# CITY OF LINCOLN, NEBRASKA, STANDARD SPECIFICATIONS

## CHAPTER 13

### TRAFFIC PAVEMENT MARKING

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CHAPTER 13

TRAFFIC PAVEMENT MARKING

13.00 GENERAL

The Contractor shall use a crew experienced in the work of installing the type of pavement marking material designated and shall supply all the equipment and materials necessary for pavement preparations and the placement of the pavement markings. At least one member of the crew installing the pavement markings, or the on-site crew supervisor, shall have satisfactorily passed the examination which accompanies the training course for Traffic Control Technician or Traffic Control Supervisor offered by the American Traffic Safety Services Association (ATSSA) or the Basic Traffic Control or Advanced Traffic Control courses offered by Nebraska’s local technical assistance program (LTAP). A copy of certification shall be submitted to the City’s Project Manager prior to the beginning of the project.

All pavement markings shall be pre-marked by the contractor. The pre-markings shall be reviewed and approved by the City’s Project Manager prior to the application of durable marking material. The Contractor shall provide 48 hours advance notice to the City’s Project Manager to review the pre-markings.

All pavement markings shall be installed prior to that segment of street being opened to traffic.

Traffic lane width and other transverse dimensions on the marking plan indicate the nominal distance from the back of curb to the center of the marking line, and between centers of marking lines.

The Contractor shall field verify the pavement marking quantities required for the project prior to purchasing material. The City of Lincoln will not be responsible for the Contractor's shortage or surplus of material.

A. MATERIALS

Certificate of Compliance: The Contractor shall furnish manufacturer’s certifications for each marking material to be supplied or used on the project. Certificates shall indicate compliance with the provisions of the Standard Specifications.

The City reserves the right to conduct testing to identify and determine the quality, characteristics, and uniformity of any material applied to the street surface.

Durable traffic pavement marking materials listed in this Standard Specification are materials which have a normal life of at least two years beyond application. The following materials are considered durable marking materials:

Thermoplastic (preformed)
Thermoplastic (molten)
Polyurea
13.00 GENERAL (Continued)

B. INSTALLATION

All pavement markings will be installed according to manufacturer specifications, pavement marking plans and Standard Specifications unless other provisions have been made with the City Project Manager. The markings shall be installed in accordance with the Manual on Traffic Control Devices (MUTCD).

Existing pavement marking materials shall be removed prior to the installation of new pavement markings. This type of pavement marking removal is considered part of the pavement marking preparation and is not a separate pay item.

Pavement marking materials shall only be placed on properly prepared surfaces. Dirt, grease, or any deleterious materials that would reduce the adhesion of the pavement marking material to the surface of which it is being applied must be removed by the Contractor before application of the new marking material.

All pavement markings shall have a uniform cross section. The density and quality of markings shall be uniform throughout their thickness. The applied markings shall have no more than 5%, by area, of holes or voids and shall be free of blisters.

The pavement markings shall be installed at the approved pre-marked alignment. Deviation from the approved alignment shall not exceed 1 inch.

Existing pavement markings are not to be used as guides for the layout of new markings, except when the plan specifies “match existing markings.”

When the temperature, humidity or other conditions exist that prevent the installation of the specified marking material, the Contractor shall install and maintain temporary paint markings or other traffic pavement markings approved by the City’s Project Manager, at the Contractor’s cost, until conditions are adequate for installation of permanent markings.

C. GROOVING

Asphalt surfaces: Asphalt shall not be grooved. The durable markings will be surface applied or applied in pre-existing grooves.

Concrete surfaces: Concrete shall only be grooved one time. If the surface where the marking material is to be applied is already grooved, additional grooving shall not be performed. If the markings are being installed on concrete that has not been grooved, the contractor will groove the concrete prior to installing the markings.

Grooved markings consist of the installation of marking material in grooves or recesses cut into the pavement surface to allow the material to be partially embedded below the general surface of the pavement.

The specified marking material shall be applied to the pavement surface within the grooved area following the standard installation method specified for that type of marking material.

The grooves shall be cut into the pavement with equipment designed and developed to recess grooves into pavement. The unit shall have a fully articulated head design that follows the contour of the pavement surface and ensures proper depth of the groove. All cut material shall be removed from the groove and surface of the pavement.
C. GROOVING (Continued)

The pavement marking shall be placed in the grooves within 24 hours of the grooves being cut. Grooves shall be clean and dry prior to applying the pavement marking.

Grooved surfaces shall meet the following:

1. Groove width: Pavement marking width +2 inch maximum
2. Groove depth: 100 mils +/- 10 mils for 125 mils thick material
   45 mils +/- 10 mils for 60 mils thick material
   35 mils +/- 10 mils for 25 mils thick material
3. Groove length: Marking material length + required grooving transition
4. Groove position: 2 inches off the joint line (per plan).

D. CLEANUP

Any material used to prepare the surface for the application of markings shall be removed by the Contractor.

Any pavement marking material that is removed shall be cleaned/removed by the Contractor. Cleaning shall be by any effective method approved by the City’s Project Manager, which completely and effectively removes old pavement markings, contaminants and loose materials.

No pavement marking equipment shall be purged in the public right-of-way.
13.01 REMOVAL

A. SURFACE PREPARATION

Existing traffic pavement markings which are in alignment with approximately the same location as proposed new pavement markings must be removed to the extent necessary to prepare the street surface for the installation of the new pavement marking material in accordance with these Standard Specifications and the material manufacturer’s recommendations. This type of pavement marking removal is considered subsidiary to the new markings and is not a separate pay item.

Methods of pavement marking removal include grinding, scraping, sandblasting, shot blasting, high-pressure water jetting, or other methods approved by the City’s Project Manager. The removal process shall not damage the pavement surface. Pavement markings shall be removed to the satisfaction of the City’s Project Manager.

Any residue remaining after removal of the marking shall be collected and removed from the project by the Contractor.

B. BASIS OF PAYMENT

Payment for the removal of existing pavement markings shall be measured or counted and paid for at the contract unit price bid, per linear foot or each, as listed in Appendix A, Standard Item Description, REMOVE MKG, LINE, < 8"; REMOVE MKG, WIDE LINE, > 8"; or REMOVE MKG, SYMBOL. Such payment shall be full compensation for removing and disposing of all material, for all labor, equipment, tools, materials, and incidentals necessary to complete the work.
13.02 PREFORMED THERMOPLASTIC

A. MATERIAL SPECIFICATIONS

1. General

These markings will be durable, skid resistant, retroreflective pavement markings suitable for use on streets or other public ways for delineation.

The markings must be a resilient white, yellow or green colored thermoplastic product, the surface of which must contain glass beads and abrasives in an alternating pattern. The markings must be resistant to the detrimental effects of motor fuels, lubricants, hydraulic fluids etc. Lines, legends and symbols are capable of being affixed to asphalt pavement and/or concrete pavement by the use of heat.

The markings must be capable of conforming to pavement contours, breaks and faults through the action of traffic at normal pavement temperatures. The markings shall have resealing characteristics, such that it is capable of fusing with itself and previously applied thermoplastic when heated.

2. Approved Material

Material must be composed of an ester modified rosin resistant to degradation by motor fuels, lubricants etc. in conjunction with aggregates, pigments, binders, abrasives, and glass beads which have been factory produced as a finished product, and satisfies the requirements of the current edition of the Manual on Uniform Traffic Control Devices for Streets and Highways. The thermoplastic material shall conform to AASHTO designation M249, with the exception of the relevant differences due to the material being supplied in a preformed state.

a. Graded Glass Beads:

The material must contain a minimum of thirty percent (30%) intermixed graded glass beads by weight. The intermixed beads shall conform to AASHTO designation M247, with minimum 80% true spheres and minimum refractive index of 1.50.

The material must have factory applied coated surface beads and abrasives in addition to the intermixed beads at a rate of 1/2 lb. (.23 kg) [± 20%] per 11 sq. ft. (1 sq. m). The surface beads and abrasives must be applied in an alternating arrangement across the surface of the material so that the surface is covered in what is best described as a “checkerboard” pattern of glass beads and abrasive materials. The abrasive material must have a minimum hardness of 9 (Mohs scale). The factory applied coated surface beads shall have a minimum of 80% true spheres, minimum refractive index of 1.50, and satisfy the following gradation:

<table>
<thead>
<tr>
<th>Size Gradation</th>
<th>Retained, %</th>
<th>Passing, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>US Mesh</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>0 - 2%</td>
<td>98 - 100%</td>
</tr>
<tr>
<td>14</td>
<td>0 - 6%</td>
<td>94 - 100%</td>
</tr>
<tr>
<td>16</td>
<td>1 - 21%</td>
<td>79 - 99%</td>
</tr>
<tr>
<td>18</td>
<td>28 - 62%</td>
<td>38 - 72%</td>
</tr>
<tr>
<td>20</td>
<td>62 - 71%</td>
<td>29 - 38%</td>
</tr>
<tr>
<td>30</td>
<td>67 - 77%</td>
<td>23 - 33%</td>
</tr>
<tr>
<td>50</td>
<td>86 - 95%</td>
<td>5 - 14%</td>
</tr>
<tr>
<td>80</td>
<td>97 - 100%</td>
<td>0 - 3%</td>
</tr>
</tbody>
</table>
13.02 PREFORMED THERMOPLASTIC (Continued)

A. MATERIAL SPECIFICATIONS (Continued)

2. Approved Material (Continued)
   
   b. Pigments:

   White: The material shall be manufactured with sufficient titanium dioxide pigment to satisfy FHWA Docket No. FHWA-99-6190 Table 5 and Table 6 as revised and corrected.

   Yellow: The material shall be manufactured with sufficient pigment to satisfy FHWA Docket No. FHWA-99-6190 Table 5 and Table 6 as revised and corrected. The yellow pigments must be organic and must be heavy-metal free.

   Other Colors: The pigments must be heavy-metal free.

   c. Heating indicators:

   The top surface of the material (same side as the factory applied surface beads/abrasives) shall have regularly spaced indents. The closing of these indents during application, shall act as a visual cue that the material has reached a molten state allowing for satisfactory adhesion and proper bead embedment, and as a post-application visual cue that the application procedures have been followed.

   d. Skid Resistance:

   The surface of the preformed thermoplastic material shall contain factory applied non-skid material with a minimum hardness of 9 (Mohs scale). Upon application the material shall provide a minimum skid resistance value of 60 BPN when tested according to ASTM E 303.

   e. Thickness

   The material must be supplied at a minimum thickness of 90 mils (2.29 mm) or 125 mils (3.15 mm).

   f. Retro reflectivity:

   The material, when applied in accordance with manufacturer’s guidelines, must demonstrate a uniform level of sufficient nighttime retroreflection when tested in accordance to ASTM E 1710. The applied material must have an initial minimum intensity reading of 275 mcd·m-2·lx-1 for white. Devices used to measure the retro reflectivity of a marking shall be calibrated in accordance with the manufacturer’s recommendations. Record of calibration may be requested by the City Project Manager.

   Note: Initial retroreflection and skid resistance are affected by the amount of heat applied during installation. When ambient temperatures are such that greater amounts of heat are required for proper installation, initial retroreflection and skid resistance levels may be affected.
13.02  PREFORMED THERMOPLASTIC (Continued)

A. MATERIAL SPECIFICATIONS (Continued)

2. Approved Material (Continued)

g. Environmental Resistance:

   The material must be resistant to deterioration due to exposure to sunlight, water, salt or adverse weather conditions and impervious to oil and gasoline.

h. Abrasives:

   The abrasives and surface beads must be applied in an alternating arrangement across the surface of the material so that the surface is covered in what is best described as a “checkerboard” pattern of glass beads and abrasive materials. The abrasive material must have a minimum hardness of 9 (Mohs scale).

B. INSTALLATION METHODS

   The materials shall be applied using methods recommended by the manufacturer. The material must be able to be applied without the use of a thermometer. The pavement shall be clean, dry and free of debris. A primer shall be used when recommended by manufacturer.

C. BASIS OF PAYMENT

   Pavement markings installed in conformance with the Plans and Standard Specifications and acceptable to the City’s Project Manager shall be measured or counted and paid for at the contract unit price bid, per linear foot or each, as listed in Appendix A, Standard Item Description, PREFORMED THERMOPLASTIC MKG, SYMBOL; PREFORMED THERMOPLASTIC MKG, RR XING ASSY; or PREFORMED THERMOPLASTIC MKG, ___ " (various widths).

   Such payment shall be full compensation for preparation of pavement surface, removing and disposing of all existing material, furnishing and installing marking materials, and for all labor, equipment, tools, materials, and incidentals necessary to complete the work.
**13.03 MOLTEN THERMOPLASTIC**

**A. MATERIAL SPECIFICATIONS**

1. General

   White and yellow reflectorized molten thermoplastic pavement marking material shall be of a type that is applied only to asphalt pavement in a molten state by mechanical means with surface application of glass beads which, upon cooling to under normal pavement temperature, produces an adherent reflectorized marking of specified thickness and width and capable of resisting deformation by traffic.

   The material shall have resealing characteristics such that it is capable of fusing with itself and previously applied marking material of the same composition to patch worn areas of previously applied material.

   The material shall not deteriorate upon contact with sodium chloride, calcium chloride, or other chemicals used to prevent formation of ice on streets, or because of the content of pavement materials, and shall be impervious to oil and grease drippings from traffic.

2. Approved Material

   The composition minimum percentages by weight are shown in Table A.

<table>
<thead>
<tr>
<th>Table A</th>
<th>Minimum Composition Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>White</td>
</tr>
<tr>
<td></td>
<td>Minimum Percentage</td>
</tr>
<tr>
<td>Binder</td>
<td>18</td>
</tr>
<tr>
<td>TiO₂ (Type 2 Rutile)</td>
<td>8</td>
</tr>
<tr>
<td>Glass Beads</td>
<td>35</td>
</tr>
<tr>
<td>Yellow Pigment</td>
<td>N/A</td>
</tr>
</tbody>
</table>

   a. The alkyd binder shall consist of maleic modified medium lead chromate pigment with a minimum of 50% lead-free content.

   b. The alkyd binder shall consist of maleic modified rosin ester and not more than 20% petroleum derived resin.

   c. The yellow pigment used shall be a heat established medium lead pigment with zero percent lead content.
13.03 MOLTEN THERMOPLASTIC (Continued)

A. MATERIAL SPECIFICATIONS (Continued)

2. Approved Material (Continued)

d. Physical Requirements:

(1) Color:

(a) The white thermoplastic shall be pure white and free from any tint. When tested with a Colorimeter, such as a Gardner Color Difference Meter, the material shall not show deviations from a magnesium oxide color standard that are greater than shown in Table B.

<table>
<thead>
<tr>
<th>Scale Definitions</th>
<th>Color Deviations</th>
<th>Sample</th>
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<tbody>
<tr>
<td>RD Reflectance</td>
<td>Magnesium Oxide Standard</td>
<td>75% Min.</td>
</tr>
<tr>
<td>a Redness-Greenness</td>
<td>0</td>
<td>-5 to +5</td>
</tr>
<tr>
<td>b Yellowness-blueness</td>
<td>0</td>
<td>-10 to +10</td>
</tr>
</tbody>
</table>

(b) The color of the yellow thermoplastic shall visually match that of FHWA PR Color #1 when tested in accordance with ASTM D 4960. The daytime reflectance values and chromaticity coordinates shall fall within the limits in Table C.

<table>
<thead>
<tr>
<th>Reflectance and Chromaticity</th>
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<tbody>
<tr>
<td>Reflectance</td>
</tr>
<tr>
<td>Chromaticity</td>
</tr>
<tr>
<td>Coordinates x,y</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

e. Color Retention: The thermoplastic materials shall maintain the color values specified herein for white and yellow after the samples are prepared and subjected to an ultraviolet light source as described in ASTM D 795. A General Electric 275-watt sun lamp (Type RS) with a built-in reflector may be substituted for the light source.

f. Water Absorption: The thermoplastic compound shall have no more than 0.5% by weight of retained water when tested in accordance with ASTM D 570.

g. Softening Point: The compound shall have a softening point of not less than 195°F (90°C), as determined by ASTM E 28.

h. Low Temperature Stress Resistance: A concrete substrate coated with a minimum of 32 square inches (206 cm2) of thermoplastic material shall be immersed in cold water for one hour; then immediately placed in an insulated cold compartment and maintained at a temperature of minus 50°F (minus 45°C) for a period of 24 hours. When removed and allowed to come to room temperature, the sample shall still adhere to the contact substrate with no cracking or flaking.
A. MATERIAL SPECIFICATIONS (Continued)

2. Approved Material (Continued)

i. Reheating: The thermoplastic compound shall maintain proper performance properties when heated four times to the application temperature. After heating to 425°F (218°C) for 6 hours while continually stirring at 50 to 100 RPM, the Brookfield viscosity shall not exceed 16,000 cps at 12 RPM.

j. Safety: In the plastic state, the material shall not give off fumes which are toxic or otherwise injurious to persons or property.

k. Specific Gravity: The specific gravity of the compound as determined by the water-displacement method shall be between 1.9 and 2.5.

l. Drying Time: When the material is applied at 400°F (204°C), the line shall be completely solid and show no effect of tracking after 15 minutes.

m. Indentation Resistance: The hardness shall be measured by a Shore Durometer, Type A-2, as described in ASTM D 2240. The durometer and the panel shall be at least 110°F (43°C). With a 4.4-pound (2 kg) load applied, the reading shall not be less than 45 after 15 seconds.

n. Abrasion Resistance: The sample shall show a maximum loss of 0.0132 pound (6 g) when tested by the blasting box method.

o. Impact Resistance: The average impact resistance of (four) separate samples shall not be less than 10.0 inch-pounds (1.13 N-m) when tested according to Method A of ASTM D 256.

p. Sealing Primer: The particular type and the proportions used shall be as recommended by the manufacturer of the thermoplastic compound.

q. Glass Beads:

(1) Refractive Index: The reflective glass beads pre-mixed into the compound and the reflective glass beads used for surface application shall have a refractive index of not less than 1.50 when tested by the liquid emersion method at 75°F (24°C).

(2) Roundness: Not less than 75% of the beads overall and not less than 70% of the beads retained on any specified sieve shall be true spheres when tested by ASTM D 1500.

(3) Heavy Metal Concentration: Glass beads shall not contain more than 75 ppm (total) of arsenic or 100 ppm (total) of lead, when tested in accordance with EPA Methods 3052 and 6010B. Other suitable x-ray fluorescence spectrometry analysis methods may be used to screen samples of glass beads for arsenic and lead.

r. Coatings: The intermix and drop-on beads shall have an adhesion promoting coating which is specific for the thermoplastic system.
13.03 MOLTEN THERMOPLASTIC (Continued)

A. MATERIAL SPECIFICATIONS (Continued)

2. Approved Material (Continued)

s. Flowing Properties:

(1) The glass beads shall flow uniformly through dispensing equipment in atmospheric humidity up to 94%.

(2) 0.22 pounds (0.1 kg) of glass beads, spread evenly and thinly in a suitable container, shall be conditioned at 75°F (24°C) for 4 hours over a solution of sulfuric acid (Sp. Gr. 1.10) in a closed desiccator. After 4 hours, the glass beads shall flow readily through a clean glass analytical funnel, 60 degrees, 0.20-inch (5 mm) diameter and 4-inch (100 mm) stem. Inside diameter of the stem shall be a nominal 1.4 inches (35 mm).

t. Adhesion Coating: The glass beads shall be coated with an adhesion promoting coating that is compatible with thermoplastic material and that passes the dansyl chloride test procedure.

u. Gradation: The intermixed and surface applied glass beads shall meet the gradation requirement in Table D.

<table>
<thead>
<tr>
<th>Table D Glass Bead Gradation</th>
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</thead>
<tbody>
<tr>
<td>Sieve Size</td>
</tr>
<tr>
<td>No. 16 (1.18mm)</td>
</tr>
<tr>
<td>No. 20 (850 µm)</td>
</tr>
<tr>
<td>No. 30 (600 µm)</td>
</tr>
<tr>
<td>No. 50 (300 µm)</td>
</tr>
<tr>
<td>No. 100 (150 µm)</td>
</tr>
</tbody>
</table>

v. Application:

(1) The surface application of beads shall be not less than 12 lbs./100 SF (0.58 kg/m²).

(2) Properties of Finished Striping and Marking Installation:

(a.) The stripe shall not be slippery when wet.

(b.) The compound shall not lift from the pavement in freezing weather.

(c.) The compound shall not deteriorate by contact with sodium chloride, calcium chloride, or oil drippings from traffic.

(d.) After application and proper drying time, the stripe shall show no appreciable deformation or discoloration under traffic at temperatures up to 140°F (60°C).

(e.) The stripe or marking shall maintain its original dimensions and placement. The exposed surface shall be free from tack. Cold ductility of the material shall be such as to permit normal movement with the street surface without chipping.
B. INSTALLATION METHODS

1. Two weeks prior to the installation of the permanent pavement markings, the Contractor shall provide a printed copy of the material manufacturer's installation procedures to the City Project Manager.

2. The Contractor shall check the pavement surface moisture each day prior to marking application. The Contractor shall place and hold a two square foot (0.2 m²) piece of clear plastic on the existing pavement for a period of 15 to 20 minutes. Remove and hold the plastic in a vertical position. If water drips from the underside of the plastic sheet, the pavement has excess moisture, do not install the pavement marking.

3. Thermoplastic material must be installed in a molten state between 395°F and 425°F (201.66°C and 218.33°C).

4. Thermoplastic material shall be installed at a thickness of 110 mils +/- 10. The initial measurement will be made above the pavement surface. The material may slightly penetrate the pavement on fresh asphalt surfaces.

5. If the material appears to be less than 100 mils thick above the pavement surface, the line will be “chipped” and checked to determine the actual thickness. If the actual thickness is less than 100 mils, the deficient portions of the line shall be ground down to no more than 0.05 inch (1.3 mm) above the pavement surface and sufficient thermoplastic and glass beads placed over the line to bring it up to the specified thickness.

6. Unless otherwise specified, pavement markings shall be MUTCD standard size. Deviations from reasonable standards of workmanship are cause for rejection.

7. Thermoplastic pavement marking material may be installed by the Extrusion Method or Ribbon Extrusion Method.

8. Equipment used for placing markings shall be manufactured for that purpose and of sufficient size and stability to ensure a smooth and straight application.

   a. A full-sized, truck-mounted unit capable of maintaining an operating speed of 3 to 5 mph (5 to 8 km/h) shall be required. It shall have the capability of automatically placing intermittent as well as continuous lines from either the left or right side of the vehicle. The vehicle shall be capable of applying either extrusion or ribbon thermoplastic in uniform dimensions and accurately following pavement irregularities.

   b. The City Project Manager may allow the use of a hand-operated or small riding machine where a limited quantity of edge and lane lines are required, or for turn lanes, gore areas or other small work, provided sufficient traffic control is in place to close the lane adjacent to the marking operations.
B. INSTALLATION METHODS (Continued)

9. Retro reflectivity:
   
a. Immediate reflectivity shall be accomplished by the application of glass beads to the surface of the marking through a gun that is located directly behind the thermoplastic applicator. The beads shall be applied into the material in a manner that will result in the surface beads being embedded to about their midpoint. Glass beads shall be applied uniformly at a minimum rate of 12 lb./100 SF (0.58 kg/m2). These beads shall be in addition to those that are provided as part of the thermoplastic mixture itself.

b. The glass bead dispenser shall be adjustable to regulate the flow of the beads and shall uniformly dispense the glass beads over the entire width of the line.

c. The beads shall adhere to the cured thermoplastic, or all marking operations shall cease until corrections are made.

C. BASIS OF PAYMENT

Pavement markings installed in conformance with the Plans and Standard Specifications and acceptable to the City’s Project Manager shall be measured or counted and paid for at the contract unit price bid, per linear foot or each, as listed in Appendix A, Standard Item Description, MOLTEN THERMOPLASTIC MKG, ___" (various widths).

Such payment shall be full compensation for preparation of pavement surface, removing and disposing of all existing material, furnishing and installing marking materials, and for all labor, equipment, tools, materials, and incidentals necessary to complete the work.
13.04 POLYUREA

A. MATERIAL SPECIFICATIONS

1. General

Polyurea shall be Epoplex LS 90 or approved equivalent. The markings shall be comprised of a polyurea coating adhered to the pavement surface and reflective media adhered to the polyurea coating. The polyurea coating shall consist of a mixture of high-quality resins, curing agent and pigments. The reflective media shall consist of glass beads.

The polyurea marking material shall be applied by spray method onto concrete pavement or asphalt pavement surfaces. Following an application of glass beads or black aggregate, and upon curing, the resulting marking shall be an adherent reflectorized pavement marking of the specified thickness and width that is capable of resisting deformation by traffic.

2. Approved Materials

a. Color and Weathering Resistance:

The mixed polyurea compound, when applied to a 3" x 6" aluminum panels at 15±1 mil in thickness with no glass beads or elements and exposed for 500 hours in a Q.U.V. Environmental Testing Chamber, as described in ASTM-G154, Cycle #1, shall conform to the following minimum requirements. The color of the white polyurea system shall not be darker than Federal Standard No. 595A-17778. The color of the yellow polyurea system shall conform to Federal Standard No. 595A-13538.

b. Track-Free Time (Laboratory):

When tested in accordance with ASTM D 711, the polyurea marking material shall reach a track-free condition in 5 minutes or less for a 15-mil thickness. This test shall be performed with AASHTO Type 1 beads coated at a rate of 0.099 pounds per square foot. The track-free time shall not increase substantially with decreasing temperature.

c. Adhesion to Concrete:

The polyurea coating, when tested according to ACI Method 503, shall have such a high degree of adhesion to the specified concrete surface that there shall be a 100% concrete failure in the performance of this test. The prepared specimens shall be conditioned at room temperature (75°± 2° F) for a minimum of 24 hours and maximum of 72 hours prior to the performance of the tests indicated.

d. Adhesion to Asphalt:

The polyurea coating, when tested according to ACI Method 503, shall have such a high degree of adhesion to the specified asphalt surface that there shall be a 100% asphalt failure in the performance of this test. The prepared specimens shall be conditioned at room temperature (75°± 2° F) for a minimum of 24 hours and maximum of 72 hours prior to the performance of the tests indicated.
A. MATERIAL SPECIFICATIONS (Continued)

2. Approved Materials (Continued)

d. Adhesion to Asphalt: (Continued)

The polyurea coating shall be formed by the reaction of two components. Neither component shall contain appreciable amounts of dilutents. The polyurea coating shall be essentially 100% solids. Volatile content of the mixed components determined by ASTM D2369 shall be less than 2%.

The polyurea coating materials shall be manufactured without the use of lead chromate pigments or other similar, lead-containing chemicals.

The white polyurea coating shall contain not less than 20% by weight rutile titanium dioxide pigment to ensure adequate opacity, hiding power and reflective properties.

The markings shall consist of white or yellow films with pigments selected and blended to conform to standard highway colors. The daytime luminance (CAP Y) of the coating without reflective media shall not be less than 80% white and 50% yellow when tested using a spectrophotometer with a 45-degree circumferential/0-degree geometry, illuminant D65, and 2-degree observer angle in accordance with ASTM E1349.

The polyurea coating, when applied to aluminum panels at 20 +/- 2 mils in thickness with no glass beads, allowed to cure for at least 72 hours, and exposed in a Q.U.V. Environmental Testing Chamber, as described in ASTM G-154-00, Cycle #2 for 1000 hours, shall conform to the following minimum requirements.

The daytime color of the white and yellow polyurea systems shall conform to ASTM D6628. The daytime luminance (CAP Y) after exposure shall differ no more than 1% when compared to the initial measurement.

The polyurea pavement marking materials, when tested according to ACI Method 503, shall have such a high degree of adhesion to the specified concrete surface that there shall be a 100% concrete failure in the performance of this test. The prepared specimens shall be conditioned at 75 degrees +/- 2 degrees for a minimum of 24 hours and maximum of 72 hours prior to performance of the tests indicated.

When tested in accordance with ASTM D711, the polyurea marking material shall reach no-track condition in 10 minutes or less for a 20 +/- 2 mils thickness. This test shall be performed with AASHTO Type 1 beads coated at a coverage of 0.119 pounds per square foot.

The polyurea pavement marking materials when tested according to ASTM D2240, shall have a shore D hardness of between 70 and 100. The mixed polyurea coating, when applied to aluminum panels of 20 +/- 2 mils in thickness, shall be allowed to cure at room temperature for at least 72 hours before testing.

The reflective media shall be made up of glass beads for drop-on application and shall conform to the following requirements or be an approved equivalent.
A. MATERIAL SPECIFICATIONS (Continued)

2. Approved Materials (Continued)

d. Adhesion to Asphalt: (Continued)

The required glass beads shall be a 60/40 blend (60% sinkers and 40% floaters) of AASHTO M 247-81 Type I gradation 1.5 index glass beads. The glass beads shall have a minimum of 70% Rounds as measured according to ASTM D1155. Crush Resistance shall be measured according to the procedures of ASTM D1213 and shall be a minimum of 30 pounds retained on US #40 Mesh.

e. Acid Resistance:

A sample of glass beads supplied by the manufacturer shall show resistance to corrosion of their surface after exposure to a 1% solution (by weight) of sulfuric acid. The 1% acid solution shall be made by adding 5.7 cc of concentrated acid into 1000 cc of distilled water.

CAUTION: Always add the concentrated acid into the water, not the reverse. The test shall be performed as follows:

Take a 1" x 2" sample, adhere it to the bottom of a glass tray and place just enough acid solution to completely immerse the sample. Cover the tray with a piece of glass to prevent evaporation and allow the sample to be exposed for 24 hours under these conditions. Then decant the acid solution (do not rinse, touch, or otherwise disturb the bead surfaces) and dry the sample while adhered to the glass tray in a 150° F (66° C) oven for approximately 15 minutes. Microscopic examination (20X) shall show not more than 15% of the beads having a formation of very distinct opaque white (corroded) layer on their entire surface.

f. On-the-road Track-Free Time:

When installed at 77° F and at a wet film thickness of 15±1 mils, the markings shall reach a no-track condition in less than 10 minutes. Track-free shall be considered as the condition where no visual deposition of the polyurea marking to the pavement surface is observed when viewed from a distance of 50 feet, after a free-rolling traveling vehicle's tires have passed over the line. The track-free time shall not increase substantially with decreasing temperature.

g. Skid Resistance:

The average initial skid resistance shall be 45 BPN or greater when tested according to ASTM E303.
13.04 POLYUREA (Continued)

A. MATERIAL SPECIFICATIONS (Continued)

2. Approved Materials (Continued)

h. Reflectance:

The initial retro reflectance averaged over many installations shall be at least 500 \([(mcd)(ft^{-2})(fc^{-1})]\) for white and 350 \([(mcd)(ft^{-2})(fc^{-1})]\) for yellow. The standard deviation of initial retro reflectance for many installations shall be no more than 130 \([(mcd)(ft^{-2})(fc^{-1})]\) for both white and yellow.

The initial retro reflectance of a single installation shall be the average value determined according to the measurement and sampling procedures outlined in ASTM D 6359, using a 30-meter retro reflectometer. The 30-meter retro reflectometer shall measure the coefficient of retroreflected luminance, RL, at an observation angle of 1.05 degrees and an entrance angle of 88.76 degrees. RL shall be expressed in units of millicandelas per square foot per foot-candle \([(mcd)(ft^{-2})(fc^{-1})]\].

The metric equivalent shall be expressed in units of millicandelas per square meter per lux \([(mcd)(m^{-2})(lux^{-1})]\).

Contractor shall notify the City Project Manager upon completion of application of pavement markings.

B. INSTALLATION METHODS

1. General

The Contractor shall furnish equipment and apply the materials according to the following Standard Specifications.

2. Equipment

The equipment shall be capable of producing markings that meet the Standard Specifications contained herein.

The equipment shall be capable of spraying the mixed polyurea components onto the pavement surface. It shall be capable of proportioning and mixing the liquid components continuously to ensure proper cure.

The equipment shall include individual material reservoirs, or space, for the storage of both liquid components. The material reservoir for one of the parts shall be provided with a means to exclude moisture, such as nitrogen blanket or air input that has been dried with a desiccant.

The equipment shall be capable of heating and maintaining the liquid component at separate, controllable temperatures to enable proper pump loading, mixing, and spraying of the material.

The applicator may be equipped with mechanical glass bead dispensing equipment capable of dispensing glass beads with air pressure after the mixed polyurea has been applied. If the applicator is not equipped to dispense beads, an alternative means of dispensing glass beads shall be required.
13.04 POLYUREA (Continued)

B. INSTALLATION METHODS (Continued)

2. Equipment (Continued)

   Equipment for applying material to the street shall be equipped with a pump stroke counter or material metering device to allow the recording of gallons of material applied through the spray gun. The Contractor shall provide this information as required and shall have the conversion factors for gallons pumped per pump stroke if necessary, as provided by the equipment manufacturer. After a measured quantity of area applied to the street is complete, this total shall be compared against the metered flow through the spray gun converted to theoretical coverage based on the recommended binder thickness provided in this Standard Specification.

   At any time throughout the duration of the project, the Contractor shall provide free access to his application equipment for inspection by the City’s Project Manager or a materials representative.

3. Application Conditions

   The markings shall be applied per manufacturer specifications to pavement that is dry and free of moisture. The street and air temperatures shall be above 40° F and rising.

   The polyurea coating shall be applied at rates to achieve 20-25 mils thickness.

   The specified glass beads shall be applied onto the liquid pavement marking immediately following application of Polyurea.

   The Contractor shall ensure proper proportioning and mixing of the polyurea components so that the markings are adequately hardened throughout and are free of soft uncured or “blackened” spots.

   The Contractor shall ensure that the polyurea coating is well adhered to the street surface, and that the beads are well adhered to the binder. The Contractor shall ensure that the beads are properly set in the polyurea coating, evenly applied according to the specified application rates. The exposed portions shall be free of the polyurea coating material.

   During the application of the polyurea material, the City’s Project Manager may require the Contractor to verify application rate in conformance with the parameters required in this Standard Specification.

C. BASIS OF PAYMENT

   Pavement markings installed in conformance with the Plans and Standard Specifications and acceptable to the City’s Project Manager shall be measured or counted and paid for at the contract unit price bid, per linear foot or each, as listed in Appendix A, Standard Item Description, POLYUREA MKG, ___" (various widths); GROOVED POLYUREA MKG, ___" (various widths); POLYUREA MKG, SYMBOL; GROOVED POLYUREA MKG, SYMBOL; POLYUREA MKG, RR XING ASSY; or GROOVED POLYUREA MKG, RR XING ASSY.

   Such payment shall be full compensation for preparation of pavement surface, removing and disposing of all existing material, furnishing and installing marking materials, and for all labor, equipment, tools materials, and incidentals necessary to complete the Work.
13.05 PAINT

A. MATERIAL SPECIFICATIONS

Paint marking material shall be acrylic waterborne white or yellow traffic paint suitable for use as a reflective pavement marking on concrete pavement or asphalt pavement when covered with drop-on glass beads.

The paint shall not contain lead or chromium and shall have a Volatile Organic Compound (VOC) content of less than 1.25 lbs./gal.

B. INSTALLATION METHODS

1. Surface Preparation

   The surface that is to be painted shall have pre-existing marking materials removed prior to the installation of the new material. Surface areas that are to receive paint markings shall be cleaned to remove dirt, grease, or any foreign material that would affect the adhesion of the paint to the pavement.

2. Procedures

   Paint shall be applied to clean, dry pavement at a thickness of 15 mils when wet, which is equivalent to 16 gallons of paint applied per mile of painted 4-inch line.

   Paint markings shall not be installed if pavement, air, or paint temperature do not meet manufacturer specifications or requirements. Waterborne paint may be heated to a maximum of 150°F.

3. Equipment

   Longitudinal paint marking lines shall be applied with a self-propelled, riding-type line stripper capable of applying solid or continuous lines and broken or skip lines at regular intervals, and capable of mechanically applying a regulated amount of glass beads directly to the wet film surface of the marking paint. The glass bead nozzles or guns shall be mounted directly behind the paint applicators.

   The City’s Project Manager may allow the use of a walk behind type machine with a limited quantity of markings, provided sufficient traffic control is in place.

4. Drop-on Beads

   Glass beads shall be mechanically and uniformly applied to the wet paint line in the amount of 6 pounds of beads per gallon of paint applied. Beads shall be applied so that they receive maximum capture and binding by the paint.

   Glass beads for use with Acrylic Waterborne Traffic Paints shall be designated as AASHTO M 247 Type I Coarse Dual-Coated moisture resistant beads.

   The glass beads, as received, shall be free from clumps and lumps, shall contain no extraneous material and shall flow freely when applied to traffic paint.

   The glass beads shall be highly resistant to the effects of weathering as determined by laboratory tests and field tests. The glass beads shall show good adherence to the paint and provide good night visibility throughout the useful life of the reflectorized traffic paint.
13.05 PAINT (Continued)

B. Installation Methods (Continued)

4. Drop-on Beads (Continued)

The glass beads shall allow sufficient capillary action to form a firm embedment in typical traffic paint when dropped on a freshly applied paint film of 15 ± 1.5 mils wet thickness.

Imperfections - The percentage of imperfect beads and non-glass material shall be determined by testing conducted according to AASHTO PP 74. The percentage of total imperfect beads on all sieves shall not exceed 20 percent. In addition, the glass beads shall have not more than 30 percent imperfect beads passing any sieve with the exception of sieve #80. If less than 2 percent of the beads pass the #80 sieve, the imperfect bead requirement shall not apply and the percent imperfect shall not be included when calculating the total imperfect beads. Imperfect beads are defined as ovate or otherwise non-spherical in shape; two or more beads fused together; and beads which show turbidity, pitting, scratching, surface wrinkling, internal air bubbles, or other inclusions.

Index of Refraction – The glass beads shall have an index of refraction of not less than 1.50 when tested by the liquid immersion method at 25° C according to AASHTO T 346.

Gradation – The drop-on glass beads in a representative sample shall meet the following gradation requirement when tested in accordance with AASHTO PP 74.

<table>
<thead>
<tr>
<th>TYPE 1 Coarse Dual-Coated Moisture Resistant Beads</th>
<th>U.S. Standard Sieve No.</th>
<th>Sieve Opening (millimeters)</th>
<th>Amount Passing (Percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>20</td>
<td>0.850</td>
<td>90-100</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>0.600</td>
<td>55-80</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>0.300</td>
<td>5-25</td>
</tr>
<tr>
<td></td>
<td>80</td>
<td>0.180</td>
<td>0-5</td>
</tr>
</tbody>
</table>

Moisture Resistance – The glass beads shall pass the “Moisture Resistance Test” according to AASHTO T 346 Section 13.

Embedment Coating Test – The glass beads shall be tested for verification of silane presence/adhesion promoter, by performing the “Dansyl Chloride Test” according to AASHTO T 346 Section 11.

Heavy Metal Concentration – Glass traffic beads shall not contain more than 75 ppm (total) of arsenic or 100 ppm (total) of lead, when tested in accordance with EPA Methods 3052 and 6010B or AASHTO TP 106. Other suitable x-ray fluorescence spectrometry analysis methods may be used to screen samples of glass spheres for arsenic and lead.

C. BASIS OF PAYMENT

Pavement markings installed in conformance with the Plans and Standard Specifications and acceptable to the City’s Project Manager shall be measured or counted for at the contract unit price bid, per linear foot, as listed in Appendix A, Standard Item Description, PAINT MKG, _____ " (various widths).

Such payment shall be full compensation for preparation of pavement surface, removing and disposing of all existing material, furnishing and installing marking materials, and for all labor, equipment, tools materials, and incidentals necessary to complete the Work.
13.06 TEMPORARY MARKINGS

A. GENERAL

Temporary pavement markings may be used to provide guidance through construction work zones or to provide temporary pavement markings on completed streets until date, temperature, or humidity conditions allow the installation of specified permanent marking material.

Temporary markings shall be maintained until such time that conditions allow the installation of the specified permanent marking material.

When the Contractor is unable to install the specified marking material because of failure to complete the project by the original project completion date or approved extensions, the installation, maintenance, and removal of the temporary pavement markings shall be at the Contractor’s expense.

B. FLEXIBLE RAISED PAVEMENT MARKER

Flexible raised pavement markers shall be made of a polyurethane body formed in an “L” shape. The marker shall be approximately 4 inches wide and the vertical portion of the marker shall be at least 1.5 inches high. The base of the marker shall be at least 1 inch deep. A cube-corner microprism reflective tape material shall be placed horizontally along both sides of the top of the vertical section of the marker. The reflective material shall be recessed in an “I-Beam” design to protect the reflective material from aggregate. A clear flexible polyvinyl chloride plastic cover is to be attached to the vertical section of the marker with a heavy-duty staple to cover the reflective material during surfacing operations. The flexible raised pavement marker must be readily visible at night when viewed with high beam automobile headlights. The marker shall be the same color as the material it is to replace or supplement. The marker shall be approved by the City Project Manager prior to use.

Flexible raised pavement markers shall be installed on the pavement surface by methods recommended by the manufacturer but shall be able to be removed by the Contractor without damage to the pavement surface.

Flexible raised pavement markers shall have a spacing of 5 feet when used as a solid line. A skip line shall consist of 3 markers spaced 2 feet apart with an 18-foot gap between sets of markers. Placement of these markers may differ if pre-approved by the City Project Manager. Flexible raised pavement markers shall be removed by the Contractor when no longer needed.

C. TAPE

Temporary pavement marking tape shall be a retroreflective plastic material suitable for use as a temporary marking on concrete pavement and asphalt pavement surfaces. The tape shall have a pressure sensitive adhesive which allows application to the pavement surface without additional adhesive. Tape intended to be removed from the pavement surface shall be capable of being removed by hand from the pavement surface intact or in large pieces at temperatures above 40° F.

D. TEMPORARY PAINT

Paint that is applied as a temporary marking shall be applied to clean, dry pavement at a thickness of 7 mils when wet, which is equivalent to 7.46 gallons of paint applied per mile of painted 4-inch line. Painted lines shall have sharply defined edges at the overall line width shown on the plan.
13.06 TEMPORARY MARKINGS (Continued)

E. BASIS OF PAYMENT

Temporary pavement markings installed in conformance with the Plans and Standard Specifications and acceptable to the City’s Project Manager shall be measured or counted and paid for at the contract unit price bid, per linear foot or each, as listed in Appendix A, Standard Item Description, TEMPORARY MKG, TAPE, 4"; TEMPORARY MKG, PAINT, ___" (various widths); or FLEXIBLE RAISED PAVEMENT MARKER.

Such payment shall be full compensation for preparation of pavement surface, removing and disposing of all existing material, furnishing and installing marking materials, and for all labor, equipment, tools materials, and incidentals necessary to complete the Work.

13.07 GUARANTEE PERIOD

Following initial completion of all pavement markings, there shall be a 1-year observation period, except for paint which shall be a 180-day observation period, during which the Contractor, at no expense to the City of Lincoln, shall replace any marking that the City’s Project Manager determines is not performing satisfactorily. At the end of the observation period, the minimum required retention percentage for markings installed shall be 90% and shall meet all millicandels requirements for retro reflectivity of material.

The percentage retained shall be calculated as the nominal area of the marking less the area loss, divided by the nominal area and expressed as a percentage of the nominal area. Zones of measurement shall be 1000 feet in street length or between intersections, whichever is shorter. Within a zone of measurement, marking retained shall be measured as follows:

<table>
<thead>
<tr>
<th>Description</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid line of one width and color</td>
<td>Total length of solid line retained</td>
</tr>
<tr>
<td>Skip segments of one color</td>
<td>Total number of marking segments retained (each at least 90% complete)</td>
</tr>
</tbody>
</table>

A claim, made by the City against the Contractor, shall be submitted to the Contractor in writing no later than 30 days after the 180-day observation period for paint or a 1-year observation period for all durable markings.

Final acceptance of all marking will include an inspection of the appearance of the markings during daylight and darkness. Any markings that fail to have a satisfactory appearance during either period, as determined by the City’s Project Manager, shall be reapplied at no expense to the City.

Final acceptance of the pavement marking shall be after 180 days for paint or 1 year for all other materials listed above after the initial completion of all Work, or upon completion of all corrective Work, whichever occurs last.