

**City of Sioux Falls**  
**Standard Specifications**  
**for**  
**Pavement Marking**  
**Section 633**

Adopted: September 3, 2008

City of Sioux Falls  
Public Works/Engineering  
224 West Ninth Street  
P.O. Box 7402  
Sioux Falls, SD 57117-7402

**633.1 DESCRIPTION**

This work consists of furnishing and applying pavement marking materials and surface grooving of Portland cement concrete pavement or asphalt concrete pavement.

**633.2 MATERIALS**

Materials shall conform to the following:

**A. Traffic Paint**

The finished paint shall be smooth and homogeneous, free of coarse particles, skins, or any other foreign materials that are detrimental to its use or appearance.

The vehicle shall be composed of a 100 percent acrylic polymer such as Rohm and Haas Rhoplex Fastrack 3427, Dow DT-250, or an approved equal.

1. **Accepted Brands of Paint:** Acceptable brands of traffic paint known to meet the quantitative and qualitative requirements outlined below are Sherwin Williams and Diamond Vogel. Alternate brands will only be allowed if they are tested by an independent facility to verify conformity to the specifications. All costs for testing shall be the responsibility of the Contractor.
2. **Manufactured Date:** The paint supplied shall be manufactured during the same calendar year that the contract work is done.
3. **Quantitative Requirements:** The finished paint shall meet the following quantitative requirements:

	<b>White</b>	<b>Yellow</b>
<i>Lead</i> , parts per million max. ASTM D 3335 or X-ray fluorescence	100	100
<i>Pigment</i> , percent by weight	60.0–62.5	58.5–61.0
<i>Pigment</i> , percent by weight; when tested in accordance with ASTM D 3723 (See Note 1)	60.0–62.5	56.1–58.6

Note 1: The residual extracted pigment upon analysis shall conform to the following quantitative compositional requirements when tested in accordance with ASTM D 1394 or ASTM D 4764.

Titanium Dioxide ASTM D 476 Type II Rutile 92% min. TiO <sub>2</sub> tested in accordance with ASTM D 1394 or ASTM D 4764	1.00 lb/gal min.	0.20 lb/gal min.
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**PAVEMENT MARKING**

**633**

<i>Total Solids</i> , percent by weight; min. when tested in accordance with ASTM D 3723	77.0	76.1
<i>Non-volatile Vehicle</i> , percent by weight vehicle; min. when tested in accordance with FTMS 141c (Method 4051.1)	42.5	42.5
<i>Consistency</i> . Krebs-Stormer Shearing rate 200 r.p.m. Grams	190 to 300	190 to 300
Equivalent K.U. when tested in accordance with ASTM D 562 (See Note 2)	80 to 95	80 to 95

Note 2: The consistency of the paint shall be within the stated specification when determined a minimum 48 hours after packaging the material.

<i>Weight per Gallon</i> , pounds minimum when tested in accordance with ASTM D 1475 (See Note 3)	13.90	13.35
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Note 3: In addition to compliance with the minimum, the weight per gallon shall not vary more than  $\pm 0.3$  lbs / gal. between batches.

<i>Fineness of Dispersion</i> Hegman Scale, min. when tested in accordance with ASTM D 1210	2 min. "B" Cleanliness	2 min "B" Cleanliness
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<i>Drying Time</i> , No Pick-Up, Minutes, max. when tested in accordance with ASTM D711, except the wet film thickness shall be $12.5 \pm 0.5$ mils. The applied film shall be immediately placed in a laboratory drying chamber maintaining the relative humidity of $65 \pm 3\%$ , the temperature $73.5 \pm 3.5^{\circ}\text{F}$ , and airflow less than one foot (1') per minute.	12 max.	12 max.
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<i>Drying Time</i> , Dry-through, Minutes max., when tested in accordance with ASTM 1640, except the wet film thickness shall be $12.5 \pm 0.5$ mils. The applied film shall be immediately placed in a laboratory drying chamber maintaining the relative humidity at $90 \pm 3\%$ , and the temperature $23 \pm 2^{\circ}\text{C}$ . The pressure exerted will be the minimum needed to maintain contact between the thumb and	120 max.	120 max.
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film. A reference-control paint will be run in conjunction with the candidate paint. Rohm and Haas formulation will be referenced-control paint.

Note 4: If either the candidate or reference-control paint exceeds the 120-minute maximum, then the candidate paint shall not exceed the dry time of the reference-control paint by more than 15 minutes.

<i>Field Drying Time, Track-Free, Minutes max.</i> When applied under the following conditions, the line shall show no visual tracking when viewed from 50 feet after driving a passenger vehicle over the line at a speed of 25-35 mph:  Fifteen mils wet film thickness Six lbs. of glass beads per gal. of paint Paint temperature at nozzle between 70 to 120°F Pavement dry, pavement temperature 50 to 120°F Relative humidity of 85% maximum	2	2
<i>Directional Reflectance, minimum.,</i> when applied at a wet film thickness of 15 mils and when tested in accordance with ASTM E 1347 (Illuminate C 2°)	85	50
<i>pH, minimum when tested</i> in accordance with ASTM E70	9.80	9.80
<i>Dry Opacity, Contrast ratio, min.,</i> when applied at a wet film thickness of 6 to 7 mils and when tested in accordance with FTMS 141c (Method 4121 Illuminate C 2°)	0.955	0.880
<i>Volatile Organic Content (VOC), max.</i> in accordance with ASTM D 3960	115 g/liter	115 g/liter
<i>Flash Point, closed cup, min.</i>	115°F	115°F

*Color:* The paint shall meet the color specification limits and luminance factors listed in Tables 1 and 2 when tested in accordance with ASTM E1347 or ASTM E1349. The paint shall not discolor in sunlight and shall maintain the colors and luminance factors throughout the life of the paint. No Bayferrox 3950, iron oxides, or other color enhancers will be permitted to achieve the color chromaticity coordinates.

Table 1\*

Color	Chromaticity Coordinates (corner points)								Min. Luminance Factor (Y %)
	X	Y	X	Y	X	Y	X	Y	
White	0.355	0.355	0.305	0.305	0.285	0.325	0.335	0.375	35
Yellow	0.560	0.440	0.490	0.510	0.420	0.440	0.460	0.400	25

\* Daytime Color Specification Limits and Luminance Factors for Pavement Markings Material with CIE 2° Standard Observer and 45/0 (0/45) Geometry and CIE Standard Illuminant D65

Table 2\*\*

Color	Chromaticity Coordinates (corner points)							
	1		2		3		4	
	X	Y	X	Y	X	Y	X	Y
White	0.480	0.410	0.430	0.380	0.405	0.405	0.455	0.435
Yellow	0.575	0.425	0.508	0.415	0.473	0.453	0.510	0.490

\*\* Nighttime Color Specification Limits for Pavement Marking Retroreflective Material With CIE 2° Standard Observer, Observation Angle = 1.05°, Entrance Angle + 88.76° and CIE Standard Illuminant A.

4. **Qualitative Requirements:** The finished paint shall meet the following qualitative requirements:

*Condition in Container—Storage Stability.* Within a period of twelve (12) months from the time of delivery and when examined in accordance with FTMS 141C (Method 3011.2), the paint shall not show excessive settling in a freshly opened full can and shall be easily redispersed with a paddle to a smooth homogeneous state. The paint shall show no undesirable characteristics to include curdling, livering, caking, gelling, or thixotropic properties, lumps, skins, or color separation. The consistency shall not change more than 5 Krieb Units from that of the original sample, the degree of settling shall have a rating of six (6) or better, and the drying time shall be as specified.

*Skinning.* The paint shall not skin within 48 hours in a three-quarter filled, tightly closed container when examined in accordance with FTS 141C (Method 3021.1).

*Flexibility and Adhesion.* The paint shall show no cracking, flaking, or loss of adhesion when tested as specified. Apply a wet film thickness of 0.005 inches with a film applicator to a 3- x 5-inch tin panel weighing 0.39 to 0.51 lbs. per sq. foot, previously cleaned with benzene and lightly buffed with steel wool. Dry the paint film at 70 to 80°F in a horizontal position for 18 hours, then bake in an oven at 122 ± 4°F (47.8 to 52.2°C) for two hours, and cool to room temperature for at least one-half hour. Bend over a 1/2-inch diameter rod and

examine, without magnification, in accordance with FMTS 141C (Method 6221).

*Water Resistance.* The paint shall show no softening, blistering, loss of adhesion, or other evidence of deterioration, other than a slight loss in gloss when tested as specified. Apply a wet film thickness of 0.015 inches with a film applicator to a clean glass plate. Dry the paint film at 70 to 80°F in a horizontal position for 72 hours. Immerse one-half of the painted plate in distilled water in a vertical position at room temperature (70 to 80°F) for 18 hours in accordance with FTS 141C (Method 6011). Remove the painted plate from the immersion liquid, allow to air dry for two hours, and then examine.

*Dilution Stability.* The paint shall be capable of dilution with water with no separation, curdling, or precipitation observed when examined in accordance with FTS 141C (Method 4203.1), such that the wet paint can be readily cleanable with only water.

*Spraying Properties.* The paint as received shall have satisfactory spraying and hiding properties when applied by either airless or air-assisted type traffic stripers to glass or metal plates at a wet film thickness of 0.015 inches.

*Bleeding.* The paint shall have a minimum bleeding ratio of 0.97 when tested in accordance with Federal Specification TT-P-1952 B. The asphalt-saturated felt shall conform to ASTM D 226 (Type I).

*Freeze-Thaw Stability.* The paint shall show no coagulation or change in consistency greater than 5 Krieb Units when tested in accordance with TT-P-1952 B.

*Heat Stability.* The paint shall show no coagulation, discoloration, or change in consistency greater than 5 Krieb Units when tested in accordance with TT-P-1952 B. The degree of settling shall have a rating of six (6) or better when evaluated in accordance with ASTM D 869.

*Abrasion Resistance.* No less than 190 liters of sand shall be required for removal of the paint film when tested in accordance with TT-P-1952 B.

The manufacturer shall submit a "Certificate of Compliance" for each batch of paint produced for use under this specification. The certification shall contain the manufacturer's code number and batch number along with the test results of each batch for weight per gallon, viscosity, drying time, percent pigment, percent vehicle, and fineness of grind.

## B. Epoxy Pavement Marking Paint

1. **General:** This specification provides for the classification of epoxy pavement marking systems by type. The plans will specify the type epoxy paint to be used.

Type I: A fast-cure material suitable for line applications but may require coning.

Type II: A slow-cure material suitable for all applications of pavement markings performed under controlled traffic conditions requiring coning.

2. **Certifications:** The manufacturer shall certify that the components meet the following requirements and shall furnish certified test results for each batch. The Contractor shall provide the Engineer with a copy of the manufacturer's product data sheet, instructions for surface preparation and material application at least one week before application work begins. Whenever the manufacturer's recommendations are more stringent than these provisions, the manufacturer's recommendations shall apply.
3. **Epoxy Material:** Furnish a two-component 100 percent solids epoxy material containing no fillers or pigment extenders. Follow the manufacturer's mixing ratio when mixing the two components. Mix the components within plus or minus 2 1/2 percent of the manufacturer's recommended mix ratio. No solvents are to be given off to the environment upon application to a pavement surface. The components, when combined, shall not contain or produce volatile solvents. Type II material shall be completely free of TMPTA (Tri-Methylol Propane Tri-Acrylate) and other multi-functional monomers. All materials shall be free of lead, cadmium, mercury, hexavalent chromium, and other toxic heavy metals as defined by the United States Environmental Protection Agency.

The Resin/Pigment component shall meet the following percentages by weight:

<b>Pigment</b>	<b>White</b>	<b>Yellow</b>
TiO <sub>2</sub> , meeting ASTM D-476, Type II	18–25	12–17
Organic Yellow		7–9
<b>Epoxy Resin</b>	75–82	74–82

Test the epoxy content of the epoxy resin in accordance with ASTM D 1652 and calculate as the Weight per Epoxy Equivalent (WPE) for both white and yellow. Determine the epoxy content on a pigment-free basis. The accepted epoxy content range (WPE) is  $\pm 50$  of the manufacturer's target value.

Ensure the Activator/Curing Agent meets the following requirements:

Test the amine value in accordance with ASTM D 2074. Ensure the total amine value meets the manufacturer's target value with the acceptance range being  $\pm 50$  of the target value.

**a. Color:**

White: The color shall be within the Chromaticity coordinates listed in Tables 1 and 2 when tested in accordance with ASTM E-1347 or ASTM E-1349

Yellow: The color shall match Federal Test Standard Number 595a, Color 13538, or shall be within the Chromaticity coordinates listed in Tables 1 and 2 when tested in accordance with ASTM E-1347 or ASTM E-1349.

**TABLE 1**

Color	Chromaticity coordinates (corner points)							
	x	Y	x	y	x	y	x	y
White	.355	.355	.305	.305	.285	.325	.335	.375
Yellow	.560	.440	.490	.510	.420	.440	.460	.400
w								
Color	Y values %							
	With Glass Beads		Without Glass Beads					
	Min	Max	Min	Max				
White	60	--	70	--				
Yellow	30	--	35	--				
w								

Table 1: Daytime Color Specification Limits for Pavement Markings Material with CIE 2° Standard Observer and 45/0 (0/45) Geometry and CIE D65 Standard Illuminant

**TABLE 2**

Color	Chromaticity coordinates (corner points)							
	1		2		3		4	
	x	y	x	y	x	y	x	y
White	.480	.410	.430	.380	.405	.405	.455	.435
Yellow	.575	.425	.508	.415	.473	.453	.510	.490

Table 2: Nighttime Color Specification Limits for Pavement Marking Retroreflective Material With CIE 2° Standard Observer and Observation

Angle =  $1.05^\circ$ , Entrance Angle =  $88.76^\circ$  (beta angle 2 and epsilon =  $0^\circ$ ) and CIE Standard Illuminant A

- b. **Shelf Life:** The individual components shall not require mixing prior to use when stored for a period of 12 months or less.
- c. **Adhesion Capabilities:** When the adhesion of the material to Portland cement concrete (the concrete shall have a minimum of 300 psi. tensile strength (2,070 kPa)) is tested in accordance with the American Concrete Institute Committee 503 testing procedure, the failure of the system must take place in the concrete. The concrete shall be a minimum of  $90^\circ\text{F}$  ( $32^\circ\text{C}$ ) when the material is applied, after which the material shall be allowed to cure for 72 hours at  $73^\circ\text{F} \pm 5^\circ\text{F}$  ( $23^\circ\text{C} \pm 2^\circ\text{C}$ ).
- d. **Abrasion Resistance:** When the abrasion resistance of the material is tested in accordance with ASTM C 501 with a CS-17 wheel under a load of 1,000 grams for 1,000 cycles, the wear index shall be no greater than 82. (The wear index is the weight in milligrams that is abraded from the sample under the test conditions.)
- e. **Hardness:** The Type D durometer hardness of the material shall not be less than 75 nor more than 90 when tested in accordance with ASTM D 2240 after the material has cured for 72 hours at  $73^\circ\text{F} \pm 5^\circ\text{F}$  ( $23^\circ\text{C} \pm 2^\circ\text{C}$ ).
- f. **Tensile Strength:** The tensile strength of the material, when tested in accordance with ASTM D 638, shall not be less than 6,000 psi. (42 MPa) after 72 hours cure at  $73^\circ\text{F} \pm 5^\circ\text{F}$  ( $23^\circ\text{C} \pm 2^\circ\text{C}$ ).
- g. **Compressive Strength:** The compressive strength of the material, when tested in accordance with ASTM D 695, shall not be less than 12,000 psi (83 MPa) after 72 hours cure at  $73^\circ\text{F} \pm 5^\circ\text{F}$  ( $23^\circ\text{C} \pm 2^\circ\text{C}$ ). The rate of compression of these samples shall be no more than 1/4 inch (6 mm) per minute.
- h. **Weather Resistance:** Apply the mixed epoxy, both white and yellow, at 15 mils  $\pm 1$  mil thick to 3- x 6-inch (75 mm x 150 mm) aluminum panels. Do not apply beads to the epoxy sample. Expose the cured sample in an Environmental Test Chamber meeting the requirements of ASTM G 53. Conduct the test for 80 hours at  $122^\circ\text{F}$  ( $50^\circ\text{C}$ ), alternating four-hour cycles of condensation and ultraviolet light.

### C. Glass Beads

Glass beads for use with pavement marking paint shall be moisture resistant and shall meet the requirements of AASHTO M 247, Type I. The glass beads shall be without floatation properties. The glass beads shall have dual surface treatment

consisting of a moisture resistant silicone treatment, and silane adherence surface treatment. The glass beads shall have a minimum of 80 percent true spheres. Roundness shall be tested in accordance with SD 510.

#### D. Cold Applied Plastic Pavement Markings and Legends

This material shall consist of a homogeneous mixture of resins, plasticizers, fillers, pigments, and glass beads. The marking material shall be designed to adhere to bituminous and Portland cement concrete pavements. All cold-applied plastic pavement markings and legends shall be Type A unless otherwise specified.

Type A reflectorized plastic pavement marking shall consist of a homogeneous, extruded, prefabricated, pliant polymer material of specified thickness and width, which shall contain abrasion-resistant ceramic or ceramic coated beads bonded in a highly durable polyurethane topcoat. The material shall be fabricated with a patterned surface that presents a near vertical face to traffic to maximize retroreflectance. The pavement marking material shall be capable of being affixed to the pavement surface by means of a precoated, pressure-sensitive adhesive.

An adhesive activator supplied by the manufacturer shall be utilized on applications of this material when required by the product specification, except on newly installed asphalt when the surface temperature is 80°F or above, or when the material is inlaid at the time asphalt is being installed.

An acceptable brand of Cold-Applied Plastic Pavement Marking material known to meet the specific requirements outlined below is 3M Series 380I ES. Alternate brands will only be allowed if they are tested by an independent facility to verify conformity to the specifications. All costs for testing shall be the responsibility of the Contractor.

#### Type A Specific Requirements:

- 1. Reseal Test:** The plastic marking material shall reseal to itself when tested. Cut two 1" x 3" pieces of plastic. Overlap these pieces face-to-face for an area of 1 square inch on a flat steel plate with the adhesive backing material remaining in place. Center a 2.2 lb weight over the 1 square inch overlap area and place in an oven at 190°F for one hour. After cooling to 77°F, the pieces shall be inseparable without tearing.
- 2. Pull Test:** The plastic shall require a pull of 8 to 20 pounds to break. The elongation shall be no greater than 50 percent. The specimens for this test shall be Type 1 prepared in accordance with ASTM D 638. One-inch square pieces of carborundum extra coarse emery cloth, or its equivalent, may be applied at each end of the test specimens to prevent the plastic adhesive from adhering to the test equipment. The break resistance shall be based on an average of at least three samples, and the rate of pull shall be 1/4 inch per minute. This test shall be conducted at a temperature of 70°F to 80°F.

3. **Support Test:** A test specimen cut to dimension of 1 inch by 6 inches shall support a dead load of 6 pounds for 30 minutes. This test shall be conducted at a temperature of 70°F to 80°F.
4. **Color:** The plastic marking material shall meet the color specification limits and luminance factors listed in Tables 1 and 2 when tested in accordance with ASTM E1347 or ASTM E1349. The plastic marking material shall maintain the color and luminance factors provided in the following tables throughout its service life.

**Table 1**

Color	Chromaticity Coordinates (corner points)								Luminance Factor (Y %)	
	X	Y	X	Y	X	Y	X	Y	Minimum	Maximum
White	0.355	0.355	0.305	0.305	0.285	0.325	0.335	0.375	35	
Yellow	0.560	0.440	0.490	0.510	0.420	0.440	0.460	0.400	25	
Red	0.480	0.300	0.690	0.315	0.620	0.380	0.480	0.360	6	15
Blue	0.105	0.100	0.220	0.180	0.200	0.260	0.060	0.220	5	14

**Daytime Color Specification Limits and Luminance Factors for Pavement Markings Material with CIE 2° Standard Observer and 45/0 (0/45) Geometry and CIE Standard Illuminant D65**

**Table 2**

Color	Chromaticity Coordinates (corner points)							
	1		2		3		4	
	X	Y	X	Y	X	Y	X	Y
White	0.480	0.410	0.430	0.380	0.405	0.405	0.455	0.435
Yellow	0.575	0.425	0.508	0.415	0.473	0.453	0.510	0.490

**Nighttime Color Specification Limits for Pavement Marking Retroreflective Material with CIE 2° Standard Observer and Observation Angle = 1.05°, Entrance Angle + 88.76° and CIE Standard Illuminant A**

**633.3 CONSTRUCTION REQUIREMENTS**

- A. **General:** Traffic control for the pavement marking operations shall be in conformance with the MUTCD. Unless otherwise specified, all costs for traffic control shall be considered incidental to the various pavement marking bid items.

Any pavement markings not conforming to the specifications shall be removed. The removal shall be accomplished using suitable sand blasting, water blasting, or grinding equipment unless the Engineer authorizes other means. The removal process shall remove at least 90 percent of the deficient line with no excessive scarring of the existing pavement. The removal width shall be 1 inch wider all around the nominal width of the pavement marking to be removed. Removal shall be at Contractor’s expense with no cost incurred by the City.

**B. Cold-Applied Plastic Pavement Marking and Legends:**

1. **Width Tolerance:** Width shall be as specified with a tolerance of  $\pm 1/8$  inch.
2. **Surface and Air Temperature:** The surface and air temperature shall meet the requirements of the manufacturer's specifications.
3. **Bonding:** To ensure a uniform bond of material to asphalt or concrete surfaces after initial laydown, rolling of the material with a truck wheel, car wheel, or heavy hand roller is required.
4. **Pavement Condition:** Pavement must be dry, free of dirt, dust, and oily substances.
5. **Lane Lines:** Lane lines shall not be placed over a longitudinal pavement joint and shall not be installed closer than 1/2 inch or more than 1 1/2 inches away from the joint. Lane lines shall not deviate more than 1 inch per 200 feet, nor shall any deviations be abrupt.
6. **Waste Disposal:** It shall be the responsibility of the Contractor to provide for disposal of empty material cartons, liner papers, etc.
7. **Molding and Sealing:** The material shall mold to the pavement contours, breaks, and faults by the action of traffic. The material shall have resealing characteristics, which enable the material to fuse with itself and with previously applied marking materials of the same composition without externally applied tackifiers or adhesives.
8. **Prefabrication:** Prefabricated legends and symbols shall conform to the applicable shapes and sizes as outlined in the MUTCD.
9. **Application Instructions:** The manufacturer shall supply proper application instructions and shall identify activators and adhesives which are to be used. A copy of the application instructions shall be provided to the Engineer prior to use. The plastic markings shall be manufactured and packaged in a manner which will permit storage at normal temperatures for up to one year after purchase.
10. **Uniformity:** The material shall have a uniform cross section and be free of air inclusions and other film abnormalities.
11. **Thickness:** The material shall be a minimum of 0.060 inch thick when measured without the precoated adhesive.
12. **Deterioration:** Material must exhibit no significant deterioration due to exposure to climatic conditions, sunlight, water, oil, gasoline, or salt.

13. **Serviceability:** Material must be free of ragged edges, die line, cracks, discolorations, and other defects, which would affect serviceability.

**C. Inlay on Asphalt Surface Installation Requirements:**

1. **Surface Temperature:** Surface temperature of the asphalt shall not be less than 120°F or more than 150°F.
2. **Application:** Plastic pavement marking shall not be applied until compaction of the asphaltic mixture has been completed and all residual moisture has evaporated.
3. **Initial Contact:** Pressure by foot or light hand roller shall be applied to ensure initial contact with the surface.
4. **Final Rolling:** Final inlay shall be accomplished with the use of a 5- to 10-ton tandem roller.
5. **Rolling Procedure:** The roller motion shall be slow at all times, and shall not be reversed when wheels are on the marking material. The roller shall run straight at all times. Turning or twisting of roller wheels on the material shall not be permitted.
6. **Use of Water:** Water shall be shut off or reduced to a minimum on roller wheels when rolling in pavement marking material.

**D. Pavement Marking Paint and Beads:** Pavement marking paint shall be applied by machine. On special areas and markings that are not adaptable to machine application, hand application will be permitted.

The paint shall be used as furnished by the manufacturer. Thinner or diluent shall not be added. Filling tanks, pouring paint, or cleaning of equipment shall not be allowed on the pavement.

The pavement marking shall be applied during daylight hours when the ambient air temperature is above 45°F and the road surface is dry. The pavement shall be cleaned of dirt, loose stones, and other foreign material before the paint is applied.

The paint applicator shall be a self-propelled spraying machine with nozzles capable of applying a minimum of three lines at one time, each gun applying 4 to 8 inches wide.

During pavement marking operations on sections of roadway open to traffic, the Contractor shall protect the markings from tracking either by placing suitable traffic control devices or by utilizing a shadow vehicle. The work shall be arranged such that half of the traveled roadway will be open to traffic at all times.

The Contractor shall take the steps necessary to assure that the permanent pavement markings will match the markings on the existing surface.

The Contractor shall sweep the street within 24 hours prior to the application of the paint.

**Tolerances:**

1. The length of the painted stripe shall not vary more than plus or minus 3 inches from the plans requirement.
2. The width of the painted stripe shall not vary more than plus or minus 1/2 inch from the plans requirement.
3. The length of a 40-foot cycle length (stripe and gap) shall not vary more than 3 inches.
4. The alignment from the plans requirement or existing markings shall not vary more than plus or minus 2 inches.
5. The maximum longitudinal deviation from the existing markings at either end of the painted roadway segment shall not vary more than plus or minus 6 inches.
6. Lane lines shall not deviate more than 1 inch per 200 feet, nor shall any deviations be abrupt.

Any markings that deviate outside these tolerances will be removed and replaced by the Contractor at no cost to the City. Removal shall be performed utilizing equipment that is not detrimental to the final surface, as required by the Engineer.

The pavement marking paint shall be applied at a minimum wet thickness of 15 mils, equivalent to a dry thickness of 7 to 8 mils (A 4 inch wide stripe 320 feet long equals 1 gallon of paint at 15 mils thick or 105 square feet equals 1 gallon of paint at 15 mils thick). Glass beads shall be applied on the wet paint line at a minimum of 6 pounds of glass beads per gallon of paint. Restriping of pavement markings to meet this requirement and to provide a quality retroreflective line shall be at the expense of the Contractor with no additional cost to the City. Sections to be restriped shall be determined by the Engineer.

The paint shall be capable of being applied at paint temperature up to 160°F. When applied with glass beads at pavement temperatures above 45°F and at relative humidities of up to 75 percent, the paint shall dry to a no-track condition within three minutes.

- E. Groove Pavement for Pavement Marking:** Grooving will only be required for longitudinal pavement marking tape. Grooving will not be required for transverse pavement markings such as stop bars or crosswalks, arrows, or words. The

equipment shall be capable of performing uniform grinding for alignment and depth.

The grooving shall be performed by a self-propelled machine equipped with gang-mounted blades on a turning head. The equipment shall be capable of grooving the total width of the groove in one pass or be capable of grooving uniform depths with multiple passes. The equipment shall be capable of grooving double lines simultaneously or parallel lines to a uniform depth with two passes.

The grooving shall be performed within the following tolerances:

	Minimum Dimension	Allowable Variation
Depth of Groove	Material Thickness	+10 mils
Width of 4" Groove	4 1/2"	± 1/8"
Width of 6" Groove	6 1/2"	± 1/8"
Width of 8" Groove	8 1/2"	±1/8"
Width of 12" Groove	12 1/2"	±1/8"
Width of 24" Groove	24 1/2"	± 1/8"
Length of Skip Lines	10'6"	± 3"
Tapers at Ends of Lines	6" to 9"	
Between Double Lines	4"	± 1/2"

Lane lines shall not be placed over a longitudinal pavement joint and shall not be installed closer than 1/2 inch or more than 1 1/2 inches away from the joint. Lane lines shall not deviate more than 1 inch per 200 feet, nor shall any deviations be abrupt.

Priming and tape application shall only be performed on dry clean pavement in weather conditions acceptable to the Engineer and according to the pavement marking tape manufacturer recommendations. If the groove is exposed to traffic or adverse weather conditions overnight, the Contractor shall sand blast the groove prior to priming and applying tape.

## F. Epoxy Pavement Marking Paint

1. **Equipment:** Equipment furnished shall be designed to apply an epoxy pavement marking material and glass reflectorizing beads in a continuous or intermittent line pattern. The equipment shall be capable of placing stripes on the left and right sides. The left carriage shall be capable of placing two lines simultaneously with either line in a solid or intermittent pattern in yellow or white. The equipment shall be capable of accumulating the footage of paint applied per gun, individually, each day; and the gallons of paint applied each day. Only material application shall activate the footage accumulators. The readout shall be digital and shall not be adjustable. The equipment shall accurately meter the two components. The equipment shall produce and maintain the mixing head temperature meeting the manufacturer's

specifications. The equipment shall be equipped with a high-pressure air blast device that cleans the surface immediately ahead of the epoxy application.

The equipment shall be capable of applying glass beads in a pressurized system at a rate of at least 25 lb./gal synchronized with the spray guns. A greater bead application rate may be necessary to meet minimum levels of retroreflectivity. All guns on the spray carriages shall be in full view of the operator(s) during operation.

The equipment in the striping train shall have permanently mounted Type C flashing arrow boards. All vehicles shall be visible to oncoming or following traffic. All traffic control items that are mounted on the equipment shall be incidental to the other contract items. No separate payment will be made.

2. **Surface Preparation for Pavement Marking:** When specified in the plans, all pavement surfaces shall be ground lightly prior to the air blast and epoxy application. Light grinding is defined as surface abrasion 15 mils to 20 mils deep to establish a roughened surface free of surface treatments, laitance, loose paint chips, loose seal aggregate, and surface impurities. If the light grinding does not remove all of the existing or temporary pavement markings, the Contractor shall increase the grinding depth sufficient to remove the existing pavement marking material. Removal depth is measured vertically from the bottom of a 3-foot or longer straight edge placed on the roadway surface to the ground surface.

Meet the following removal limits:

- a. Grind not more than 2 inches wider than the stripe.
- b. Grind no more than 4 inches from the beginning or end of the stripe.
- c. Remove the remains of existing pavement marking.

Immediately following the surface preparation grinding, the Contractor shall broom the surface and vacuum up the removed residue with a vacuum truck or pickup broom.

3. **Application:** Pavement markings shall be placed in accordance with the details shown in the plans. When the epoxy pavement marking paint is to be placed over existing pavement markings, the surface preparation and the placement of the pavement markings shall be directly over the existing pavement marking patterns on the street. This requirement supersedes the 40-foot cycle standard. Markings shall not be applied when the wind or other conditions cause a film of dust to be deposited on the pavement surface before the material can be applied.

The Contractor shall place necessary control points for striping and to indicate necessary starting and cutoff points.

The epoxy material application shall be preceded by an air blast, minimum pressure of 100 psi, and shall immediately follow the pavement grinding. Placement of epoxy materials shall be only on clean, dry pavement with air and pavement temperatures at least 50°F and rising.

The Engineer may require brooming to ensure a clean, dry pavement surface free of deleterious material. All costs of brooming shall be incidental to the other contract items. No separate payment will be made.

Tracking of applied pavement marking will not be allowed. The Contractor shall adjust the pavement marking operation to prevent tracking. The "no-tracking" time shall be determined by passing over the line with a passenger car or pickup truck at a speed of 25 to 30 mph in a simulated passing maneuver. A line showing no visual deposition of the material to the pavement surface when viewed from a distance of 50 feet shall be considered as showing "no-tracking" and conforming to the requirement for time to "no-track."

All material heated over 140°F shall be discarded.

Glass beads shall be applied immediately after the placement of the epoxy.

The Contractor shall complete the painting application on all areas that have had the existing pavement marking removed by the end of each workday.

#### 4. Minimum Application Rates and Retro-reflective Values

- a. **Epoxy Application Thickness:** 20 mils  $\pm$ 2 mils wet film thickness.
- b. **Glass Beads:** Glass beads shall be applied at a rate of at least 25 lb./gal. A greater bead application rate may be necessary for meeting minimum levels of retro-reflectivity.
- c. **Retro-reflective Values:** Ensure the pavement markings have the following minimum retro-reflective values (measured using a 30-meter geometry unit) once the loose beads are removed from the line:

White: 310 mcd/m<sup>2</sup>/lux

Yellow: 190 mcd/m<sup>2</sup>/lux

#### 5. Application Tolerances:

The length of the painted stripe shall not vary more than plus or minus 3 inches from the plans requirement.

The minimum width of the painted stripe shall be its nominal width as required in the plans with 1/2 inch greater than nominal width allowed

provided the variation is gradual and does not detract from the general appearance.

The alignment from the plans requirement or existing markings shall not vary more than plus or minus 2 inches in 80 feet.

The maximum longitudinal deviation from the existing markings at either end of the painted roadway segment shall not vary more than plus or minus 6 inches.

6. **Retro Reflective Testing:** The Contractor will be required to furnish a portable or mobile retroreflectometer conforming to 30-meter geometry to take retro-reflectivity readings on the pavement marking lines. The Contractor will be required to coordinate this testing with the Engineer and City Traffic Engineering personnel. City Traffic Engineering personnel will accompany the Contractor and will randomly select a minimum of two test locations per quarter mile from each of the street segments painted. The Engineer may order additional testing. Retro-reflectivity readings will be taken on each line at each test location. Segments not meeting the minimum requirements will be required to be corrected by the Contractor. No additional payment will be made for this testing and the costs to perform this work shall be considered incidental to the epoxy paint installation.

#### 633.4 METHOD OF MEASUREMENT AND BASIS OF PAYMENT

- A. **Cold-Applied Plastic Pavement Marking:** Cold-applied plastic pavement marking of the width and color specified will be measured by the foot. Pavement marking of each width specified will be paid for at the contract unit price per foot. Payment will be full compensation for all material, labor, equipment, and incidentals necessary.

Measurement and payment for cold applied plastic pavement marking arrows and messages will be per each type specified. Payment will be full compensation for all material, labor, equipment, and incidentals necessary.

Measurement and payment for cold-applied plastic pavement marking used for areas shall be to the nearest square foot. Payment will be full compensation for all material, labor, equipment, and incidentals necessary.

- B. **Pavement Marking Paint and Beads:** Measurement and payment for pavement marking paint will be as specified in the plans. Paint and beads will be measured to the nearest one-half gallon of paint or to the nearest foot of the width and color of paint specified. Paint and beads will be paid for at the contract unit price per gallon for each color of pavement marking paint or to the nearest foot of the width and color of paint. Payment will be full compensation for furnishing paint and beads and for labor, equipment, and incidentals necessary.

Measurement and payment for pavement marking paint and beads used for arrows and words will be per each type specified. Payment will be full compensation for furnishing paint and beads and for labor, equipment, and incidentals necessary.

Measurement and payment for pavement marking paint and beads used for areas shall be to the nearest square foot. Payment will be full compensation for furnishing paint and beads and for labor, equipment, and incidentals necessary.

- C. Groove Pavement for Pavement Marking:** Groove pavement for pavement marking will be measured to the nearest foot, along the length of the groove for the width of grooving specified in the plans. Grooving will be paid for at the contract unit price per foot for the width of groove specified. Payment will be full compensation for equipment, labor, materials, and all incidentals required.

- D. Epoxy Pavement Marking Material:** Measurement and payment for epoxy pavement marking material will be as specified in the plans. Epoxy paint and beads will be measured to the nearest one-half gallon of paint or to the nearest foot of the width and color of paint specified. Epoxy paint and beads will be paid for at the contract unit price per gallon for each color of epoxy pavement marking paint or to the nearest foot of the width and color of paint. Payment will be full compensation for furnishing the epoxy paint and beads and for labor, equipment, and incidentals necessary.

Measurement and payment for epoxy pavement marking material and beads used for arrows and messages will be per each type specified. Payment will be full compensation for furnishing the epoxy paint and beads and for labor, equipment, and incidentals necessary.

Measurement and payment for epoxy pavement marking material and beads used for areas shall be to the nearest square foot. Payment will be full compensation for furnishing the epoxy paint and beads and for labor, equipment, and incidentals necessary.

- E. Surface Preparation for Pavement Marking:** Surface preparation for pavement marking will be measured to the nearest foot, along the length of the groove for the width of grooving specified in the plans. Surface preparation for pavement marking will be paid for at the contract unit price per foot for the width of surface preparation. Payment will be full compensation for equipment, labor, materials, and all incidentals required.

Measurement and payment for surface preparation for pavement marking used for arrows and messages will be per each type specified. Payment will be full compensation for equipment, labor, materials, and all incidentals required.

Measurement and payment for surface preparation used for areas shall be to the nearest square foot. Payment will be full compensation for equipment, labor, materials, and all incidentals required.