SECTION 424 -- PERMANENT PAVEMENT MARKING

424.01 -- Description

This work shall consist of furnishing and installing retroreflective preformed pavement markings in accordance with these *Specifications* and in reasonably close conformance to the dimensions and lines shown in the plans or established by the Engineer. This specification covers the following permanent pavement marking materials and application methods:

1. Durable Retroreflective Preformed Pavement Marking, Type I (1.5 mm thickness) .

2. Durable Retroreflective Preformed Pavement Marking, Type II (preformed marking film).

3. Durable Retroreflective Preformed Pavement Marking, Type III (intersection grade).

4. Durable Retroreflective Preformed Patterned Pavement Marking, Type IV (with improved retroreflectivity retension).

5. Thermoplastic Pavement Marking.

6. Thermoplastic Pavement Marking, Type Spray.

424.02 -- Material Requirements

1. Acceptable Durable Retroreflective Preformed Pavement Marking, Types I, II, III, and IV shall be on the NDR Approved Products List.

2. Thermoplastic Pavement Marking Materials:

   a. The composition minimum percentages by mass are shown in Table 424.01.

Table 424.01

Minimum Composition Requirements		
	White Minimum Percentage	**Yellow Minimum Percentage**
Binder	18	18
TiO_2 (Type 2 Rutile)	8	N/A
Glass Spheres	35	35
Yellow Pigment	N/A	5.0

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

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

d. The yellow pigment used shall be a heat stabilized medium lead pigment with zero percent lead content.

e. Physical Requirements:

(1) Color:

(i) 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 424.02.

Table 424.02

Color Deviations		
Scale Definitions	**Magnesium Oxide Standard**	**Sample**
RD Reflectance	100	75% Min.
a Redness - Greenness	0	-5 to +5
b Yellowness - Blueness	0	-10 to +10

(ii) 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 424.03.

Table 424.03

Reflectance and Chromaticity	
Reflectance	45 Percent Minimum
Chromaticity	Shall fall in an area bounded by these coordinates:
Coordinates x, y	x - 0.470 0.493 0.516 0.490 y - 0.455 0.467 0.444 0.433

f. Color Retention:

(1) 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.

Note: A General Electric 275 watt sun lamp (Type RS) with a built-in reflector may be substituted for the light source.

g. Water Absorption:

The thermoplastic compound shall have no more than 0.5 percent by mass of retained water when tested in accordance with ASTM D 570.

h. Softening Point:

The compound shall have a softening point of not less than 90 C, as determined by ASTM E 28.

i. Low Temperature Stress Resistance:

A concrete substrate coated with a minimum of 206 cm^2 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 10°C for a period of 24 hours. When removed and allowed to come to room temperature, the sample shall still adhere to the contract substrate with no cracking or flaking.

j. Reheating:

The thermoplastic compound shall maintain proper performance properties when heated 4 times to the application temperature. After heating to 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.

k. Safety:

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

l. Specific Gravity:

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

m. Drying Time:

When the material is applied at 204°C, the line shall be completely solid and show no effect of tracking after 15 minutes.

n. 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 45°C. With a 2 kg load applied, the reading shall not be less than 45 after 15 seconds.

o. Abrasion Resistance:

The sample shall show a maximum loss of 6 g when tested by the blasting box method.

p. Impact Resistance:

The average impact resistance of 4 separate samples shall not be less than 561 mm/kg when tested according to Method A of ASTM D 256.

q. Sealing Primer:

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

r. Glass Spheres:

(1) Refractive Index:

The reflective glass spheres pre-mixed into the compound and the reflective glass spheres used for surface application shall have a refractive index of not less than 1.50 when tested by the liquid emersion method at 25°C.

(2) Roundness:

Not less than 75 percent of the beads overall and not less than 70 percent of the beads retained on any specified sieve shall be true spheres when tested by ASTM D 1500.

s. Coatings:

The intermix and drop-on beads shall have an adhesion promoting coating which is specific for the thermoplastic system. The beads for surface application shall be resistant to clumping caused by moisture.

t. Flowing Properties:

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

(2) One hundred grams of glass beads, spread evenly and thinly in a suitable container, shall be conditioned at 25°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, 5 mm diameter, and 100 mm stem. The inside diameter of the stem shall be a nominal 35 mm.

u. 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.

v. Gradation:

(1) The intermixed and surface applied glass beads shall meet the gradation requirement in Table 424.04.

Table 424.04

Glass Bead Gradation	
Sieve Size	**Percent Passing**
1.18 mm	100
850 µm	75-95
600 µm	20-40
300 µm	0-5
150 µm	0-2

(2) The surface application of beads shall be not less than 0.58 kg/m².

(3) Properties of Finished Striping and Marking Installation:

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

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

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

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

(v) 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 road surface without chipping.

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

3. Hot Spray Thermoplastic Pavement Marking Material:

a. Binder:

The binder shall consist of a mixture of synthetic alkyd resins, at least one of which is solid at room temperature. The total binder content of the thermoplastic compound shall be well distributed through the compound. The binder shall be free from all foreign objects or ingredients that would cause bleeding, staining or discoloration. The binder shall be at least 25 percent by mass of the thermoplastic compound.

b. Pigment:

(1) White. The pigment used for the white thermoplastic compound shall be a high-grade pure (minimum 93 percent) titanium dioxide (TiO_2). The white pigment content shall not be less than 10 percent by mass and shall be uniformly distributed throughout the thermoplastic compound.

(2) Yellow. The pigments for the yellow thermoplastic compound shall be heat stabilized medium lead chromate pigment with a minimum of 50 percent lead-free content. The yellow pigment shall not be less than 5 percent by mass and shall be uniformly distributed throughout the thermoplastic compound.

c. Filler:

The filler to be incorporated with the resins as a binder shall be a white calcium carbonate, silica, or an approved substitute. Any filler which is insoluble in 5N hydrochloric acid shall be of such particle size as to pass a 150 µm sieve.

d. Mixed Compound:

The mixed thermoplastic compound, after heating for 4 hours ± 5 minutes at 190.6° ± 2°C and cooled at 25°C, shall meet the following requirements for daylight reflectance and color when tested using a color spectrophotometer with 45 degree circumferential, 0 degree geometry, illuminant C, and 2 degree observer angle. The color instrument shall measure the visible spectrum from 380 to 721 nm with a wavelength measurement interval and spectral bandpass of 10 nm. Reflectance and chromaticity limits are shown below.

Reflectance and Chromaticity Limits				
White: Daylight Reflectance (Y) 75 percent minimum				
* Yellow: Daylight Reflectance (Y) 42-59 percent				
* Shall match Federal 595 Color No. 33538 and chromaticity limits as follows:				
	X	.470	.510	.485	.530
	Y	.455	.485	.452	.456

e. Specific Gravity:

The specific gravity of the thermoplastic material shall not exceed 1.85.

f. Softening Point:

After heating the thermoplastic material for 4 hours ± 5 minutes at 190.6° ± 2°C and testing in accordance with ASTM E 28, the material shall have a minimum softening point of 82.2°C as measured by the ring and ball method.

g. Tensile Bond Strength:

After heating the thermoplastic material for 4 hours ± 5 minutes at 190.6°C, the drawdown film thickness shall be 1.587 mm; and when tested at 23° ± 1°C in accordance with ASTM D 4796, the tensile bond strength to unprimed, sandblasted portland cement block shall exceed 1.24 MPa.

h. Impact Resistance:

The thermoplastic material is heated for a period of 4 hours at a temperature of 190.6°C. A 1.587 mm thick drawdown film shall be created on an unprimed, sandblasted portland cement concrete block. Allow the sample to reach room temperature by standing overnight. Using a suitable falling ball apparatus that includes the male indentor 15.875 mm (no female die), impact the sample and observe for any cracking or loss of bond. When tested in accordance with ASTM D 2794, the material shall have a minimum impact resistance of 8.0 kN with no visible cracks or loss of bond.

i. Yellowness Index:

The white thermoplastic material shall not exceed a yellowness index of 12 when tested in accordance with ASTM D 1925.

j. Packaging:

(1) The thermoplastic material shall be packaged in suitable containers which will not adhere to the product during shipment and storage. The container's awkward mass shall be approximately 22.7 kg. Each container shall designate the color, type of binder, spray, and user information. The label shall warn the user that the material shall be heated in the range of 177 to 218°C.

(2) Each package shall be marked with the name of the manufacturer, the type of material, the month and year the material was packaged, and the lot number.

k. Glass Beads:

(1) Intermix Beads:

(i) Intermix beads shall be uncoated and shall be uniformly sized throughout the thermoplastic material at the rate of not less than 35 percent by mass (retained on the 150 µm sieve) of the thermoplastic material.

(ii) Intermix beads shall meet the gradation requirements in Table 424.05.

Table 424.05

Intermix Bead Gradation	
Sieve Size	**Percent Passing**
850 µm	100
600 µm	75-95
300 µm	15-35
150 µm	0-5

(2) Drop-on Beads:

(i) Drop-on beads shall be moisture resistant, imbedment coated, and shall consist essentially of transparent, water-white glass particles of a spherical shape. They shall be manufactured from a glass of a composition designed to be highly resistant to traffic wear and to the effects of weathering and shall conform to the requirements specified herein.

(ii) Drop-on beads shall meet the gradation requirements in Table 424.06.

Table 424.06

Drop-On Bead Gradation	
Sieve Size	**Percent Passing**
1.18 mm	100
850 µm	75-95
600 µm	20-40
300 µm	0-5
150 µm	0-2

l. Specific Properties of Intermix and Drop-on Beads:

(1) Imperfections. The surface of the glass beads shall be free of pits and scratches. The glass beads shall be spherical in shape and shall contain not more than 20 percent by mass of irregular shapes when tested by the standard method using a vibratile inclined glass plate.

(2) Index of Refraction. The index of refraction of the glass bead shall be not less than 1.50 when tested by the immersion method at 25°C.

(3) Silica Content. The glass bead shall contain not less than 65 percent silica ($Si0_2$).

(4) Chemical Stability. Glass beads which show a tendency toward decomposition, including surface etching, when exposed to paint or thermoplastic constituents will be rejected. The glass beads shall be tested by Federal Specification T-T-B-1325A, Section 4.3.11 (water resistant soxhlet extraction method), with the following exceptions:

(i) Under "Procedure", the size of sample to be tested shall be 25 g.

(ii) Under "Testing", Paragraph (1), the reflux item shall be 5 hours and, upon examination after testing, the glass beads shall show no dulling effect.

(iii) Under Paragraph (2), use of more than 4.5 mL of 0.1N hydrochloric acid to reach the end point shall constitute failure of the test.

(5) Flowing Properties:

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

(ii) One hundred grams of glass beads, spread evenly and thinly in a suitable container, shall be conditioned at 25°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, 5 mm diameter and 100 mm stem. The inside diameter of the stem shall be a nominal 35 mm.

(6) Adhesion Coating. The glass beads shall be coated with an adhesion promoting coating that is compatible with thermoplastic material and that passes the manufacturer's adhesion test.

(7) Packaging. Glass beads shall be delivered in approved, moisture-proof bags consisting of at least 5-ply paper construction. Each bag shall contain 22.7 kg net, and shall be legibly marked with the name of the manufacturer, type of bead, lot number, and the month and year the glass beads were packaged.

4. Performance Life/Acceptance.

All permanent pavement markings shall have the following acceptance requirements:

a. Following initial completion of all pavement marking, there will be a 180 day observation period before final acceptance. During the observation period, the Contractor, at no additional cost to the Department, shall replace any markings that the Engineer determines are not performing satisfactorily due to defective materials, workmanship in manufacture and/or application. At the end of the observation period, the minimum required retention percentage, by area, for markings installed will be 95 percent.

b. Determination of Percentage Retained:

The percentage retained shall be calculated as the nominal area of the strip less the area of loss divided by the nominal area and expressed as a percentage of the nominal area.

c. (1) The Contractor shall be notified in writing within 30 calendar days after the 180 day observation period if there is a failure to achieve the required percentage retained.

(2) When such a notification is made prior to September 1, the replacement material shall be installed during the same construction season. Replacement materials for any notification made after September 1 shall be installed prior to June 1 of the following year. Marking replacement shall be performed in accordance with the requirements specified herein for the initial application, including but not limited to surface cleaning, primer applications, etc.

d. Final acceptance of all markings 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 Engineer, shall be reapplied at no additional cost to the Department.

e. Final acceptance of the pavement marking will be:

(1) 180 days after the initial completion of all pavement marking work, or

(2) Upon completion of all corrective work, whichever occurs last.

424.03 -- Construction Methods

1. General:

a. Line Appearance. Markings shall essentially 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 percent, by area, of holes or voids and shall be free of blisters.

b. The pavement markings shall be placed at the alignment markings established on the roadway. Deviation from the alignment established shall not exceed 50 mm and, in addition, the deviation in alignment of the marking being placed shall not exceed 25 mm per 60 m of roadway nor shall any deviation be abrupt.

c. Longitudinal markings shall be offset at least 50 mm from construction joints of portland cement concrete surfaces and joints and shoulder breaks of asphalt surfaces.

d. All permanent pavement markings shall be applied according to the manufacturer's instructions.

e. When deemed necessary by the Engineer to achieve specified alignment, the Contractor, at his/her expense, shall place any additional markings required to achieve the specified alignment throughout both straight and horizontally-curved sections of roadway. Any and all additional markings placed on the roadway for alignment purposes shall be temporary in nature and shall not establish a permanent marking on the roadway. Materials used for alignment markings and equipment used to place such markings shall be approved by the Engineer.

f. The Contractor shall have on the project at all times during the application of the permanent pavement markings at least one employee with a valid "American Traffic Safety Services Association" (ATSSA) certification. The ATSSA certification may be for either a "Certified Pavement Marking Technician" or a "Certified Pavement Marking Specialist." The Contractor shall provide the Engineer a copy of the employee's certification prior to the beginning of work.

g. Prior to the installation of the permanent pavement marking, the Contractor shall provide to the Engineer a printed copy of the material manufacturer's installation procedures.

h. The pavement upon which the pavement markings are to be placed shall be cleaned and prepared in a manner and to the extent recommended by the manufacturer prior to placement of the markings. Cleaning shall be by any effective method, approved by the Engineer, that completely and effectively removes contaminants, loose materials, and conditions deleterious to proper adhesion without damaging the roadway.

i. Existing painted pavement markings on both concrete and asphalt pavement shall be removed prior to placement of the permanent markings. Existing durable pavement markings (plastic or old epoxy) shall be removed or prepared in a manner and to the extent recommended by the manufacturer prior to placement of the new markings. Conflicting lines shall be removed. The area of removal shall be the width needed for the new pavement marking and/or the existing line(s), whichever is greater.

2. "Durable Retroreflective Preformed Pavement Marking, Type _____ Grade _____":

a. The Contractor's liability will be limited to material replacement only for the amount of markings actually missing from the roadway.

b. The markings shall be applied in accordance with the manufacturer's recommendations. Marking configurations shall be in accordance with the *Manual on Uniform Traffic Control Devices*.

c. When markings are specified in the contract for newly paved asphaltic concrete surfaces, they shall be applied before public traffic is allowed on the freshly paved surface. Preferably, the markings should be inlaid in the fresh surface during final rolling of the mat; but in any case, they shall be applied before the close of the shift on the day which the surface is paved. These markings can also be overlaid on existing pavement surfaces.

d. (1) The Contractor and/or manufacturer shall provide application equipment, manual or automatic as necessary for the job requirements. These applicators shall be capable of applying two 110 mm lines simultaneously with a 110 mm spacing between lines. These units shall be capable of applying an unlined, precoated, pressure sensitive adhesive pavement marking tape.

(2) The manual unit shall have a manually actuated product feed advance system and a foot operated product cutting mechanism.

(3) The automatic unit shall have the capability of advancing, applying, and cutting the pavement marking tape at specific preprogrammed lengths at speeds up to 10.5 km/h when towed by an appropriate vehicle.

3. Thermoplastic Pavement Marking:

a. Dirt, grease, or any foreign materials that would reduce the adhesion of the thermoplastic to the pavement must be removed by the Contractor before the application of thermoplastic material.

b. The Contractor shall check the pavement surface moisture each day prior to marking application as follows:

(1) Apply a thermoplastic line on a piece of tar paper (approximately 2 m long) over the area to be striped.

(2) After 30 seconds, visually inspect the underside of the tar paper. If the underside is wet, **do not** install the thermoplastic.

(3) After 1 hour, perform this test again. If only a damp area appears on the underside (i.e., no dripping or wetness), the pavement is ready for thermoplastic application.

c. A binder-sealer material, either epoxy, butadiene, styrene, neoprene, or others recommended by the thermoplastic manufacturer, must be applied in sufficient quantities to entirely cover the surface on which the marking is to be applied. This binder-sealer is required on all portland cement concrete pavement surfaces, as well as on all bituminous pavements over 60 days old.

d. Thermoplastic marking material shall not be applied until approval from the NDR Materials and Tests Division has been received. The Contractor is required to notify the appropriate District Construction Office 72 hours prior to the placement of the thermoplastic markings in order that an inspector can be present during the operation. At the time of this notification, the Contractor must indicate the manufacturer and lot numbers of thermoplastic and glass beads intended for use. A check should be made to insure that the approved lot numbers appear on the material package. Failure to do so is cause for rejection.

e. In no case shall thermoplastic pavement marking material be applied after November 15 or earlier than April 15 or when pavement or air temperatures are less than 10°C.

f. Thermoplastic material must be installed in a molten state between 232°C and 240°C.

g. Thermoplastic material must be installed at a thickness of not less than 3.175 mm or more than 4.775 mm. The initial measurement should be made above the pavement surface. In some cases, however, primarily on fresh bituminous concrete, the material may slightly penetrate the pavement.

h. If the material appears to be less than 3.175 mm thick above the pavement surface, the line shall be "chipped" and checked to determine the actual thickness. If the actual thickness is found to be less than 3.175 mm, the deficient portions of the line shall be ground down to no more than 1.27 mm above the pavement surface and sufficient thermoplastic and glass beads placed over the line to bring it up to the specified thickness.

i. Thermoplastic material may be applied over the temporary painted edge line markings. Unless otherwise specified, 100 mm lines shall be laid a minimum of 25 mm from longitudinal joints.

j. Unless otherwise specified, pavement markings, words, and symbols shall be the *MUTCD* standard size. Deviations from reasonable standards of workmanship are cause for rejection.

k. Thermoplastic pavement marking material may be installed by the following methods:

(1) Extrusion Method:

This is basically a "slip form" method. As the applicator moves forward, a "die" or "shoe" with a fully-adjustable gate is dragged along the pavement to apply the material to the specified area.

(2) Ribbon Extrusion Method:

In this method, the hot thermoplastic material moves through a heated "block" where it drops through an orifice onto the pavement as the applicator moves forward.

l. Equipment used for placing markings shall be manufactured for that purpose and of sufficient size and stability to ensure a smooth and straight application for the following facility types:

(1) Freeways:

(i) A full-sized, truck-mounted unit capable of maintaining an operating speed of 5-8 km/h is required. It must 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.

(ii) The Engineer may allow the use of a hand-operated or small riding machine where a limited quantity of edge and lane lines are required, provided sufficient traffic control is in place to close the lane adjacent to the marking operations.

(2) Non-Freeway:

Thermoplastic pavement marking may be placed with either truck-mounted or hand-operated equipment. Small riding units are considered "hand-operated."

m. Reflectivity:

Immediate reflectivity is 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 should be dropped or sprayed 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 0.58 kg/m². These beads are in addition to those that are provided as part of the thermoplastic mixture itself.

4. Thermoplastic Pavement Marking, Spray Type:

a. Application Equipment. All equipment for application of thermoplastic marking materials shall be of such design and maintained in such condition as to properly heat, mix, and apply the materials.

b. Melting Kettle. The melting kettle shall be capable of heating the thermoplastic material to its recommended application temperature and maintaining that temperature without scorching. The heating kettle shall have a heat transfer medium, and the flame shall not come in direct contact with the material container surface. A temperature gauge shall be visible on the outside of the kettle to indicate the temperature of the thermoplastic material. The melting kettle shall have a continuous mixer or agitator capable of thoroughly mixing the material at such a rate as to maintain homogeneity of material and uniformity of temperature throughout.

c. Thermoplastic Dispensing Devices. The equipment shall be capable of applying molten thermoplastic material at the temperature recommended by the manufacturer of the thermoplastic material in lines from 100 mm to 300 mm wide at a 760 µm thickness. Dispensing devices shall be of the spray type.

d. Glass Bead Dispenser. The thermoplastic dispenser shall be equipped with a drop-on type glass bead dispenser. The glass bead dispenser shall be located so as to drop the glass beads immediately after the molten thermoplastic material is applied. 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.

e. Surface Preparation. The pavement surface on which the thermoplastic material is to be placed shall be clean and dry. Pavement surfaces shall be inspected for cleanliness and any dirt, debris, or other contaminants on the surface to be marked shall be removed as required by the manufacturer.

f. Temperature Limitations. The pavement surface where the thermoplastic material is to be placed shall have a minimum temperature of 10°C. The air temperature shall be at least 10°C during marking operations. The pavement surface temperature and air temperature shall be determined before the start of each day of marking operation and at any other time deemed necessary by the Engineer. Temperatures are to be obtained in accordance with MHTD Test Method T20.

g. Primer Application. A primer is not required on new bituminous surfaces unless recommended by the manufacturer of the thermoplastic material. If primer is

recommended, it shall be applied and cured in accordance with the recommendations of the manufacturer of the thermoplastic material.

h. Thermoplastic Application. The thermoplastic marking material shall be sprayed onto the pavement surface.

i. The temperature of the thermoplastic material at the time of application shall be at least 177°C and less than 218°C. The temperature of the thermoplastic material shall be checked on the surface as it is placed with a calibrated thermometer at the beginning of each day's marking. Check the temperature after the material is added to the dispensing device, after delays in the marking operation, and any time deemed necessary by the Engineer.

j. Pavement striping shall comply with the standard striping practices shown on the plans. The Contractor shall begin centerline and lane line striping at the beginning of the last existing 3 m stripe in order to maintain a 12 m cycle along the entire pavement.

k. Finished markings shall have well defined edges, and lateral deviation shall not exceed 25 mm in 60 m. The minimum thickness of thermoplastic markings shall be 760 µm and the maximum shall be 1270 µm. The thickness will be measured as a wet film, except the Engineer may measure cured film by placing the thermoplastic material and then removing a section of cured line and measuring its thickness.

l. Damage to pavement marking caused by the Contractor's operation shall be repaired or replaced at his/her expense.

m. Glass Bead Application. The drop-on bead shall be mechanically deposited on the molten thermoplastic line immediately after placement of the thermoplastic at the rate of at least 0.4 kg/m^2. The glass beads shall not be dropped at the point of application of the thermoplastic or ahead of that point. The beads shall adhere to the cured thermoplastic, or all marking operations shall cease until corrections are made.

n. (1) Workmanship. The applied thermoplastic markings should be inspected continually for overall workmanship. Markings shall have clean cut edges. The glass beads shall appear uniform on the entire marking surface. Adhesion to the pavement surface shall be checked with a stiff putty knife or similar instrument. The marking should not be removable from a concrete surface. The marking can be removed from a bituminous surface; however, residue of the bituminous substrate shall be stuck to the marking material.

(2) If the thermoplastic line does not provide initial nighttime reflectivity or, if the marking does not have the required minimum thickness, the Contractor shall, at no additional cost to the Department, apply additional thermoplastic material to obtain the total thickness specified. If the marking does not meet the required color, the Contractor shall, at no additional cost to the Department, remove the marking in a manner approved by the Engineer and re-apply the material. If the markings do not comply with the specifications for any other reason, the Engineer may require complete removal or correction at no additional cost to the Department.

424.04 -- Method of Measurement

All permanent pavement marking is measured as follows:

1. Arrows and legends are measured by the each.

2. Lines are measured by the meter of material installed for each width of line installed. Gaps between line segments are not measured.

424.05 -- Basis of Payment

1.

Pay Item	Pay Unit
_____ mm _____ Preformed Pavement Marking, Type _____	Meter (m)
_____ Preformed Pavement Marking, Type _____	Each (ea)
_____ mm _____ Thermoplastic	Meter (m)
_____ Thermoplastic	Each (ea)
_____ mm _____ Thermoplastic, Type _____	Meter (m)
_____ mm _____ Epoxy Pavement Marking	Meter (m)
_____ Epoxy Pavement Marking	Each (ea)

2. Removal or preparation of existing pavement marking for the placement of the new material shall be considered subsidiary to the pavement marking items.

3. Payment is full compensation for all work prescribed in this Section.