1710 for 30-meter geometry. RL shall be measured in the skipline or centerline areas.

<table>
<thead>
<tr>
<th>Coefficient of Retroreflected Luminance (R&lt;sub&gt;L&lt;/sub&gt; (mcd/ft&lt;sup&gt;2&lt;/sup&gt;/fc) Polyurea)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Color</strong></td>
</tr>
<tr>
<td>White</td>
</tr>
<tr>
<td>Yellow</td>
</tr>
</tbody>
</table>

b. **Color and Luminance (Y%)**: According to ASTM D6628

c. **Durability**: Polyurea shall have a durability rating of at least 8 when determined in the wheel path area in accordance with NTPEP guidelines.

d. **Skid Resistance**: The initial skid resistance shall be at least 45 BPN, if available.

2. **Batch Testing:**

Polyurea batch testing will be performed by the Department on samples obtained from the point of manufacture or from the field in accordance with the Materials Division's Manual of Instructions. Tests results shall be compared against the following specifications and requirements:
a. TiO2 (%) White, ASTM D476, (Types II, III, IV) according to ASTM D1394 or equivalent  White = 18.0 % Min. / Yellow = 10.0% Min.

b. **Hardness**: Hardness, Shore D as determined in accordance with ASTM D2240, shall be 75 to 100.

c. **Adhesion to concrete**: Adhesion, determined in accordance with ACI 503, shall be at 100 percent concrete failure after the material has cured for 72 hours at 73 ± 4 degrees F. Concrete used for the test shall have a tensile strength of at least 300 pounds per square inch and shall be 90 degrees F when the material is applied.

d. **No-Track Time**: Material shall dry to a “no-track” condition in the time limit stated according to the manufacturer’s specification.

e. **Abrasion resistance**: The wear index shall be no greater than 80 when abrasion resistance is tested in accordance with ASTM D4060.

f. **Hiding (Contrast Ratio)**: The marking shall show a dry hiding quality that will yield a contrast ratio of at least 0.96 with the Morest Black and White Power Chart, Form 03B (or equivalent), when drawn down at a 15-mil wet film thickness. Readings will be determined in accordance with ASTM E1349 using CIE 1931, 2 degrees standard observer and CIE standard Illuminant D65.

(f) **Permanent, Plastic-Backed, Preformed Tapes (Type B, Class IV and Type B, Class VI)**

Permanent tape shall be a durable, retro-reflective prismatic material consisting of a mixture of polymeric materials, pigments, and glass beads (reflective optics) evenly distributed throughout its cross-sectional area and embedded into the surface. Permanent tapes shall be selected from the Materials Division’s Approved Products List No. 17. Tape shall be applied in strict accordance with the manufacturer’s instructions and the limitations set herein or on the Approved Products List.

**Flat Tape (Type B, Class IV)** – Flat tape shall be capable of being surface applied to asphalt cement or hydraulic cement concrete pavement following paving operations on new, dense, or open graded asphalt concrete and shall be ready for traffic immediately after application.

**Patterned Preformed Tape (Type B, Class VI)** – Patterened preformed tape shall be capable of being surface applied to asphalt cement or hydraulic cement concrete surfaces following paving operations or inlaid during paving operations on new asphalt concrete, and shall be ready for traffic immediately after application.

**Contrast Tape** – When specified, Contrast tape shall be a minimum of 3 inches wider than the width specified in the pay item. This additional tape width shall be black and non-reflective with 1 1/2 inches minimum on both sides of the white or yellow product. The black area of the contrast tape shall meet initial requirements of durability, skid resistance, thickness, and adhesion as noted below. Batch testing (sampled per the Manual of Instructions) shall meet the requirements of thickness, width, length, and skid resistance as noted below.

1. **Initial Approval** - Maintained retroreflectivity, color (including luminance), durability, and adhesion shall conform to the following requirements after the material has been installed on the test deck for 1 year:
a. Retroreflectivity: The photometric quantity to be measured is the coefficient of retro-
reflected luminance \( (R_c) \) in accordance with ASTM E1710 for 30-meter geometry
when measured in the skip line or centerline areas.

| Coefficient of Retroreflected Luminance  |
|---------------|----------------|
| \( (R_c) \) (mcd/ft²/ft²) Tape-Type B, Class IV and VI |
| Color | Initial | 1 Year In-Service |
| White | 400 | 300 |
| Yellow | 300 | 200 |

b. **Day and Nighttime Color and Luminance (Y%):** According to ASTM D6628.

c. **Durability:** Permanent tape shall have a durability rating of at least 8 as determined
in the wheel path area when tested in accordance with the NTPEP Work Plan.

d. **Skid Resistance:** The initial skid resistance shall be at least 45 BPN when tested
according to ASTM E303, if available.

e. **Thickness (without adhesive):**

   - **Class IV** 60 - 120 mils.
   - **Class VI** Thinnest portion, 20 Mils Minimum; Thickest portion, 65 Mils Minimum

f. **Adhesion:** No line shall be displaced, torn or missing per NTPEP Pavement Marking
Work Plan.

2. **Batch Testing:**

   Permanent tape batch testing will be performed by the Department on samples obtained
from the point of manufacture or from the field in accordance with the Materials Divi-
sion’s Manual of Instructions. Test results shall be compared against the following spec-
fications and requirements:

a. **Maintained Retroreflectivity** (Refer to initial requirements). Retroreflectivity will
be measured in both directions on the roll. The lowest value being recorded.

b. **Color (including Luminance, Y%):** Refer to initial requirements

c. **Thickness:** Refer to initial requirements.

d. **Width:** The width shall be no less than the nominal width and no greater than 1/8”
of the nominal width.

e. **Length:** The length shall be no less than the length stated on the manufacturer’s
packaging.

f. **Skid Resistance:** Refer to initial requirements

(g) **Temporary Pavement Marking Materials:** Construction (temporary) pavement markings
shall consist of Type D removable tape; Type E removable black, non-reflective tape; and Type
F temporary pavement marking material. Determination of conformance will include, but not be limited to, the evaluation of test data from AASHTO’s NTPEP or other VDOT Test Facilities.

1. **Removable Tape (Type D, Class II):**

Removable tape shall be a durable, retro-reflective pliant material consisting of a mixture of polymeric materials, pigments and glass beads (reflective optics) evenly distributed throughout its cross-sectional area and embedded into the surface. Temporary removable tape shall be suitable for use on both asphalt and hydraulic cement concrete pavement surfaces and shall be selected from the Materials Division’s Approved Products List No. 17.

a. **Initial Approval** - Maintained retroreflectivity, color (including luminance), and adhesive bond rating shall conform to the following requirements after the material has been installed on the test deck for 90 days:

1) **Maintained Retroreflectivity:** The photometric quantity to be measured is the coefficient of retroreflected luminance ($R_v$) in accordance with ASTM E1710 for 30-meter geometry when measured in the skipline or centerline areas.

<table>
<thead>
<tr>
<th>Coefficient of Retroreflected Luminance ($R_v$) (mcd/ft&lt;sup&gt;2&lt;/sup&gt;/fc) Removal Tape-Type D, Class II</th>
<th>Color</th>
<th>Initial</th>
<th>1 Year In-Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>250</td>
<td>150</td>
<td></td>
</tr>
<tr>
<td>Yellow</td>
<td>200</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>

2) **Day and Nighttime Color and Luminance (Y%):** According to ASTM D6628.

3) **Adhesive Bond Rating:** The average adhesive bond rating (from transverse and longitudinal lines) shall be 3 or higher according to the NTPEP Work Plan.

4) **Skid Resistance:** The initial skid resistance shall be at least 45 BPN when tested according to ASTM E303, if available.

5) **Thickness:** Per the manufacture’s recommendation.

6) **Adhesion:** No line shall be displaced, be torn or missing.

b. **Batch Testing**

Removable tape batch testing will be performed by the Department on samples obtained from the point of manufacture or from the field in accordance with the Materials Division’s Manual of Instructions. Test results will be compared against the following specifications and requirements:

1) **Maintained Retroreflectivity:** Refer to initial requirements

2) **Color (including Luminance):** Refer to initial requirements

3) **Thickness:** Refer to initial requirements
4) **Width**: The width shall be no less than the nominal width and no greater than 1/8” of the nominal width.

5) **Length**: The length shall be no less than the length stated on the manufacturer’s packaging.

6) **Skid Resistance**: Refer to initial requirements

2. **Wet Reflective, Removable Tape (Type D, Class III):**

Wet reflective, removable tape shall be a durable, retro-reflective pliant material consisting of a mixture of polymeric materials, pigments, and glass beads (reflective optics) evenly distributed throughout its cross-sectional area and embedded into the surface. This tape shall be suitable for use on both asphalt and hydraulic cement concrete surfaces and shall be selected from the Materials Division’s Approved Products List No. 17.

   a. **Initial Approval** - Maintained retroreflectivity (dry and wet), color (including luminance), and adhesive bond rating shall conform to the following requirements after the material has been installed on the test deck for 90 days:

   1) **Maintained Dry Retroreflectivity**: The dry photometric quantity to be measured is the coefficient of retroreflected luminance ($R_L$) in accordance with ASTM E1710 for 30-meter geometry when measured in the skip line or centerline areas.

   
<table>
<thead>
<tr>
<th>Color</th>
<th>Initial</th>
<th>90 Days In-Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>250</td>
<td>150</td>
</tr>
<tr>
<td>Yellow</td>
<td>200</td>
<td>100</td>
</tr>
</tbody>
</table>

   2) **Maintained Wet Retroreflectivity**: The wet photometric quantity to be measured is the coefficient of retroreflected luminance ($R_L$) in accordance with VTM-124 (Visual Evaluation or ASTM E2177, Recovery Method) when measured in the skip line or centerline areas.

<table>
<thead>
<tr>
<th>Color</th>
<th>Initial</th>
<th>90 Days In-Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>150</td>
<td>100</td>
</tr>
<tr>
<td>Yellow</td>
<td>125</td>
<td>75</td>
</tr>
</tbody>
</table>

   3) **Day and Nighttime Color and Luminance ($Y%$)**: According to ASTM D6628.

   4) **Adhesive Bond Rating**: The average adhesive bond rating (from transverse and longitudinal lines) shall be 3 or higher according the NTPEP Work Plan.
5) **Skid Resistance:** The initial skid resistance shall be at least 45 BPN when tested according to ASTM E303, if available.

6) **Thickness:** Per the manufacturer’s recommendation.

7) **Adhesion:** No line shall be displaced, torn or missing.

b. **Batch Testing:**

Wet reflective, removable tape batch testing will be performed by the Department on samples obtained from the point of manufacture or from the field in accordance with the Materials Division’s Manual of Instructions. Test results shall be compared against the following specifications and requirements:

1) **Retroreflectivity:** Refer to initial requirements

2) **Day and Night Color and Luminance:** Refer to initial requirements

3) **Thickness:** Refer to initial requirements

4) **Width:** The width shall be no less than the nominal width and no greater than 1/8” of the nominal width.

5) **Length:** The length shall be no less than the length stated on the manufacturer’s packaging.

6) **Skid Resistance:** Refer to initial requirements.

3. **Removable Black, Non-Reflective Tape (Type E):**

Removable black, non-reflective tape shall be a durable, pliant material consisting of a mixture of polymeric materials, pigments and a friction material evenly distributed throughout its cross-sectional area and embedded into the surface. Removable black, non-reflective tape shall be suitable for use on asphalt concrete pavement surfaces, and shall be selected from the Materials Division’s Approved Products List No. 17.

a. **Initial Approval** - Maintained adhesive bond rating shall conform to the following requirements after the material has been installed on the test deck for 90 days:

1) **Adhesive Bond Rating:** The average adhesive bond rating (from transverse and longitudinal lines) shall be 3 or higher according to the NTPEP Work Plan.

2) **Skid Resistance:** The initial skid resistance shall be at least 45 BPN when tested according to ASTM E303, if available.

3) **Thickness:** Per the manufacturer’s recommendation.

4) **Adhesion:** No line shall be displaced, be torn or missing.

b. **Batch Testing**
Black removable, non-reflective tape batch testing will be performed by the Department on samples obtained from the point of manufacture or from the field in accordance with the Materials Division’s Manual of Instructions. Test results shall be compared against the following specifications:

1) **Skid Resistance:** Refer to initial requirements

2) **Thickness:** Refer to initial requirements

3) **Width:** The width shall be no less than the nominal width and no greater than 1/8” of the nominal width.

4) **Length:** The length shall be no less than the length stated on the manufacturer’s packaging.

4. **Temporary Pavement Marking Material (Type F):**

Temporary pavement marking material (waterborne paint) shall be suitable for use on both asphalt and hydraulic cement concrete pavement surfaces, and shall be selected from the Materials Division’s Approved Products List No. 48.

a. **Initial Approval** - Maintained retroreflectivity, color (including luminance), and durability shall conform to the following requirements after the material has been installed on the test deck for 90 days:

1) **Maintained Retroreflectivity:** The photometric quantity to be measured is the coefficient of retroreflected luminance \( (R_L) \) in accordance with ASTM E1710 for 30-meter geometry. \( R_L \) shall be expressed in millicandels per square foot per foot-candle when measured in the wheel path areas:

<table>
<thead>
<tr>
<th>Color</th>
<th>Initial</th>
<th>90 Days In-Service</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>200</td>
<td>100</td>
</tr>
<tr>
<td>Yellow</td>
<td>150</td>
<td>100</td>
</tr>
</tbody>
</table>

2) **Day and Nighttime Color and Luminance (Y%):** According to ASTM D6628.

3) **Durability:** Material shall have a durability rating of at least 8 when determined in the wheel path area.

4) **Skid Resistance:** The initial skid resistance shall be at least 45 BPN when tested according to ASTM E303, if available.

5) **Thickness:** Not to exceed 15 mils.

b. **Batch Testing**

Temporary pavement marking paint materials batch testing will be performed by the Department on samples obtained from the point of manufacture or from the field
in accordance with the Materials Division's Manual of Instructions. The batch tests and results are the same batch test parameters described in the section above for waterborne paint.

SECTION 247—REFLECTIVE SHEETING

247.01—Description

This specification covers reflective sheeting used on traffic control devices to provide a retroreflective surface or message. The color of the reflective sheeting shall be as specified in the Contract. Reflective sheeting shall be certified in accordance with Section 106.06.

247.02—Detail Requirements

Reflective sheeting shall be selected from the Materials Division’s Approved Products List No. 46. Reflective sheeting products are included on the Approved Products List only after the Department determines conformance to the specification requirements listed herein. Determination of conformance will include, but not be limited to, the evaluation of test data from AASHTO’s National Transportation Product Evaluation Program (NTPEP), VDOT’s own testing facility, or other Department-approved facilities, except when outdoor testing is not a requirement as noted herein. NTPEP testing includes analysis of new and outdoor weathered sign sheeting. When tested after outdoor weathering, sign sheeting color (Chromaticity and Luminance Factor, Y%) and retroreflectivity must have been maintained within the Specifications limits for the duration of the test period noted. The sheeting and any applied coatings such as inks, overlay films, and other coatings shall be weather resistant according to ASTM D4956 after being tested by AASHTO, NTPEP, VDOT, or other Department approved facilities, except where outdoor testing is not required as noted herein.

Reflective sheeting shall conform to the following for the applications listed:

(a) Type IX sheeting used for the following applications shall conform to the retroreflectivity and color requirements of ASTM D4956:

- Permanent signs, except those addressed in Sections 247.02(b)
- Construction signs (used during temporary construction, maintenance, permit, utility, and incident management activities)
- Object markers (including bridge end panel markers)
- Guardrail end terminals
- Permanent impact attenuators (except permanent sand barrels)
- Delineators - Standard ED-2, Standard ED-3, barrier, guardrail, and permanent flexible post
- Vertical panels - (Group 2 channelizing devices) and directional indicator barricades