California Department of Transportation
Specification for
Sprayable Thermoplastic Traffic Striping Material,
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 CT 423 and CT 660 (latest revision).
- California Department of Transportation, Standard Specifications.
- AMS-STD-595A, 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 hydrocarbon or alkyd thermoplastic resins
which are 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. The type of resin binder (alkyd or hydrocarbon) may be
specified in the purchase order. 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 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:**

The thermoplastic material shall be suitable for air-atomized spray application at temperatures between 350 F and 400 F. The viscosity of the molten material at these temperatures shall be suitable for applying thermoplastic traffic stripes that are 40 mils thick.

3.4 **Characteristics of the Finished Thermoplastic:**

Use CT 423 unless otherwise specified.

<table>
<thead>
<tr>
<th>Section Number</th>
<th>Material</th>
<th>White</th>
<th>L/F Yellow</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.4.1</td>
<td>Glass Bead Content, intermixed, percent by weight. Glass beads shall meet AASHTO Designation: M 247 Type I, 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>
<tr>
<td>3.4.2</td>
<td>Binder Content, percent by weight, minimum</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>3.4.3</td>
<td>Inert Fillers, insoluble in hydrochloric acid, percent passing a sieve with openings of 150µm, percent by weight, minimum, ATSM Designation: E-11.</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>3.4.4</td>
<td>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.</td>
<td>10</td>
<td>---</td>
</tr>
<tr>
<td>Section Number</td>
<td>Material</td>
<td>White</td>
<td>L/F Yellow</td>
</tr>
<tr>
<td>----------------</td>
<td>-------------------------------------------------</td>
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</tr>
<tr>
<td>3.4.5</td>
<td>Specific Gravity, maximum.</td>
<td>2.10</td>
<td>2.10</td>
</tr>
<tr>
<td>3.4.6</td>
<td>Ring and Ball Softening Point, ATSM Designation: E 28.</td>
<td>90-121°C</td>
<td>90-121°C</td>
</tr>
<tr>
<td>3.4.7</td>
<td><strong>Perform the remaining tests on the material after 4 hours heating</strong> with stirring at 375°F. This 4-hour period includes time required (~1 hour) for melting and temperature stabilization of the 6 kg sample.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.4.7.1</td>
<td>Tensile Bond Strength to an unprimed abrasive blasted Portland cement concrete brick, 60 mils thick film drawn down at 375°F, tested at 25±2°C, MPa, minimum</td>
<td>1.24 MPa</td>
<td>1.24 MPa</td>
</tr>
<tr>
<td>3.4.7.2</td>
<td>Brookfield Thermosel Viscosity, Spindle SC4-27, 20 rpm at 191°C, Poise</td>
<td>≤20</td>
<td>≤20</td>
</tr>
<tr>
<td>3.4.7.3</td>
<td>Daylight Luminous Reflectance. Use a BYK-Gardner “Color-Guide” spectrophotometer. Follow the manufacturer’s instructions to obtain the reflectance or “Y value”.</td>
<td>80 min</td>
<td>47-60</td>
</tr>
<tr>
<td>3.4.7.4</td>
<td>Yellow Color, shall match AMS-STD-595, 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)=(0.4450, 0.4300) (x3, y3) = (0.4600, 0.4150) (x4, y4) = (0.5348, 0.4646) Reflectance(Y) shall be between 47 and 60. Use a BYK-Gardner “Color-Guide” Spectrophotometer to measure the color. Follow the manufacturer’s instructions to obtain the (x, y) chromaticity coordinates.</td>
<td>---</td>
<td>Pass</td>
</tr>
</tbody>
</table>
### 3.4.7.5 Yellowness Index, maximum

<table>
<thead>
<tr>
<th>Material</th>
<th>White</th>
<th>L/F</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8</td>
<td>----</td>
</tr>
</tbody>
</table>

Use a BYK-Gardner “Color-Guide” Spectrophotometer to measure the Yellowness Index of the white thermoplastic using the ASTM Designation: E313 mode.

### 3.4.7.6 Color Stability after Accelerated Weathering, ASTM Designation: G 154, Table X2.1, Cycle 1; UVA-340 lamp, 0.89 W/(m²*nm) typical irradiance, 340 nm approximate wavelength, four hours condensation at 40°C, four hours UV exposure at 60°C. 500 hours total exposure time.

Prepare sample by dipping a sheet aluminum panel into the molten thermoplastic and removing it to obtain a 40 to 80 mils 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 3.4.7.4 or 3.4.7.5 above. Material must meet the color stability requirements below after this exposure.

<table>
<thead>
<tr>
<th>Material</th>
<th>Yellowness Index, maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>White</td>
<td>20</td>
</tr>
</tbody>
</table>

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. See attached Yellow Color graph.

\[(x_1, y_1) = (0.5125, 0.4866)\]
\[(x_2, y_2) = (0.4450, 0.4300)\]
\[(x_3, y_3) = (0.4600, 0.4150)\]
\[(x_4, y_4) = (0.5348, 0.4646)\]

### 3.4.7.7 Hardness, Type A Needle-type Durometer

<table>
<thead>
<tr>
<th>Material</th>
<th>20-65</th>
<th>20-60</th>
</tr>
</thead>
</table>

### 3.4.7.8 Lead, mg/kg in thermoplastic, maximum, ASTM D3335

| Material | 20 | 20 |

### 3.4.7.9 Chromium, mg/kg in thermoplastic, maximum, ASTM D3718

| Material | 5 | 5 |

### 3.4.7.10 Initial retroreflectivity of applied thermoplastic striping (with beads), \(mcd\cdot m^{-2}\cdot lx^{-1}\), minimum

<p>| Material | 250 | 125 |</p>
<table>
<thead>
<tr>
<th>Section Number</th>
<th>Material</th>
<th>L/F White</th>
<th>Yellow</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>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.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3.4.7.11 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 3.4.7.6 (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 3.4.7.4 and 3.4.7.5).

3.5 Manufacturer Quality Assurance Program:
3.5.1 CTB Certificate of Compliance Program:
Follow the Chemical Testing Branch Certificate of Compliance (COC) Program (See attachments 1 and 2).

3.6 Other Requirements:
3.6.1 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 350°F and 400°F. 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 60°F, and in not more than 10 minutes when the pavement surface temperature is 130°F.
3.6.2 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.

3.6.3 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.

3.6.4 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.

For questions, please contact Caltrans, Division of Engineering Services, Materials and Engineering Testing Services, Chemical Laboratory branch by e-mail sent to <Chemistry.Branch@dot.ca.gov>.
Certificate of Compliance

State Specification Type: **PTH-02SPRAY, (January 2022)**

Manufacturer’s Product #: ______________________

ID #s of batches comprising the lot and lot number: ______________________

Lot Quantity: ______________________ Date COC Issued: ________________

Date of Manufacture: ________________ Color: _________ Viscosity Type __________

Issued To: ________________ CC: ______________________

{Contractor Name here} California Department of Transportation

{State Project Number here} OCL, Chemical Testing Branch

{Dist-County-Route} 5900 Folsom Boulevard

Sacramento, CA 95819

The {Manufacturer} representatives whose signatures are below certify that this lot of thermoplastic meets or exceeds the requirements in Section 84-2 of the 2018 and 2022 Standard Specifications, and all the specification requirements in the current State Specification listed above.

Attach a certificate of compliance and test results from an independent laboratory for each lot of intermixed glass beads used in the thermoplastic formulations.

### Batch Test Results

<table>
<thead>
<tr>
<th>Quality Characteristic</th>
<th>Test Method</th>
<th>Date Tested</th>
<th>Test Result</th>
<th>Tested By</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brookfield Thermosel Viscosity, 20 rpm, 375°F, Poise</td>
<td>CT 423</td>
<td></td>
<td></td>
<td></td>
<td>≤ 2</td>
</tr>
<tr>
<td>Hardness, Shore A-2 Durometer 115°F</td>
<td>CT 423</td>
<td></td>
<td></td>
<td></td>
<td>20-65</td>
</tr>
<tr>
<td>Yellowness Index, white only, max</td>
<td>CT 423</td>
<td></td>
<td></td>
<td></td>
<td>8</td>
</tr>
</tbody>
</table>
| Daytime Luminance Factor                     | CT 423      |             |             |           | White ≥ 80
|                                              |             |             |             |           | Yellow – 47-60               |
| Yellow Color, yellow only                    | CT 423      |             |             |           | Within color box             |
| Glass Bead Content, %                        | CT 423      |             |             |           | 30-35                        |
| Binder Content, %, min                       | CT 423      |             |             |           | 25                           |
## Intermix Glass Bead Test Results

<table>
<thead>
<tr>
<th>Quality Characteristic</th>
<th>Test Method</th>
<th>Test Results</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead content, mg/kg</td>
<td>EPA Test Method 3052 and 6010B or 6020C</td>
<td>&lt;200</td>
<td></td>
</tr>
<tr>
<td>Arsenic content, mg/kg</td>
<td>EPA Test Method 3052 and 6010B or 6020C</td>
<td>&lt;200</td>
<td></td>
</tr>
</tbody>
</table>

Certified by (person in charge of testing):

Name

Title

Executed by (authorized representative of manufacturer):

Name

Title
Manufacturer makes a batch/lot of thermoplastic

Manufacturer performs the tests designated on the COC form, they are all passing tests and manufacturer completes the form

On the same day, 22,000 lb batch and completed COC form

Ship material to the Caltrans project; Provide the COC to Caltrans staff on the project

Send a 13 lb sample and the COC to the Chemical Testing Branch. (Department acceptance testing)

Chemical Testing Branch tests the sample

Manufacturer is unresponsive and fails to resolve the issue

Fails; Notify manufacturer of failure

Passes

Rescind COC process for this manufacturer, fall back to batch by batch testing until manufacturer proves that they can meet our specification

Manufacturer resolves the issue and subsequent testing indicates the property has been fixed.