

SECTION 1600 - PAVEMENT MARKING

1601 SCOPE. This section covers the work necessary to furnish and install permanent or temporary pavement marking materials.

1602 GENERAL. The permanent pavement markings shall be installed immediately after the roadway surface is complete. The installation of the yellow markings (as required) is the first priority.

Contractor's personnel must be completely knowledgeable of all application requirements and procedures prior to product application. It is the responsibility of the Contractor to contact the supplier of the cold plastic material if questions regarding application procedures or conditions arise.

1603 GENERAL INSTALLATION AND REMOVAL. The proposed permanent markings shall be laid out by the Contractor in advance of the marking installation. Markings shall not be applied until the layout and conditions of the surface have been approved by the Engineer. If a paint line is used for layout purposes, in lieu of a chalk line or string line, the paint line shall not be wider than ½ inch in width. If wider, the paint shall be removed following the application of the final permanent marking. New markings shall match existing markings as applicable in areas abutting existing road surfaces. The surface shall be dry. All dust, debris, oil, grease, dirt, temporary markings and other foreign matter shall be removed from the road surface prior to the application of the permanent marking material.

The Contractor shall be responsible for keeping traffic off freshly applied markings until they have set sufficiently to bear traffic. Traffic control is the responsibility of the contractor and shall conform to the Manual on Uniform Traffic Control Devices (MUTCD). Failure to comply with traffic control guidelines will result in the Pavement Marking Contractor being directed to stop operations and leave the site until proper and approved traffic control has arrived and put in place on site.

Removal: Temporary pavement markings on milled surfaces scheduled to be overlaid do not have to be removed prior to performing the overlay. Permanent pavement markings installed on new asphalt surfaces shall be removed without structurally damaging the pavement or scarring the surface. The method of pavement marking tape removal shall be by high-pressure water blast, low-pressure water and sand blast, steel shot blast, or burning. Grinding or black paint covering shall not be allowed on new pavement surfaces.

1604 PREFORMED THERMOPLASTIC PAVEMENT MARKING

A. Materials: This specification is for the furnishing of retroreflective preformed thermoplastic pavement marking materials that can be adhered to asphalt pavements by means of heat fusion. The applied markings shall be very durable, oil and grease impervious and provide immediate and continuing retroreflectivity.

1. Characteristics

The preformed marking material shall consist of a resilient white and yellow polymer thermoplastic with uniformly distributed glass beads throughout its entire cross section.

Preformed words and symbols shall conform to the applicable shapes and sizes as prescribed in the latest revision of the MUTCD.

The preformed markings shall be fusible to asphalt pavements by means of the normal heat of a propane type of torch. Adhesives, primers or sealers shall not be used prior to the preformed marking application on asphalt pavements.

The preformed markings shall conform to pavement contours, breaks and faults through the action of traffic at normal pavement temperatures. The markings shall have resealing characteristics and be capable of fusing to itself and previously applied worn hydrocarbon and/or alkyd thermoplastic pavement markings.

The preformed markings shall be capable of application on new, dense and open graded asphalt wearing courses during the paving operation in accordance with the manufacturer's instructions. After application, the markings shall be immediately ready for traffic. The preformed markings shall be suitable for use for one year after the date of receipt when stored in accordance with the manufacturer's recommendations.

The preformed thermoplastic markings shall not be brittle and must be sufficiently cohesive and flexible at temperatures exceeding 50 degrees F for one person to carry without the danger of fracturing the material prior to application.

2. Composition: The retro-reflective pliant polymer thermoplastic pavement markings shall consist of a homogeneous mixture of high quality polymeric thermoplastic binders, pigments, fillers, and glass beads. The thermoplastic material must conform to AASHTO designation M 249 with the exception of the relevant differences due to the material being supplied in a preformed state.

3. Glass Beads: The markings shall contain thirty (30%) percent glass spheres, which shall conform to AASHTO M 247 Type 1, except that glass spheres shall have a minimum of seventy (70%) percent true spheres on each sieve and eighty (80%) percent true spheres overall. The glass beads must be homogeneously blended throughout the material with a securely bonded protruding exposed layer of beads that provide immediate and continuous retro-reflectivity. Curved arrows must be available without protruding glass beads if reversibility is needed.
4. Retro-reflectivity: The preformed marking shall upon application exhibit uniform adequate nighttime retro-reflectivity. At 86 degree thirty (30') feet incidence angle and 1 degree thirty (30') feet divergence angle, the markings shall have average minimum intensities of 350 millicandelas for white and 175 mill candelas for yellow as measured with a MiroLux retroreflectometer. Using a Taber Abraser with an H-18 wheel and a 4.4 ounce (125 g) load, the sample shall be inspected at 200 cycles, under a microscope, to observe the extent and type of bead failure. No more than fifteen (15%) percent of the beads shall be lost due to popout and the predominant mode of failure shall be "wear down" of the beads.
5. Color Characteristics: The thermoplastic material without glass beads shall meet the following:

White: Daylight reflectance at 45-degree/0 degree of 80% minimum

Yellow: Daylight reflectance at 45-degree/0 degree of 45% minimum

The daylight reflectance shall not change significantly when the preformed thermoplastic is properly applied to the roadway surface.

For highway use, the white markings shall contain a minimum of 8% by weight of titanium dioxide pigment to ensure a color similar to Federal Highway White, color No. 17886 Standard 595. Yellow color shall reasonably match color chip Number 13538 of Federal Standard number 595 and be lead free.

6. Skid Resistance: The surface of the preformed thermoplastic markings shall provide a minimum skid resistance value of 45 BPN when tested according to ASTM E303.
7. Thickness: The width of the supplied material shall have a minimum average thickness of 90 mils.

8. Flexibility: The preformed thermoplastic marking material shall have flexibility at 50 degrees F such that no cracking occurs in the test sample when a one (1") inch by six (6") inches sample is bent through an arc of 90 degrees at a uniform rate in 10 seconds (9 seconds per degree) over a one inch mandrel. The sample must be conditioned prior to testing at 50 + 2 degrees F for a minimum of four (4) hours. At least two specimens tested must meet the flexibility requirements at 50 degrees F for a passing result.
 9. Environmental Resistance: The applied markings shall be resistant to deterioration due to exposure to sunlight, water, oil, diesel fuels, gasoline, pavement oil content, salt and adverse weather conditions.
 10. Effective Performance Life: When properly applied, in accordance with the manufacturer's instructions, the pavement markings shall be neat and durable. The markings shall remain retroreflective and show no fading, lifting, shrinkage, tearing, roll back or other signs of poor adhesion.
- B. Installation: The markings shall be applied in accordance with the manufacturer's recommendations on clean and dry surfaces.
1. Asphalt: The materials shall be applied using the propane torch method recommended by the manufacturer.
 - a. At temperatures below 50 degrees F, the preformed thermoplastic pavement markings shall be kept as warm as possible to maintain flexibility.
 - b. Remove pavement surface moisture by holding a propane torch approximately six (6") inches above the section of asphalt using a continuous circular motion.
 - c. Heat the pavement with the torch upon placing the material to a temperature of 200 degrees F for 90 mil, and up to 300 degrees F for 125 mil materials.
 - d. Immediately after the road surface has been properly preheated, position the material with exposed bead side up and heat.
 - e. Position the torch approximately 12 inches over the marking so the flame is extended and heat is evenly applied moving the torch in a circular motion across the marking. When the correct temperature of the marking has been reached, it will turn slightly

darker or pale yellow if the material is white. Over heated or burned material shall be removed.

- f. After the entire material section has been heated and bonded to the pavement, re-heat the perimeter of the marking and the road surface to bond the edges.
 - g. If installing reversible arrows, which do not contain a top coating of glass beads, the glass spheres shall be hand applied on the molten material.
 - h. Feather the leading edge of the pavement marking with a putty knife or bevel with the torch. Leading edges are any edge that would be susceptible to snow plow blades approaching from the direction of normal travel.
2. Concrete: Entirely remove curing compound from new concrete surfaces prior to applying marking material using a method approved by the Engineer. The same application procedure shall be used as described for asphalt pavements. However, a compatible primer sealer may be applied before application to assure proper adhesion

1605 COLD PLASTIC PAVEMENT MARKINGS

A. Materials: This specification covers a white and yellow pre-formed cold plastic reflectorized pavement marking material of a type that is applied to a road surface by an inlaid, pre-coated pressure sensitive adhesive that produces an adherent reflectorized stripe of specified thickness and width and is capable of resisting deformation.

1. Characteristics: The material shall be manufactured without the use of lead-chromate pigments or other similar lead-containing chemicals.

Glass beads shall be incorporated to provide immediate and continuing retroreflection. Ceramic skid particles shall be bonded to the top layer to provide a skid-resistant surface.

Preformed word and symbol markings shall conform to the applicable shapes and sizes as outlined in the Manual on Uniform Traffic Control Devices.

The preformed markings shall be capable of being adhered to pavements by an inlaid, pre-coated pressure sensitive adhesive. A surface preparation adhesive may be used to precondition the inlay pavement surface.

The preformed marking film shall mold itself to pavement contours by the action of traffic. Following proper inlay application and tamping, the markings shall be immediately ready for traffic.

2. Composition: The retroreflective pavement marking film shall consist of a mixture of high-quality polymeric materials, pigments and glass beads distributed throughout its base cross-sectional area. A reflective layer of glass beads and a layer of skid-resistant ceramic particles shall be bonded to the top urethane-wearing surface. The urethane wear surface shall have a nominal thickness of five one thousands of (0.005") inches. The film shall have a pre-coated, shear-resistant, pressure sensitive adhesive.
3. Color: The daytime color the white film shall provide a minimum initial luminance factor, Y, of 80 and shall conform to the following chromaticity requirements. The daytime color of the yellow film shall provide an initial luminance factor, Y, in a range of 36 to 59 and shall conform to the following chromaticity requirements.

White		Yellow	
X Values	Y Values	X Values	Y Values
0.290	0.315	0.474	0.455
0.310	0.295	0.491	0.435
0.330	0.360	0.512	0.486
0.350	0.340	0.536	0.463

Measurements shall be made in accordance with ASTM #1349, using illuminant "C" and 0/45 (45/0) geometry. Calculations shall be in accordance with ASTM E308 for the 2-degree observer.

4. Reflectance: The white and yellow films shall have the following initial minimum reflectance values as measured in accordance with the testing procedures of ASTM D4061. The photometric quantity to be measured shall be coefficient of retroreflected luminance (R_L) and shall be expressed as millicandelas per square foot per foot-candle ($\text{mcd-ft}^2\text{-fc}^{-1}$).

	White			Yellow		
	86.0°	86.0°	86.5°	86.0°	86.0°	86.5°
Entrance Angle	86.0°	86.0°	86.5°	86.0°	86.0°	86.5°
Observation Angle	0.2°	0.5°	1.0°	0.2°	0.5°	1.0°
Retroreflected Luminance, R_L	700	500	400	410	250	175

5. Skid Resistance: The surface of the retroreflective films shall provide an initial minimum skid resistance value of 55 BPN as measured by the British Portable Skid Tester in accordance with ASTM E303.

The surface of the retroreflective film shall retain an average skid resistance value of 45 BPN when tested in accordance with ASTM E303, for a period of one year when installed in non-snow removal areas. The 45 BPN minimum value shall be an average of several readings taken in both the wheel track and the non-wheel track areas.

6. Tensile Strength and Elongation: The film shall have a minimum tensile strength of 150 lbs. per square inch of cross-section when measured in the direction of the length of the roll and tested in accordance to ASTM D638, except that a sample 6 inch x 1 inch shall be tested at a temperature between 70 degrees F and 80 degrees F using a jaw speed of 10 to 12 inches per minute. The sample shall have a maximum elongation of 50% at break when tested by this method.

7. Reflectivity Retention: The glass beads must be strongly bonded and not be easily removed by traffic wear. Using a Taber Abraser with an H-18 wheel and a 4.4 ounce load, the sample shall be inspected at 200 cycles, under a microscope, to observe the extent and type of bead failure. No more than 15% of the beads shall be lost due to popout and the predominant mode of failure shall be "wear down" of the beads.

8. Glass Beads: The size, quality and refractive index of the glass beads shall be such that the performance requirements for the markings shall be met. The bead adhesion shall be such that beads are not easily removed when the material surface is scratched.

The film shall have glass bead retention qualities such that when a 2-inch x 6-inch sample is bent over a ½-inch diameter mandrel, with a 2-inch dimension perpendicular to the mandrel axis, microscopic examination of the area on the mandrel shall show no more than 10% of the beads with entrapment by the binder of less than 40%.

9. Thickness: The film, without adhesive, shall have a minimum thickness of 60 mils.

- B. Installation: The Contractor shall furnish and install white and yellow permanent retro-reflectorized cold preformed plastic pavement marking

material at the location shown on the plans, in conformance with the details and material specifications included herein.

The cold plastic markings shall consist of a homogeneous, extruded, prefabricated material of specified thickness and width which shall contain reflective glass spheres uniformly distributed through-out the cross-section, and shall be applied to pavement surfaces by means of an approved inlaid process with pre-coated adhesive and pressure.

1. Procedure: Apply the tape according to manufacturer's instruction in conjunction with an approved method. Cold plastic pavement markings shall be installed as soon as practical.
2. Road conditions: Clean the surface of the road using a broom and/or high-pressure air blower. If either of these methods fails to clean the road surface, then high-pressure water wash shall be used. Road surface must be dry and all dust, dirt, debris, oil, grease and foreign material removed before applying tape.
3. Application Conditions: Road surfaces must be clean and dry, and temperatures must be above the minimum required for application of all tapes. If rainfall occurs within 24 hours prior to application, a surface moisture test (plastic wrap or roofing paper method as approved by the inspector) may be performed and approval obtained from the inspector.
 - a. Air temperature 60 degrees F and rising.
 - b. Surface temperature 70 degrees and rising.
 - c. Overnight air temperature 40 degrees F (minimum) the night before tape application.
 - d. Butt splices must be used. Do not overlap tape ends.
4. Tape Application:
 - a. Cold plastic shall be inlaid into hot asphalt and rolled in to asphalt surfaces.
 - b. Groove the pavement surface on concrete pavements prior to installation. Grooving shall be performed using a cutting head with diamond-tipped cutting blades. The groove width shall be equal to the tape width plus a maximum of two (2) inches. The depth of the groove shall be the tape thickness plus 10 mils. The bottom of the groove should have a smooth, flat surface. If a coarse tooth pattern is present, increase the number of blades and decrease the thickness of the spacers between the blades on the cutting head. Water-cool the blades as necessary on long lines. If water-cooling is used, flush the groove immediately after grooving to clean the surface.

- c. If there is a crack in the pavement, or if the tape is to be applied over a bridge expansion joint, manhole or utility box, lay the tape over the crack, joint or fitting, then cut the tape 1 inch away from the crack or joint on each side.
 - d. Apply the required surface preparation adhesive and allow to dry completely, but not over 30 minutes, before tape is applied.
 - e. Traffic must be kept off of pavement surfaces coated with a surface preparation adhesive prior to tape application. Follow manufacturer's instructions regarding the use of surface preparation adhesive.
5. Tamping: Tamp the tape thoroughly with a tamping cart with a minimum 200 pound load, three times back and forth (six passes) over each part of the tape. Start in the center of the marking and work out to the edges removing any trapped air. Do not twist or turn the tamper on the tape. Make sure all edges are firmly adhered.

1606 TEMPORARY TAPE

- A. Materials: This material shall be a pavement striping tape designed to provide reflective delineation under both dry and moderate rainfall conditions. It shall be white or yellow, and either Type I – Regular or Type II – Removable, as indicated on the drawings or specified in the Special Provisions.

The tape shall consist of glass spheres tightly embedded to a binder on a conformable backing precoated with a pressure sensitive adhesive. The striping material shall be thin, flexible, formable and following application shall remain conformed to the texture of the pavement surface. The tape shall be furnished in the color and type designated on the Plans or in the contract. The markings shall be capable of being adhered to asphalt concrete or Portland cement concrete in accordance with manufacturer's instructions without the use of heat, solvents or other additional adhesive means, and shall be immediately ready for traffic after application. The adhesive shall not require a liner or release paper. The striping material shall have a uniform appearance, free from cracks and the edges shall be true, straight and unbroken. The material shall be weather resistant and show no appreciable fading, lifting or shrinkage when applied in accordance with the manufacturer's recommendations.

1. Color and Daylight Reflectance: The daylight reflectance (ASTM E1347) of white shall be not less than 70%. The color of yellow shall be within the red and green tolerance limits of the Highway Yellow Color Tolerance Chart issued by the U.S. Department of Transportation.

2. Dimensions: The width and length shall be as shown on the Plans or in the contract. The material shall be available in rolls and there shall be no more than three splices per 50 yards of length.
 3. Packaging: The material shall be packaged in accordance with accepted commercial standards and, when stored under normal conditions, shall be suitable for use for a period of at least one year after purchase.
 4. Adhesion: The material shall adhere to asphalt and concrete surfaces when applied according to manufacturer's recommendations at surface temperatures above 50 degrees F and shall be immediately ready for traffic following application.
 5. Removability: Type II tape shall be removable from asphalt and Portland cement concrete intact or in large pieces, either manually or with a roll-up device, at temperatures above 40 degrees F without use of heat, solvent, grinding or blasting.
 6. Reflection: The white and yellow material shall be retroreflective, reflecting white or yellow respectively and shall be readily visible at night when viewed with automobile headlamps using high beams from a distance of at least 300 feet.
 7. Durability: Type II material shall maintain adhesion, show no alligating, show no signs of pulling apart, and shall suffer no more than a 25% loss of beads, sand and grit when subjected to 30,000 revolutions on a small-wheel circular track as described in ASTM E660, with the following variations or exception:
 - a. Two opposite wheels mounted with Goodyear 3.40-5 NHS Industrial Rib tires shall be used with a total load of 51.5 lbs. on each tire. Tire air pressure shall be maintained at 25 lbs. The wheels shall be mounted perpendicular to the specimens and toed out 2° to produce a slight abrading action.
 - b. Specimens shall be applied to 6-inch diameter dense-graded bituminous concrete surface which has been compacted at 3000 psi for two minutes. After application, the specimens shall be allowed to cure at least 16 hours before beginning the test.
- B. Installation: Temporary pavement markings shall be installed the same day that the existing pavement markings are damaged, removed or covered up prior to lane opening. Temporary pavement markings shall be installed using the same cycle length as the permanent markings

and be at least 2 feet long. Double yellow marking shall be used for temporary centerline and single white markings shall be used for temporary lane lines on four lane roadways. Single yellow markings shall be used for temporary centerline on two lane roadways as directed by the Engineer. Contractor shall maintain temporary markings in good condition until overlying pavement or permanent markings are installed, or project completion if required.