SPECIAL SPECIFICATION

8582

All Weather Thermoplastic Pavement Markings

1. Description.

A. This specification covers a reflectorized thermoplastic pavement striping material that is applied to the road surface in a molten state by mechanical means with surface application of bonded core elements and glass beads that can be used on bituminous and hydraulic cement concrete pavements.

B. The thermoplastic traffic marking will be applied by spray method onto asphalt cement, concrete, and hydraulic cement concrete surfaces and immediately followed by application of bonded core reflective elements and glass beads. Upon cooling to normal pavement temperatures the resulting traffic marking shall produce a stripe of specified thickness and width that is retroreflective in dry and wet conditions and capable of resisting deformation by traffic.

2. MATERIALS

A. The physical and chemical properties and requirements contained in this specification shall apply regardless of the thermoplastic supply.

B. The thermoplastic material will be homogeneously composed of pigment, binder, glass beads and bonded core elements.

C. The binder will be based on maleic modified rosin ester resin and high boiling plasticizer. The binder will be a minimum of 50% maleic modified rosin ester.

D. The pigment beads and filler will be well dispersed in the resin.

E. The thermoplastic material will be free of skins, dirt and foreign debris.

F. The reflective media will be made up of reflective bonded core elements and glass beads and will conform to the following requirements:

1. Glass Beads- The required beads will have an index of refraction of 1.5 when tested by immersion method at 25° C (77° F). The glass beads will have a minimum of 70% rounds as measured according to ASTM D 1155. The surface of the glass beads will be free of pits and scratches. The glass beads retained on the #40 US Mesh sieve (425 microns) will have minimum crush strength of 30 pounds in accordance with ASTM D 1213.

2. Glass beads (pre-mix)- The pre-mix beads will conform to AASHTO M 247 (Type I) and FP96 (Type III) and do not require surface treatment
a. Glass beads (surface-drop) - Glass spheres in the size range of Type 3 will be surface treated with an adhesion coating. Glass beads may be dual coated. Bead size distribution will conform to the requirements stated in the second drop bead gradation, Table 1 below:

Gradation of the Second Surface Drop of Glass Bead

The gradation of the second drop must meet or be within the limits in Table 1.

<table>
<thead>
<tr>
<th>US Mesh</th>
<th>Micron</th>
<th>FP03 718.19 Type 3</th>
<th>Utah Performance Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>1700</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>1410</td>
<td>95-100</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>1180</td>
<td>80-95</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>1000</td>
<td>10-40</td>
<td>65-80</td>
</tr>
<tr>
<td>20</td>
<td>850</td>
<td>0-5</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>710</td>
<td>0-2</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>600</td>
<td></td>
<td>0-30</td>
</tr>
<tr>
<td>40</td>
<td>425</td>
<td></td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>300</td>
<td>0-5</td>
<td></td>
</tr>
<tr>
<td>70</td>
<td>212</td>
<td></td>
<td></td>
</tr>
<tr>
<td>80</td>
<td>180</td>
<td></td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>150</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**A minimum of 15% of the total weight shall be made from direct melt glass beads.*** All +30 U.S. Mesh beads shall be 85% minimum rounds.

There are many types of glass beads that meet or fit within this range from various manufacturers.

G. Bonded Core Elements (pre-mix and surface-drop) - The bonded core reflective elements will contain either clear or yellow tinted microcrystalline ceramic beads bonded to the core. All “dry-performing” microcrystalline ceramic beads bonded to the core will have a minimum index of refraction of 1.7 when tested using the liquid oil immersion method. All “wet performing” microcrystalline ceramic beads bonded to the core will have a minimum index of refraction of 2.30 when tested using the liquid oil immersion method in Section 8.0 - Appendix A. Element size distribution will conform to the requirements stated in the element gradation Table 2 below:
Table 2

<table>
<thead>
<tr>
<th>US Mesh</th>
<th>Micron</th>
<th>Standard Elements</th>
<th>“S” Series</th>
</tr>
</thead>
<tbody>
<tr>
<td>12</td>
<td>1700</td>
<td>80-100</td>
<td>85-100</td>
</tr>
<tr>
<td>14</td>
<td>1410</td>
<td>45-80</td>
<td>70-96</td>
</tr>
<tr>
<td>16</td>
<td>1180</td>
<td>5-40</td>
<td>50-90</td>
</tr>
<tr>
<td>18</td>
<td>1000</td>
<td>0-20</td>
<td>5-60</td>
</tr>
<tr>
<td>20</td>
<td>850</td>
<td>0-7</td>
<td>0-25</td>
</tr>
<tr>
<td>30</td>
<td>600</td>
<td></td>
<td>0-7</td>
</tr>
</tbody>
</table>

3. Requirements.

A. General.

1. The traffic marking materials will be comprised of a durable thermoplastic white and yellow traffic paint with reflective media adhered to the paint. The reflective media will consist of glass beads as well as bonded core reflective elements. Use thermoplastic materials with the following characteristics:

   a. Will not deteriorate upon contact with pavement materials, petroleum droppings from traffic and chemicals, such as sodium chloride or calcium chloride, used to prevent formation of ice on roadways or streets.

   b. Will not scorch, discolor, or deteriorate if kept at the manufacturer’s recommended application temperature, or deteriorate when kept at the manufacturers recommended application temperature, or at least 400° F (204.4° C) for 4 hours.

   c. Will have a temperature versus viscosity characteristic that remains constant from batch to batch through 3-4 re-heat cycles.

   d. The thermoplastic material in the plastic state will not exude fumes that are toxic, or cause injury to persons or property.

   e. The thermoplastic will be supplied in either granular or block form

B. Composition.

1. Composition – The pigment, beads and filler will be uniformly dispersed in the resin. The thermoplastic will be free of skins, dirt, and foreign objects and will comply with requirements according to Table 3.
Table 3 - COMPOSITION

<table>
<thead>
<tr>
<th>Component</th>
<th>Weight Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>White</td>
</tr>
<tr>
<td>Binder</td>
<td>20% minimum</td>
</tr>
<tr>
<td>Type I Glass Spheres</td>
<td>20% minimum</td>
</tr>
<tr>
<td>Type III Glass Spheres</td>
<td>15% minimum</td>
</tr>
<tr>
<td>Bonded Core Elements</td>
<td>5% minimum</td>
</tr>
<tr>
<td>Bonded Core Elements</td>
<td>None</td>
</tr>
<tr>
<td>TiO2, Type II Rutile</td>
<td>10% minimum</td>
</tr>
<tr>
<td>Pigment Yellow 83 (Lead Free)</td>
<td>None</td>
</tr>
<tr>
<td>Calcium Carbonate and Inert Filler (200 mesh sieve)</td>
<td>30% Minimum</td>
</tr>
</tbody>
</table>

a. The amount of yellow pigment, calcium carbonate and inert fillers will be at the option of the manufacturer, providing all other requirements of this specification are met.

b. The thermoplastic material will be produced without the use of lead chromate or arsenic.

c. The thermoplastic will contain clear glass beads as described in section 2.6.

d. The thermoplastic will contain microcrystalline ceramic beads as described in section 2.7.

e. The thermoplastic will be formulated and manufactured from first-grade materials and specifically compounded for traffic markings.

f. The thermoplastic will resist smearing or spreading under normal traffic conditions below 120° F (49° C).

g. The finished line maintains its original dimensions and placement.

h. The finished line is free from tack below 120° F (49° C) and is not slippery when wet.

i. The thermoplastic line will be homogenous with even distribution of pigments, beads and elements throughout the plastic matrix.

j. The physical properties of the thermoplastic line will be uniform throughout the plastic matrix.

k. The thermoplastic line will resist lifting from the pavement in freezing weather and possess cold ductility properties that permit reasonable movement resulting from thermal expansion and contraction with the road surface to minimize chipping or cracking.
2. PHYSICAL CHARACTERISTICS
   a. Storage Life – The thermoplastic material will meet the requirements of this specification and melt uniformly with no evidence of skins or un-melted particles for a period of one year.

   b. Yellowness Index – Test according to recommendations in ASTM D 4960 and make yellowness index measurements according to ASTM E 1349 using a 2 degree observer and D 65 illuminant. The yellowness index for the white thermoplastic will not exceed 15.

   c. Set to Bear Traffic – When applied at a temperature range of 412.5 +/- 12.5°F (211 +/- 7° C) and a thickness of 60 mils to 185 mils (1.5mm-4.7mm) the material will set to bear traffic in not more than 2 minutes when the air and road temperature is 50 +/- 3° F (10 +/-2° C) and not more than ten minutes when the air and road temperature is 90 +/- 3° F (32 +/-2° C).

   d. Cracking Resistance at Low Temperature - After heating the thermoplastic for 240 +/- 5 minutes at 425 +/- 3° F (218 +/- 2° C) and then applying to concrete blocks, and cooling to 15 +/- 3.6° F (-9.4 +/-2.0° C) the material will show no cracks. Ref: (AASHTO T-250-04 section 12)

   e. Impact Resistance - After heating the thermoplastic for 240 +/- 5 minutes at 425 +/- 3° F (218 +/- 2° C) and making test specimens and testing per ASTM 256, Method A (un-notched), the impact resistance will be a minimum of 8.8 inch-lbs (1.0 J) Ref: (AASHTO T-250-04 section 14)

   f. Softening Point - After heating the thermoplastic for 240 +/- 5 minutes at 425 +/- 3° F (218 +/- 2° C) and testing in accordance with ASTM D 36 the materials will have a softening point of 215 +/- 15° F (102.5 +/- 5° C)

   g. Flowability - After heating the thermoplastic for 240 +/- 5 minutes at 425 +/- 3° F (218 +/- 2° C) and testing for flowability, the white thermoplastic shall have a maximum percent residue of 18 and the yellow thermoplastic shall have a maximum percent residue of 21. Ref: (AASHTO T-250-04 section 11)

   h. Flowability with Extended Heating - After heating the thermoplastic for 8.0 +/- 0.5 hrs at 425 +/- 3° F (218 +/- 2° C), with stirring the last 6 hrs, and testing for flowability, the thermoplastic shall have a maximum percent residue of 28. Ref: (AASHTO T-250-04 section 17)

   i. Flash Point – When tested in accordance with ASTM D 92 the thermoplastic will have a flash point not less than 475° F (248° C).

   j. Indentation Resistance – Test according to ASTM D 2240 Shore Durometer, A2. Durometer and panel at 110° F (43.3° C) with a 4.4 lb load applied. Measurement is taken after 15 seconds. The thermoplastic should have a minimum value of 40 and a maximum value of 75.
Note: Extra care should be taken to ensure the intermix is thoroughly mixed and uniform in the test samples. A non-uniform sample will result in erratic measurement values.

Note: During measurement of thermoplastic containing large elements and or glass beads the durometer probe may impact a large bead or large element during the test resulting in a much higher than expected result. If the value is unreasonably high, it may be necessary to retest in another location on the sample.

k. Specific Gravity – Test according to ASTM D 153. The thermoplastic should have a minimum no less than 1.9 maximum of no more than 2.3.

l. Water Absorption - Test according to ASTM D 570. The thermoplastic sample should have a maximum of 0.5% water absorption.

m. Ultra Violet Light and Condensate Exposure – Make samples and test according to ASTM G 154. After 300 hrs exposure the thermoplastic samples shall meet the requirements below.

n. Color – Make and test thermoplastic samples according to ASTM D 4960. Make color measurements according to ASTM D 6628-03 using a 2 degree observer and D 65 illuminant. The thermoplastic material, after heating for 240 +/- 5 minutes at 425 +/- 3° F (218 +/- 2° C) and then cooled to 77 +/- 3° F (25 +/- 2° C) shall meet the following criteria:
   (1) White Reflectance: Daylight reflectance (Cap Y) measured at 45/0 degrees is 75% minimum.
   (2) White Color: The color shall reasonably match Federal Test Standard number 595B, color 17886 and shall be within the following chromaticity limits “color box” defined by plotting the following four (x,y) pairs on a C.I.E. 1931 chromaticity diagram.
      (x1,y1) = (0.355, 0.355)
      (x2,y2) = (0.305, 0.305)
      (x3,y3) = (0.285, 0.325)
      (x4,y4) = (0.335, 0.375)
   (3) Yellow Reflectance: Daylight reflectance (Cap Y) measured at 45/0 degrees is 45% minimum.
   (4) Yellow Color: The color shall reasonably match Federal Test Standard number 595B, color 13538 and shall be within the following chromaticity limits “color box” defined by plotting the following four (x,y) pairs on a C.I.E. 1931 chromaticity diagram.
      (x1,y1) = (0.560, 0.440)
      (x2,y2) = (0.490, 0.510)
      (x3,y3) = (0.420, 0.440)
      (x4,y4) = (0.460, 0.400)

A. Retroreflectance – Typical initial retroreflectance are shown in the Table 4 below.
   Typical retroreflectivity averaged over many readings (mcd(ft-2)(fc-1)) metric equivalent (mcd(m-2)(lux-1))

<table>
<thead>
<tr>
<th></th>
<th>White</th>
<th>Yellow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry (ASTM E1710)</td>
<td>500</td>
<td>405</td>
</tr>
<tr>
<td>Wet recovery (ASTM E2177)</td>
<td>500</td>
<td>405</td>
</tr>
<tr>
<td>Wet Continuous (ASTM E2176)</td>
<td>180</td>
<td>150</td>
</tr>
</tbody>
</table>

*Note: Typical Retroreflectivity results represent average performance for smooth pavement surfaces. Results may vary due to differences in pavement type and surface roughness. Increased element drop rate may be necessary to compensate for increased surface area characteristics of rough pavement surfaces.

B. Some reasonable variance should be expected (for example, application on very rough road surfaces or differences in glass beads).

1. The initial retroreflectance of a single installation will be the average value determined to the measurement and sampling procedures outlined in ASTM D 6359, using a 30-meter (98.4 feet) retroreflectometer. $R_L$ will be expressed in units of millicandels per square foot per foot-candle (mcd(ft-2)(fc-1)) metric equivalent (mcd(m-2)(lux-1)).

2. Initial performance of pavement marking will be measured no sooner than 3 days after application.

3. Wet retroreflectance values measured under a “condition of continuous wetting” (simulated rain) will be in accordance with ASTM E2176, and to reduce variability between measurements, the test method will be performed in a controlled laboratory environment while the marking is positioned with a 3 to 5 degree lateral slope. Measurements will be reported as the average of the minimum of three locations. Samples of the completed finished product will be applied to flat panels during application and brought back to the lab for testing.

C. On The Road Track-Free Time – When applied at a temperature range of 412.5 +/- 12.5° F (211 +/- 7° C) and a thickness of 60 mils to 185 mils (1.5mm-4.7mm) the material will set to bear traffic in not more than 2 minutes when the air and road temperature is 50 +/- 3° F. (10 +/- 2° C) and not more than ten minutes when the air and road temperature is 90 +/- 3° F (32 +/- 2° C).

1. Track Free - will be considered as the condition where no visual deposition of the traffic marking to the pavement surface is observed when viewed from a distance of 50 feet, after a free-rolling traveling vehicle’s tires have passed over the line.
2. **Color After Application** – The color of the applied white and yellow stripes and markings (with elements and beads) will conform to the daytime and nighttime color requirements in ASTM Designation: D 6628-03.

   a. **White Reflectance**: Daylight reflectance *(Cap Y)* measured at 45/0 degrees is 35% minimum.

   b. **White Color**: The color will reasonably match Federal Test Standard number 595B, color 17886 and will be within the following chromaticity limits “color box” defined by plotting the following four (x,y) pairs on a C.I.E. 1931 chromaticity diagram.
      \[(x_1, y_1) = (0.355, 0.355)\]
      \[(x_2, y_2) = (0.305, 0.305)\]
      \[(x_3, y_3) = (0.285, 0.325)\]
      \[(x_4, y_4) = (0.335, 0.375)\]

   c. **Yellow Reflectance**: Daylight reflectance *(Cap Y)* measured at 45/0 degrees is 25% minimum.

   d. **Yellow Color**: The color will reasonably match Federal Test Standard number 595B, color 13538 and will be within the following chromaticity limits “color box” defined by plotting the following four (x,y) pairs on a C.I.E. 1931 chromaticity diagram.
      \[(x_1, y_1) = (0.560, 0.440)\]
      \[(x_2, y_2) = (0.490, 0.510)\]
      \[(x_3, y_3) = (0.420, 0.440)\]
      \[(x_4, y_4) = (0.460, 0.400)\]

   Take a minimum of 3 measurements for each 1 mile section of roadway for each series of markings (i.e. edge-line, center skip line, each line of a double line, etc.) and for each direction of travel. Make all measurements in the direction of traffic flow, except for broken centerline on 2-way roadways, where measurements will be made in both directions. The spacing between each reading must be at least 1000 ft. The Engineer may decrease the mileage frequency for the readings if the previous readings provide satisfactory results. The Engineer may require the original number of readings if concerns arise.

   If 2 or more of the measurements taken on a specific series of markings within each mile segment falls below the minimum retroreflectivity values, take a minimum of 5 more measurements within that mile segment for that series of marking. If 2 or more of these readings fail, then restripe once at the Contractor's expense. Take a minimum of 5 more measurements after 3 days but before 10 days of this second application within that mile segment for that series of markings.

   Provide a portable retroreflectometer or mobile retroreflectometer, which uses 30-meter geometry meeting the requirements described in ASTM E 1710. The retroreflectometer will have either an internal global positioning system (GPS) or the ability to be linked with an external GPS. The unit must be able to record and print the location and the retroreflective reading for each location where readings are taken.
The GPS must have a minimum accuracy rating of 16.4 ft. in accordance with the circular error probability (CEP) method. CEP is defined as the radius of the circle with its origin at a known position that encompasses 50% of the readings returned from the GPS instrument. Perform all retroreflectivity measurements used for acceptance. Mobile retroreflectometers used for this operation must be approved by the Construction Division. Obtain written approval to use a mobile retroreflectometer and have the equipment approved before placing any striping. These retroreflective readings may be done after completion of all striping if the mobile retroreflectometer is approved for use. Use all equipment in accordance with the manufacturer’s recommendations and directions. Provide a video tape of all the stripes being measured with high quality resolution and include data overlay. Inform the Engineer at least 24 hrs in advance of taking any type of readings.

Provide traffic control when retroreflectivity measurements are taken after marking application. On low volume roadways (as defined on the plans), refer to the figure, "Temporary Road Closure" in Part VI of the Texas Manual on Uniform Traffic Control Devices for the minimum traffic control requirements. For all other roadways, the minimum traffic control requirements will be as shown on the standard plans TCP (3-1) and TCP (3-2). The lead vehicle will not be required on divided highways. The traffic control plan and traffic control devices must meet the requirements listed in Item 502, “Barricades, Signs, and Traffic Handling.” Time restrictions that apply during striping application will also apply during the retroreflectivity inspections except when using the mobile retroreflectometer unless otherwise shown on the plans or approved by the Engineer.

Initial performance of pavement markings will be measured anytime after 3 days but not later than 10 days after application.

5. Application.

A. Equipment

1. Equipment will be capable of providing uniform heating of striping materials to temperatures exceeding 390° F (199° C)

2. Equipment will be capable of mixing and agitating the molten thermoplastic to provide a homogenous mixture and prevent settling of intermixed beads and elements.

3. Equipment will be capable of maintaining the thermoplastic striping material in a plastic state in all mixing and conveying parts, including the line dispensing device until applied.

4. Equipment will be comparable of producing varying widths and thickness of thermoplastic traffic stripes.

5. The equipment will be a mobile, truck mounted and self–contained pavement marking machine or a walk behind hand cart applicator with an accompanying mobile pre-meter.
6. Mobile truck mounted applicators will be capable of traveling at a uniform, predetermined speed over variable road grades to produce uniform application of striping material, following straight lines and making normal curves in a true arc. The equipment will be capable of air-blasting the pavement, applying the thermoplastic stripe and immediately dropping the bonded core elements and glass beads in a single pass at speeds up to 8 mph.

7. Hand cart applicators will be capable of uniform application of striping material at walking speeds, following straight lines and making tight turns symbols and legends. Mobile equipment must be available to air blast the areas immediately prior to hand cart application of thermoplastic. The hand cart will be capable of applying the thermoplastic stripe and immediately dropping the bonded core elements and glass beads in a single pass at walking speeds.

8. The equipment will be capable of application of bonded core elements and glass beads to the surface of the pavement marking by double drop application. The element dispenser for the first drop will be attached to the striping machine in such a manner that the elements are dispensed closely behind the thermoplastic application device (ribbon gun, screed, and spray gun). The bead dispenser for the second drop will be attached to the striping machine in such a manner that the beads are dispensed immediately after the first drop (bonded core elements).

9. The applicator for the bonded core elements and glass beads will be equipped with an automatic cut-off control that is synchronized with the cut-off of the thermoplastic material.
   a. The applicator for the bonded core elements and glass beads will be capable of delivering a uniform drop rate at variable thermoplastic application speeds.
   b. The bonded core elements and glass spheres are applied such that they appear uniform on the entire traffic stripe and markings.
   c. The bonded core elements and glass beads are applied such that they are embedded 50%-60% for adhesion to the thermoplastic marking.
   d. The melt kettle must be equipped with an automatic temperature control device and thermometer to thermostatically control the temperature and prevent overheating of the thermoplastic material. It must also be equipped with sufficient agitation to prevent settling of the beads and elements.
   e. Must meet the requirements of the National Fire Protection Association and state and local authorities.

B. Application Conditions

1. **Moisture** – The markings will only be applied during conditions of dry weather and when the pavement surface is dry and free of moisture.

2. **Air temperature and humidity** – The markings will only be applied when road and air temperatures are not less than 50° F (10° C) and the relative humidity is less than 85%.
3. **Surface preparation** – Marking operations will not begin until applicable surface preparation work is completed and approved by the engineer.

   a. Prior to marking application, the contractor will remove any markings that show obvious signs of degradation and/or loss of adhesion.

   b. Prior to marking application, the contractor will remove all curing compounds on new Portland cement concrete surfaces.

   c. Prior to marking application, the contractor will remove all dirt, sand, dust, oil, grease, loose beads and any other contaminants from the road surface.

C. **Application Plan**

1. Reflectorized markings will be placed only on properly prepared surfaces and at the widths, thickness and patterns as designated on the contract plans.

2. Markings will be applied in accordance with the “Manual on Uniform Traffic Control Devices” and in accordance with engineers plans.

3. **Restrictions** - The engineer and/or contractor will determine further restrictions and requirements of weather and pavement conditions necessary to meet all application specifications and produce markings that perform to the satisfaction of the engineer. If the pavement surface contains heavy tines or very large aggregate used in open grade friction course or stone matrix asphalt mixes it may require additional surface preparation prior to application of thermoplastic pavement markings.

4. **Thickness** – The thermoplastic binder will be applied to the proper thickness of 100 mills.

5. **Reflective media application** – The specified reflective media will be dropped at rates to achieve the following coating weights in Table 5 & 6.

<table>
<thead>
<tr>
<th>Table 5</th>
<th>Element Application Rates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Units</td>
<td>Composite Reflective Elements</td>
</tr>
<tr>
<td>Pounds per 4-inch linear foot</td>
<td>0.022</td>
</tr>
<tr>
<td>Grams per 4-inch linear foot</td>
<td>10</td>
</tr>
<tr>
<td>Pounds per 100 sq ft</td>
<td>6.6</td>
</tr>
<tr>
<td>Grams per square meter</td>
<td>323</td>
</tr>
</tbody>
</table>
Table 6
Glass Bead Application Rates

<table>
<thead>
<tr>
<th>Units</th>
<th>Utah Performance Specification</th>
<th>FP03 718.19 Type 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pounds per 4-inch linear foot</td>
<td>0.048</td>
<td>0.026</td>
</tr>
<tr>
<td>Grams per 4-inch linear foot</td>
<td>22</td>
<td>12</td>
</tr>
<tr>
<td>Pounds per 100 sq ft</td>
<td>14.4</td>
<td>7.8</td>
</tr>
<tr>
<td>Grams per square meter</td>
<td>710</td>
<td>388</td>
</tr>
</tbody>
</table>

a. **Adhesion** – The contractor will ensure that the thermoplastic marking is well adhered to the road surface, and that the glass spheres and bonded core elements are well adhered to the binder with 50% to 60% embedment.

b. **Retroreflectivity** – The contractor will ensure that the reflectorized thermoplastic pavement marking meets the following performance criteria Table 7:

<table>
<thead>
<tr>
<th>Typical Minimum Initial Retroreflectivity*</th>
<th>White</th>
<th>Yellow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average values over many applications</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(mcd(ft-2)(fc-1); {metric equivalent mcd(m-2)(lux-1)})</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry (ASTM E1710)</td>
<td>400</td>
<td>325</td>
</tr>
<tr>
<td>Wet recovery (ASTM E2177)</td>
<td>400</td>
<td>325</td>
</tr>
<tr>
<td>Wet continuous (ASTM E2176)</td>
<td>150</td>
<td>125</td>
</tr>
</tbody>
</table>

* Note: Typical Retroreflectivity results represent average performance for smooth pavement surfaces. Results may vary due to differences in pavement type and surface roughness. Increased element drop rate may be necessary to compensate for increased surface area characteristic of rough pavement surfaces.

c. The average initial retroreflectance will be determined according to the measurement and sampling procedures outlined in ASTM D 6359, using a 30 meter retroreflectometer. The 30 meter retroreflectometer will measure the coefficient of retroreflected luminance, RL, at observation angle of 10.5 degrees and an entrance angle of 88.76 degrees. RL will be expressed in units of millicandelas per square foot per foot-candle. [(mcd(ft-2)(fc-1)]. The metric equivalent will be expressed in units of millicandelas per square meter per lux [(mcd(m-2)(lux-1)].

d. Initial performance of the pavement markings will be measured no sooner than 3 days after application.

e. Wet retroreflectance values measured under a “condition of continuous wetting” (simulated rain) will be in accordance with ASTM E2176, and to reduce variability between measurements, the test method will be performed in a controlled laboratory environment while the marking is positioned with a 3 to 5 degree lateral slope. Measurements will be reported as an average of a minimum of three locations. A sample of the complete finished product will be applied to flat panels during application and brought back to the lab for testing.
All markings (and replacement markings) must meet all requirements of this specification, Retroreflective Requirements, for a minimum of 15 calendar days after installation. Remove all pavement markings that fail to meet all requirements of this specification and replace at the Contractor’s expense unless otherwise directed. Replace all failing markings within 30 days of notification.

Initial performance of pavement markings will be measured anytime after 3 days but not later than 10 days after application.


A. INSPECTION AND TESTING

1. At any time throughout the duration of the project, the contractor will provide free access to his application equipment for inspection by the engineer, his authorized representative, or a materials representative.

2. During the application of the thermoplastic marking, the engineer may request the following tests to verify application to the parameters required in this specification.

a. Thickness – During appropriate locations along the alignment of the project site the engineer may obtain a sample of the molten thermoplastic onto a test panel of aluminum for the purposes of checking of proper film thickness. The thermoplastic will be applied without bonded core elements or glass spheres. Upon hardening, the thickness shall be verified by the engineer to meet the requirements of the plan. The contractor will provide to the engineer the application speed of the equipment during the time of the sample.

b. Reflective media – When required by the engineer, the contractor will demonstrate to the engineer the proper calibration of reflective elements and glass beads compared with the manufacturer’s requirement and may be conducted by one of the two methods.

(1) Pressurized delivery systems - The calibration will be conducted with a graduated cylinder or other similar device. Reflective elements or glass beads shall be collected from the reflective element and glass bead guns for a timed period. The volume of the reflective elements and glass beads will be measured and compared with the manufacturer’s requirements.

(2) Non-pressurized delivery systems – The calibration will be conducted with catch pans of known geometry, sufficiently wide to capture the width of the drop. The pans are positioned in the marking application path on the road. Then, separately for each glass spheres and bonded core elements, with the thermoplastic applicator off, the applicator is passed over the catch pan at the appropriate speed and drop rate. The catch is then weighed and the drop area is calculated from the length of the pan and the width of the drop. Drop rate = drop capture weight / ((drop width) X (drop length))
c. **Application Panel** – The contractor will provide to the engineer at least one representative sample coated onto an aluminum panel or equivalent. This panel will serve as a record of the project output and application conditions and settings.

7. **Measurement.** This Item will be measured by the foot complete-in-place.

8. **Payment.** The work performed and materials furnished in accordance with this Item and measured as provided under “Measurement” will be paid for at the unit price bid for “Reflectorized Pavement Markings” of the type and color, shape and size specified. This price is full compensation for cleaning and preparing the pavement surface, for furnishing and placing all materials, and for all materials, labor, tools, equipment and incidentals necessary to complete the work.

   When materials are found to be non-conforming under Article 2, the material supplier will provide replacement materials at no cost.

   When markings are found to be non-conforming under Article 3, the Contractor will bear full responsibility for all repair work and associated costs, including purchase of replacement materials.

   When the fault of non-conformance with the specification is indeterminate or in dispute, the materials supplier will provide replacement materials and the Contractor will repair the markings, both at no cost to the Department.