Appendix A

VDOT – SPECIFICATIONS (*)

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* Consult the current or applicable VDOT Road and Bridge Specification Book and Special Provisions for the most current specifications.

SECTION 106—CONTROL OF MATERIAL

106.01 Source of Supply and Quality Requirements

The materials used throughout the work shall conform to the requirements of the contract. The Contractor shall regulate his supplies so that there will be a sufficient quantity of tested material on hand at all times to prevent any delay of work. Except as otherwise specified, materials, equipment, and components that are to be incorporated into the finished work shall be new. Within 30 days after notification of award of the contract, but not later than 7 days prior to the beginning of construction operations under the contract, the Contractor shall file a statement of the known origin, composition and manufacture of all materials to be used in the work, including optional or alternate items. Material requirements not previously reported shall be submitted at least 60 days prior to their use on the project, but not less than two weeks prior to delivery. The Contractor’s statement shall be electronically submitted by use of Form C-25 and shall be identified by the complete project number, and all items or component materials shall be identified by the specific contract item number and the specification reference shown in the contract.

At the option of the Engineer, materials may be approved at the source of supply. If it is found during the life of the contract that previously approved sources of supply do not supply materials or equipment conforming to the requirements of the contract, do not furnish the valid test data required to document the quality of the material or equipment, or do not furnish documentation
to validate quantities to document payment, the Contractor shall change the source of supply and furnish material or equipment from other approved sources. The Contractor shall notify the Department of this change, and provide the same identifying information noted in this section, at least 60 days prior to their use on the project, but less than two weeks prior to delivery.

SECTION 234—GLASS BEADS FOR REFLECTORIZING TRAFFIC MARKINGS

234.01—DESCRIPTION.

This specification covers glass beads for application on liquid traffic marking materials so as to produce a reflective surface.

234.02—DETAIL REQUIREMENTS.

Beads shall be manufactured from glass of a composition designed to be highly resistant to traffic wear and weather. Glass beads shall be spherical in shape and shall conform to AASHTO M247 Type 1, except that at least 80 percent of the beads shall be round when tested in accordance with the requirements of ASTM D 1155 Procedure B. Beads shall be essentially free of sharp angular particles, milkiness and surface scoring or scratching.

SECTION 235—RETROREFLECTORS

235.01—DESCRIPTION

Retro-reflectors shall consist of a housing/backing with a retro-reflective surface on the front and back, if applicable.

Retro-reflectors for delineators and pavement markers, except temporary markers, shall be molded of methyl methacrylate plastic conforming to Federal Specification L-P-380, Type I, Class 3.

Retro-reflectors for temporary pavement markers shall have a surface consisting of reflective sheeting or a plastic prismatic element. The housing/backing for temporary pavement markers shall be constructed of methyl methacrylate plastic conforming to the requirements of Federal Specification L-P-380, Type I, Class 3.

Retro-reflectors for delineators shall be the same color as the adjacent pavement marking. Retro-reflectors for pavement markers shall be the same color as the adjacent pavement marking except the backside shall be as follows:
(a) **One-Way Markers:** The backside shall be red for white raised and white snow plowable raised pavement markers. The backside shall be blank for recessed, temporary pavement markers and yellow raised and yellow snow plowable raised pavement markers.

(b) **Two-Way Markers:** The backside shall match the adjacent pavement marking, except on recessed markers which shall be blank.

### 235.02—Detail Requirements.

(a) **Steel castings for snow plowable pavement markers** shall conform to ASTM A536, hardened to 52-54 RC and shall weigh approximately 5½ pounds. Keels shall be parallel, approximately 0.70 inch thick by 1.90 inch in depth and shall have notched edges. The forward and rear noses of the casting shall be shaped to deflect snowplow blades. Castings shall retain their hardness after removal of adhesives and other foreign residues or shall be capable of conforming to the specified hardness with additional heat treating to ensure recyclability of the castings.

(b) **Plastic panels for delineators** shall be at least 0.080 inch thick, have a minimum tensile strength at yield of 5000 pounds per square inch when tested in accordance with ASTM D638, and have minimum impact strengths of 2.0 foot-pounds per inch of notch at -20°F and 14.0 foot-pounds per inch of notch at 73°F when tested in accordance with ASTM D256, Method A. The panels shall be flexible and able to recoil, to within 5° of vertical after impact. Panels shall not deteriorate when exposed to the following:

1. Ultraviolet rays  4. Petroleum products
2. Ozone  5. Deicing salts
3. Exhaust fumes  6. Herbicides

(c) **Aluminum panels for delineators** shall be at least 0.064 inch thick conforming to ASTM B-209, alloy 5052.

(d) **Delineators** shall have the retro-reflective surface and the housing/backing fused to form a homogenous unit sealed against dust, water and vapor. Retro-reflectors shall show no change in shape or color when subjected to four hours in a circulating air oven at 170° to 180°F. The adhesion system shall be as recommended by the manufacturer.

The specific intensity shall not be less than the values below:

<table>
<thead>
<tr>
<th>Entrance Angle</th>
<th>Observation Angle</th>
<th>Specific Intensity (cd/FC)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Clear</td>
</tr>
<tr>
<td>0°</td>
<td>0.1°</td>
<td>119</td>
</tr>
<tr>
<td>20°</td>
<td>0.1°</td>
<td>47</td>
</tr>
</tbody>
</table>
(e) **Raised, Recessed and Snow Plowable Raised Pavement Markers** shall have a retro-reflective surface area of no less than 1.4 square inches and the slope of the reflective surfaces shall be no less than 30° nor more than 33° when measured from the pavement surface. The reflective surface shall be protected with a bonded glass face or coated with a clear acrylic compound that utilizes an ultraviolet inhibitor.

The specific intensity shall not be less than the values below when tested in accordance with VTM-70:

<table>
<thead>
<tr>
<th>Entrance Angle (°)</th>
<th>Observation Angle (°)</th>
<th>Raised and Recessed Pavement Markers</th>
<th>Specific Intensity (cd/FC)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>White</td>
<td>Yellow</td>
</tr>
<tr>
<td>0°</td>
<td>0.2°</td>
<td>3.0</td>
<td>1.8</td>
</tr>
<tr>
<td>20°</td>
<td>0.2°</td>
<td>1.2</td>
<td>0.72</td>
</tr>
</tbody>
</table>

**Snow Plowable Raised Pavement Markers**

<table>
<thead>
<tr>
<th>Entrance Angle (°)</th>
<th>Observation Angle (°)</th>
<th>Specific Intensity (cd/FC)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>White</td>
</tr>
<tr>
<td>0°</td>
<td>0.2°</td>
<td>4.0</td>
</tr>
<tr>
<td>20°</td>
<td>0.2°</td>
<td>1.6</td>
</tr>
</tbody>
</table>

The crushing strength shall be not less than 4,000 pounds when tested in accordance with VTM-71.

Raised and recessed pavement markers shall be at least 4 inches and not more than 4.75 inches in width and not more than 0.55 inch in height.

Retro-reflectors for snow plowable raised pavement markers shall be installed in steel castings conforming to (a) herein and shall have a nominal width of 4 inches excluding the castings.

(f) **Temporary pavement marker** shall have a retro-reflective surface of no less than 1.0 square inch. The specific intensity shall not be less than the values below:

<table>
<thead>
<tr>
<th>Entrance Angle (°)</th>
<th>Observation Angle (°)</th>
<th>Specific Intensity (cd/FC)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>White</td>
</tr>
<tr>
<td>0°</td>
<td>0.2°</td>
<td>3.0</td>
</tr>
<tr>
<td>20°</td>
<td>0.2°</td>
<td>1.2</td>
</tr>
</tbody>
</table>
SECTION 246—PAVEMENT MARKING

246.01—DESCRIPTION.

These specifications cover material for use in the 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.

Materials shall withstand air and roadway temperature variations from 0 degrees F to 140 degrees F without deforming, bleeding, staining, or discoloring and shall maintain their original dimensions and placement without chipping, spalling, or cracking. Material shall not deteriorate because of contact with sodium chloride, calcium chloride, mild alkalies and acids, or other ice control materials; oil in the pavement material; or oil and gasoline drippings from vehicles.

(a) **White and Yellow Pavement Marking Material:** White pavement marking material shall be equal to Federal Standard Color No. 595-17886, and yellow pavement marking material shall be equal to Federal Standard Color No. 595-33538.

Color determination will be made for markings and the diffuse daytime color of the markings shall conform to the below CIE Chromaticity coordinate limits. Color determination for liquid marking materials will be made without drop on beads at least twenty-four (24) hours after application. Color determination for thermoplastic will be made in accordance with the requirements of AASHTO T 250.
### Cie Chromaticity Coordinate Limits (Initial without drop-on beads)

<table>
<thead>
<tr>
<th>Color</th>
<th>Color</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>Daytime Luminance Factor Y (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>X</td>
<td>Y</td>
<td>X</td>
<td>Y</td>
<td>X</td>
</tr>
<tr>
<td><strong>White</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Types A; B - Classes I, II &amp; III; &amp; F)</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>
</tr>
<tr>
<td><strong>Yellow</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Types A; B – Classes II &amp; III; &amp; F – except thermoplastic)</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>
</tr>
<tr>
<td><strong>Yellow</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Types B – Class I; &amp; F - if thermoplastic)</td>
<td>0.499</td>
<td>0.466</td>
<td>0.545</td>
<td>0.455</td>
<td>0.518</td>
<td>0.432</td>
</tr>
</tbody>
</table>

Color readings will be determined in accordance with the requirements of ASTM E1349 using CIE 1931 2 degrees standard observer and CIE standard Illuminant D65.

Retained daytime color of markings shall conform to the following CIE Chromaticity coordinate limits when measured on a beaded marking after a period of ninety days for construction pavement markings and one year for all other markings:

### Cie Chromaticity Coordinate Limits (Retained)

<table>
<thead>
<tr>
<th>Color</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>X</td>
<td>Y</td>
<td>X</td>
<td>Y</td>
</tr>
<tr>
<td><strong>White</strong></td>
<td>0.355</td>
<td>0.355</td>
<td>0.305</td>
<td>0.305</td>
</tr>
<tr>
<td><strong>Yellow</strong></td>
<td>0.560</td>
<td>0.440</td>
<td>0.490</td>
<td>0.510</td>
</tr>
</tbody>
</table>

Retained color readings will be determined using a 0 degrees /45 degrees Hunter Labminiscan Spectro-Colorimeter or equal in accordance with the requirements of ASTM E 1349 using CIE 1931 2 degrees standard observer and CIE standard Illuminant D65.

Initial nighttime color of yellow thermoplastic and yellow epoxy pavement marking material shall conform to the following CIE chromaticity coordinate requirements when tested in accordance with VTM 111.
CIE CHROMATICITY COORDINATE LIMITS
(INITIAL WITH DROP-ON BEADS)

<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>

The marking material 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 amount and type of yellow pigment and inert filler for yellow material shall be at the option of the manufacturer provided the material complies with all other requirements of this specification.

(b) **Paint Pavement Marking Material (Type A):** Paint material shall be a fast drying water based, nonlead, acrylic resin paint suitable for use on both asphalt and hydraulic cement concrete surfaces. Paint shall be selected from the Department’s approved list. Paint products will be included on the approved list after the Department determines conformance to the specifications on both asphalt and hydraulic cement concrete roadways.

Determination of conformance will include, but will not be limited to, the evaluation of test data from AASHTO’s National Transportation Product Evaluation Program (NTPEP) or other Department approved facilities.

1. **Hiding Power:** Paint shall show a dry hiding quality that will give a contrast ratio of at least 0.96 at 0.38 mm (15 mil) wet film thickness.

2. **Settling Properties:** Settling shall be no less than a rating of 8 when tested in accordance with ASTM D869.

3. **Freeze-Thaw and Heat Stability:** Paint shall show no coagulation or change in viscosity greater than +/- 5 KU.

4. **Water Resistance:** Paint shall show no blistering, peeling or wrinkling, softening or loss of adhesion.

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

6. **Flash Point:** Paint shall have a flash point of at least 140 degrees F when tested in accordance with ASTM D93, Pensky-Martens Closed Cup.

7. **No-Track Time:** Paint shall have a 60-second maximum vehicle no-track time when measured in accordance with the NTPEP Field Test Procedures.
8. **Maintained Retroreflectivity and Durability:** Maintained retroreflectivity and durability shall conform to the following requirements after being installed on the test deck for 1 year:

   a. **Maintained Retroreflectivity:** Photometric quantity to be measured is coefficient of retroreflected luminance ($R_L$) in accordance with the requirements of ASTM E1743 for 15 meter geometry and ASTM E1710 for 30 meter geometry. $R_L$ shall be expressed in millicandela per square foot per foot-candle and shall be at least either 150 for 15 meter or 100 for 30 meter when measured in the skipline or centerline areas.

   b. **Durability:** Paint shall have a durability rating of at least 4 when determined in the wheel path area.

(c) **Thermoplastic Pavement Marking Material (Type B, Class I):** Thermoplastic material shall be suitable for use on asphalt concrete surfaces and yellow thermoplastic shall be selected from the Department’s approved list. Yellow thermoplastic products will be included on the approved list after the Department determines conformance to the specifications. Thermoplastic material shall have the pigment, beads, and filler well dispersed in the resin and shall be free from skins, dirt, and foreign objects.

1. **Composition:**

<table>
<thead>
<tr>
<th>Component</th>
<th>White (Percent by Weight)</th>
<th>Yellow (Percent by Weight)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Binder</td>
<td>18.0 min</td>
<td>18.0 min</td>
</tr>
<tr>
<td>Glass Beads</td>
<td>25.0 min</td>
<td>25.0 min</td>
</tr>
<tr>
<td>Titanium Dioxide</td>
<td>8.0 min</td>
<td>---------------</td>
</tr>
<tr>
<td>Calcium Carbonate &amp; Inert Fillers</td>
<td>49.0 max</td>
<td>---------------</td>
</tr>
</tbody>
</table>

The binder shall be either alkyd or hydrocarbon. 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 $\frac{1}{2}$ 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.

2. **Physical requirements:**

   a. **Water absorption:** Materials shall not have more than 0.5 percent retained water by weight when tested in accordance with the requirements of ASTM D570, Procedure A.

   b. **Softening point:** Materials shall have a softening point of at least 194 degrees F as determined in accordance with the requirements of ASTM E28.
c. **Specific gravity:** The specific gravity of the thermoplastic compound at 77 degrees F shall be from 1.7 to 2.2.

d. **Impact resistance:** Impact resistance shall be at least 10 inch-pounds at 77 degrees F after 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 the requirements of ASTM D256, using the 25 inch-pound scale.

e. **Drying time:** Material shall set to bear traffic in not more than 2 minutes when the road temperature is 50 degrees F or above.

f. **Durability and wear resistance:** Material shall be designed to provide a life expectancy of at least 3 years under an average daily traffic count per lane of approximately 9,000 vehicles.

g. **Glass beads:** Glass beads shall conform to the requirements of Section 234.

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

(d) **Polyester-Resin Pavement Marking Material (Type B, Class II):** Polyester-resin is a two-component pavement marking material suitable for use on hydraulic cement concrete surfaces.

1. **Composition (uncatalyzed material):**

<table>
<thead>
<tr>
<th></th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pigment</td>
<td>36.0</td>
<td>40.0</td>
</tr>
<tr>
<td>Acrylic monomer</td>
<td>8.5</td>
<td>-----</td>
</tr>
<tr>
<td>Polyester resin</td>
<td>-----</td>
<td>55.5</td>
</tr>
</tbody>
</table>

2. **Physical requirements (uncatalyzed material):**

   a. **Viscosity:** Viscosity (25 degrees C), ASTM D562, shall be 80 to 90 Kreb units.

   b. **Weight per gallon:** Weight per gallon shall be at least 11.5 pounds.

   c. **Drying time:** The catalyst/resin ratio shall be adjusted by the operator so that the applied line shall dry to a no-tracking condition in 15 minutes or less when applied at an application temperature of 77 degrees F to 100 degrees F, a substrate temperature of at least 60 degrees F, a wet thickness of 15 to 25 mils, and with 10 to 15 pounds of glass beads, conforming to the requirements of Section 234, applied per gallon. No-track time shall be determined by passing over the line with
a passenger car or pickup truck at a speed of 25 to 35 mph in a simulated passing maneuver. A line showing no visual deposition of the material to the pavement surface when viewed from a distance of 50 feet shall be considered as showing “no-track” and conforming for time to “no-track”.

d. **Catalyst:** The catalytic component of the system shall be a commercially available type recommended by the manufacturer of the polyester. The peroxide shall not be exposed to any form of heat, such as direct sunlight, radiators, open flame, or sparks. Heat may cause the organic peroxide to decompose violently or burn if ignited. The peroxide shall not come into contact with easily oxidized metals, such as copper, brass, or mild steel or galvanized steel as this can also initiate a violent reaction.

e. **Weight loss:** Beaded catalyzed material shall not have a weight loss of more than 125 milligrams after 1,000 revolutions when abraded according to Federal Test Method Standard No. 141b, Method 6192, using CS-17 wheels with a 1,000-gram load on each wheel.

f. **Shelf life:** The shelf life of uncatalyzed material shall be at least 6 months when stored in a cool area below 85 degrees F.

g. **Durability and wear resistance:** Material shall be designed to provide a life expectancy of at least 3 years under an average daily traffic count per lane of approximately 9,000 vehicles.

h. **Hiding:** The marking shall show a dry hiding quality that will give a contrast ratio of at least 0.96 with the Morest Black and White Power Chart, Form 03B when drawn down at a fifteen (15) mil wet film thickness. Readings will be determined in accordance with the requirements of ASTM E 1349 using CIE 1931 2 degrees standard observer and CIE standard Illuminant D65.

(e) **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 surfaces. Pigment, beads, and filler shall be well dispersed in the resin. Material shall be free from skins, dirt, and foreign objects and shall conform to the following:

1. **Composition**

<table>
<thead>
<tr>
<th>Component</th>
<th>ASTM</th>
<th>White</th>
<th>Yellow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Epoxy resins</td>
<td>D1652</td>
<td>Max. 82%</td>
<td>Max. 77%</td>
</tr>
<tr>
<td>Titanium dioxide</td>
<td>D476 Type IV</td>
<td>Min. 18%</td>
<td>------</td>
</tr>
<tr>
<td>Pigments</td>
<td>------</td>
<td>-------</td>
<td>Min. 23%</td>
</tr>
</tbody>
</table>

2. **Physical requirements:**
a. **Hardness**: Hardness, Shore D, ASTM D2240, shall be 75 to 100.

b. **Tensile strength**: Tensile strength, ASTM D638, shall be at least 6,000 pounds per square inch after the material has cured for 72 hours at 73±4 degrees F.

c. **Compression strength**: Compression strength, ASTM D695, shall be at least 12,000 pounds per square inch after the material has cured for 72 hours at 73±4 degrees F.

d. **Adhesion to concrete**: Adhesion, 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.

e. **Drying time**: Material shall dry to a “no-track” condition in 15 minutes or less at pavement temperatures from 50 degrees F to 120 degrees F and under all humidity conditions, providing the pavement is dry. No-track time shall be determined by passing over the line with a passenger car or pickup truck at a speed of 25 to 35 mph in a simulated passing maneuver. A line showing no visual deposition of the material to the pavement surface when viewed from a distance of 50 feet shall be considered as showing “no-track” and conforming for time to “no-track”.

f. **Weight per epoxy equivalent**: 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 the requirements of ASTM D1652.

g. **Total amine value**: Total amine value of Part B of the epoxy pavement marking material shall be within ±50 of the target value provided by the manufacturer when tested in accordance with the requirements of ASTM D2074.

h. **Durability and wear resistance**: Material shall be designed to provide a life expectancy of at least 3 years under an average daily traffic count per lane of approximately 9,000 vehicles.

i. **Abrasion resistance**: Wear index shall be no greater than 80 when abrasion resistance is tested in accordance with the requirements of ASTM D4060.

j. **Hiding**: The marking shall show a dry hiding quality that will give a contrast ratio of at least 0.96 with the Morest Black and White Power Chart, Form 03B when drawn down at a fifteen (15) mil wet film thickness. Readings will be determined in accordance with the requirements of ASTM E 1349 using CIE 1931 2 degrees standard observer and CIE standard Illuminant D65.
(f) **Plastic-Backed Preformed Tape Pavement Marking Material (Type B, Class IV):** Plastic-backed preformed tape shall conform to the requirements of ASTM D4505 for a Type I or VI, Grade B, C, D or E material and any additions and/or exceptions indicated herein. Tape shall be suitable for use on both asphalt and hydraulic cement concrete surfaces and shall be capable of being applied to previously applied marking material of the same composition under normal conditions of use. Tape shall be selected from the Department’s approved list. Tape products will be included on the approved list after the Department determines conformance to the specifications on both asphalt and hydraulic cement concrete roadways. Determination of conformance will include, but will not be limited to, the evaluation of test data from AASHTO’s National Transportation Product Evaluation Program (NTPEP) or other Department approved facilities.

1. **Thickness (No Adhesive):** Thickness shall be at least 60 mils and no more than 90 mils.

2. **Skid Resistance:** Skid resistance requirements for a Type I material shall be the same as required for a Type VI material.

3. **Initial Retroreflectivity:** Initial retroreflectivity requirements for a Type VI material shall be the same as required for a Type I material.

4. **Maintained Retroreflectivity, Durability and Adhesion:** Maintained retroreflectivity, durability and adhesion shall conform to the following requirements after being installed on the test deck for 1 year:
   
   a. **Maintained Retroreflectivity:** Photometric quantity to be measured is coefficient of retroreflected luminance ($R_L$) in accordance with the requirements of ASTM E 1743 for 15 meter geometry and ASTM E1710 for 30 meter geometry. $R_L$ shall be expressed in millicandelas per square foot per foot-candle and shall be at least either 150 for 15 meter or 100 for 30 meter when measured in the skipline or centerline areas.

   b. **Durability:** Tape shall have a durability rating of at least 4 when determined in the wheel path area.

   c. **Adhesion:** No line shall have walked nor shall it be torn or missing.

(g) **Construction Pavement Marking Materials:** Construction pavement markings shall consist of removable tape, non-retroreflective black removable tape and temporary pavement marking material. Construction pavement marking materials shall be selected from the Department’s approved list. Products will be included on the approved list after the Department determines conformance to the specifications on both asphalt and
hydraulic cement concrete roadways and the manufacturer has supplied information to the Department indicating conformance to the below warranty requirements for the tape products except Type E material will only be evaluated for asphalt concrete roadways. Determination of conformance will include, but will not be limited to, the evaluation of test data from AASHTO's National Transportation Product Evaluation Program (NTPEP) or other Department approved facilities.

1. Removable Tape (Type D, Class I and II): Removable tape shall be suitable for use on both asphalt and hydraulic cement concrete surfaces and shall conform to the following requirements:

   a. **Initial Skid Resistance:** Initial skid resistance value shall be at least 45 BPN.

   b. **Warranty:** The manufacturer shall provide a full manufacturer’s warranty on their product that shall cover the retroreflectivity, removability and adhesiveness. The warranty period shall be no less than 90 days, beginning on the date of installation and shall include all material and labor costs when installed in accordance with the manufacturer’s recommendations.

   c. **Maintained Retroreflectivity, Removability and Adhesion:** Maintained retroreflectivity, removability and adhesion shall conform to the following requirements after being installed on the test deck for 90 days:

      (1) **Maintained Retroreflectivity:** Photometric quantity to be measured is coefficient of retroreflected luminance \( R_l \) in accordance with the requirements of ASTM E 1743 for 15 meter geometry and ASTM E1710 for 30 meter geometry. \( R_l \) shall be expressed in millicandelas per square foot per foot-candle and shall be at least the following values for either 15 meter or 30 meter when measured in the wheel path area.

      | Color | Type D, Class I (15 meter) | Type D, Class I (30 meter) | Type D, Class II (15 meter) | Type D, Class II (30 meter) |
      |-------|---------------------------|---------------------------|---------------------------|---------------------------|
      | White | 150                       | 100                       | 500                       | 335                       |
      | Yellow| 100                       | 65                        | 335                       | 225                       |

      (2) **Removability:** Removability value shall be at least 8 for materials submitted to NTPEP prior to the year 1998. For materials submitted to NTPEP in the year 1998 and later, the internal tape strength value shall be no greater than 3, and the adhesive bond value shall be no greater than 7. Values shall be the average of the three monthly readings for the transverse line.

      (3) **Adhesion:** No line shall have walked nor shall it be torn or missing.
2. **Non-retroreflective Black Removable Tape (Type E):** Non-retroreflective black removable tape shall be suitable for use on asphalt concrete surfaces and shall conform to the following:

   a. **Initial Skid Resistance:** Initial skid resistance value shall be at least 45 BPN.

   b. **Warranty:** The manufacturer shall provide a full manufacturer’s warranty on their product that shall cover the removability and adhesiveness. The warranty period shall be no less than 90 days, beginning on the date of installation and shall include all material and labor costs when installed in accordance with the manufacturer’s recommendations.

   c. **Removability and Adhesion:** Removability and adhesion shall conform to the following requirements after being installed on the test deck for 90 days:

      (1) **Removability:** Removability value shall be at least 8 for materials submitted to NTPEP prior to the year 1998. For materials submitted to NTPEP in the year 1998 and later, the internal tape strength value shall be no greater than 3, and the adhesive bond value shall be no greater than 7. Values shall be the average of the three monthly readings for the transverse line.

      (2) **Adhesion:** No line shall have walked nor shall it be torn or missing.

3. **Temporary Pavement Marking Material (Type F, Class I and II):** Temporary pavement marking material shall be suitable for use on asphalt and hydraulic cement concrete surfaces and shall conform to the following:

   a. **Paint Products**

      (1) **Settling Properties:** Settling rating shall be at least 8 when tested in accordance with ASTM D869.

      (2) **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 test procedure.

      (3) **Water Resistance:** Paint shall show no blistering, peeling, wrinkling, softening or loss of adhesion when tested in accordance with the NTPEP test procedure.

      (4) **VOC:** The Volatile Organic Compound content shall be no greater than 150 grams/liter when tested in accordance with EPA Method 24.

   b. **Tape Products**

      (1) **Initial Skid Resistance:** Initial skid resistance value shall be at least 45 BPN.
(2) **Warranty:** The manufacturer shall provide a full manufacturer’s warranty on their product that shall cover the retroreflectivity, removability and adhesiveness. The warranty period shall be no less than 90 days, beginning on the date of installation and shall include all material and labor costs when installed in accordance with the manufacturer’s recommendations.

(3) **Adhesion:** No line shall have walked nor shall it be torn or missing after being installed on the test deck for 90 days.

c. **All Products (including paint and tape products)**

(1) **Thickness:** Thickness shall be no greater than 40 mils.

(2) **Maintained Retroreflectivity and Durability:** Maintained retroreflectivity and durability shall conform to the following requirements after being installed on the test deck for 90 days:

a) **Maintained Retroreflectivity:** Photometric quantity to be measured is coefficient of retroreflected luminance ($R_L$) in accordance with the requirements of ASTM E1743 for 15 meter geometry and ASTM E1710 for 30 meter geometry. $R_L$ shall be expressed in millicandelas per square foot per foot-candle and shall be at least the following values for either 15 meter or 30 meter when measured in the wheel path area.

<table>
<thead>
<tr>
<th>Color</th>
<th>Type F</th>
<th>Type F</th>
<th>Type F</th>
<th>Type F</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Class I</td>
<td>Class I</td>
<td>Class II</td>
<td>Class II</td>
</tr>
<tr>
<td></td>
<td>(15 meter)</td>
<td>(30 meter)</td>
<td>(15 meter)</td>
<td>(30 meter)</td>
</tr>
<tr>
<td>White</td>
<td>150</td>
<td>100</td>
<td>290</td>
<td>190</td>
</tr>
<tr>
<td>Yellow</td>
<td>100</td>
<td>65</td>
<td>190</td>
<td>125</td>
</tr>
</tbody>
</table>

b) **Durability:** Marking material shall have a durability rating of at least 4 when determined in the wheel path area.
SECTION 512—MAINTAINING TRAFFIC

512.01—DESCRIPTION.

This work shall consist of maintaining and protecting traffic through areas of construction, maintaining public and private entrances and mailbox turnouts, constructing and obliterating detours, and protecting the traveling public within the limits of the project and over detours that are not a part of the state highway system in accordance with the contract documents.

512.02—MATERIALS.

(a) **Materials** salvaged from the roadway shall be used in the maintenance of traffic insofar as possible. Material shall conform to the requirements of the applicable specifications.

(b) **Signalization, barricades, channelizing devices, safety devices, and pavement markings** shall conform to the requirements of Division VII Traffic Control Devices of these specifications and the *Virginia Work Area Protection Manual* except where otherwise indicated. Retroreflective surfaces shall conform to the requirements of Sections 235, 247 and 702 as applicable.

(c) **Temporary pavement markers** shall conform to the requirements of Section 235.

(d) **Construction pavement markings** shall conform to the requirements of Section 246.

512.03 Procedures

(i) **Construction Pavement Markings:** Construction pavement markings shall be installed at locations shown on the plans and in the *Virginia Work Area Protection Manual*, and at other locations as directed by the Engineer. Construction pavement markings shall be selected from the Department’s approved list of Construction Pavement Marking Materials. Construction pavement markings are classified as Types D, Classes I and II (removable tape), E (non-reflective black removable tape) and F, Classes I and II (temporary markings). Construction pavement markings shall be used as follows:

1. **Type D construction pavement markings** shall be used on final roadway surfaces or in areas where traffic patterns are subject to change before pavement is resurfaced unless the surface temperature of the pavement is below the pavement marking manufacturer’s recommended minimum application temperature. When the surface temperature of the pavement is below the manufacturer’s minimum application temperature, a Type F construction pavement marking on the approved list under the same class as the specified Type D construction pavement marking may be used except on final surfaces. The Contractor shall select a Type F product known to perform the best under those temperature conditions. When a Type F construction pavement marking is utilized in lieu of a Type D due to the surface temperature being below the manufacturer’s
minimum application temperature, the Contractor will be paid the price bid for Type D, which will include the Type F markings and any necessary eradication of existing pavement markings.

2. Type E construction pavement markings shall be used to cover existing markings in accordance with Section 512.03(j).

3. Type F construction pavement markings shall be used where the roadway is to be resurfaced prior to changes in the traffic pattern or where pavement is to be demolished and traffic patterns will not change before demolition.

Construction pavement markings shall be installed in accordance with the manufacturer’s recommendations. Application thickness and bead application shall be in accordance with the manufacturer’s recommendations except as follows. In the event the manufacturer’s recommendation for material thickness and quantity of beads is less than utilized when the material was tested by the National Transportation Product Evaluation Program (NTPEP), the minimum values used during product installation shall conform to the NTPEP test values which are indicated on the approved list for the specific marking. The Contractor shall furnish a copy of the manufacturer’s installation recommendations including the thickness, bead embedment and dispersement to the Engineer.

The Contractor shall maintain the construction pavement markings and shall correct any deficient markings by reapplying markings. Deficient construction pavement markings are considered to be any markings that do not provide adequate guidance to motorists due to inadequate retroreflectivity or color qualities, or due to problems with adherence to the pavement. The Engineer will make a visual nighttime inspection of all construction pavement markings to identify areas of markings that have inadequate retroreflectivity qualities.

Those markings that have inadequate retroreflectivity qualities as determined by the Engineer shall be replaced by the Contractor with the following exceptions:

a. Reapplication of skip line construction pavement markings is not required unless the inadequate retroreflectivity qualities are for at least two consecutive skip lines.

b. Reapplication of center, lane (except skip lines) or edge line construction pavement markings is not required unless the inadequate retroreflectivity qualities are for at least a continuous section of 70 feet.

c. Reapplication of transverse markings is not required unless the inadequate retroreflectivity qualities are for at least a continuous section exceeding 3 feet.
In lieu of replacement of construction pavement markings based on visual observations by the Engineer, the Contractor may have retroreflectivity readings made. These measurements shall be taken within 48 hours after the Contractor has been notified of the deficient markings except additional time will be granted due to inclement weather that prevents the adequate measurement of the markings. The Contractor shall brush any form of debris from the line before performing the measurements. Measurements shall be taken in the presence of the Engineer using Contractor furnished equipment conforming to the requirements of ASTM E1710. The Contractor shall operate the equipment in accordance with the manufacturer’s instructions and a copy of such instructions shall be provided to the Engineer. The photometric quantity to be measured is coefficient of retroreflected luminance ($R_l$) which shall be expressed as millicandela per square foot per foot-candle.

Measurements shall be accomplished at three random locations within each area of markings that have inadequate retroreflectivity qualities. When the length of the visually inadequate area is greater than one mile, measurements shall be accomplished at three locations per mile segment or portion thereof. Measurements for all lines shall be accomplished in the middle of the line horizontally. Measurements for skip lines shall be accomplished in the middle of its length. Measurements for transverse lines shall be taken outside of the wheel path locations. The Engineer will designate the locations along the line segments that the measurements shall be taken. The Contractor shall make a log of the measurements along with their locations and provide a copy to the Engineer. When the average of the three readings for an area is below 100 millicandela per square foot per foot-candle, the Contractor shall reapply the markings as indicated above.

Construction pavement markings that have become unadhered to the pavement shall be reapplied by the Contractor with the following exceptions:

1. Reapplication of skip line construction pavement markings is not required unless the unadherence is for at least two consecutive skip lines.
2. Reapplication of center, lane (except skip lines) or edge line construction pavement markings is not required unless the unadherence is for at least a continuous section of 70 feet.
3. Reapplication of transverse markings is not required unless unadherence is for at least a continuous section exceeding 3 feet.

However, all construction pavement markings that have become unadhered to the roadway that may cause guidance problems for the motorists shall be removed by the Contractor.

Removable construction pavement markings shall also be replaced on tined concrete and high hit asphalt locations on time frames as recommended by the manufacturer of the marking to prevent the need for eradication. The Contractor shall furnish a copy of the manufacturer’s recommendations to the Engineer.
Those construction pavement markings found in need of reapplication in accordance with the above requirements shall be reapplied by the Contractor at no additional cost to the Department with the following exceptions:

a) Markings that have been under traffic for more than 90 days will be paid for at the contract unit price when needing reapplication unless the manufacturer’s warranty coverage is still in effect.

b) Markings damaged by the Department’s snow removal or other maintenance and construction operations will be paid for at the contract unit price.

Construction pavement markings shall be replaced in accordance with the time requirements of Section 704.

Eradication for reapplication of Type F construction pavement markings is not required if allowed by the marking manufacturer provided the existing marking is well adhered and the total thickness of both the existing and reapplied marking combined will not exceed 40 mils. If not well adhered, 90 percent of the existing markings shall be removed prior to reinstallation of the markings. Temporary pavement markers shall be installed with construction pavement markings in accordance with (k) herein.

(j) **Eradicating Pavement Markings:** Markings that may conflict with desired traffic movement, as determined by the Engineer, shall be eradicated as soon as is practicable: either immediately prior to the shifting of traffic or immediately thereafter and prior to the conclusion of the workday during which the shift is made.

Eradication shall be performed by grinding, blasting, or a combination thereof. Grinding shall be limited to removal of material above the pavement surface except when removing thermoplastic and preformed tape markings, which may be removed by grinding alone. Blasting shall be used on both asphalt concrete and hydraulic cement concrete pavements to remove all other types of markings. Other methods may be submitted for approval by the Engineer. The Contractor shall ensure that the least amount of damage as possible occurs to the roadway surface when accomplishing the eradication.

When eradicating pavement markings, the Contractor shall ensure workers are protected in conformance to the requirements of *Occupational Safety and Health Administration’s (OSHA)* standards as detailed in 29 CFR 1910 or 1926, whichever is the most stringent at the time. The Contractor shall collect the eradication residue during or immediately after the eradication operation, except dust shall be collected during the entire operation. Eradication residue from the removal of any pavement markings is considered to be a non-hazardous waste material and shall be disposed of in a properly permitted waste disposal facility in accordance with state and federal laws and regulations. Testing of the eradication residue for the eight RCRA metals will not be required.
When markings are removed for lane shifts/transitions, 100 percent of the marking shall be removed.

Non-reflective removable black construction pavement marking may be used to cover existing markings in lieu of eradication methods on asphalt concrete surfaces when its use will not be required for more than 120 days and when specified as a pay item. The Contractor shall use this material to cover markings as indicated in the plans or as directed by the Engineer. Non-reflective removable black construction pavement marking shall be applied in accordance with the manufacturer’s recommendations.

(k) **Temporary pavement markers** shall be installed with construction pavement markings, except non-reflective removable markings, in transition (lane drop) or lane shift areas of work zones which will encroach upon the traveled roadway for a period of more than three days and in other areas as required by the Engineer.

Temporary pavement markers shall be installed on twenty-foot centers in lane shift and transition areas. When temporary pavement markers are required in other areas, they shall be installed on forty-foot centers unless otherwise required by the Engineer. Temporary pavement markers shall be located between and in alignment with broken lines and beside solid line pavement markings. Where double line pavement markings separating traffic are installed, two-way markers shall be installed beside each line. The Contractor may install two one-way markers in lieu of each two-way marker at no additional cost to the Department.

Temporary pavement markers shall be installed with a hot applied bitumen adhesive except epoxy may be used on hydraulic cement concrete roadways and non-final surfaces of asphalt concrete roadways. Damage created in the pavement by removal of markers shall be repaired in kind by the Contractor at no additional cost to the Department.

Temporary pavement markers found in need of replacement shall be replaced by the Contractor at no additional cost to the Department except those markers damaged by the Department’s snow removal operations or other maintenance and construction operations will be paid for at the contract unit price.

(n) **Construction Pavement Message Markings:** Markings shall be installed at locations designated on the plans and as determined by the Engineer and shall consist of messages in accordance with the requirements of Section 704. Construction pavement message marking material including maintenance of the markings shall be in accordance with the requirements for construction pavement markings.

Retroreflective measurements shall be taken out of the wheel path locations and each separate entity of a pavement message marking shall be replaced when the average of the three readings for that entity is below 100 millicandelas per square foot per footcandle.
Replacement and correction of ineffective work zone traffic control devices shall be accomplished in accordance with the American Traffic Safety Service Association’s (ATSSA) Quality Standards For Work Zone Traffic Control Devices publication with the following additions and exceptions:

1. Requirements herein for replacement and correction of construction pavement markings shall be used in lieu of the requirements contained in the section entitled Evaluation Guide Pavement Tape & Raised Pavement Markers.

SECTION 704—PAVEMENT MARKINGS AND MARKERS

704.01—Description.

This work shall consist of establishing the location of pavement markings and installing pavement markings, pavement markers, and reflectorized material on specified pavements in accordance with these specifications, the MUTCD and as directed by the Engineer.

704.02—Materials.

The Contractor shall use an approved inventory tracking system for all materials received from the manufacturer. Shipment of materials from such inventory shall be accompanied by the following certification:

Material shipped under this certification has been tested and approved by VDOT as indicated by laboratory test numbers listed hereon.

__________________________________________

Signature and Title

__________________________________________

Date

(a) Pavement markings shall conform to the requirements of Section 246.

(b) Glass beads shall conform to the requirements of Section 234.

(c) Pavement markers shall conform to the requirements of Section 235.
704.03—Procedures.

The Contractor shall have a certified Pavement Marking Technician present during pavement marking operations.

Pavement markings shall be installed on new roadways prior to opening the roadway to traffic. Pavement marking installation shall be completed within the time limits herein on roadways where the pavement markings have been removed or obscured and the roadway is open to traffic unless otherwise directed by the Engineer. Installation of Type B, Class VI pavement markings on asphalt roadways are not applicable to these requirements if they are inlaid with the last pass of the asphalt roller or directly after the asphalt roller utilizing a separate roller.

Installation of edge lines on roadways where the existing pavement markings have been removed or obscured are also required within these time limits unless otherwise indicated by the Engineer. Exceptions to the below time limits will be granted only for weather restrictions, and installation of epoxy resin pavement markings on new pavement shall not commence until after 24 hours of final surface placement.

Pavement marking installation on roads having traffic volumes of 10,000 ADT or more shall be completed within 24 hours after the end of the workday where the pavement markings were removed or obscured.

Pavement marking installation on roads having traffic volumes between 3,000 and 10,000 ADT shall be completed within 48 hours after the end of the workday where the pavement markings were removed or obscured.

Pavement marking installation on roads having traffic volumes of less than 3,000 ADT shall be completed within 72 hours after the end of the workday where the pavement markings were removed or obscured.

If the Contractor will not have pavement markings installed within the time limits set above, the Contractor shall install Type D construction pavement markings within the same time limits and maintain such until the final pavement markings can be installed. The cost of installing, maintaining and removing the Type D construction pavement markings shall be borne by the Contractor with no cost to the Department.

When establishing the location of pavement markings, the Contractor may mark the locations on the roadway by installing premarkings. Premarkings shall be accomplished using Type D (removable – any class) tape, chalk, or lumber crayons except special pavement markings such as stop lines, crosswalks, messages, hatching, etc. shall be accomplished using chalk or lumber crayons. All premarkings shall be of the same general color as the pavement markings being premarked. When tape is used as premarking, premarking shall consist of 4-inch x 4-inch maximum squares or 4-inch maximum diameter circles spaced at 100-foot minimum intervals in tangent sections and 50-foot minimum intervals in curved sections. At locations where the pavement marking will switch colors,
e.g. gore marking, the ends of the markings may be premarked regardless of the spacing. When chalk or lumber crayon are used as premarking, the entire length of the pavement marking may be premarked. All premarkings shall be installed whereby its installation shall not affect the adhesion of the pavement markings. When Type D tape is used as the premarking and the lateral location of such premarkings to the final pavement markings exceeds 6 inches, the premarkings shall be removed at no cost to the Department.

704.03

(a) **Pavement Markings:** Pavement markings shall be white or yellow markings as required by the *MUTCD* for the specific location or as specified by the Engineer and shall be installed in accordance with Table VII-1 unless otherwise recommended by the manufacturer and approved by the Engineer. The Contractor shall furnish a copy of the manufacturer’s installation recommendations to the Engineer.

The Contractor shall perform quality control testing for application thickness and glass bead rate in accordance with VTM-94 at the beginning of each workday and every 3 hours thereafter. The Contractor shall be responsible for providing the apparatus indicated in VTM-94 that are needed to perform the quality control testing. Testing shall be performed in the presence of the Engineer.

The Contractor shall maintain a daily log (Form C-85) for both temporary and permanent pavement markings and markers. Entries in the log shall be made in ink, shall be legible, and the log shall be signed by the Contractor and delivered to the Engineer or designee by the end of each workday.

Pavement line markings shall consist of stop lines, crosswalks, and solid or skip lines used for, but not limited to, dividing lanes, marking edges, channelizing, outlining and marking safety zones around objects, and forming islands and parking lot stalls.
# TABLE VII-1

## PAVEMENT MARKINGS

<table>
<thead>
<tr>
<th>Type</th>
<th>Class</th>
<th>Name</th>
<th>Surface Temp. at Time of Application</th>
<th>Film Thickness (mils)</th>
<th>Pavement Surface</th>
<th>Application Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>-</td>
<td>Traffic Paint</td>
<td>50 °F+</td>
<td>15 ± 1 when wet</td>
<td>AC HCC</td>
<td>May be applied directly after paving operations</td>
</tr>
<tr>
<td></td>
<td>A</td>
<td>Thermoplastic Alkyd</td>
<td>50 °F+</td>
<td>90 ± 5 when set</td>
<td>AC HCC</td>
<td>May be applied directly after paving operations</td>
</tr>
<tr>
<td></td>
<td>A</td>
<td>Thermoplastic Hydrocarbon</td>
<td>50 °F+</td>
<td>90 ± 5 when set</td>
<td>AC HCC</td>
<td>Do not apply less than 30 days after paving operations</td>
</tr>
<tr>
<td>B</td>
<td>I</td>
<td>Polyester resin</td>
<td>50 °F+</td>
<td>15 ± 1 when wet</td>
<td>HCC</td>
<td>Needs to be coned</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>Epoxy resin</td>
<td>50 °F+</td>
<td>20 ± 1 when wet</td>
<td>AC HCC</td>
<td>Manufacturer’s Recommendations</td>
</tr>
<tr>
<td></td>
<td>IV</td>
<td>Plastic-backed preformed tape</td>
<td>Manufacturer’s Recommendation</td>
<td>60 - 90</td>
<td>AC HCC</td>
<td>Manufacturer’s Recommendations</td>
</tr>
<tr>
<td></td>
<td>VI</td>
<td>Patterned preformed tape</td>
<td>Manufacturer’s Recommendation</td>
<td>20 * 65**</td>
<td>AC HCC</td>
<td>Manufacturer’s Recommendations</td>
</tr>
<tr>
<td></td>
<td>D</td>
<td>I &amp; II Removable tape</td>
<td>Manufacturer’s*** Recommendation</td>
<td>AC</td>
<td>Construction zone pavement marking</td>
<td></td>
</tr>
<tr>
<td></td>
<td>E</td>
<td>Removable black tape (non-reflective)</td>
<td>Manufacturer’s *** Recommendation</td>
<td>AC</td>
<td>Construction zone pavement marking for covering existing markings</td>
<td></td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>I &amp; II Temporary markings</td>
<td>Manufacturer’s *** Recommendation (Film Thickness = 40 mils max)</td>
<td>AC</td>
<td>Construction zone Pavement marking</td>
<td></td>
</tr>
</tbody>
</table>

* Thinnest portion of the tapes cross-section. This is the minimum required thickness.

** Thickest portion of the tapes cross-section. This is the minimum required thickness.

*** In the event the manufacturer’s recommendation for film thickness is less than utilized when the material was tested by the National Transportation Product Evaluation Program (NTPEP) or other Department approved test facility, the minimum values used during installation shall conform to the test values which are indicated on the approved list for the specific marking.

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Section 704.03

Crosswalks and stop lines shall be installed using Type B, Class I or IV markings.

Solid lines or skip lines shall be installed using Type A or Type B markings as specified.

Pavement message markings shall be installed using Type B, Class I, IV or VI markings and shall include, but not be limited to, school zone markings, railroad crossing markings, disabled parking symbols, elongated arrows, word messages, etc. The word SCHOOL shall be formed with characters that are 10 feet in height where permitted by the normal roadway width. School zone markings shall extend transversely across both lanes of two-lane roadways and across two or more approach lanes of roadways of three or more lanes. Disabled parking symbols shall be 41 inches in height, 36 inches in width and shall use a 4-inch stroke width for the lines.

The Contractor shall protect the public from damage attributable to pavement marking operations. The Contractor shall be responsible for the complete preparation of the pavement surface, including, but not limited to, removing dust, dirt, loose particles, oily residues, curing compounds, concrete laitance, residues from eradication, and other foreign matter immediately prior to installing pavement markings. The pavement surface shall be dry at the time of installation when tested in accordance with VTM-94. The Contractor shall be responsible for providing the apparatus indicated in VTM-94 that are needed to perform the moisture test. Marking material shall not be applied within 24 hours following rain or other inclement weather.

Liquid markings shall be applied so as to prevent splattering and overspray and shall be protected from traffic until track free by the use of guarding or warning devices as necessary. If a vehicle crosses a marking and tracks it or if splattering or overspray occurs, the affected marking and resultant tracking shall be removed and new markings applied at the Contractor’s expense.

Equipment shall also be thoroughly cleaned between changes in colors of materials.

Pavement markings shall have clean and well-defined edges without running or deformation; shall be uniform, free of waviness; shall be straight on tangent alignment; and shall be on a true arc on curved alignment. The widths of pavement markings shall not deviate more than ¼ inch on tangent nor more than ½ inch on curves from the required width. The length of the gap and the length of the individual stripes that form skip lines shall not deviate more than two inches. The length of the gap and individual skip line shall be of such uniformity throughout the entire length of each that a normal striping machine will be able to repeat the pattern and superimpose additional striping upon the existing marking.
Section 704.03

Glass beads shall be applied at the rate specified herein and shall be evenly distributed over the entire surface of the marking. Beads shall be applied to the surface of liquid markings by a bead dispenser attached to the applicator that shall dispense beads simultaneously on and in the just-applied marking. The bead dispenser shall be equipped with a cut-off control synchronized with the cut off of the applied marking material so that the beads are applied totally to the completed line. Beads shall be applied while the liquid marking is still fluid. Approximately 70 percent of beads shall be buried in the marking, and the remaining 30 percent shall be 50-60 percent embedded in the surface. Beads installed on crosswalks and stop lines on roadways with curbs only (no gutter) may be hand applied for two feet at the end of each line next to the curb with 100 percent of the beads embedded 50-60 percent in the surface.

Markings found to be unacceptable shall be removed, and new markings applied at the Contractor’s expense.

1. **Type A markings:** Paint may be applied to asphalt concrete and hydraulic cement concrete pavements. Paint shall not be applied over existing pavement markings of other materials unless the existing marking is 90 percent removed. Paint may be applied over existing paint markings.

   Paint shall be applied with a line painting machine that is capable of hot spraying paint directly onto the pavement surface with a uniformity of feed through its nozzles for widths of 4 through 8 inches. The machine shall be capable of applying two pavement stripes, either solid or skip, at the same time when double line markings are required. Paint tanks on the equipment shall be equipped with a mechanical agitator and paint shall be thoroughly mixed and heated such that it will not track within 60 seconds after its application.

   Non-truck mounted equipment shall be self-propelled and regulated to allow for calibration of the amount of material applied.

   Glass beads shall be applied to the surface of the paint at the rate of 6 pounds per gallon of paint.

2. **Type B markings:**

   Equipment shall be capable of providing mixing, heating and agitation of material. Material shall be uniformly heated throughout the system in accordance with the manufacturer’s recommendations. Thermoplastic material shall be maintained in the heating kettle and applied to the road surface at a minimum temperature of 400 degrees F. Heating kettles shall be equipped with an automatic thermostatic control device. The Contractor shall furnish a properly calibrated infrared instrument for the purpose of measuring the actual temperature of molten thermoplastic material. Multi-component material shall be applied using internally injected guns for the mixing of catalyst and hardener.
Section 704.03

Non-truck mounted equipment for application of thermoplastic material shall be of the screed extrude type with a screw drive or shall be self propelled and regulated to allow for calibration of the amount of material applied. Non-truck mounted equipment for application of polyester and epoxy resin material shall be self propelled and regulated to allow for calibration of the amount of material applied.

a. **Thermoplastic (Class I)** material shall only be applied on asphalt concrete pavements and shall be applied by screed extrude, ribbon gun or spray equipment. Alkyd thermoplastic may be applied directly after the paving operations, however hydrocarbon thermoplastic shall not be applied less than 30 days after the paving operations.

Alkyd and hydrocarbon materials shall not be mixed together. Equipment shall be thoroughly cleaned before types of material are changed.

Thermoplastic shall not be applied over existing pavement markings of other materials unless the existing marking is 90 percent removed. Thermoplastic may be applied over existing thermoplastic markings. For concrete bridge decks that occur in asphalt roadways, Type B, Class VI tape shall be used.

Primer/adhesive shall be applied to asphalt concrete surfaces more than two years old and shall be from the same manufacturer as the thermoplastic.

Glass beads shall be applied to the surface of the marking at the rate of 7 pounds per 100 square feet.

b. DELETED

c. **Epoxy resin (Class III)** material shall only be applied to asphalt concrete pavement more than one day old and hydraulic cement concrete pavement. Epoxy resin shall not be applied over existing pavement markings unless the existing marking is 90 percent removed.

Glass beads shall be applied by the gravity method to the surface at the rate of 25 pounds per gallon of material.

d. **Plastic-backed preformed tape** shall be installed in accordance with the manufacturer’s recommendations and as denoted herein. Tape may be applied to asphalt concrete and hydraulic cement concrete pavements. Tape may be installed immediately following the final rolling of the new asphalt concrete surface. Tape shall not be applied over existing pavement markings of other materials unless the existing marking is 90 percent removed.
Section 704.03

Primer/adhesive shall be used for all installations except when tape is applied immediately following the final rolling of the new asphalt concrete surface and shall be from the same manufacturer as the tape.

Tape for pavement line markings shall be applied by an application cart as recommended by the manufacturer. Tape shall be tamped into place with a tamper cart with the weight as recommended by the manufacturer. The use of a vehicle to ride over the markings for tamping will not be permitted.

(b) Eradication:

Eradication of pavement markings for restriping when required shall be in accordance with Section 512 except only 90 percent removal of the existing markings is required.

(c) Pavement Markers:

1. **Snow-plowable raised pavement markers** shall be installed by cutting two parallel grooves into the pavement at the depth and dimensions recommended by the manufacturer. Grooves shall be parallel to the adjacent pavement marking. Grooves shall be cut with saw blades having a diameter to match the curvature of the steel casting bottom and keels. Keel surfaces shall be free from scale, dirt, oil, grease, or any other contaminant that might reduce bonding.

Casting keels shall be bonded in the saw-cut grooves in the manner recommended by the manufacturer of the marker. The bonding material shall be from the Department’s approved list or as recommended by the manufacturer of the marker. Noses of the casting shall be installed flush with the pavement surface. The installed height of the raised pavement marker shall be approximately 1/2 inch above the pavement surface. Ambient temperature at the time of installation of the snow-plowable raised pavement markers shall be at least 50 degrees F or higher.

The top of reflectors shall be mounted flush with the top of the casting.

2. **Raised pavement markers** shall be bonded to the pavement surface in accordance with the manufacturer’s recommendations. Bonding material shall be from the Department’s approved list or as recommended by the manufacturer of the marker except epoxy shall not be used on asphalt concrete pavements.
704.04—Measurement and Payment.

Pavement line markings will be measured and paid for at the contract unit price per linear foot. This price shall include the pavement marking material, surface preparation, quality control tests, daily log, guarding devices, primer/adhesive, and glass beads.

Pavement message markings will be measured and paid for at the contract unit price per each per location. This price shall include the pavement marking material, surface preparation, quality control tests, daily log, guarding devices, primer/adhesive, and glass beads.

Pavement markers will be measured and paid for at the contract unit price per each. This price shall include prismatic retroreflectors, pavement cutting, adhesive, and castings.

Eradication of pavement markings will be measured and paid for in accordance with Section 512.

Payment will be made under:

<table>
<thead>
<tr>
<th>Pay Item</th>
<th>Pay Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pavement line marking (Type and/or class and width)</td>
<td>Linear foot</td>
</tr>
<tr>
<td>Pavement message marking (Message)</td>
<td>Each</td>
</tr>
<tr>
<td>Pavement marker (Type, [ ]-way, and/or type pavement)</td>
<td>Each</td>
</tr>
</tbody>
</table>