

CITY OF MEMPHIS – STANDARD CONSTRUCTION SPECIFICATIONS
SECTION 02760 PAVEMENT MARKINGS

PART 1 - SCOPE

1.01 Pavement markings are painted or plastic markings applied to the street surface for regulating, warning, or guiding traffic on the street. The work covered by this section shall consist of furnishing and supplying pavement markings in accordance with these Specifications and the latest revision of the Manual on Uniform Traffic Control Devices for Streets and Highways (MUTCD) published by the Tennessee Department of Transportation and in conformity with the lines, dimensions, patterns, locations, and details shown on the Plans or established by the Owner.

1.02 This Section describes the general and specific requirements for conventional and rapid dry pavement marking paint, reflective hot plastics, reflective cold preformed plastics, pliant polymer film, sheeting or tape, powder pavement marking materials, glass beads for reflective pavement marking paint and plastics, and raised reflective pavement markers used by the City in its pavement marking program.

PART 2 - MATERIALS AND EQUIPMENT

The methods of sampling and testing all materials and products covered by this specification shall be in accordance with the latest standards of the American Society for Testing Materials, the American Association of State Highway and Transportation Officials, the Federal Government, or of other recognized standardizing agencies as indicated for each material.

2.01 MATERIALS

A. Conventional Reflective Pavement Marking Paint (Type "A" Paint).

This describes the general and specific requirements for reflective pavement marking paints to be used by the City in its pavement marking program. This covers ready mixed paint products of spraying consistency suitable for use as reflecting pavement markings on Portland cement concrete or asphaltic concrete pavements. The paint type relative to drying time hereinafter shall be referred to as conventional paint – over 3 minutes drying time (requiring line protection devices).

1. General Properties.

a. Condition and Stability.

The paint shall be homogeneous, shall be well ground to a uniform and smooth consistency and shall not skin or settle badly, nor cake, liver, thicken, curdle or gel in the container. The paint shall be capable of being broken up and mixed without difficulty by use of a paddle and shall show the desired characteristics at any time within a period of 6 months from the date of delivery. The paint shall be tested in accordance with ASTM D 869 and D1309 and a paint rated below six (6) shall be considered unsatisfactory.

b. Foreign Matter.

The paint shall be free from skins, dirt and other foreign matter and shall not contain more than 1 percent water. The paint shall be tested in accordance with methods 4081, 4091 and 4092 of Federal Test Method No. 141.

c. Suitability to Application.

The paint shall be suited to application by means of spray type pavement marking equipment used by the City and when used with such equipment shall be capable of producing a solid, full width line of the required thickness.

d. No Tracking Time.

The conventional paint, when applied with glass spheres to dry concrete or bituminous pavement surface under normal field conditions at the required application rates with pavement temperature between 35⁰F and 45⁰F and under all humidity conditions suitable for applying paint, shall dry to a no tracking condition in 45 minutes. The no tracking time shall

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be determined by passing over the line in a simulated passing maneuver with a passenger car after the expiration of above time. A line showing no visual paint deposition to the pavement surface when viewed from a distance of 50 feet shall be considered as showing no tracking and conforming to the requirements for field drying conditions. The paint may also be tested in accordance with ASTM D 711 and when so tested, shall dry to no pickup in 30 minutes.

e. Viscosity.

The conventional paint, as received, shall have a consistency determined on the Stormer Viscosimeter and expressed as Krebs Units at 77⁰ of 70-80 K.U. Any paint which changes consistency within six months after receipt so that the consistency falls outside the viscosity limits stated above shall be considered to have failed this requirement.

f. Color.

The paint shall visually match the Federal Highway Administration color tolerance chart for standard highway yellow or white. The color determination shall be made after the paint has dried for 24 hours on premix as received and on combination and drop-on types after the beads have been dropped in. The paint shall not contain any organic coloring matter and shall not discolor in sunlight.

g. Bleeding.

When tested and evaluated on both tar and asphalt substrates in accordance with the Method of Laboratory Test for Degree of Resistance of Traffic Paint to Bleeding, ASTM D 969, and The Method of Evaluating Degree of Resistance of Traffic Paint to Bleeding, ASTM D 868, the numerical rating of degree of bleeding shall not be less than six (6). Paints will be tested for bleeding with the prescribed quantity of glass spheres in or on the paint.

h. Hiding Power.

The pigmented binder, when tested in accordance with Method 4121 of Federal Test Method 141, "Dry Opacity," and when applied at the rate of 10 mils wet film thickness over a Mostest Black and White Hiding Power Chart, Form 03-B, shall show complete hiding or give a contrast ration of not less than 0.98 between the reflectance of the black and of the white chart surfaces as determined by a Hunter Multipurpose Reflector.

2. Packaging.

Paint purchased under this Specification for regular use by the City shall be shipped in clean, open headed pails of 5 gallons capacity, sealed, vapor proof, and meeting current Interstate Commerce Commission requirements. Each container shall be plainly marked, both on the head and side, with a durable, weather resistant ink or paint, showing the name and address of the manufacturer or vendor, description of material, purchase order number, batch number and volume and weight of contents.

3. Special Handling or Use Instructions.

Any special handling, storage or use instructions made necessary by the use of unusually flammable solvents shall be provided by the manufacturer.

B. Rapid Dry Reflective Pavement Marking Paint (Type "B" Paint).

This describes the general and specific requirements for reflective pavement marking paints to be used by the City in its pavement marking program. This covers ready mixed paint products of spraying consistency suitable for use as reflecting pavement markings on Portland cement concrete or asphaltic concrete pavements. The paint type relative to drying time hereinafter shall be referred to as rapid dry paint—1 to 3 minutes drying time. The rapid dry paint is heated during application to achieve uniform sprayable viscosity.

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1. General Properties.

a. Condition and Stability.

The paint shall be homogeneous, shall be well ground to a uniform and smooth consistency and shall not skin or settle badly, nor cake, liver, thicken, curdle or gel in the container. The paint shall be capable of being broken up and mixed without difficulty by use of a paddle and shall show the desired characteristics at any time within a period of six months from the date of delivery. The paint shall be tested in accordance with ASTM D 869 and D 1309 and a paint rated below six (6) shall be considered unsatisfactory.

b. Foreign Matter.

The paint shall be free from skins, dirt and other foreign matter and shall not contain more than 1 percent water. The paint shall be tested in accordance with methods 4081, 4091 and 4092 of Federal Test Method No. 141.

c. Suitability to Application.

The paint shall be suited to application by means of spray type pavement marking equipment used by the City of Memphis and when used with such equipment shall be capable of producing a solid, full width line of the required thickness.

d. No Tracking Time.

The rapid dry paint, when applied with glass spheres to dry concrete or bituminous pavement surface under normal field conditions at the required application rates with pavement temperature between 35⁰F and 45⁰F and under all humidity conditions suitable for applying paint shall dry to a no tracking condition in 60 seconds. The no tracking time shall be determined by passing over the line in a simulated passing maneuver with a passenger car after the expiration of above time. A line showing no visual paint deposition to the pavement surface when viewed from a distance of 50 feet shall be considered as showing no tracking and conforming to the requirements for field drying conditions. The paint may also be tested in accordance with ASTM D 711 and when so tested, shall dry to no pickup in 8 minutes.

e. Viscosity.

The rapid dry paint, as received, shall have a consistency determined on the Stormer Viscosimeter and expressed as Krebs Units at 77⁰ of 90-110 K.U. Any paint which changes consistency within 6 months after receipt so that the consistency falls outside the viscosity limits stated above shall be considered to have failed this requirement.

f. Color.

The paint shall visually match the Federal Highway Administration color tolerance chart for standard highway yellow or white. The color determination shall be made after the paint has dried for 24 hours on premix as received and on combination and drop-on types after the beads have been dropped in. The paint shall not contain any organic coloring matter and shall not discolor in sunlight.

g. Bleeding.

When tested and evaluated on both tar and asphalt substrates in accordance with the Method of Laboratory Test for degree of Resistance of Traffic Paint to Bleeding, ASTM D 969, and The Method of Evaluating Degree of Resistance of Traffic Paint to Bleeding, ASTM D 868, the numerical rating of degree of bleeding shall not be less than six (6). Paints will be tested for bleeding with the prescribed quantity of glass spheres in or on the paint.

h. Hiding Power.

The pigmented binder, when tested in accordance with Method 4121 of Federal Test Method 141, "Dry Opacity", and when applied at the rate of 10 mils wet film thickness over a Mostest Black and White Hiding Power Chart, Form 03-B, shall show complete hiding or give a

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contrast ratio of not less than 0.98 between the reflectance of the black and of the white chart surfaces as determined by a Hunter Multipurpose Reflector.

2. Packaging.

Paint purchased under this specification for regular use by the City shall be shipped in clean, open headed drums of 55 gallons capacity, sealed, vaporproof, and meeting current Interstate Commerce Commission requirements. Each container shall be plainly marked, both on the head and side, with a durable, weather resistant ink, or paint, showing the name and address of the manufacturer or vendor, description of material, purchase order number, batch number and volume and weight of contents.

3. Special Handling or Use Instructions.

Any special handling, storage or use instructions made necessary by the use of unusually flammable solvents shall be provided by the manufacturer.

C. Hot Extruded and Hot Spray Thermoplastics.

1. Type of Material.

This section covers thermoplastic materials suitable for use as reflecting pavement markings on Portland cement concrete or bituminous pavement. The materials shall be manufactured for application by extrusion or spraying onto the pavement in molten form with glass spheres mixed in and also dropped into the material immediately after it is applied.

2. General Characteristics.

The compound shall resist deterioration by contact with sodium chloride, calcium chloride or other chemicals used to prevent roadway ice, or because of the oil content of pavement materials or from oil droppings or other effects of traffic. In the plastic state, materials shall be free of fumes which are toxic or otherwise injurious to persons or property. The material shall withstand deterioration if held at the plastic temperature for a period of four hours, or by reason of three reheatings to the plastic temperature. The temperature versus viscosity characteristics of the plastic material shall remain constant through up to three reheatings and shall be the same from batch to batch. The color shall be stable for at least three reheatings and between batches. To insure the best possible adhesion, the compound, as specified, shall be installed in a melted state at the temperature recommended by the manufacturer, and the material shall retain its color if kept at this temperature for up to four hours.

a. Foreign Matter.

The binder shall consist of a mixture of resins, at least one of which is solid at room temperature. The total binder content of the thermoplastic compound shall be a minimum of 15 percent and a maximum of 35 percent by weight. The pigmented binder shall be well dispersed and free from all skins, dirt, foreign objects or such ingredients as will cause bleeding, staining, or discoloration. The filler shall be a white calcium carbonate silica or an equivalent filler with a compression strength of 5,000 pounds per square inch (34.5 MPa).

b. Suitability for Application.

The thermoplastic material shall be a product especially compounded for traffic markings. The markings shall remain intact under normal traffic conditions at temperatures below 140^oF (60^oC). The markings shall have a uniform cross-section. Pigment shall be evenly dispersed throughout the material. The density and character of the material shall be uniform throughout its thickness. The stripe shall maintain its original dimensions and placement. The exposed surface shall be free from tack and shall not be slippery when wet. The material shall not lift from the pavement in freezing weather. Cold ductility of the material shall be such as to permit normal movement with the road surface without chipping or cracking.

c. Drying Time.

The drying time shall follow a characteristic straight line function, the lower limits of which are

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2 minutes maximum at 50⁰F (10⁰C), the upper limits of which are 15 minutes at 90⁰F (32.2⁰C), both temperatures measured as surface temperatures. After application and proper drying time, the material shall show no appreciable deformation or discoloration under local traffic conditions or in air and/or road temperatures ranging from -20⁰F to 120⁰F (-30⁰C to 50⁰C).

d. Reflectorization.

During manufacture, reflectorizing glass spheres shall be mixed into the material as follows by weight of the material; Extruded Thermoplastic -- 20 percent minimum to 50 percent maximum. Hot Spray Thermoplastic -- 20 percent minimum to 30 percent maximum. Glass spheres shall also be automatically applied to the surface of the material at a uniform rate of approximately 6 pounds (2.72 kg) of glass spheres of every 100 square feet (9.29 m²) of line.

These glass spheres shall be dropped or sprayed onto the thermoplastic material while it is in a molten state immediately after it has been applied to the pavement. Required properties of glass spheres used in hot thermoplastic installations are described in Specification Section 02760 Paragraph 2.01 J.

3. Physical Requirements.

a. Color.

The color shall conform to the following when tested by Federal Test Method Standard 141 Method 4252;

White: Federal Color Chip No. 37875 (Fed. Std. No. 595).

Yellow: Federal Color Chip No. 33535 (Fed. Std. No. 595).

b. Water Absorption.

Materials shall have a maximum of 0.5 percent by weight of retained water when tested by ASTM D 570. "Water-Absorption of Plastics", procedure (A).

c. Softening Point.

Materials shall have a softening point of 190⁰F (87.8⁰C) minimum, as determined by ASTM E 28, "Method of Test for Softening Point by Ring and Ball Apparatus".

d. Specific Gravity.

Specific gravity of the thermoplastic compound, at 77⁰f (23.2⁰C), shall be from 1.6 to 2.3.

e. Impact Resistance.

Impact resistance shall be a minimum of 10 inch pounds (1.13J) at 77⁰F (23.2⁰C) after the material has been heated for four hours, at application temperature and cast into bars of 1 inch (2.54cm) cross-sectional area, 3 inches (7.62 cm) long and placed with 1 inch (2.54 cm) extending above the vice in a cantilever beam (Izod type) tester using the 25 inch-pound (2,825 J) scale. This instrument is described in ASTM D 256.

f. Abrasion Resistance.

The material shall show a maximum loss of 0.5 grams when subjected to 200 revolutions on a Taber Abraser at 77⁰F (23.2⁰C) using H-22 calibrate wheels weighted to 500 grams. The panel for this test will be prepared by forming a representative lot of material at a thickness of 125 mils (3.175 mm) on a 4 inch square (25.8 cm²) monel panel 0.050 inch (1.27 mm) thick, on which a suitable primer has been applied. The wearing surface shall be kept wet with distilled water during the test.

4. Packaging.

a. The material shall be delivered in containers of sufficient strength to permit normal handling during shipment and transportation on the job without loss of material. Each container when filled shall weigh a minimum of 21 pounds (9.59 kg) and a maximum of 52

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pounds (23.6 kg).

b. Each unit container shall be clearly and adequately marked to indicate the color of the material, the process batch number or other similar manufacturer's identification, the manufacturer's name, address of the plant and the date of manufacture.

D. Cold Thermoplastics.

1. Type of Material.

This section covers reflectorized cold thermoplastic materials preformed into rolls or ribbons of various lengths and widths or other specified shapes suitable for use as reflecting pavement markings on Portland cement concrete or bituminous pavement.

2. General Characteristics.

a. Reflectorized cold plastic pavement marking material shall consist of homogeneous, extruded, prefabricated thermoplastic ribbon of specified thickness and width of either white or yellow color and shall contain reflective glass spheres uniformly distributed throughout the entire cross-section that shall be capable of being affixed to nonbleeding bituminous or Portland cement concrete pavements. The reflectorized material shall be of the plastic, cold flow type.

b. The reflectorized cold plastic pavement marking material shall consist of the following components with maximum and minimum composition by weight tolerances as shown:

	Maximum	Minimum
Plastics and Plasticizers	46%	40%
Pigments	42%	38%
Glass Spheres	18%	14%

c. Pigments shall include titanium dioxide conforming to the requirements of ASTM D 476 for white plastic material and CP medium chrome yellow conforming to the requirements of ASTM D 211 for yellow materials. Reflective glass spheres shall contain the physical properties described in Specification Section 02760 Paragraph 2.01 H.

d. When extruded, the reflectorized cold thermoplastic material without precoated adhesive shall be 0.09 inch thick, with a tolerance of plus or minus 5 percent. The edges shall be clear cut and true. The cold plastic material may be supplied complete with a precoated, factory applied adhesive backed with a protective release paper so as to make possible immediate pavement application without the use of heat, solvent, or other types of adhesive operations or it may be furnished with separate adhesives as recommended by the manufacturer. Whether the adhesive is precoated or supplied separately, the adhesive shall be such as to allow the cold thermoplastic material to be repositioned on the pavement surface to which it is applied before permanently fixing it in its final position with a downward pressure.

3. Physical Requirements.

a. Bend Test No. 1 (With Precoated Adhesive).

The plastic shall be of such a structure that at a temperature of 80°F, a piece of 3 inch x 6 inch material (with paper backing) placed upon a 1 inch diameter mandrel, may be bent over the mandrel until the end faces are parallel and 1 inch apart. By visual inspection, there shall be no fracture lines apparent in the uppermost surface.

b. Bend Test No. 2. (Without Paper Backing).

A piece of plastic 6 inch x 12 inch in size (paper backing removed) when balanced upon a supported ½ inch diameter mandrel, reflective side up, and left in this position at a

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temperature of 80⁰F, shall have flexed out of its own weight at the end of eight hours into an inverted “V” position with the free ends at an angle of not more than 30⁰ from the vertical. The uppermost surface of the plastic shall show no fracture or breaks. Upon removing the plastic from the mandrel, the material should be firmly but not abruptly returned to a semi-flat position with the reflective side down. The plastic, at a temperature of 80⁰F on a smooth, flat, glass surface, shall have returned to its original flat condition in not more than 8 hours.

c. Tensile Strength.

Employing ASTM D 638, the plastic shall have a tensile strength of 300 psi plus or minus 100 psi. The elongation shall be no greater than 50 percent. The tensile strength calculations should be based on the minimum measured thickness of the test specimen. The rate of pull of the test shall be 0.25 inch per minute. The test shall be conducted at a temperature of 70⁰ to 80⁰ F using a strip of material 6 inches long and 1 inch wide.

d. Plastic Pull Test.

A 6 inch long by 1 inch wide section of the thermoplastic material shall support a dead load weight of 6 pounds for not less than thirty minutes. This test shall be conducted at a temperature of 70⁰ to 80⁰ F.

e. Glass Sphere Retention.

A 2 inch specimen of thermoplastic material shall be cut at right angle to the beveled edge and bent parallel to the beveled edge on a ½ inch diameter mandrel. While the specimen is bent, a strip of ½ inch wide masking tape shall be applied firmly along the length of the area of maximum bend and then removed. Retention of any glass spheres on the masking tape when the tape is removed shall be cause for rejection of the material

f. Gloss.

The plastic material shall have a maximum 60⁰ gloss of 10 units as measured in accordance with ASTM D 523.

g. Abrasion Resistance.

The plastic material shall have a maximum loss in weight of 0.25 grams in 500 revolutions when abraded according to Federal Test Method Standard No. 141 (Method 6192), using H-18 calibrate wheels with 1,000 gram load on each wheel.

4. Suitability for Application.

a. The cold thermoplastic material shall be capable of application to nondefective pavement surfaces that are free from dirt or other foreign matter and at a temperature of 60⁰F or more.

b. Adhesive, activators, or special coatings for various types of pavement surfaces shall be provided with the thermoplastic material. Detailed information must be supplied with the thermoplastic material outlining required application procedures for such adhesives, activators, or special coating.

c. Cold plastics shall be capable of being applied to new asphaltic pavement immediately prior to the final rolling of the new surface and of being rolled into place with conventional pavement and highway rollers. The plastic material and adhesives used in such applications shall be of the type that water used on the road roller to prevent asphalt pickup shall not be harmful to the successful application of the plastic.

5. Packaging.

The cold thermoplastic strips shall be supplied in rolls or strips of specified lengths (usually 150 feet), of the width specified, except for standard symbols and words. Rolls or strips shall be packaged in cartons suitable to allow for easy dispensing.

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E. Pliant Polymer Films.

1. Type of Material.

This section covers reflectorized pliant polymer film materials processed into rolls or ribbons of various lengths and widths or other specified shapes suitable for use as reflecting pavement markings on Portland cement concrete or asphaltic concrete pavement.

2. General Characteristics.

a. Reflectorized pliant polymer film shall consist of a laminated retroreflective coating of glass beads bonded to a conformable resilient pliant polymer film white or yellow in color which is protected on the reverse side by a protective liner. This liner is removed before application. The marking film shall have reflective elements uniformly dispersed throughout and when properly applied using a specially designed contact cement shall conform and adhere to asphaltic concrete and portland cement concrete surfaces.

b. Color shall be white and yellow, consistent with normal highway use.

c. The normal thickness of the marking films shall be available as follows:

White	Yellow
0.06" (1.5mm)	0.06" (1.5mm)

3. Physical Requirements.

a. The marking film shall have the following average minimum brightness values at 0.2° and 0.5° observation angles and 86° entrance angle, measured in accordance with the photometric testing procedure in Federal Specification FP-74, Section 718.01 (a), except that the brightness values shall be expressed as candlepower per foot candle per 5 sq. ft. panel (2-1/2 feet by 2 feet (0.76 m x 0.61 m)). The five square feet is derived from a standard stripe, defined as 4 inches by 15 feet = 5 sq. ft. (10.1 cm by 4.57 m = 0.46 sq. meters).

b. Brightness Values (candle power per foot candle per 5 sq. ft.)

	White		Yellow	
Observation Angle	0.2°	0.5°	0.2°	0.5°
Entrance Angle – 86°	0.20	0.15	0.15	0.10

4. Suitability for Application.

The marking film shall adhere to asphaltic concrete and Portland cement concrete surfaces when applied according to the manufacturer's recommendations at pavement surface and ambient air temperatures down to 50°F (10°C) when daily temperatures above 70°F are prevailing to ensure film conformance and adherence to pavement surface. Following application the marking film shall be ready for traffic. Areas of minor damage may be readily patched with an inlay of this film in accordance with the manufacturer's recommendation.

5. Durability.

The marking film, when applied in accordance with the manufacturer's recommended procedures, shall provide a neat, durable marking maintaining the original design and configuration. Although the reflectivity will be reduced by wear, the film shall provide a cushioned resilient substrate to reduce bead crushing and loss. The film shall be weather resistant and through normal traffic wear shall show no appreciable fading, lifting or shrinkage throughout the useful life of the marking, and shall show no significant tearing, roll back, or other signs of poor adhesion. Applied

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as recommended the marking film shall be expected to have an effective performance life, under normal conditions, of 3 years.

6. Packaging.

The pavement marking film as supplied shall be of good appearance, free of cracks, and the edges shall be clean cut and well defined. The film and contact cement shall be packaged in standard commercial containers in accordance with commercially accepted standards. These materials as supplied may be stored at normal temperatures for a period of one year after purchase.

F. Sheeting and Tape.

1. Type of Material.

This section covers reflectorized sheeting or tape materials processed into rolls of various lengths and widths or other specified shapes suitable for use as reflecting pavement markings on Portland cement concrete or asphaltic concrete pavement.

2. General Characteristics.

Reflectorized sheeting or tape shall consist of a white or yellow, weather and traffic resistant reflective film on a conformable backing precoated with a pressure sensitive adhesive. The adhesive shall be protected by a removable liner. Color shall be white or yellow as specified for pavement markings. The average thickness of the sheeting or tape shall be 0.03 inch.

3. Physical Requirements.

a. Reflectivity.

(1) The white and yellow sheeting or tape shall be retroreflective reflecting white or yellow respectively, shall be readily visible when viewed with automobile headlights at night, and shall have the following minimum reflective values at 0.2° and 0.5° divergence angles measured in accordance with the photometric testing procedures of Federal Specification LS-300A, "Sheeting & Tape, Reflective; Nonexposed Lens Adhesive Backing", Para. 4.4.7 or as amended. Reflective values shall be expressed as candlepower per foot candle per square foot (candelas per lux per square meter) measured on a 5 sq. ft. panel (2-1/2 feet by 2 feet) at an 86° incidence angle. The 5 sq. ft. is derived from a standard stripe, defined as 4 inches by 15 feet = 5 square feet. From this the 2-1/2 feet x 2 feet panel used is for convenience in testing and comparison.

Reflectivity Value (candle power per foot candle per square foot)

Divergence Angle	White		Yellow	
	0.2°	0.5°	0.2°	0.5°
Incidence Angle 86°	0.20	0.18	0.18	0.16

(2) A 2-1/2 feet x 2 feet panel, completely covered with either white or yellow pavement marking sheeting, shall be placed, reflective side up, in a horizontal pan sufficiently high above the pan side (or edge) so that the reflective pan shall be completely in view for measurement. The panel shall be tipped at an angle of 4° to the horizontal bottom of the pan for drainage. The entire panel shall be quickly flooded with clean water and allowed to drain. The minimum reflective value expressed as candlepower per foot candle per square foot shall be measured between 15 and 30 seconds after the panel starts to drain.

The minimum reflective values shall be as follows:

Reflectivity Value (candle power per foot candle per square foot)

Divergence Angle	White		Yellow	
	0.2°	0.5°	0.2°	0.5°

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Incidence Angle 86⁰ 0.10 0.09 0.09 0.08

b. Adhesive and Liner.

(1) The marking material shall have a precoated pressure sensitive adhesive and require no activation. The adhesive shall be protected, prior to application, with a removable liner to prevent contamination during processing, cutting, and handling. The liner shall release from the adhesive easily, without splitting or tearing, and shall not shrink or prematurely release from the adhesive during processing, storage or handling.

(2) Test pieces of the marking material shall be applied according to manufacturer's instructions and tested in accordance with ASTM D 1000, Method D, with two exceptions:

(a) A stiff, short bristle, roller type, tamper brush shall be substituted for the weighted rubber roller used to roll the test strips onto the metal test panel. The stiff, short bristles, shall be required to produce a tamping action between the beads to assure maximum contact of the marking material adhesive to the metal panel. Heavy pressure shall be exerted on the brush when rolling the sample.

(b) The beaded surface of the marking test pieces shall be covered with a thin tape not over 1 inch wide to prevent interference with or locking of the beads when the test piece is bent back 180⁰ on itself for the adhesion test.

c. Application Properties.

The material shall adhere to asphalt and concrete surfaces when applied to manufacturer's recommendations at surface temperatures down to 35°F (2°C) and shall be immediately ready for traffic following application.

d. Conformability.

The marking material shall be thin, flexible, formable, and following application shall remain conformed to the texture of the pavement surface.

e. Thickness.

The average thickness of the material, excluding liner, shall be determined by taking 5 micrometer readings (using micrometer with approximately ¼ inch anvil and spindle) on a sample applied to an aluminum panel and deducting the thickness of the aluminum panel. The average thickness of 5 readings shall not be less than 20 mils nor more than 45 mils.

f. Removability.

Marking material shall be removable by following the manufacturer's recommendations, if the material is substantially intact. Removal shall not require sandblast, solvent or grinding methods and shall not result in objectionable staining of the pavement surface.

g. Durability and Wear Resistance.

The pavement marking material applied to asphalt or concrete in accordance with the manufacturer's recommended procedures shall be weather-resistant and show no appreciable fading, lifting, or shrinkage during the useful life of the line. Samples of material shall be applied to 4 inch by 4 inch test panels of 0.040" aluminum, (6061-T6 alloy), prepared according to recommendations of marking material manufacturer. The applied sample shall be tested in accordance with Federal Test Method Standard No. 141, Method 6192, using a CS-17 wheel and 1000 gram load and shall not wear through to the metallic surface in less than 5000 cycles. Care shall be taken to adjust the vacuum suction for the most effective removal of the abrasings.

NOTE: Taber wheels used for this test shall have a "Shore A" Durometer hardness of

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between 76 and 86 measured according to ASTM D 2240.

4. Packaging.

a. The pavement marking material as supplied shall be of good appearance, free from cracks, and edges will be true, straight and unbroken. The marking material shall be available in precut symbols and legends as specified and as roll goods up to 48 inches in width with no more than three splices per 50 yards of length.

b. The pavement 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.

G. Striping Powder.

1. Type of Material.

This section covers ready mixed powder products of application consistency suitable for use as reflecting pavement markings on Portland cement concrete or asphaltic concrete pavement with or without liquid road surface conditioner.

2. General Properties.

a. Description.

The striping powder shall be a free flowing plastic type pavement marking material which is premixed with glass spheres for reflectorization. When flame sprayed to clean portland cement concrete and asphaltic concrete pavement road surface by a suitable mechanical striper, the striping powder shall produce an instant dry to no pickup, adherent, reflectorized stripe capable of resisting deformation by traffic. A liquid may be desired for application to some road surfaces before application of the marking powder; if so, it shall be so stated on the request for bid.

b. Suitability to Application.

(1) The powder shall be suited to application by means of flame sprayed gun type pavement marking equipment used by the City of Memphis and when used with such equipment shall be capable of producing a solid, full width line of the required thickness.

(2) The liquid road surface conditioner shall be suited to application by pressure spray gun system or by conventional paint roller.

c. Physical Characteristics of Striping Powder.

The striping powder shall be a dry mixture capable of freely flowing through the flame spray marking equipment at the rate of 14 to 18 ounces per 30 seconds when exposed to combined conditions of humidity up to 90 percent relative humidity and ambient air temperature up to 100°F. The striping powder shall require no thinning, mixing or heating prior to use and shall be satisfactorily usable at minimum road surface temperatures of 50°F and minimum ambient air temperature of 60°F.

d. Color.

The striping powder shall match the Federal Highway Administration color tolerance chart for standard highway yellow or standard highway white as required by the order. Color determinations shall be made on casts of samples melted at 200°F and poured into aluminum foil weighting dishes of the following dimensions:

Rim diameter - 58mm

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Height - 18mm

e. Particle Size.

The finished powder as supplied shall have the following grading:

U.S. Sieve No.	Percent by Weight Retained
30	0 - 2
230	93 - 100
Pan	0 - 5

f. Softening Point.

Tested in accordance with “ring and ball softening point determination” ASTM Test No. E 28, the softening point shall be from 215⁰ to 225⁰F.

g. Liquid Road Surface Conditioner.

The liquid, when specified, shall require no thinning, be easily applied, and be compatible with road surfaces and the marking powder supplied.

h. Glass Spheres.

The finished powder shall contain intermixed glass spheres.

NOTE: Representative finished powder samples, taken from a thoroughly mixed, full carton of finished powder, must be used for all glass sphere determinations.

(1) Index of refraction of glass spheres: 1.5 minimum; 1.6 maximum.

(2) Percent of weight of glass spheres: 30 percent minimum; 35 percent maximum.

Method of Determination of Percent by Weight of Glass Spheres:

- Equipment:

- Laboratory triple beam balance.
- U.S. standard screen (270) mesh.
- 400 ml. glass beaker.
- Oven at 200⁰F.

- Procedure:

- Weigh 100 grams of finished powder in 400 ml. beaker.
- Add 200 ml. of suitable solvent (alcohol, aromatic solvent, or Ketone)
- Pour solution on 270 mesh screen (flush beaker with solvent to remove all the beads).
- Wash the beads on the screen with solvent until they are clear.
- Dry in oven at 200⁰F and weigh the amount of beads recovered.
- Calculate percent of beads by:

$$\frac{\text{Wt. of Beads}}{\text{Wt. of Sample}} \times 100\% = \% \text{ of beads.}$$

(3) Grading of glass spheres.

U.S. Sieve No.	Percent by Weight Retained
40	0 - 5
70	15 - 60
230	35 - 85
Pan	0 - 15

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(4) Other Properties of Glass Spheres.

The properties of crushing resistance, roundness, index of refraction and chemical resistance shall be as required in Specification Section 02760 Paragraph 2.01 H.

3. Equipment.

Striping powder is designed for application by a light weight hand propelled striper as described in Specification Section 02760 Paragraph 2.02 D.

4. Packaging.

The finished powder shall be delivered ready for use and shall be packaged in 25 pound cartons or other acceptable containers clearly identified as to manufacturer, color, contents and quantity and shall be free of lumps, foreign particles or other matter. Cartons employed for packaging shall withstand normal handling and shall have a suitable protective interliner to resist moisture absorption. The powder, as supplied, may be stored at temperatures not to exceed 90°F for up to one year, without adversely affecting the physical properties stated in this Specification. The liquid road surface conditioner, if required, shall be delivered ready for use in one gallon containers meeting current Interstate Commerce Commission requirements.

5. Properties of Applied Powder Line.

Dispensed and properly applied by flame spray gun type striper, the finished line shall be reflective and shall adhere so as to form a smooth continuous film on both portland cement concrete and asphaltic concrete road surfaces. Minor temporary line discoloration, due to surface soot, shall be permissible on adjacent overlapping lines. Lines exhibiting surface soot shall regain full color with traffic wear. A properly applied striping powder line shall not exhibit bleeding when applied on cured asphalt surfaces. An applied line shall dry to no pickup (10 mils application) when tested in accordance with ASTM Test No. D 711. Determination shall be made by averaging a minimum of 3 no-pickup readings at each pavement temperature tested. When the pavement temperature is between 50°F and 90°F, drying time should be 10 seconds or less. When the pavement temperature is between 90°F and 140°F, drying time should be 25 seconds or less. Liquid road surface conditioner shall be easily applied by pressure spray gun or conventional paint roller with a solvent resistant sleeve with 7/16 inch nap. It shall be allowed to dry on the pavement surface for approximately 5 minutes prior to applying marking powder.

H. Glass Spheres For Reflectorization.

This section describes the general and specific requirements for glass beads to be applied with pavement marking paints and the physical properties of glass spheres to be applied with other binders to be used by the City.

1. Physical Properties for all Glass Spheres.

a. General.

Glass beads shall be clear, colorless, and clean, and of such character as to permit their embedment in a pigmented binder having their upper surface exposed to permit the refracting of light rays. The beads shall be bisymmetric bonding in that when applied to a paint, plastic, or polymer binder they shall hemispherically embed (to approximately their equator) in the binder film for maximum durability and brightness.

b. Crushing Resistance.

The crushing resistance of glass spheres shall be determined in accordance with ASTM D 1213. A 40 pound dead weight for 20 to 30 mesh spheres shall be the average resistance of the spheres tested.

c. Roundness.

The roundness of glass spheres shall be determined by ASTM D 1155. A maximum of 25 percent (by weight) shall contain irregular or fused spheroid particles

d. Refractive Index.

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The spheres shall have an average index of refraction not less than 1.50 nor more than 1.60 when tested by the liquid immersion method at 25°C.

e. Chemical Resistance.

The glass spheres shall withstand immersion in water and acids without undergoing noticeable corrosion or etching and shall not be darkened or otherwise noticeably decomposed by sulfides. The tests for chemical resistance shall consist of one hour immersion in water and in solutions of corrosive agents followed by microscopic inspection. A 3 to 5 gram portion of the sample shall be placed in each of three Pyrex glass beakers or porcelain dishes; one sample shall be covered with distilled water, one with a 3N solution of sulfuric acid and the other with a 50 percent solution of sodium sulfide. After one hour of immersion, the glass spheres of each sample shall be examined microscopically for evidence of darkening and frosting.

NOTE: The tests described in United States Federal Specification TT-P-85b, items 4.4:13; 4.4:14; 4.4:15; and 4.4:16 may be substituted for the test described above.

f. Flow Properties.

The glass spheres shall flow freely through the dispensing equipment in any weather suitable for striping.

g. Color.

The glass spheres shall be colorless to the extent that they impart no off-color day or nighttime hue to the binder when applied at normal application rates.

2. Properties Of Glass Spheres For Use With Pavement Marking Paint.

a. Gradation.

A sieve analysis of glass spheres shall be made in accordance with ASTM D 1214. Required gradations are as follows:

- (1) 5 to 20 percent passing #20; retained on #30 sieve.
- (2) 30 to 75 percent passing #30; retained on 350 sieve.
- (3) 9 to 32 percent passing #50; retained on #80 sieve.
- (4) 0 to 10 percent passing #80 sieve.

b. Flotation.

(1) A minimum of 90 percent of the flotation glass spheres shall float on xylol (aromatic solvent) and a minimum of 75 percent shall float on heptane (aliphatic solvent) when tested as follows:

(2) A single layer of spheres shall be spread on the flat center of a clean inverted pint tin can lid. Solvent shall be slowly introduced with a syringe or dropper into the circular groove at the edge of the lid until it overflows into the center. The percentage of spheres floating on the solvent surface shall be estimated visually.

3. Gradation of Glass Spheres For Use With Plastic Pavement Marking Materials.

A sieve analysis of glass spheres should be made in accordance with ASTM D 1214. Gradations of glass spheres must be approved by the Owner for use with each plastic material. Typical gradations required for various types of plastic pavement marking materials are as follows:

a. To be included in hot thermoplastic material:

- (1) 80 to 100 percent passing #60 sieve.
- (2) 0 to 10 percent passing #140 sieve.

b. For application on molten thermoplastic material:

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- (1) 90 to 100 percent passing #20 sieve.
- (2) 20 to 50 percent passing #50 sieve.
- (3) 0 to 10 percent passing #80 sieve.

- c. For cold thermoplastics and pliant polymer film:
 - (1) 100 percent passing #60 sieve.
 - (2) 0 to 15 percent passing #140 sieve.

4. Packaging.

The glass spheres shall be packaged in multiply paper, polyethelene, or burlap bags with a waterproof liner. The bags shall be strong enough to permit normal handling during shipment and transportation on the job without any loss of spheres and shall be sufficiently water resistant so that spheres will not become wet or caked during transit. The bags of glass spheres shall weigh a maximum of 60 lbs. each.

I. Raised Reflective Pavement Markers.

1. Classification.

- Type 1, One Color, Reflective Markers (Two-way Traffic).
- Type 2, One Color, Reflective Markers (One-way Traffic).
- Type 3, Two Color, Reflective Markers (One-way Traffic).

2. Description.

Reflective pavement markers shall be of the prismatic reflector type, consisting of a high impact plastic shell filled with a mixture of inert thermosetting compound and filler material. The exterior surface of the shell shall be smooth and contain one or two prismatic faces, molded to reflect incident light, from a single direction or from opposite directions. The shell shall be of one color or of a combination of two colors which will be the same as reflective elements and shall be of size and shape shown on the plans. The base of the marker shall be free from gloss or substances which may reduce its bond to the adhesive. The presence of a soft or resin film on the surface of the base will be cause for rejection.

3. Specific Intensity.

The specific intensity of each reflective surface, when tested at 0.2 degree angle of divergence, shall not be less than the following specified values:

	Clear	Yellow	Red
0 ⁰ Incidence Angle -	3.0	1.5	0.75
20 ⁰ Incidence Angel -	1.2	0.60	0.30

The following definitions and tests shall be applicable:

a. Angle of Incidence.

The angle formed by a ray from the light source to the marker, and the normal to the leading edge of the marker face.

b. Angle of Divergence.

The angle formed by a ray from the light source to the marker and the returned ray from the marker to the measuring receptor.

c. Specific Intensity.

The mean candle power of the reflected light at a given incidence and divergence angle for each foot candle at the reflector on a plane perpendicular to the incident light.

$$SI = R_L / I_L \times D^2$$

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Where: SI = Specific Intensity
R_L = Reflected Light
I_L = Incident Light
D = Test Distance

d. Test Method.

The markers to be tested shall be located with the center of the reflecting face at a distance of 5 feet from a uniformly bright light source having an effective diameter of 0.2 inch. The photocell receptor width shall be 0.05 inch and shall be shielded to eliminate stray light. The distance from the center of the light source aperture to the center of the photocell shall be 0.21 inch. If a test distance of other than 5 feet is used, the source and receptor shall be modified in the same proportion as the test distance.

4. Color.

The color of the raised reflective pavement markers when illuminated by an automobile headlight shall be clear, yellow, or red as required. Off-color reflection shall constitute grounds for rejection.

5. Load Test.

The raised reflective pavement markers shall support a minimum load of 2,000 pounds applied in the following manner: A random sample of three markers shall be selected for the load test. The markers shall be centered base down over the open end of a vertically positioned hollowed metal cylinder. The cylinder shall be one inch high, with an internal diameter of 3 inches and a wall thickness of ¼ inch. A load necessary to test the marker shall be applied at a speed of 0.2 inch per minute to the top of the marker through a one inch diameter solid metal plug centered on the top of the marker. Failure shall consist of either (1) breakage or significant deformation of the marker at a load of less than 2,000 pounds; or (2) significant delaminating of the shell and the filler material regardless of the load required to break the marker.

6. Sampling and Tolerances.

a. Sampling.

Twenty markers selected at random will constitute a representative sample for each lot consisting of 10,000 markers or less. Forty markers will constitute a representative sample for lots consisting of more than 10,000 markers. The lot size shall not exceed 25,000 markers.

b. Tolerances.

(1) At least 90 percent of the original sampling of each lot of markers shall pass all tests except the strength tests. If less than 90 percent but more than 70 percent pass all tests, a resample of that lot will be allowed at the request of the Contractor. When less than 70 percent of the markers from the original sample comply with the requirements, the lot represented by the samples will be rejected and not resample will be allowed.

(2) Should any one of the 3 samples selected for strength testing fail to comply with the strength requirements of this Specification, 6 additional samples will be tested. The failure of any one of these 6 samples shall be cause for the rejection of the entire lot or shipment represented by the samples.

7. Packing And Shipping.

Shipments shall be made in containers which are acceptable to common carriers and packages in such a manner as to ensure delivery in perfect condition. Any damaged shipments shall be replaced by the Contractor. Each package of pavement markers shall be clearly marked as to name of the manufacturer, color, type, lot number, quantity enclosed, and date of manufacture.

J. Epoxy Adhesive For Pavement Markers.

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1. General.

a. This Specification describes Type 1R epoxy adhesive (Rapid Setting Pavement Marker Adhesive) which is designed to bond plastic traffic markers to roadway and bridge surfaces. The adhesive is intended for mixing by automatic metering, mixing and application equipment. Rapid Setting Marker Adhesive must be used when pavement temperature is above 50°F.

b. The adhesive shall be furnished in two components, herein referred to as Epoxy Resin Component and Hardener Component; the two components shall be mixed 1 to 1 by volume just prior to use.

2. Component Properties.

The manufacturer shall certify by lot number the following chemical properties as determined by the designated test methods.

a. Component Resin:

- | | |
|---|----------------------|
| (1) Viscosity, Poises @ 77°F. | ASTM D 445 Note (1) |
| (2) Epoxide Equivalent (Filled and also unfilled when applicable) | ASTM D 1652 Note (2) |
| (3) Volatiles, percent by weight distilled below 350°F. | ASTM D 1078 |
| (4) Ash Content percent by weight | ASTM D 482 |

b. Component Hardener.

- | | |
|---|---------------------|
| (1) Viscosity, Poises @ 77°F. | ASTM D 445 Note (1) |
| (2) Volatiles, percent by weight distilled below 350°F. | ASTM D 1078 |
| (3) Ash content percent by weight | ASTM D 482 |

Note (1) 400 ml. sample with Brookfield Viscometer, Model LVT with specified spindle rotating at specified speed.

Note (2) Grams of material containing 1 gram equivalent of epoxide (WPE).

c. Component Ratio.

The ration of Resin and Hardener components to be mixed together to form the finished adhesive shall be 1 to 1 by volume and the components will be packaged in the proper proportions.

d. Dispersion.

All pigments, fillers, and/or thixotropic agents present in either the Epoxy Resin or Hardener component must be sufficiently dispersed so that no appreciable separatin or settling will occur during storage.

e. Nonvolatile Components.

Each component of the adhesives shall be 100 percent nonvolatiles. A test for any volatiles shall be made.

f. Color Coding.

The components shall be color coded so that visual inspection will assure homogeneous mixing. The color will be subject to approval of the Owner.

3. Mixed Components – Physical Properties

The mixed marker adhesive shall comply with the following physical requirements when tested according to the methods which are available from the Owner.

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Property	Requirements
Thixotropy – Sag Test (Maximum)	.250 inches
Gel Time or Pot Life	7 – 12 minutes

Property	Requirements
Set time (to obtain a minimum strength of 180 psi) @ 77°F or at temperature recommended by manufacturer:	40 minutes
Bond Strength (24 hours @ 77°F) (Minimum)	250 psi
Property Retention – after 5 cycles 0°F to 100°F (Minimum)	98 percent

4. Packing and Marking.

The component resin and component hardener shall be delivered in the manufacturer’s original clean, sealed containers. Each container shall bear a label with the following information shown thereon: The name and address of the manufacturer, designation (component resin or component hardener), date of manufacture, batch number (a batch shall consist of a single charge of all components in a mixing chamber), mixing instructions, a warning concerning toxicity and handling precautions.

5. Sampling.

A sample from each batch of each component shall be submitted to the City for testing. The sample shall be taken from the vendor’s stock or from the shipment to the Contractor.

2.02 APPLICATION EQUIPMENT

All equipment required for the satisfactory performance of this Work shall be on hand and approved by the Owner before execution of the Work will be permitted to begin.

A. Painting Equipment.

1. Paint shall be applied by means of a machine of the spray type capable of satisfactorily applying the paint under pressure through a nozzle spraying directly upon the pavement. The machine shall be equip[ed] with an air blast device for cleaning the pavement ahead of the painting operation, a guide pointer to keep the machine on an accurate line, and a device to agitate the paint. It shall also have a device to maintain a uniform flow and application of the paint, an automatic device to provide a broken or skip line of the length required, and a least 3 spray guns capable of being operated either individually or 2 or 3 together. The machine shall be equipped with a bead or sphere dispenser which can be regulated to dispense the spheres automatically at the uniform rate required. The equipment shall be so designed and operated as to permit traffic to pass on the roadbed with safety.

2. Each spray application machine must be equipped with an automatic counting mechanism capable of recording the number of linear feet of material applied to the roadway surface with an accuracy of 0.50%, to be checked by the Owner.

3. The equipment required for the application of conventional paints may range from simple hand or self-propelled strippers to relatively large truck mounted equipment. Paint heating equipment is not normally required for the application of this type material.

4. The application equipment for rapid dry paint shall be truck-mounted due to the pain heating equipment required. Rapid dry paints require heating to a maximum of 170°F at the spray nozzle as recommended by the manufacturer.

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B. Hot Plastic Application Equipment.

1. The equipment used to install hot extruded thermoplastic materials by contract under this Specification shall be constructed to provide continuous mixing and agitation of the material. Conveying parts of the equipment between the main material reservoir and the shaping die shall prevent accumulation and clogging. All parts of the equipment which come in contact with the material shall be constructed for easy accessibility and exposure for cleaning and maintenance. The equipment shall operate so that all mixing and conveying parts, including the shaping die, maintain the material at the plastic temperature. The use of pans, aprons or similar appliances which the die overruns will not be permitted under this Specification. The equipment shall provide for varying die widths and to produce varying widths of traffic marking. The equipment shall permit preheating of the pavement immediately prior to application of the thermoplastic material if preheating is recommended by the thermoplastic manufacturer.

2. The equipment used to install hot extruded or spray thermoplastic materials by contract under this Specification shall be constructed so as to insure continuous uniformity in the dimensions of the stripe. The thickness of the material on the pavement shall be as specified on the Plans. The applicator shall provide a means for clearly cutting off square stripe ends and shall provide a means for applying “skip” lines. The equipment shall provide for varying widths of traffic markings. The applicator shall be mobile and maneuverable to the extent that straight lines can be followed and normal curves can be made in a true arc.

3. Glass spheres applied to the surface of the completed stripe shall be applied by an automatic bead dispenser attached to the striping machine so that the beads are dispensed almost instantaneously upon the installed line. The glass sphere dispenser shall be equipped with an automatic cut-off control synchronized with the cut-off of the thermoplastic material.

4. A special kettle shall be provided for melting and heating the thermoplastic material. The kettle must be equipped with an automatic thermostatic control device for positive temperature control and to prevent overheating of the material. The heating kettle and applicator shall meet the requirements of the National Board of Fire Underwriters, of the National Fire Protection Association of the state and of the local authorities.

C. Cold Plastic Application Equipment.

Cold thermoplastics may be rolled into place with conventional pavement and highway rollers. Special equipment necessary for the successful installation of any cold thermoplastic shall be provided on a loan basis by the manufacturer of the thermoplastic material.

D. Striping Powder Application Equipment.

Striping powder is designed for application by a light weight hand propelled striper with a propane fired application gun. An external compressor capable of delivering 18 cfm at 70 psi is required for the system.

PART 3 - APPLICATION REQUIREMENTS

3.01 REFLECTIVE PAVEMENT MARKING PAINT.

A. Cleaning and painting shall be performed utilizing equipment of the kind and in the manner specified herein. On sections where no previously applied line is available to serve as a guide or if the line is to be relocated, the proposed location of the new line shall be spotted with paint in advance of the application. On tangent sections the control points shall be spaced no more than 500 feet apart and on curves at intervals that will insure the accurate location of the line. Gaps in all lines shall be left at intersections as shown in the MUTCD, or as directed.

B. No paint shall be applied over a chalk line, wire, or cord, but such guide marks shall offset the

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paint line to be placed. On sections where previously applied lines are visible, the Contractor shall use the old lines unless otherwise directed. No paints shall be applied to areas of pavement when any moisture remains on the surface, or wind conditions are such as to cause a film of dust to be deposited on the line areas after these areas have been prepared for painting.

C. Paint shall be applied so as to deposit a uniform wet film thickness of 0.015 inches, which is at the rate of 16.5 gallons per mile for a solid stripe 4 inches wide, or as recommended by the manufacturer when approved in writing by the Owner. This rate of application shall apply to all types of paint, with proper adjustment made in gallons for an intermittent line or wider lines. The quantity of paint shall not underrun the designated amount by more than 5%, and if a check of the rate of application (are of line applied per unit volume of material) indicates a greater variation than this, the work shall be stopped until the paint machine is properly adjusted or replaced. This percent of variation is set out to give the contractor some leeway in starting the job and in getting his machine in adjustment but it is not expected that there shall be either a continuous overrun or underrun but that the final figures shall indicate that the average rate application closely approaches the rate established above.

D. Rapid dry (Type "B") paint shall be heated before application to a maximum of 170⁰F at the spray nozzle or as recommended by the manufacturer.

E. Drop-on type glass beads shall be uniformly applied to the painted surface at a uniform rate of not less than six pounds per gallon of paint applied.

F. Protection of traffic lines and markings shall be provided by the Contractor. Warning and directional signs as shown on the Plans or as directed shall be placed to control traffic in the marking area. If the drying time of the material being used exceeds 60 seconds, the newly applied markings shall be protected by placing traffic cones or other approved warning devices at frequent intervals as directed. These devices shall be left on the line until the material is dry or firm enough not to track or receive impressions from normal traffic. They shall be removed as soon as possible (because of the traffic hazard) and shall never be left in the roadway overnight. If so directed, flaggers shall be provided to direct traffic.

G. The general appearance shall be that of clearly delineated lines with a minimum crooked and waving appearance, due consideration being given to the contours and roughness of the pavement. Segments of broken line strip shall square off positively at each end. The paint lines shall be without mist, drip or splatter. Lines that do not meet these requirements when placed shall be removed and/or corrected by the Contractor to the satisfaction of the Owner and without extra compensation.

H. The paint equipment shall be so operated that it will be unnecessary for traffic to cross the newly painted line behind the equipment in order to safely pass the painting machine, and traffic shall be allowed to keep moving at all times.

3.02 HOT THERMOPLASTICS.

A. The material shall be applied to the pavement by the spray method or by the extrusion method wherein one side of the shaping die is the pavement and the other three sides are contained by, or a part of, suitable equipment for heating and controlling the flow of material.

B. The material, when formed into traffic stripes, must be readily renewable by placing a thin overlay of new material directly over an old line of the same material. Such new material shall bond itself to the old line in such a manner that no splitting or separation takes place.

C. The finished lines shall have well-defined edges. The Contractor shall clean off dirt and grease where necessary by sand blasting or other approved methods.

D. A primer sealer of a type and if recommended by the manufacturer of the thermoplastic material shall be applied to the pavement surface prior to the installation of the thermoplastic material.

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E. To insure optimum adhesion, the thermoplastic material shall be installed in a melted state at a temperature of 375⁰ to 475⁰F (190⁰ – 246⁰C).

F. Longitudinal lines shall be offset at least (2) inches (5cm) from construction joints of portland cement concrete pavements.

G. Openings of (6) inch (15cm) lengths shall be provided at (20) foot (6m) intervals in edge lines placed on the inside of superelevated curves to prevent the ponding of water on the pavement surface.

H. For non-defective pavement surfaces carrying volumes less than 50,000 vehicles per day, the contractor shall guarantee to replace or renew without cost to the City that part of the pavement markings installed which have not remained to perform useful service as follows:

1. Crosswalks and Stop Lines applied at a thickness of 125 mils (3.157mm):
75% of the total of any one intersection for one year

2. Lane Lines, Edge Lines and Center Lines applied at a thickness of 90 mils (2.286mm):
80% of a unit for one year and 60% of a unit for two years. (A “unit” is defined as any length of highway having installed thereon 2,000 lineal feet (610 m) of line of specified width in any combination or pattern). Warranties for thinner lines in these applications or for traffic volumes may be reduced commensurately.

3. The replacement material installed under this guarantee shall be guaranteed the same as the original material, from the date of the original installation.

Note 1: The intent is not to extend the original warranty period.

Note 2: The warranty does not cover those markings that have been removed by such devices as snow plows, chains, or studded tires.

3.03 COLD THERMOPLASTICS.

A. The cold thermoplastic material shall be applied to non-defective pavement surfaces that are free from dirt or other foreign matter. For normal application the pavement temperature shall be 60⁰F or more. Application to be made at pavement temperatures below 60⁰F shall be approved in writing by the Owner. Special instructions shall be supplied by the vendor for application to be made at pavement temperatures below 60⁰F.

B. Adhesive, activators, or special coatings for various types of pavement surfaces provided with the thermoplastic material shall be installed according to the manufacturer’s specifications. Cold plastics may be applied to new asphaltic pavement immediately prior to the final rolling of the new surface and rolled into place with conventional pavement and highway rollers.

C. Longitudinal lines shall be offset at least 2 inches from construction joints of portland cement concrete pavements. Openings of 6 inches length shall be left at 20 foot intervals in edge lines placed on the inside of superelevated curves so as to prevent the ponding of drainage of the pavement surface.

3.04 PLIANT POLYMER FILM.

The marking film shall be applied to asphaltic concrete and portland cement concrete surfaces according to the manufacturer’s recommendations at pavement surface and ambient air temperatures 60⁰F or more and when daily temperatures above 70⁰F are prevailing to insure film conformance and adherence to pavement surface. Following application, the marking film is ready for traffic. Areas of minor damage shall be patched with an inlay of this film in accordance with the manufacturer’s recommendation.

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3.05 SHEETING AND TAPE.

Sheeting and tape material shall be applied directly to clean portland cement concrete and asphaltic concrete surfaces according to the manufacturer's recommendations at surface temperatures above 35⁰F and shall be ready for traffic immediately following application.

3.06 STRIPING POWDER.

The powder shall be flame sprayed to clean portland cement concrete and asphaltic concrete to produce a solid, full width line of the required thickness. A liquid road surface conditioner may be required for application to some road surfaces before the application of the marking powder. Liquid road surface conditioner shall be applied by pressure spray gun system or by conventional paint roller.

3.07 RAISED REFLECTIVE PAVEMENT MARKERS.

A. Raised reflective pavement markers shall be cemented to the pavement with epoxy resin adhesive spaced as shown on the Plans. Markers shall not be installed over joints in rigid type pavements.

B. The portion of the highway surface to which the marker is attached by the adhesive shall be free of dirt, curing compound, grease, oil, moisture, loose or unsound layers and any other material which would adversely affect the bond of the adhesive. Cleaning shall be done by sand blast cleaning on all pavement surfaces. The adhesive shall be placed uniformly on the cleaned pavement surface or on the bottom of the marker in a quantity sufficient to result in complete coverage of the area of contact of the marker with no voids present and with a slight excess after the marker has been pressed in place.

All markers shall be cemented to the pavement within 10 minutes after the start of mixing of any one batch of adhesive. The marker shall be placed in position and pressure applied until firm contact is made with the pavement. Excess adhesive around the edge of the marker and all adhesive obscuring the reflective surface of the marker shall be immediately and completely removed with a clean, absorbent cloth. The use of thinners or solvents or any type for this purpose is prohibited. The marker shall be protected against impact until the adhesive has hardened to the degree designated by the Owner.

C. The specified adhesive requires that mixing operation and placing of the marker be done rapidly. The pot life of the adhesive may be prolonged by cooling after mixing the components or by spreading it out in a thin layer on a board before application. Any mixed batch of adhesive which becomes viscous because of its acquiring a partial set such that the marker cannot be pressed into place with the adhesive readily extruding from the edges shall not be used.

D. Immediately prior to mixing, each component of the adhesive (Package A and B) shall be thoroughly redispersed by stirring. Any material that cannot be readily redispersed shall be rejected. After redispersion, one volume from Package A shall be mixed with one volume from Package B until a uniform gray color without visible streaks of white or black is obtained.

E. When approved fast setting adhesive is used, the components shall be mixed by a 2 component type automatic mixing and extrusion apparatus, and the markers shall be placed immediately after the adhesive has been mixed and extruded.

3.08 REMOVAL OF PAINTED MARKINGS.

A. Painted pavement markings shall be removed where specified. The method used for paint removal shall be approved by the Owner prior to the beginning of the work. Removal of existing painted pavement markings by painting over with black paint or asphalt will not be allowed.

B. When the method of removal causes sand or other material to be accumulated on the pavement, the residue shall be removed as the work progresses. Painted markings shall be removed by methods that cause the least possible damage to the pavement. All damage to the pavement or surface caused by pavement marking removal shall be repaired as directed by the Owner at the

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Contractor's expense.

C. Where a plastic marking will replace the painted marking, paint removal shall consist of removing enough paint to assure proper installation of the plastic. The paint removal shall be uniform and shall expose a minimum of 75 percent of the surface area that is to receive the plastic materials.

PART 4 – CERTIFICATION AND GUARANTEE

4.01 The Contractor shall furnish the Owner at, or before, the time of delivery, three copies of certification of conformance to the tests and requirements for traffic pavement marking materials of these Specifications. The certification shall consist of the following:

A. The name of the manufacturer of the material.

B. The batch or lot number of the material represented.

C. The test results of each required test.

D. A statement to the effect that a representative sample of the specific lot shipped has been tested and meets the requirements of these Specifications.

E. The name and title of the authorized representative of the manufacturer certifying to the correctness of the report.

F. The manufacturer shall guarantee the traffic pavement marking material supplied under these Specifications to meet all parts of these Specifications and shall agree to replace any amount of material found defective during inspection or installation of the material.

G. All replacement by the manufacturer shall be free of charge to the City, including all freight and handling charges. Material replaced under this guarantee shall, at the written request and expense of the manufacturer, be returned to the manufacturer by the City, unless said material has been installed.

PART 5 - MEASUREMENT

Accepted installed items related to pavement marking shall be measured in the units and as described herein.

All work not described herein, included removal of existing pavement marking, shall be considered incidental to the installation of pavement markings and shall not be measured separately.

5.01 RAISED REFLECTIVE PAVEMENT MARKERS.

Accepted raised reflective pavement markers of each type shall be measured by the raised reflective pavement marker complete in place, per each.

5.02 PAINTED CURB.

Accepted curb painting shall be measured in linear feet to the nearest foot along the edge of the painted curb complete in place.

5.03 SOLID BARRIER LINE (4")

Accepted solid barrier lines shall be measured in linear feet to the nearest foot along the center of each line complete in place.

5.04 BROKEN LANE LINE (4")

Accepted broken lane lines shall be measured in linear feet to the nearest foot along the center of each line including painted and unpainted portions complete in place.

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5.05 DOUBLE SOLID BARRIER LINE (4")

Accepted double solid barrier lines shall be measured in linear feet to the nearest foot along the center of each pair of lines complete in place.

5.06 DOUBLE BROKEN BARRIER LINE (4")

Accepted double broken barrier lines for reversible lanes shall be measured in linear feet to the nearest foot along the center of each pair of lines including painted and unpainted portions complete in place.

5.07 DOUBLE BROKEN / SOLID BARRIER LINE (4")

Accepted double broken / solid barrier lines for restriction of passing in one direction or two-way left turn lanes shall be measured in linear feet to the nearest foot along the center of each pair of lines including painted and unpainted portions complete in place.

5.08 DOTTED LINE (4")

Accepted dotted lines for extension of lines through intersections shall be measured in linear feet to the nearest foot along the center of each marked dot complete in place.

5.09 SOLID BARRIER LINE (12")

Accepted solid barrier lines for channelization shall be measured in linear feet to the nearest foot along the center of each line complete in place.

5.10 CROSSWALK.

Accepted crosswalk lines shall be measured in linear feet to the nearest foot along the center of each line complete in place. The boundary lines shall be measured separately.

5.11 STOP LINE.

Accepted stop lines shall be measured in linear feet to the nearest foot along the center of each line complete in place.

5.12 TRANSVERSE SHOULDER LINES.

Accepted transverse shoulder lines shall be measured in linear feet to the nearest foot along the center of each line complete in place.

5.13 CHANNELIZATION.

Accepted pavement channelization marking complete in place shall be measured in square feet to the nearest square foot for the total area, marked and unmarked, to be channelized including boundary lines.

5.14 – 5.20 PAVEMENT MARKING (DESCRIPTION).

Accepted pavement marking (description) complete in place shall be measured as described on the Plans or in the Contract Documents.

5.21 STRAIGHT ARROW.

Accepted straight arrows shall be measured by the pavement arrow complete in place, per each.

5.22 TURN ARROW.

Accepted turn arrows shall be measured by the pavement arrow complete in place, per each.

5.23 STRAIGHT-TURN ARROW.

Accepted straight-turn arrows shall be measured by the pavement marking arrow complete in place, per each.

5.24 DOUBLE TURN ARROW.

Accepted double turn arrows shall be measured by the pavement marking arrow complete in place, per each.

5.25 PAVEMENT MARKING WORD "ONLY"

Accepted word "ONLY" pavement markings shall be measured by each pavement marking word complete in

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place, per each work.

5.26 PAVEMENT MARKING WORD (DESCRIPTION).

Accepted pavement marking words as described on the Plans shall be measured by each pavement marking word complete in place, per each word.

5.27 PAVEMENT MARKING DESIGNS (DESCRIPTION).

Accepted pavement marking designs as described on the Plans shall be measured by each pavement marking design complete in place, per each design.

5.28 EXISTING STRIPING REMOVAL AS PER PLAN.

Accepted lane striping and pavement markings in place as per plan. Payment will be made for the work, completed and accepted by the Owner, at the contract lump sum price, which price shall be full compensation.

5.29 LANE STRIPING AND PAVEMENT MARKINGS IN PLACE AS PER PLAN.

Accepted removal of all existing striping as shown per plan. Payment will be made for the work, completed and accepted by the Owner, at the contract lump sum price, which price shall be full compensation.

PART 6 – PAYMENT

6.01 The unit price to be paid for pavement markings shall include the locating and layout of all pavement markings. The contract unit price shall be full compensation for accepted and installed pavement marking, complete in place, measured as described herein and shall include layout, materials, labor, equipment, tools, royalties, and other incidentals required to complete the work. Payment shall be made under the Pay Item Schedule which describes each pay item. The material of which each pavement marking except Item 02760 5.01, "Raised Reflective Pavement Markers", is to be constructed is defined by the two digits following the decimal according to the following code:

A. <u>Code</u>	<u>Material</u>
01	Conventional Reflective Pavement Marking Paint (Type "A" Paint)
02	Rapid Dry Reflective Pavement Marking Paint (Type "B" Paint)
03	Hot Thermoplastics
04	Cold Thermoplastics
05	Pliant Polymer Film
06	Sheeting and Tape
07	Striping Powder

6.02 PAYMENT WILL BE MADE UNDER:

<u>Item Number</u>	<u>Item Description</u>	<u>Pay unit</u>
02760-5.01	RAISED REFLECTIVE PAVEMENT MARKER	Each
02760-5.01.01	Raised Reflective Pavement Marker (Type I)	Each
02760-5.01.02	Raised Reflective Pavement Marker (Type II)	Each
02760-5.01.03	Raised Reflective Pavement Marker (Type III)	Each
02760-5.02.____	PAINTED CURB	Lin. Ft.
02760-5.03.____	SOLID BARRIER LINE (4")	Lin. Ft.

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02760-5.04.____	BROKEN LANE LINE (4")	Lin. Ft.
02760-5.05.____	DOUBLE SOLID BARRIER LINE (4")	Lin. Ft.
02760-5.06.____	DOUBLE BROKEN BARRIER LINE (4")	Lin. Ft.
02760-5.07.____	DOUBLE BROKEN / SOLID BARRIER LINE (4")	Lin. Ft.
02760-5.08.____	DOTTED LINE	Lin. Ft.
02760-5.09.____	SOLID BARRIER LINE (8")	Lin. Ft.
02760-5.10.____	CROSSWALK	Lin. Ft.
02760-5.11.____	STOP LINE	Lin. Ft.
02760-5.12.____	TRANSVERSE SHOULDER LINES	Lin. Ft.
02760-5.13.____	CHANNELIZATION	Lin. Ft.
02760-5.14-5.20.____	PAVEMENT MARKING (DESCRIPTION)	Each
02760-5.21.____	STRAIGHT ARROW	Each
02760-5.22.____	TURN ARROW	Each
02760-5.23.____	STRAIGHT-TURN ARROW	Each
02760-5.24.____	DOUBLE TURN ARROW	Each
02760-5.25.____	PAVEMENT MARKING WORD "ONLY"	Each
02760-5.26.____	PAVEMENT MARKING WORD (DESCRIPTION)	Each
02760-5.27.____	PAVEMENT MARKING DESIGN (DESCRIPTION)	Each
02760-5.28.____	EXISTING STRIPING REMOVAL AS PER PLAN	LumpSum
02760-5.29.____	LANE STRIPING & PAVEMENT MARKNGS IN PALCE AS PER PLANING REMOVAL AS PER PLAN	Lump Sum

END OF SECTION 02760

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