STATE OF CALIFORNIA  
Department of Transportation  
Specification for  
Thermoplastic Traffic Striping Material,  
Alkyd Resin Binder, White and Lead-Free Yellow

1.0 SCOPE
This specification covers a hot-melt, retroreflective, thermoplastic traffic marking material that is suitable for producing durable traffic stripes and pavement markings on Portland cement concrete or asphalt concrete pavements. This material is heated and applied to road surfaces in a molten state using a mechanical applicator. While still hot, reflectorizing glass beads are applied to the surface of the applied thermoplastic striping material. Upon cooling to normal pavement temperatures this material shall produce durable, adherent, retroreflective traffic stripes and pavement markings that are capable of resisting deformation by traffic.

2.0 APPLICABLE SPECIFICATIONS
The following specifications, test methods and standards in effect on the opening date of the Invitation for Bid form a part of this specification where referenced.

- California Test Methods (CTM); No. 423 and No. 660 (latest revision).
- Federal Standard Designation: No. 595b, color #33538.
- U.S. Environmental Protection Agency (EPA), SW-846, Methods 3052 and 6010B.
- California Code of Regulations: Title 22.

3.0 REQUIREMENTS
3.1 Composition:
The thermoplastic material shall be composed of 100% solids. The binder shall consist of a maleic-modified glycerol ester of rosin which is homogeneously blended together with all necessary prime pigments, fillers, glass beads and additives to produce a traffic striping material that meets the requirements as specified herein. All thermoplastic material shall be free from; lead, chromium, cadmium, barium and other toxic metals.

3.1.1 White Material:
White thermoplastic shall contain a minimum of 10% (by weight) titanium dioxide pigment meeting ASTM D476 Type II (Rutile). The titanium dioxide content will be determined using ASTM Designations; D 5380 and E 1621. White thermoplastic must meet the Retroreflectivity requirement when applied with drop-on glass beads.

3.1.2 Lead-Free Yellow Material:
Lead-Free (L/F) yellow thermoplastic shall contain proper amounts of C.I. Pigment Yellow 83 (opaque version) and titanium dioxide (Rutile) to produce a yellow material that has a weather-fast and heat stable yellow color which meets the; Yellow Color, Reflectance, Color Stability (Accelerated Weathering) and Retroreflectivity requirements as stated herein. Other pigments may be added to achieve these color requirements. The L/F yellow thermoplastic material shall appear yellow during both daytime and nighttime conditions when applied with drop-on beads.

3.1.3 Other Ingredients:
The remainder of the thermoplastic composition shall be determined by the manufacturer - within the constraints of the requirements below. It shall be the manufacturer's responsibility to produce a thermoplastic material containing the necessary plasticizers, antioxidants, and all other additives so that the thermoplastic will retain its color, viscosity and all other properties as specified herein. In addition to being essentially lead and chromium free, the thermoplastic shall not contain any hazardous materials at levels that would cause the thermoplastic to be classified as a hazardous waste under Title 22, Division 4, section 66261.20 of the California Code of Regulations.

3.2 Form:
The thermoplastic material shall be supplied in either block or granular form as requested in the purchase order.

3.3 Application Type/Viscosity:
Two viscosity grades of thermoplastic material shall be available for purchase; Extruded-Viscosity and Low-Viscosity. Extruded-Viscosity grade is more suitable for screed type applicators and thicker applications (+2.5mm), including recessed applications. Low-Viscosity grade material is commonly used with ribbon or spray type applicators. The thermoplastic material shall be formulated to meet the viscosity grade specified in the purchase order.

3.4 Characteristics of the Finished Thermoplastic:
Use California Test Method No. 423 (CTM 423) unless otherwise specified.

<table>
<thead>
<tr>
<th>Glass Bead Content, intermixed, Percent by weight, CTM 423 (Part 4).</th>
<th>White</th>
<th>L/F Yellow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass beads shall meet AASHTO Designation: M 247 Type 1, except the glass beads shall not contain more than 200 ppm (total) arsenic, 200 ppm (total) antimony, nor more than 200 ppm (total) lead, when tested according to EPA Methods 3052 and 6010B. Other suitable x-ray fluorescence spectrometry analysis methods may be used to screen samples of glass beads for arsenic, antimony and lead content.</td>
<td>30-35</td>
<td>30-35</td>
</tr>
</tbody>
</table>
3.4.2 Binder Content, percent by weight, minimum. 
CTM 423 (Part 3).

<table>
<thead>
<tr>
<th>White</th>
<th>L/F Yellow</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>18</td>
</tr>
</tbody>
</table>

3.4.3 Inert Fillers, insoluble in hydrochloric acid, percent passing a sieve with openings of 150µm, percent by weight, minimum, ASTM Designation: E 11.

<table>
<thead>
<tr>
<th>White</th>
<th>L/F Yellow</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

3.4.4 Titanium Dioxide (Rutile) Pigment meeting ASTM Designation D476 Type II. Analyze titanium dioxide content using ASTM Designation: D 5380 and E 1621 percent by weight, minimum.

<table>
<thead>
<tr>
<th>White</th>
<th>L/F Yellow</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>---</td>
</tr>
</tbody>
</table>

3.4.5 Specific Gravity, maximum, 
CTM 423 (Part 5).

<table>
<thead>
<tr>
<th>White</th>
<th>L/F Yellow</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.15</td>
<td>2.15</td>
</tr>
</tbody>
</table>

3.4.6 Ring and Ball Softening Point, 
CTM 423 (Part 6), ASTM Designation: E 28.

<table>
<thead>
<tr>
<th>White</th>
<th>L/F Yellow</th>
</tr>
</thead>
<tbody>
<tr>
<td>93-121°C</td>
<td>93-121°C</td>
</tr>
</tbody>
</table>

3.4.7 Perform the remaining tests on the material after 4 hours heating with stirring at 218 ± 2°C. This 4-hour period includes time required (~1 hr.) for melting and temperature stabilization of the 6 kg. sample.

3.4.7.1 Tensile Bond Strength to an unprimed abrasive blasted Portland cement concrete brick, 3.2 mm thick film draw down at 218°C, tested at 25 ± 2°C, MPa, minimum, CTM 423 (Part 7).

<table>
<thead>
<tr>
<th>White</th>
<th>L/F Yellow</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.24 MPa</td>
<td>1.24 MPa</td>
</tr>
</tbody>
</table>

3.4.7.2 Brookfield Thermosel Viscosity, 
Low-Viscosity Grade - - - - - - - - - - - - - <4.5 <4.5 
Extrude-Viscosity Grade - - - - - - - - - - - 4.5 to 10 4.5 to 10 
Spindle SC4-27, 20 rpm at 218°C, Pa•s, CTM 423 (Part 8).

<table>
<thead>
<tr>
<th>White</th>
<th>L/F Yellow</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;4.5</td>
<td>&lt;4.5</td>
</tr>
<tr>
<td>4.5 to 10</td>
<td>4.5 to 10</td>
</tr>
</tbody>
</table>

3.4.7.3 Impact Resistance, 3.2 mm thick film draw down at 218°C on an unprimed abrasive blasted Portland cement concrete brick, male indentor 15.9 mm diameter, no female die. Test at 25 ± 2°C, kilogram force•meter, with no; chips, cracks or bond loss, minimum, CTM 423 (Part 9), ASTM Designation D 2794.

<table>
<thead>
<tr>
<th>White</th>
<th>L/F Yellow</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.58</td>
<td>0.58</td>
</tr>
</tbody>
</table>
3.4.7.4 Daylight Luminous Reflectance, 
CTM 423 (Part 11) except use a BYK-Gardner “Color-Guide” Spectrophotometer. Follow the manufacturer’s instructions to obtain the Reflectance or “Y” value. Set-up the spectro-photometer for 2° Observer and Illuminant “C” measurement conditions.

3.4.7.5 Yellow Color, shall match Federal Standard Designation: No. 595b, color #33538 and shall lie within the following chromaticity limits “colorbox” defined by plotting the following four (x,y) pairs on a C.I.E. 1931 Chromaticity diagram; 
(x1,y1) = (0.5125, 0.4866) 
(x2,y2) = (0.4865, 0.4647) 
(x3,y3) = (0.5000, 0.4416) 
(x4,y4) = (0.5348, 0.4646) 
Reflectance(Y) shall be between 47 and 60. 
Measurement conditions = 2°Observer/illuminant “C”. 
Tested according to CTM 423 (Part 10) except use a BYK-Gardner “Color-Guide” Spectrophotometer to measure the color. Follow the manufacturers instructions to obtain the (x,y) chromaticity coordinates. 
See attached Yellow Color graph.

3.4.7.6 Yellowness Index, maximum 
Follow CTM 423 (Part 11) except use a BYK-Gardner “Color-Guide” Spectrophotometer to measure the Yellowness Index of the white thermoplastic using the ASTM Designation: E313 mode.

3.4.7.7 Color Stability after Accelerated Weathering, 
ASTM Designation: G 155, Table X3.1, Cycle 1, 500 hours total exposure time. Prepare sample by dipping a sheet aluminum panel into the molten thermoplastic and removing it to obtain a 1.5 to 3mm coating thickness of thermoplastic on the panel. Place the panel in the weathering apparatus for 500 hrs. After accelerated weathering, measure the Yellow Color or Yellowness Index as in section 3.4.7.5 or 3.4.7.6 above. Material must meet the color stability requirement below, after this exposure.
<table>
<thead>
<tr>
<th>White L/F Yellow</th>
</tr>
</thead>
<tbody>
<tr>
<td>White - Yellowness Index, maximum</td>
</tr>
<tr>
<td>Yellow - Measured chromaticity coordinates must fall within a “colorbox” defined by plotting the following four (x,y) pairs on a C.I.E. 1931 Chromaticity diagram.</td>
</tr>
<tr>
<td>See attached Yellow Color graph.</td>
</tr>
<tr>
<td>(x1, y1) = (0.5125, 0.4866)</td>
</tr>
<tr>
<td>(x2, y2) = (0.4650, 0.4466)</td>
</tr>
<tr>
<td>(x3, y3) = (0.4750, 0.4251)</td>
</tr>
<tr>
<td>(x4, y4) = (0.5348, 0.4646)</td>
</tr>
<tr>
<td>3.4.7.8 Hardness, Shore A-2 Durometer, measure according to CTM 423 (Part 12) except condition the sample for 2 hrs. in a 46.1°C water bath before measuring the Hardness. The Durometer is also conditioned at 46.1°C in a forced air oven. Remove the sample from the water bath and quickly place the Durometer on the sample while starting a stopwatch. Record the Hardness after 15 seconds. The total weight of the Durometer shall be 2000 grams. <strong>Note:</strong> Thermoplastic for recessed application shall have a Hardness between 30 and 50.</td>
</tr>
<tr>
<td>3.4.7.9 Abrasion Test</td>
</tr>
<tr>
<td>Use 400 g of graded glass beads between 600 and 850 µm diameter and an air pressure of 152 kPa to sandblast the sample in 4 different areas according to CTM 423 (Part 14), total weight loss, grams, maximum.</td>
</tr>
<tr>
<td>3.4.7.10 Lead, mg/kg in thermoplastic, maximum, ASTM D3335</td>
</tr>
<tr>
<td>3.4.7.11 Chromium, mg/kg in thermoplastic, maximum, ASTM D3718</td>
</tr>
<tr>
<td>3.4.7.12 Initial Retroreflectivity of applied thermoplastic striping (with beads), mcd•m²•lx⁻¹ , minimum</td>
</tr>
</tbody>
</table>

The thermoplastic shall produce delineation and pavement markings that have the required minimum level of retroreflectivity when applied with drop-on beads. Drop-on glass beads shall be uniformly applied at a minimum rate of 4-kg of beads per 10 square meters of thermoplastic. The retroreflectivity shall be measured as specified in ASTM E 1710.
3.4.7.13 Color after Application
The daytime color of the applied white and yellow thermoplastic traffic stripes and pavement
markings (with drop-on beads) shall meet the color requirements in section 3.4.7.7 (Color Stability
after Accelerated Weathering). The color shall be measured within 60 days of application using a
portable BYK-Gardner “Color-Guide” Spectrophotometer (see sections 3.4.7.5 and 3.4.7.6).

3.5 Other Requirements:
3.5.1 Melting and Applicability:
Bags of thermoplastic shall not harden during shipment and storage to the point where the
material must be broken-up with tools before loading into the melter. When heated, the
thermoplastic material shall completely melt to a homogeneous fluid with satisfactory application
qualities and shall be free of debris. The molten thermoplastic material shall be readily applied at
temperatures between 204°C and 232°C. Upon application to the pavement, the thermoplastic
material shall be sufficiently tack-free to carry traffic; in not more than 2 minutes when the
pavement surface temperature is 16°C, and in not more than 10 minutes when the pavement
surface temperature is 54°C.

3.5.2 Workmanship:
The materials’ ingredients (resins, pigments, glass beads, fillers and additives) shall be
homogeneously blended. The finished product shall be uniform from bag to bag. The melted
thermoplastic material shall have no indications of resin separation or incompatibility of resins
when melted or after cooling. The material shall be free from all; dirt, water, foreign matter, and
other deleterious substances capable of clogging; screens, valves, pumps and other striping
apparatus. The thermoplastic material shall be of such composition that it will not bleed, stain, or
discolor when applied to pavements.

3.5.3 Shelf Life:
The material shall maintain the requirements of this specification for a minimum period of one (1)
year from the date of manufacture. Any materials failing to do so shall be replaced at the expense
of the manufacturer. Ordered thermoplastic shall be no more than 120 days old (based on date of
manufacture) upon delivery to a Department of Transportation Maintenance facility. The date of
manufacture shall be clearly marked on each bag of thermoplastic.

3.5.4 Air Pollution Compliance:
This material shall comply with all applicable air pollution control rules and regulations. The
thermoplastic material shall not emit fumes that are toxic or injurious to persons or property when
it is heated to application temperature. The material shall not emit excessive smoke during
heating or application.
Opaque Yellow Color Box for Lead-Free Thermoplastic

C.I.E. (1931) Chromaticity Diagram
2-Degree Observer, Illuminant "C"
California Test 660

Sample #
Date:

Brightness(Y)=

initial lab color
requirement

applied or after accel.
weathering color
requirement