EXHIBIT A
SUPPLEMENT TO THE MARICOPA ASSOCIATION OF GOVERNMENTS' UNIFORM STANDARD SPECIFICATIONS AND DETAILS FOR PUBLIC WORKS CONSTRUCTION (SECTIONS 461, 462, 463)

SECTION 461

PAINTED PAVEMENT MARKINGS

461.1 DESCRIPTION:

The work under this section shall consist of cleaning and preparing the pavement surface, furnishing all materials, experienced supervision, labor, equipment, tools, transportation, supplies and applying white or yellow, water-borne, lead-free, rapid-dry traffic paint and reflective glass beads at the locations and in accordance with the details shown on the plans, MUTCD, the requirements of these specifications, or where determined by the Engineer.

461.2 MATERIALS:

461.2.1 Pavement Marking Paint:

(A) **General:** All material used in the formulation of the pavement marking paint shall meet the requirements herein specified. Any materials not specifically covered shall meet the approval of the Engineer.

Certificates of Compliance shall be submitted for each lot or batch of paint prior to its use. A Certificate of Analysis for the heavy metal concentration in glass beads shall be furnished to the Engineer prior to their use.

(B) **Composition Requirements:** The pavement marking paint shall be a ready-mixed, one component, water-borne lead-free traffic line paint, of the correct color, to be applied to either asphaltic or portland cement concrete pavement. The composition of the paint shall be a cross link polymer emulsion equivalent to or better than PervoPlastic™ 6050 Series, acceptability of proposed equivalency to be determined by the Engineer. The marking paint shall be a pigmented water-borne paint containing all the necessary co-solvents, dispersant, wetting agents, preservatives and all other additives, so that the paint shall retain its viscosity, stability and all of the properties as specified herein. The manufacturer shall certify that the product does not contain mercury, lead, hexavalent chromium, toluene, chlorinated solvents, hydrolyzable chlorine derivatives, ethylene-based glycol ethers and their acetates, and not any carcinogen, as defined in 29 CFR 1910.1200. Lead content shall not exceed 0.06 percent of weight of the dry film, and the test for chromium content shall be negative.

No glass beads will be allowed in the pavement marking paint. Glass beads will be applied after the paint has been applied.

(C) **Manufacturing Formulations:** The manufacturer shall formulate the pavement marking paint in a consistent manner and notify the Engineer of any change of formulation. The formulation of the paint shall be determined by the manufacturer. It will be the manufacturer's responsibility to formulate paint which will meet the quantitative and qualitative requirements of this specification. Any change in the formulation of the paint must be approved by the Engineer.

(D) **Quantitative Requirements of Mixed Paints:**

	White	**Yellow**
Pigment: Percent by weight, ASTM D3723, allowable variation from qualifying sample	± 2.0	± 2.0
Non-volatile Content: Percent by weight, ASTM D2369, allowable variation from qualifying sample	± 2.0	± 2.0
Viscosity: Krebs Units at 77º ± 1°F, ASTM D562	80 - 95	80 - 95
Weight per Gallon pounds per gallon at 77º ± 1°F, ASTM D1475, allowable variation from qualifying sample	± 0.3	± 0.3
Vehicle Composition: Vehicle Infrared Spectra, ASTM D2621, allowable variation from qualifying sample	None	None
pH: ASTM E70, allowable variation from qualifying sample	± 1.0	± 1.0
Fineness of Dispersion: HEGMAN, minimum, ASTM D1210	3.0	3.0
Volatile Organic Compounds: pounds per gallon of paint, maximum, ASTM D3960 according to 7.1.2.	2.1	2.1
Flash Point: °F, minimum, ASTM D93, Method A	100	100
Dry Time to No Pick Up: with no beads, minutes, maximum ASTM D711	10	10
Dry Through Time: minutes, ASTM D1640 except no thumb pressure is used when thumb is rotated 90 degrees on paint film	20	20

Flexibility: TT-P-1952D	Pass	Pass

(E) Qualitative Requirements:

(1) Color of Yellow Paint: The color of the yellow paint shall closely match Federal Standard 595b, Color No. 33538. The color shall be checked visually, and will be checked against Tristimulus Values for the color according to Federal Test Method Standard No. 141.

(2) Dry Opacity: Dry opacity for the paint will be determined using a black-white Leneta Chart, Form 2C Opacity and a Photovolt 577 Reflectance Meter or equal. Using a 10-mil gap doctor blade, a film of paint is drawn down, covering both black and white portions of the chart. The film shall be allowed to dry 24 hours. After calibrating the Reflectance Meter according to the manufacturer's instructions, measure the reflectance over the white and black portions with the green Tristimulus filter. Dry Opacity is calculated as follows:

$$\text{Dry Opacity} = \frac{\text{Reflectance over black}}{\text{Reflectance over white}}$$

Dry Opacity for both white and yellow paint shall be a minimum 0.90.

(3) Yellowness Index: Yellowness Index for white paint will be determined as described for dry opacity, only use a 15-mil gap doctor blade to draw down the paint. After 24 hours for drying, measure the reflectance of the paint film, using the green, blue, and amber Tristimulus filters. Calculate the Yellowness Index as follows:

$$\text{Yellowness Index} = \frac{\text{Amber} - \text{Blue}}{\text{Green}} \times 100$$

Yellowness Index for the white paint shall be a maximum of 10.

(4) Reflectance: Reflectance for both white and yellow paint will be determined using the same 15-mil drawdown film as for the Yellowness Index. For white paint the same sample may be used for both the Yellowness Index and Reflectance. Measure the reflectance of the paint film using the green Tristimulus filter.

Reflectance for the white paint shall be a minimum of 85. Reflectance for the yellow paint may range from 42 to 59, inclusive.

(5) **UV Color Durability:** UV Color Durability shall be determined using a QUV Weatherometer, with Ultra Violet Light and Condensate Exposure according to ASTM G53, for 300 hours total. The repeating cycle shall be four hours UV exposure at 60 °C followed by four hours condensate exposure at 40 °C. After 300 hours of exposure, the Yellowness Index for white paint shall not exceed 12, and yellow paint must still match Federal Standard 595b, Color No. 33538.

(6) **Static Heat Stability:** To determine static heat stability for the paint, place one pint of paint in a sealed can and heat in an air circulation oven at 120º ±1º F for a period of one week. Remove the paint from the oven and check the viscosity in Krebs Units at 77º ±1º F according to ASTM D562. The viscosity measured must be in the range from 68 to 90, inclusive. Also, check for any signs of instability.

(7) **Heat-Shear Stability:** To determine heat-shear stability for the paint, one pint of the paint is sheared in a Waring Blender at high speed to 150° F. The blender should have a tight fitting lid taped onto it to minimize volatile loss. When the paint reaches 150° F, stop the blender, immediately pour the paint into a sample can, and apply a cover to seal the can. Let the paint cool overnight and examine for jelling or other signs of instability. Measure viscosity in Krebs Units at 77º ±1º F according to ASTM D562. The viscosity measured must be in the range from 68 to 95 inclusive. If not within the upper limit, run total solids on the sheared paint and adjust solids, if necessary, by adding water to reach the original solids content. If the solids content required adjustment, again check the viscosity of the paint. The viscosity must be in the range from 68 to 95 inclusive.

(8) **Scrub Resistance:** Scrub Resistance will be determined according to ASTM D2486. Use an appropriate doctor blade to provide a dry film thickness of 3 to 4 mils. Allow the paint to cure for 24 hours. Perform the scrub resistance test at 77º ±1ºF and 50 ± five percent humidity. Record the number of cycles to remove the paint film. The number of cycles recorded must be a minimum of 800.

(9) **Spraying Properties:** The paint shall be applied at a 15-mil wet film thickness in the field. The paint shall show the following properties at ambient temperatures of 50º to 100° F with a paint spray temperature of 150º F, maximum, and 6 to 8 pounds of post-applied glass beads per gallon of paint. Beads shall

conform to Section 461.2.2.

(a) Dry to a no-track condition in five minutes or less when the line is crossed over in a passing maneuver with a standard-sized automobile.

(b) Produce a clean-cut, smooth line with no overspray or puddling.

(c) Paint immediately after application shall accept glass beads so that the spheres shall be embedded into the paint film to a depth of 50 percent of their diameter.

(d) Paint when heated to the temperature necessary to obtain the specified dry time, shall show no evidence of instability such as viscosity increase, jelling, or poor spray application.

(10) Freeze-Thaw Properties: The paint viscosity or consistency shall not change significantly when the paint is tested for resistance to five cycles of freeze-thaw according to ASTM D2243.

(11) Road Service Rating: Test stripes of the paint shall be applied transversely across the road, 4” in width and approximately 12 ft. long at a location approved by the Engineer.

Wet film thickness of the test stripes shall be approximately 15-mils as determined according to ASTM D4414 and ASTM D713 prior to test stripe application. To aid in obtaining the correct film thickness, a length of roofing paper placed by the side of the road can be used. Place a rigid metal test panel on the roofing paper in the path of a test line. Immediately after the test line is applied by the striper, measure the wet film thickness. If not satisfactory, adjust the spray pressure and repeat until the target wet film thickness is attained. It is important that no glass beads be present that would give a false wet film thickness. When the wet film thickness is correct, apply a test line across a tarred metal test panel. After this, apply another test line across a different tarred metal test panel, this time also adding the beads. These samples are necessary to determine the initial bead retention.

Glass beads conforming to the requirements of Section 461.2.2 shall be applied after the paint has been applied, but during the same striping operation at a rate such that the initial bead retention on the test line is a minimum of 6 pounds of beads per gallon of wet paint. The initial bead retention will be determined analytically by MCDOT concurrently with the determination of the dry paint thickness utilizing tarred metal test panels. The paint shall accept the glass beads so that the spheres are embedded into the paint film to a depth of 50 percent of their diameter. Test stripes will be observed for a period of 180 days from date of application. Paints

will be evaluated for wear according to ASTM D913.

After 180 days of service, on a visual rating scale of 0 to 100 percent, paints must have a rating of 92 percent or better to be acceptable. All ratings will be taken in the wheel track area. Glass beads shall show no more than a 30 percent loss after 180 days of test. This will be determined by taking close-up photographs of the paint film and by count determining the average bead loss.

The road service test may be waived at the option of the Engineer or evaluated for a period of time less than 180 days.

(12) Workmanship: Paint shall be free from foreign materials, such as dirt, sand, fibers from bags, or other material capable of clogging screens, valves, pumps, and other equipment used in a paint striping apparatus.

The paint pigment shall be well ground and properly dispersed in the vehicle. The pigment shall not cake or thicken in the container, and shall not become granular or curdled. Any settlement of pigment in the paint shall result in a thoroughly wetted, soft mass permitting the complete and easy vertical penetration of a paddle. Settled pigment shall be easily redispersed, with minimum resistance to the sidewise manual motion of a paddle across the bottom of the container, to form a smooth uniform product of the proper consistency. If the paint cannot be easily redispersed, due to excessive pigment settlement as described above or due to any other cause, the paint shall be considered unfit for use.

The paint shall retain all specified properties under normal storage conditions for 12 months after acceptance and delivery. The Contractor shall be responsible for all costs and transportation charges incurred in replacing paint that is unfit for use. The properties of any replacement paint, as specified herein, shall remain satisfactory for eight months from the date of acceptance and delivery.

(F) Manufacturing Requirements:

(1) Inspection: The manufacturer of the paint shall advise the Engineer when paint is to be manufactured, shall furnish the Engineer free access to all parts of the plant involved in the paint manufacture, and shall furnish every reasonable facility for sampling both the paint and the raw materials during the process of manufacturing.

All materials used in formulation shall meet the requirements herein specified. Any materials not specifically covered shall meet the approval of the Engineer.

All manufactured paint shall be prepared at the factory ready for application.

When paint is shipped to a distributor or paint applicator who will store the paint prior to its use, the distributor or paint applicator shall furnish the Engineer free access to all parts of the facility where paint is stored and shall furnish every reasonable facility for sampling the paint.

Paint shall normally be sampled at the place of storage either at a warehouse or on the site prior to application of the paint. Application of the paint will not be permitted until the paint has been approved by the Engineer. It is the Contractor's responsibility to notify the Engineer a minimum of 14 working days prior to any traffic painting operation and to allow access at that time for paint sampling at the storage location.

A minimum of one paint sample shall be obtained from each lot of paint.

Check-samples of finished paint while being applied will be taken at intervals as determined by the Engineer.

(2) **Testing:** All tests will be conducted in accordance with the latest test methods of the American Society for Testing and Materials, Federal Test Method Standard No. 141, and methods in use by the Materials Group, Highways Division, and the Arizona Department of Transportation as specified herein.

Evidence of adulteration or improper formulation shall be cause for rejection.

(3) **Packaging:** All shipping containers for paint must comply with the Department of Transportation Code of Federal Regulations, Hazardous Materials and Regulation Board, Reference 49 CFR. The container and lids must be lined with a suitable coating so as to prevent attack by the paint or by agents in the air space above the paint. The lining must not come off the container or lid as skins.

Containers shall be colored white, including lids, and containers shall have an identifying band of the appropriate color around and within the top one third of the container.

All containers shall be properly sealed with suitable gaskets, shall show no evidence of leakage, and shall remain in satisfactory condition for a period of 12 months after delivery to a distributor or paint applicator. The Contractor shall be responsible for all costs and transportation charges incurred in replacing paint and

containers.

(4) **Marking:** All containers of paint shall be labeled showing the manufacturer's name, date of manufacture, paint color, product code, manufacturer's batch number, and quantity or weight of paint on both the side of the container and also the lid. Containers shall be clearly marked or labeled Rapid or Fast Dry lead-free Water-Borne Traffic Paints.

All containers of paint shall be labeled to indicate that the contents fully comply with all rules and regulations concerning air pollution control in the State of Arizona, Maricopa County.

The manufacturer of the paint shall be responsible for proper shipping labels with reference to whether the contents are toxic, corrosive, flammable, etc., as outlined in the U.S. Department of Transportation, Hazardous Materials Regulations, Reference 49 CFR.

(5) **Unused Paint:** Disposal of unused quantities of traffic paint shall be the responsibility of the Contractor and must meet all applicable Federal regulations for waste disposal. Paint which is saved to be used later shall be packaged as specified previously and shipped to a storage location. Unused paint must be identified on the container. Unused paint may be used on a future project provided the paint still conforms to all specifications contained herein.

461.2.2 **Reflective Glass Beads (Spheres):** The term "glass bead" shall be synonymous with the term "glass sphere" as used herein.

The beads shall be manufactured from glass of a composition designated to be highly resistant to traffic wear and to the effects of weathering.

The glass beads shall be moisture-proof; contain less than 0.25 percent moisture by weight; and be free of trash, dirt, or other deleterious materials.

Beads shall be essentially free of sharp angular particles showing milkiness or surface scoring or scratching. Beads shall be water white in color.

(A) **Gradation:** When tested by the method provided in ASTM D1214, the grade sizes of the beads shall be as follows:

Size of Sieve	**Percent Passing**
No. 30	100

No. 50	15 - 35
No. 70	0 - 15
No. 100	0 - 5

(B) **Roundness:** When tested by the method provided in ASTM D1155 Procedure B, beads retained on any screen specified in the gradation requirements shall contain a minimum of 75 percent true spheres.

(C) **Index of Refraction:** When tested by a liquid immersion method at a temperature of 25 °C, the beads shall have an index of refraction of 1.50 to 1.57.

(D) **Specific Gravity:** The specific gravity of the beads shall be in the range 2.40-
2.60 when tested in accordance with the following procedures:

Place 100 grams in an oven at 110 °C for one hour.

Remove beads and place in a desiccator until the sample is cool.

Remove approximately 60 grams of beads from the desiccator and weigh the sample accurately.

Pour the beads slowly into a clean 100-milliliter graduated cylinder containing 50 milliliters of isopropyl alcohol. Make certain that air is not entrapped among the beads.

The total volume, minus 50, will give the volume of the beads. Calculate

the specific gravity as follows:

$$\text{Specific Gravity} = \frac{\text{Weight of the sample}}{\text{Volume of the sample}}$$

(E) **Chemical Stability:** Beads which show any tendency toward decomposition, including surface etching, when exposed to atmospheric conditions, moisture, dilute acids, or alkalis or paint film constituents, may be required to demonstrate satisfactory reflectance behavior, prior to acceptance, under such tests as may be prescribed.

(F) **Heavy Metal Concentration:** Heavy metal concentration in glass beads shall be as specified in the following table, when tested by an independent laboratory, approved by the Engineer, using EPA Method 3052 and EPA Method 6010B. A Certificate of Analysis shall be furnished to the Engineer prior to use.

Heavy Metal	**Concentration**
Arsenic	< 75 ppm

Antimony	< 75 ppm
Lead	< 100 ppm

(G) **Moisture Proofing:** All glass beads shall have a moisture-proof overlay consisting of water repellent material applied during the process of bead manufacture. The beads so treated shall not absorb moisture in storage and shall remain free of clusters and lumps and shall flow freely from dispensing and testing equipment.

The beads shall pass the test for water repellency and free flow using the following equipment:

(1) **Test bag:** The bag used is approximately 10½" by 17½" after sewing. The material used in the construction of the bag is unbleached cotton sheeting with a thread count of 48 by 48. The material before sewing is approximately 18" by 22". The cloth is folded in half lengthwise and stitched in the shape of an "L" with the short side left open at the top. The material can be obtained from selected manufacturers of cloth and paper packaging. The finished bag may also be obtained from the manufacturer of the glass beads.

Newly fabricated bags must be thoroughly washed with hot water and detergent and rinsed before use to remove the sizing which may be present in the cloth. Subsequent to the initial washing, the bags need only be rinsed clean of beads from previous tests and dried thoroughly before use.

(2) **Funnel:** The funnel used is a standard laboratory funnel with a top opening diameter of 125 millimeters and a 150-millimeter stem length. The inside diameter of the stem is between nine and 10 millimeters. This funnel is available from most laboratory glassware supply houses, Corning No. 6100 or equal.

(3) **Ring Stand and Clamp.**

(4) **Balance accurate to 0.1 grams.**

(5) **Distilled water.**

(H) **MOISTURE TESTING PROCEDURE:** Glass beads shall be tested for compliance with specification requirements. Testing shall be conducted at standard conditions of temperature (25 ± one degrees Celsius) and humidity (50 ± five percent Relative Humidity) and shall consist of the following procedure or an approved alternate:

Weigh 900.0 grams of glass beads into a clean, dry, flat-bottomed pan.

Dry beads at 150 °C for two hours.

Cool beads to room temperature (25 ± one degrees Celsius) in a desiccator.

Using the clean, pre-washed bag described under apparatus section, turn the bag inside out so that the sewn seam and seam-allowance are on the outside.

Quantitatively transfer the beads into the inverted cotton bag.

Grasp the gathered top of the bag with one hand and lower the bag into a container of distilled water until the beads are approximately 25 millimeters below the water level. The container shall be of such dimensions that the bag does not contact the bottom or sides during immersion. Each bag shall be immersed individually. Do not allow one bag to contact another if multiple tests are run.

Remove the bag after 30 seconds of immersion time.

Cradle the bottom of the bag uniformly in the palm of one hand and twist the top neck of the bag until the twisted bag is compressed firmly against the beads. Twist until excess water no longer drips from the bag.

After the excess water has been squeezed from the bag, allow the bag to unwind.

Gather the top of the bag and clamp. Suspend the bag on a ring stand or other support such that the bottom or sides of bag do not contact the support.

After a standing time of two hours at room temperature (25 ± one degrees Celsius), remove bag from support. Mix sample thoroughly by holding the bottom seam allowance in one hand and gathered neck of the bag in the other, invert bag and shake up and down five times. Transfer the sample into a clean, dry funnel of the type described under apparatus. If consecutive tests are run, be sure the funnel is clean, dry and free of beads from prior tests.

The entire sample shall flow through the funnel without stoppage.

At the start of the test only, it is permissible to lightly tap the stem of the funnel to initiate flow.

Small quantities of beads which have adhered to the side of the funnel or stem shall not be cause for failure.

461.3 CONSTRUCTION

461.3.1 Equipment: The traffic paint and beads shall be placed on the pavement by a spray-type, self-propelled pavement marking machine

except that temporary striping during construction may be placed with other equipment designed for application of paint and beads with the approval of the Engineer.

The application equipment to be used on roadway installation shall have, as a minimum, the following characteristic and/or apparatus:

The machine shall be capable of applying clear-cut lines of the width specified on the project plans.

The machines shall be equipped with a mechanical device capable of placing a broken reflectorized line with a 10 foot painted segment and a 30-foot gap.

The machine shall be equipped with an air-operated glass bead drop-in dispenser controlled by the spray gun mechanism.

A glass bead dispenser which is capable of placing the glass beads into the paint line as the paint is applied to the pavement shall be used. This dispenser shall provide satisfactory marking and delineation.

461.3.2 Application

(A) Pavement Surface: Pavement markings shall not be applied to any new asphalt pavement surface within the first 72 hours after pavement placement or after the placement of a surface treatment. Pavement markings shall be applied when the pavement surface is dry and the weather is not foggy, rainy, or otherwise adverse to the application of markings. The surface shall be free from excess asphalt or other deleterious substances before traffic paint, beads or primer are applied. The Contractor shall remove dirt, debris, grease, oil, rocks or chips from the pavement surface before applying markings. Any area that cannot otherwise be satisfactorily cleaned shall be scrubbed with a biodegradable chemical. The method of cleaning the pavement surface and removal of detrimental material is subject to approval by the Engineer and shall include sweeping and the use of high-pressure air spray.

(B) Temperature Conditions: Painting shall not be performed when the atmospheric temperature is below 50° F when using water-borne paint, nor when it can be anticipated that the atmospheric temperature will drop below said 50° F temperature during the drying period. Water-borne paints shall not be applied if rain is expected within one hour of its application, unless otherwise approved by the Engineer. Water-borne paint shall not be heated to a temperature greater than 150° F to accelerate drying.

(C) Placement Locations: The placing of traffic markings shall be done only by personnel who are experienced in this work. Pavement markings shall be positioned as defined on the plans and in the specifications. When it becomes necessary for proper installation, the Engineer may revise

individual marking locations as necessary.

When the use of temporary chip seal pavement markers have been approved for use they shall be augmented by spot marks. Temporary chip seal pavement markers shall be collected and disposed of by the Contractor prior to the final inspection.

The Contractor shall spot mark the entire project at 10-foot intervals in conformance with the striping plans. Removal of existing pavement markings shall be completed prior to the spot marking. Upon completion of the spot marking, the Contractor shall notify the Engineer that the project is ready for inspection. County will conduct an inspection after the spot marking is completed, within three working days from notification of Contractor.

Approval of the spot marking shall not relieve the Contractor from obtaining a final inspection. Upon final inspection, if the Engineer decides that more than one coat is required, it will be done at the Contractor's expense.

The final striping inspection will be made by the Engineer within three working days after all pavement markings and markers have been installed.

The Striping in the field may exceed the construction project limits in order to match and/or tie into the existing striping. Contractor shall perform a field inspection and determine if the striping exceeds the construction project limits.

If a conflict exists between actual field conditions and the pavement marking plans, the Contractor shall cease work and notify the Engineer immediately.

(D) **Paint Application:** The Contractor shall provide the necessary personnel and equipment to divert traffic from the installation area where the work is in progress and during drying time when, in the opinion of the Engineer, such diversion of traffic is necessary.

The volume of paint in place shall be determined by measuring the paint tank with a calibrated rod. At the option of the Engineer, if the striping machine is equipped with air-atomized spray units (not airless) and paint gauges, the volume of paint may be determined by utilizing said gauges.

The quantity of glass reflectorizing beads in place shall be determined by measuring the glass reflectorizing bead tank with a calibrated rod.

The paint shall not bleed, curl, or discolor when being applied to the roadway surface. If bleeding, curling or discoloration occurs, the unsatisfactory areas shall be given additional coats of paint to correct the problem. In the event that the additional coats are not sufficient, the

Engineer will determine what method of correction may be used. Such corrections will be at the Contractor's expense.

The paint shall not be applied over the decorative design in the median.

If a seal is required, sufficient drying time, minimum forty-eight (48) hours, shall be allowed before applying any pavement markings.

After the forty-eight (48) hour drying time has passed and the seal remains tacky, or excessive oil has risen to the roadway surface, a sand blotter shall be applied to absorb the excess oil. If the seal remains tacky, no pavement markings shall be applied.

If a sand blotter is applied after the installation of pavement markings, then all markings affected shall be removed and re-applied at the Contractor's expense.

(E) Tolerances for Placing Paint, Beads, and Primer: The length of painted segment and gap shall not vary more than 6 inches in a 40-foot cycle.

The finished line shall be smooth, aesthetically acceptable and free from undue waviness.

Painted lines shall be 4.0", 8.0", or 12.0" wide as shown on the plans with a tolerance of plus or minus 1/8 inch and shall be placed at a minimum rate of 16 gallons per mile for a solid 4.0 inch line and 4 gallons for a broken 4.0 inch line, based on a 10 foot stripe and a 30 foot gap (40 foot cycle).

New pavement striping shall not vary more than ½ inch in 50 feet from the striping plans. Existing pavement markings requiring re-stripe shall be re-striped to completely cover existing markings within ¼ inch and be within a longitudinal tolerance of 6 inches at the beginning and at the end of each stripe.

Glass reflectorizing beads shall be applied on the wet paint at a minimum rate of 8 lbs. to each gallon of paint.

Wet thickness shall not be less than 15 mils, unless otherwise shown on the plans.

461.4 MEASUREMENT:

Pavement marking paint will be measured by the linear foot along the centerline of the pavement stripe. Skips in dashed lines will not be included in the measurement. Length of pavement markings will be based on 4-inch wide stripe. Measurement for striping with a plan width greater or less than the basic 4 inches as shown on the plans or requested by the Engineer will be made by the following method:

$$\frac{\text{Plan Width of Striping (inches)} \times \text{Linear Feet}}{4 \text{ (inches)}}$$

Painted temporary striping installed in compliance with section 462.3.2 (B) or (B) will be measured and included in the striping quantities.

Symbols, legends, painted medians, painted curbing, and painted islands will be measured by each unit applied. Each legend, regardless of the number of letters, will be considered as a single unit.

No separate measurement will be made for cleaning and preparing the pavement surface, including abrasive sweeping and high-pressure air spray. The cost of disposal of excess materials, cleaning fluids, and empty material containers, will be considered as included in contract items

461.5 PAYMENT:

Pavement striping of the type specified, measured as provided above, will be paid for at the contract price per linear foot for the total length of painted line applied to the nearest foot, which price shall be full compensation for the work complete, including cleaning and preparing the pavement surface and glass beads, as described and specified herein and on the project Plans.

Pavement symbols, legends, painted medians, painted curbing, and painted islands measured as provided above, will be paid for at the contract price for each painted symbol or legend, which price shall be full compensation for the work complete, including cleaning and preparing the pavement surface, and glass beads, as described and specified herein and on the project Plans.

635 Part 400 add the following new Section:

SECTION 462

THERMOPLASTIC AND PREFORMED PAVEMENT MARKINGS

462.1 DESCRIPTION:

The work under this section shall consist of cleaning and preparing pavement surfaces and furnishing and applying either white or yellow thermoplastic reflectorized pavement markings or preformed pavement markings.

Thermoplastic markings shall use hot sprayed reflectorized thermoplastic material. Screed or extrusion application of thermoplastic may be allowed, if approved by the Engineer, for short application work such as may occur at intersections.

The Contractor shall furnish all materials, supervision, labor, equipment, tools, supplies, and

traffic control required to complete the work according to the pavement marking plans, these specifications and the project special provisions.

462.2 MATERIALS:

462.2.1 General Requirements: Only pavement marking materials currently shown on the Arizona Department of Transportation's Approved Products List shall be used. The current Approved Products List is available on the internet.

Certificates of Compliance conforming to the requirements of Section 106shall be submitted for each lot or batch of thermoplastic reflectorized material or preformed pavement markings prior to its use.

All symbols and legends shall be constructed using preformed pavement markings.

462.2.2 Hot Sprayed Thermoplastic Reflectorized Material: The thermoplastic reflectorized material shall consist of a solid mixture of heat-stable resins, white or yellow pigment, inter-mixed glass beads, filler, and other materials in granular or block form specifically compounded for reflectorized pavement markings to be applied to the pavement in a molten state. The characteristics of the liquefied material shall be such that complete and even coverage of specified areas to the required thickness is provided by the required application method and rate. Upon cooling to normal pavement temperature, this material shall produce an adhered reflectorized marking capable of resisting deformation and wear in the roadway.

The thermoplastic composition shall conform to the following requirements:

Component	**Percent by Weight**	
	White	**Yellow**
Binder (minimum)	20	20
Titanium dioxide (minimum)	10	-----
Yellow Lead-Free Pigment (minimum)	-----	1.5
Reflective glass inter-mix beads	30 - 45	30 - 45
Calcium carbonate or equivalent filler	20 - 42	20 - 42

The filler shall be a white calcium carbonate or equivalent filler with a compressive strength of at least 5.0 ksi.

Titanium Dioxide shall conform to the requirements of ASTM D476 Classification Type II.

The yellow pigment shall be heat resistant and lead free. The type of yellow pigment shall be at the option of the manufacturer provided that the material conforms to all color requirements in a stable and durable fashion as specified herein.

The ingredients of the thermoplastic shall be thoroughly mixed and in a solid block or free flowing granular form. The material shall readily melt into a uniform mixture and be free from all skins, dirt, foreign objects or any other ingredient which would cause bleeding, staining, blotting, or discoloration when applied to bituminous or concrete pavement.

The thermoplastic formulation shall use an alkyd binder. The alkyd binder shall consist of a mixture of synthetic resins, at least one of which is solid at room temperature, and of high boiling point plasticizers. At least one third of the binder composition and no less than eight percent by weight of the entire material formulation shall be solid maleic modified glycerol ester resin or solid maleic modified pentaerythritol ester resin. The alkyd binder shall not contain any petroleum based hydrocarbon resins.

The thermoplastic material shall not exude fumes which are toxic, injurious, or require specialized breathing apparatus when heated to the temperature range specified by the manufacturer for application. The material shall remain stable when held for four hours at this temperature, or when subjected to four reheating cycles, not exceeding a total of four hours, after cooling to ambient temperature. The temperature viscosity characteristics of the plastic material shall remain constant throughout the reheating cycles and shall show like characteristics from batch to batch. There shall be no obvious change in color of the thermoplastic material as a result of reheating, and the color of the material shall not vary from batch to batch.

(A) **Color:** The thermoplastic material, after heating for four hours ± five minutes at 425º F ± 3° F and cooled to 77º F ± 3° F, shall meet the following:

White: Daylight reflectance at 45 degrees - 0 degrees shall be 75 percent minimum.
The color shall match Federal Test Standard Number 595, Color Chip No. 17925.

Yellow: Daylight reflectance at 45 degrees - 0 degrees shall be 45 percent minimum.
The color shall match Federal Test Standard Number 595, Color Chip No. 13538.

(B) **Color Stability:** Using accelerated weathering per ASTM G155, Cycle 1, white color stability shall be measured for no color change after 500 hours of exposure, and yellow color stability shall be measured for no color

change after 1000 hours of exposure.

(C) **Retroreflectance:** The white and yellow thermoplastic materials shall have the following minimum retroreflectance values at 86.5 degrees illumination angle and 1.5 degrees observation angle as measured by an LTL-X Delta Retrometer or similar device, within 30 days after application to the roadway surface:

Color	**Retroreflectance (millicandelas/m^2/lux)**
White	350
Yellow	200

(D) **Water Absorption and Specific Gravity:** The thermoplastic material shall not exceed 0.5 percent by weight of retained water when tested in accordance with the requirements of ASTM D570.

The specific gravity of the material, as determined by Section 16 of AASHTO T 250, shall be between 1.85 and 2.15.

(E) **Bond Strength:** After heating the thermoplastic material for four hours ± five minutes at 425º F ± 3° F, the bond strength to portland cement concrete shall be not less than 0.18 ksi. The bond strength shall be determined in accordance with the procedures specified in Section 7 of AASHTO T 250.

(F) **Cracking Resistance at Low Temperature:** After heating the thermoplastic material for four hours ± five minutes at 425º F ± 3° F, applying to concrete blocks, and cooling to 15º F ± 3° F, the material shall show no cracks when observed from a distance exceeding 1 foot. Testing for low temperature crack resistance shall be in accordance with the procedures specified in Section 8 of AASHTO T 250.

(G) **Impact Resistance:** After heating the thermoplastic material for four hours ± five minutes at 425º F ± 3° F and forming test specimens, the impact resistance shall be not less than 10 inch-pounds when tested in accordance with Section 9 of AASHTO T 250.

(H) **Softening Point:** After heating the thermoplastic material for four hours ± five minutes at 425º F ± 3° F and testing in accordance with ASTM D36, the thermoplastic materials shall have a softening point of 215º F ± 15° F.

(I) **Flowability:** After heating the thermoplastic material for four hours ± five minutes at 425º F ± 3° F, and testing for flowability in accordance with Section 6 of AASHTO T 250, the white thermoplastic shall have a maximum percent residue of 18 and the yellow thermoplastic shall have maximum percent residue of 21.

(J) **Yellowness Index:** The white thermoplastic material shall not exceed a yellowness index of 0.12 when tested in accordance with Section 4 of AASHTO T 250.

(K) **Flowability (Extended Heating):** After heating the thermoplastic material for eight
± one-half hours at 425º F ± 3° F, with stirring the last six hours, and testing for flowability in accordance with Section 12 of AASHTO T 250, the thermoplastic shall have a maximum percent residue of 28.

(L) **Abrasion Resistance:** The abrasion resistance of the thermoplastic material shall be determined by forming a representative lot of the material at a thickness of 1/8 inch on a 4" by 4" square monel panel (thickness 0.05 inch ± 0.001 inch), on which a suitable primer has been previously applied, and subjecting it to 200 revolutions on a Taber Abraser at 77° F, using H-22 calibrated wheels weighted to 0.55 lbs. The wearing surface shall be kept wet with distilled water throughout the test.

The maximum loss of thermoplastic material shall be 0.0011 lbs.

(M) **Flash Point:** The thermoplastic material shall have a flash point not less than 475º F when tested in accordance with the requirements of ASTM D92.

(N) **Storage Life:** The materials shall meet the requirements of this specification for a period of one year from the date of manufacture. The thermoplastic must also melt uniformly with no evidence of skins or unmelted particles for this one-year period. Any material which does not meet the above requirements, or which is no longer within this one year period at the time of application, shall be replaced by the Contractor at no additional cost to the County

(O) **Primer Sealer:** Primer Sealers for use on portland cement concrete or hot mix asphaltic concrete surfaces prior to application of the thermoplastic material shall be either as recommended by the thermoplastic material manufacturer or especially compounded for use with the specified thermoplastic material.

462.2.3 **Reflective Glass Beads:** Inter-mix and drop-on reflective glass beads shall conform to the requirements of Section 461.2.2, except as noted herein.

The inter-mix beads shall conform to AASHTO M 247, Type 1, and may be coated or uncoated as recommended by the manufacturer. If uncoated beads are used, the thermoplastic formulation shall be configured to minimize settling of the intermix beads when the material is heated and applied.

Drop-on beads shall conform to the gradation requirements of AASHTO M 247 for Type 1 and Type 3 beads.

462.2.4 Preformed Pavement Markings: Preformed pavement markings listed on the Arizona Department of Transportation's Approved Products List shall be used. Preformed pavement markings shall be weather resistant and shall show no appreciable fading, lifting, shrinkage or significant tearing, roll back, loss of skid resistance, or signs of poor adhesion throughout the useful life of the marking. The markings shall be capable of conforming to pavement contours, breaks and faults through the action of traffic at normal pavement temperatures.

Preformed thermoplastic markings shall be supplied at a minimum thickness of 0.090 inches (90 mils).

Preformed plastic film or tape with pressure sensitive adhesive shall be a minimum of
0.065 inch thick excluding any adhesive.

462.3 CONSTRUCTION:

Thermoplastic and preformed pavement markings shall not be used on chip sealed surfaces. Preformed heat-set markings may be used on chip sealed surfaces when approved by the Engineer prior to application.

462.3.1 Location and Pre-Marking: Pavement markings shall be positioned as defined on the plans and specifications. If a conflict exists between actual field conditions and the pavement marking plans, the Contractor shall cease work and notify the Engineer immediately. The Engineer may revise individual marking locations as necessary.

The Contractor shall spot mark the entire project at 10-foot intervals in conformance with the striping plans. Upon completion of the spot marking, the Contractor shall notify the Engineer that the project spot pre-marking is ready for inspection. The County will conduct an inspection within three working days from the Contractor notification.

When the use of temporary chip seal pavement markers have been approved for use they shall be augmented by spot marks. Temporary chip seal pavement markers shall be collected and disposed of by the Contractor prior to the final inspection.

The field striping requirements may exceed the construction project limits to correctly match into the existing striping. The Contractor shall perform a field inspection with the pavement markings inspector to determine locations for matching the existing striping.

Approval of the spot marking shall not relieve the Contractor from obtaining a final inspection. Upon final inspection, if the Engineer

decides that more than one coat is required, it will be done at the Contractor's expense.

The Contractor shall mark the proposed location of all legends and symbols and have their location approved by the pavement markings inspector prior to installation.

The final striping inspection will be made by the Engineer within three working days after all pavement markings and markers have been installed.

462.3.2 Material Curing Prior to Application of Markings:

(A) Preservative or Fog Seal: Pavement markings shall not be applied to any new preservative or fog seal within the first forty-eight (48) hours applying the preservative or fog seal.

After the forty-eight (48) hour drying time has passed and if the seal remains tacky, or excessive oil has risen to the roadway surface, a sand blotter shall be applied to absorb the excess oil. The Contractor shall sweep the roadway surface free of sand prior to pavement marking applications.

If a seal or blotter is applied after the installation of pavement markings, any pavement markings affected by the seal or blotter shall be removed and re-applied at the Contractor's expense.

(B) Asphalt Pavement: Thermoplastic pavement markings shall not be applied to any new asphalt pavement surface within the first 72 hours after pavement placement or after the placement of slurry seal, microsurfacing, or other surface treatment. During hot weather if the Engineer determines that the asphalt surface is prone to tracking, the Engineer may direct the contractor to provide temporary painted pavement markings complying with Section 461.

(C) Asphalt-Rubber Pavement: Thermoplastic pavement markings shall not be applied to any new asphalt-rubber pavement surface within the first 30 days after pavement placement. The Contractor shall install painted temporary striping at locations where thermoplastic striping is required. Painted temporary striping shall comply with section 461 except temporary striping may be applied 24 hours after placement of the new asphalt-rubber pavement.

(D) Preformed Pavement Markings for legends, arrows, and other symbols may be applied 24 hours after placement of asphalt concrete pavement and asphalt-rubber asphalt concrete pavement. Preformed pavement markings for legends and symbols shall be installed when temporary painted striping is installed.

462.3.3 Pavement Surface Preparation: The Contractor shall remove all dirt,

grease, oil or other detrimental material from the road surface prior to application of stripes, arrows, legends or symbols.

The method of cleaning the surface is subject to approval by the Engineer and shall include sweeping and the use of high-pressure air spray. The method of surface preparation shall also be in accordance with the marking material manufacturer's recommendations. Loose material including all grindings and obliterated markings shall be removed from the pavement surface and disposed of properly.

462.3.4 Application: Pavement markings shall not be installed until after the location has been approved by the pavement markings inspector.

Thermoplastic markings shall not be applied over concrete pavers or decorative asphalt.

(A) Application of Hot Sprayed Thermoplastic: Preparation and application equipment shall be in accordance with the plans and specifications, and shall conform to the recommendations of the materials manufacturer.

The Contractor shall make daily maintenance and operation inspections of all application equipment to ensure that it is operable within the requirements of the specifications. The Contractor shall inform the Engineer of any equipment breakdowns, intermittent malfunctions, or other conditions that may impact the proper application of specified markings. Any equipment judged to be unsuitable by the Engineer shall be repaired or replaced.

Equipment: The equipment used to install hot sprayed applied thermoplastic material shall be constructed to provide continuous uniform heating to temperatures exceeding 400° F while mixing and agitating the material. The heating mechanism of the kettle shall be equipped with a heat transfer medium consisting of oil or air. The burner flame shall not directly contact the material vessel surface. The mixing and agitating mechanism shall be capable of thoroughly mixing the material at a rate which ensures constant uniform temperature distribution.

The kettle shall provide for uniformly melting and heating the thermoplastic material. The kettle shall be equipped with two temperature gauges: one to indicate the temperature of the oil or air heat transfer medium, and the other to indicate the temperature of the thermoplastic material. The kettle shall also be equipped with an automatic thermostatic control device that allows for positive temperature control to prevent overheating or under heating of the material.

The heating kettle and application equipment shall meet the requirements of the National Fire Underwriters and the National Fire Protection Association and of the state and local

authorities. Thermoplastic melting units, trucks or trailers, shall be equipped with foam- type fire extinguishers suitable for application to thermoplastic material that is at the flash point.

The conveying portion of the equipment, between the main material reservoir and the line dispensing device, shall be configured to prevent accumulation. All parts of the equipment which will come in contact with the material shall be constructed for easy accessibility for cleaning and maintenance. The equipment shall operate so that all mixing and conveying parts, including the line dispensing device, will maintain the material at the plastic temperature. The use of pans, aprons or similar appliances which the dispenser overruns will not be permitted. The equipment shall provide for varying traffic marking application widths.

All melting and application equipment shall have functioning and calibrated temperature sensing devices to verify that temperature requirements are being met. Upon request of the Engineer, the Contractor shall provide proof that the temperature sensing devices and verification thermometers are fully functional.

The application equipment to be used on roadway installations shall consist of either truck-mounted units, motorized ride-on equipment, or manually pushed equipment, depending on the type of marking required.

The truck-mounted or motorized ride-on units used for center lines, lane lines, gore lines, and edge lines shall consist of a mobile self-contained unit carrying its own material capable of operating at a minimum speed of five miles per hour while applying striping, and shall be sufficiently maneuverable to install curved and straight lines, both longitudinally and transversely.

The truck shall be equipped with high pressure air spray jets in front of the pavement marking material applicators to remove loose matter from the pavement surface where the marking material is to be applied.

Hand applicator equipment, to be used for all other roadway installations, shall be either self-contained melter application units or reservoir application units that are filled from a separate melter unit. Both types of units shall be equipped to maintain and measure the required application temperatures. The hand applicator equipment shall be sufficiently maneuverable to install symbols and legends, and curved and straight lines, both longitudinally and transversely.

The application equipment shall be so constructed as to assure continuous uniformity in the dimensions of the stripe. The applicator shall provide a means for cleanly cutting off square stripe ends and shall provide a method of applying "skip" lines. The equipment shall be constructed so as to provide varying widths of traffic markings. The

application equipment shall be mobile and maneuverable to the extent that straight lines can be followed and normal curves can be made in a true arc. The equipment operator shall be located in such a position as to enable full visibility of the striping apparatus.

A glass bead top dressing shall be applied to the completed thermoplastic stripe by an automatic glass bead dispenser attached to the striping machine in such a manner that the beads are applied to the molten thermoplastic material immediately after it has been applied. The bead dispenser shall use pressure type spray guns which will embed the beads into the stripe surface to at least one-half of the bead diameter. The bead dispenser shall be equipped with an automatic cut-off synchronized with the cut-off of the thermoplastic material.

If screed or extrusion application of thermoplastic is allowed by the Engineer for short applications, the screed/extrusion application method shall be used wherein one side of the shaping die is the pavement and the other three sides are contained by equipment suitable for heating or controlling the flow of material. The equipment shall form an extruded line which shall be uniform in shape having clear and sharp dimensions.

For hand liner applications, a gravity bead dispenser may be allowed by the Engineer if it properly gauges and dispenses the correct amount of glass spheres.

Materials Selection and Compatibility: All hot sprayed applied thermoplastic material, drop-on glass beads, and primer-sealer will be inspected and approved by the Engineer prior to their application. The Contractor shall also provide samples of said materials if requested by the Engineer.

All materials shall be properly packaged and stored. Each container to be used on the project shall be clearly labeled to indicate the following information:

- Nature, type, and formulation of the material;
- Manufacturer, batch number, and date of manufacture;
- Application requirements and constraints; and
- Compatibility requirements and constraints, particularly those pertaining to equipment, storage, and other materials to be used.

Incompatible materials shall not be used together. The Contractor shall not combine alkyd and hydrocarbon materials in preparation or application equipment. The Contractor shall completely clean preparation and application equipment when materials are changed.

The Contractor shall dispose of excess materials, cleaning fluids, and all empty material containers at a site in conformance with the state and federal requirements.

Pavement Temperatures: The air and road surface temperature at the time of application of hot sprayed applied thermoplastic shall not be less than 55° F, and the pavement surface shall be absolutely dry. If at any time during marking operations the air or pavement temperature falls below these requirements, all hot sprayed applied thermoplastic marking operations shall stop.

The Contractor shall measure pavement surface temperatures one half hour prior to the start of the striping installation activities and as deemed necessary by the Engineer until the end of the application period. For elevation changes greater than 1000 feet temperature readings at the highest elevation shall govern unless otherwise requested by the Engineer. The lowest temperature so measured shall govern, unless otherwise requested by the Engineer. The temperature measurements shall be recorded in a log book and provided to the Engineer when required. The pavement surface temperature shall be measured with a standard surface temperature thermometer or a non-contact infrared thermometer.

Thermoplastic Application: The hot sprayed applied thermoplastic pavement marking material shall be extruded or sprayed onto the pavement surface at a material temperature between 385° F and 415° F, depending on the manufacturer's recommendations, the ambient air and pavement temperatures, and the nature of the pavement surface. The Contractor shall verify temperature requirements with a non- contact infrared thermometer as directed by the Engineer.

The hot sprayed applied thermoplastic material temperatures shall not exceed 450° F. Material temperatures exceeding 440° F shall be allowed for short periods of time; however, in no case shall the material be held for more than four hours at temperatures above 440° F. Total heating time for any batch of material shall not exceed six hours. The Contractor shall note in the temperature log the time when each batch of thermoplastic material is first heated. The start of heating time shall also be marked on the side of the kettle to which it applies.

Specified temperature requirements shall be maintained at all times during application of applied material. The Contractor shall monitor hot sprayed applied material temperature at thirty-minute intervals, unless otherwise requested by the Engineer, and maintain a log of temperature readings taken. Readings shall be taken at the melting kettle or the application outlet point, as determined by the Engineer.

The Contractor shall minimize the thermoplastic material remaining in the kettle at the end of the work day and shall blend a minimum of 80 percent fresh material the start of each day. During project delays, the Contractor may transfer heated thermoplastic material into approved containers for later re-use, subject to specified limits on total acceptable heating time for

each batch.

Drop-on glass beads shall be mechanically deposited into the molten hot sprayed thermoplastic material immediately after the thermoplastic marking is applied, using a double drop method. Each drop shall be comprised of a minimum of six pounds of glass beads per 100 square feet of line (200 linear feet of six-inch stripe). One drop shall be Type 1 glass beads and the other drop shall be Type 3 glass beads. The contractor shall determine which type of glass bead is to be applied in each drop; however, both types shall be used. Double drop methods using all Type 1 or Type 3 beads will not be allowed.

The dispensers shall evenly distribute the beads in the thermoplastic material. Both Type 1 and Type 3 glass beads shall be embedded in the surface of the thermoplastic to a depth of between 50 and 60 percent of the bead diameter. If the glass beads do not adhere to the thermoplastic marking, operations shall be stopped until the problem has been corrected. All markings which do not meet the retroreflectance requirements of Section 462.2.2 (C), as determined by the Engineer, shall be removed by the contractor and replaced at no additional cost to the Department.

Unless otherwise specified, all hot sprayed and extruded thermoplastic pavement markings shall be 0.090 ± 0.002 inches thick. The thermoplastic thickness shall be uniform and consistent throughout the total length of the marking project.

The Contractor shall perform periodic spot checks of thermoplastic material to verify that the required thickness has been attained. Random spot checks of the thermoplastic thickness will be made by the Engineer to ensure conformance with the required criteria. Suggested spot check procedures include the following:

Wet: Thickness can be field tested immediately after the thermoplastic marking is applied by inserting a thin, graduated machinist rule or similar instrument into the molten thermoplastic to the depth of the pavement surface. The thickness is then determined visually by noting on the scale the depth of the penetration or coating of the instrument.

Dried: Thickness can be field tested by placing a small flat sheet of metal with a known thickness immediately ahead of the striping apparatus. After striping, remove the sample and use a suitable measuring device, such as a caliper or micrometer, to determine the thickness of the dried marking.

Longitudinal lines shall be offset at least 6 inches clear from construction joints unless otherwise requested by the Engineer.

The finished thermoplastic line shall have well defined edges and be free from waviness. Lateral deviation of the thermoplastic line shall not exceed

1.0 inches in 100 feet. The longitudinal deviation of a painted segment and gap shall not vary more than 6 inches in a 40-foot cycle. The actual width of line shall be within the limits specified in the following table, according to the width of stripe called for on the plans:

Plan Width	**Actual Width**
4 inches	4 to 4½ inches
8 inches	8 to 9 inches
Over 8 inches	± 1.0 inches

After application and sufficient drying time, the thermoplastic marking shall show no appreciable deformation, cracking, or discoloration under local traffic conditions with air and road temperature ranging from -10º F to 180° F. The drying time shall be defined as

the minimum elapsed time, after application, when the thermoplastic pavement markings shall have and retain the characteristics required herein, and after which normal traffic will leave no impression or imprint on the newly applied marking. When applied at a temperature range of 400º F ± 15º F and thickness of 90 mils, the material shall set to bear traffic in not more than two minutes when the air and road surface temperature is approximately 50º F ± 3° F, and not more than ten minutes when the air and road surface temperature is approximately 90º F ± 3° F. The Engineer may conduct field tests in accordance with ASTM D711 to verify actual drying times.

(B) **Portland Cement Concrete Pavement**: When pavement markings are to be applied to new portland cement concrete pavement, any curing compound present shall be removed by means of a high-pressure water jet followed by sweeping and high-pressure air spray. The concrete curing compound shall be removed at least two inches beyond the entire perimeter of each marking to be installed.

At the time of application of primer-sealer and thermoplastics, the road surface shall be absolutely dry with no detectable or measurable surface or near-surface dampness. If precipitation or other surface wetting is imminent, all marking operations shall be stopped. If any surface dampness is detected during marking activities, marking operations shall be stopped until the pavement dries. If hot-applied thermoplastic marking blisters upon application, marking operations shall be stopped until the cause, potentially including subsurface moisture is determined and corrected.

Primer Application on old and new portland cement concrete pavement, a primer-sealer shall be used if recommended by the manufacturer of the marking material. The primer- sealer shall be applied at the manufacturer's recommended application rates prior to placing the pavement marking material. The primer-sealer shall be allowed to set up for the manufacturer's specified cure or evaporation time, and shall be free of

solvent and water when the pavement marking material is applied.

The thermoplastic material shall be applied to primed pavement surfaces within the working time specified by the primer-sealer and thermoplastic materials manufacturers. If the primed surfaces are not marked within these time limits, the Contractor shall re- prime the surfaces as required by the manufacturer at no additional cost to the Department. If an epoxy primer is used, the thermoplastic application shall be completed before the epoxy has cured.

Improper primer-sealer application may result in bond failure between the thermoplastic and the pavement surface and may cause the thermoplastic surface to pinhole or blister. Should these conditions occur, application operations shall stop until the cause is determined and corrected. All such defective markings shall be removed and replaced at no additional cost to the Department.

(C) Application of Preformed Pavement Markings: All markings shall be applied in accordance with the manufacturer's recommendations. Preformed pavement markings shall not be applied over other markings or old paint unless allowed by the manufacturer and approved by the Engineer prior to application.

Adhesive markings shall not be installed on the approach to an intersection within 50’ of the near edge of pavement of the intersected road.

The contractor shall use butt splices only and shall not overlap the marking material.

The contractor shall immediately correct all misalignments when so ordered by the Engineer. The misaligned portions shall be removed and reinstalled.

All areas marked with preformed pavement markings shall be ready for traffic immediately after application.

462.4 MEASUREMENT:

Thermoplastic pavement markings of longitudinal and transverse lines, such as edge lines, lane lines, gore lines, cross-walks and stop bars, will be measured by the linear foot along the center line of the pavement stripe and will be based on a 4 inch wide stripe. Measurement for striping with a plan width greater or less than the basic 4 inches as shown on the plans or requested by the Engineer will be made by the following method:

$$\frac{\text{Plan Width of Striping (inches)} \times \text{Linear Feet}}{}$$

4 (inches)

No measurement will be made of the number of linear feet of skips in the dashed line.

Double marking lines, consisting of two 4-inch wide stripes will be measured as two individual marking lines. Crosswalk lines, stop bars, stop lines, gore lines, cross hatch lines, and chevron lines will be measured for centerline length and adjusted for widths other than 4 inches as defined above.

Pavement symbols and legends will be measured by each unit applied. Each pavement symbol and each legend, as shown on the Plans, will be considered a unit. The railroad symbol includes the cross bars, both R, and the transverse lines.

No separate measurement will be made for cleaning and preparing the pavement surface, including abrasive sweeping and high-pressure air spray. The cost of disposal of excess material, cleaning fluids, and empty material containers will be considered as included in the contract items.

Removal of curing compound from new portland cement concrete pavement and the application of primer-sealer applied to old or new portland cement concrete pavement, prior to application of thermoplastic striping or pavement legends and symbols, shall be measured by the linear foot or unit each, respectively, depending on the type of marking to be placed and in accordance with the contract fee schedule and special provisions.

462.5 PAYMENT:
The accepted quantities of pavement symbols and legends, measured as provided above, will be paid for at the contract unit price, complete in place including pavement surface preparation.

The accepted quantities for removal of curing compound from portland cement concrete pavement and the application of primer-sealer, measured as provided above, will be paid for at the contract unit price.

The accepted quantity of striping, rounded to the nearest foot, will be paid for at the contract unit price, complete in place including pavement surface preparation.

636 Part 400 add the following new Section:

SECTION 463

RAISED PAVEMENT MARKERS

463.1 DESCRIPTION:

The work under this section shall consist of cleaning and preparing the pavement surface; furnishing all materials, equipment, tools and labor; and placing raised pavement markers of the type specified at the locations and in accordance with the details shown on the plans and the requirements of these specifications.

463.2 MATERIALS:

463.2.1 General: Certificates of Compliance for raised pavement markers and adhesive shall be submitted to the Engineer at least 10 days prior to use. A minimum of one sample per lot per type of marker shall be made available to the Engineer for compliance testing.

The base of the pavement markers shall be free from glass glaze or from substances which may reduce its bond to the adhesive. The base shall be flat and it's deviation from a flat surface shall not exceed 0.05 inches.

463.2.2 Reflective Pavement Markers: Reflective markers shall be non-adhesive with an adhesive surface. Pavement markers shall be both wet and dry retro-reflective, impact resistant, abrasion resistant, water resistant and have molded-in body colors.

Reflective pavement markers shall be of the following type:

Type D Yellow, two-way
Type G Clear, one-way
Type H Yellow, one-way
Type BB Blue, two-way

Reflective pavement markers shall be of the prismatic reflector type consisting of a polycarbonate body and a polycarbonate lens with built-in micro-cube corners. The lens shall have a protective hard-coat.

The exterior surface of the shell shall be smooth and shall contain one or two prismatic reflector faces of the color specified.

When illuminated by an automobile headlight, the color of the reflectors shall be an approved clear or yellow as designated. Reflectors not meeting the required color may be rejected.

Permanent reflective pavement markers will be tested for compressive strength, abrasion resistance and specific intensity. Permanent reflective pavement markers shall have thin untempered glass or other abrasion resistant material bonded to the prismatic reflector face to provide an extremely hard and durable, abrasive resistant reflector surface.

The area covered by the glass, or other abrasion resistant surface, shall not be less than
(3) three square inches.

The strength by compressive loading shall be at least 2,000 lbs. for both permanent and temporary reflective pavement markers.

The original specific intensity of each reflecting surface for both temporary and permanent reflective markers shall not be less than the following:

Reflectance	Specific Intensity: candelas/foot-candle		
	Clear	Yellow	Red
0 Degrees Incide	3.0	1.8	0.75
20 Degrees Incide	1.2	0.72	0.30

Permanent reflective pavement markers shall be subject to an abrasion resistance test as follows:

Steel Wool Abrasion Procedure: Form a 1.0 inch diameter flat pad using No. 3 coarse steel wool per Federal Specification FF-W1825. Place the steel wool pad on the reflector lens face. Apply a force of 50 lbs. and rub the entire lens surface 100 times. After the lens surface has been abraded, the specific intensity of each clear and yellow reflective surface shall be not less than that required above for the original specific intensity.

463.2.3 Non-Reflective Pavement Markers and Reflectorized Dagmars: Non-reflective pavement markers shall be, Type A - white

Reflectorized Dagmars shall be of the following types:

Type J white
Type JY yellow

Non-reflective pavement markers and reflectorized dagmars shall consist of a heat-fired, vitreous ceramic base and a heat-fired, opaque glazed surface which will produce the required properties. Markers shall be produced from any suitable combination of intimately mixed clays, shales, flints, feldspars, or other inorganic material which will meet the properties herein required. Markers shall be thoroughly and evenly matured and free from defects which will affect appearance or serviceability.

The top surface of the marker shall be in reasonably close conformity with the configuration shown on the plans. Markers shall be convex and the radius of curvature

shall be between 3.5 inches and 6.0 inches, except that the radius of the ½ inch nearest the edge may be less. All edges shall be rounded and any change in curvature shall be gradual. The top and sides shall be smooth and free of mold marks, pits, indentations, air bubbles, or other objectionable marks or discolorations.

Non-reflective pavement markers and dagmars shall meet the following requirements:

Glaze Thickness, minimum, inches	0.005
Moh Hardness, minimum	6
Directional Reflectance (White Only), minimum Glazed Surface Body of Marker	 75 70
Yellowness Index (White Only), maximum Glaze Surface Body of Marker	 0.07 0.12
Color (Yellow Only) Purity, percent, range Dominant Wave Length, mu, range Total Lummous Reflectance (Y valve), minimum	 75 - 96 579 - 585 0.41
Compressive Strength, pounds, minimum	1,500
Water Absorption, percent, maximum	2.0
Autoclave	Glaze shall not spall, craze or peel

Reflectorized dagmars shall have encapsulated lens reflectors conforming to standard manufacturing practices.

463.2.4 Hot Applied Flexible Pavement Marker Adhesive Or Bituminous Adhesive:

Crafco, Incorporated
6975 West Crafco Way
Chandler, Arizona 85226

Materials by manufacturers other than the above listed may be used when approved by the Engineer prior to use.

463.3 CONSTRUCTION:

Raised pavement markers shall be installed after the permanent pavement striping has been completed and approved.

The portion of the highway to which the markers are to be attached shall be free of dirt, curing compound, grease, oil, moisture, loose or unsound layers and any other material which could adversely affect the bond of the adhesive. The pavement must be clean and dry. If rainfall or other pavement wetting event occurs, the pavement shall be allowed to dry for at least twenty-four (24) hours before proceeding with the installation of markers.

Markers shall not be placed on asphalt that is cracking or showing signs of failure.

Chip Seal surfaces shall be swept of excess aggregate and open to traffic for 30 days prior to installation of the markers. Markers shall not be installed on chip seal surfaces with large, void spaces and/or loose aggregate with a weak bond to the underlying road surface.

Slurry Seal and Fog Seal surfaces shall be allowed to cure at least twenty-four (24) hours prior to placement of the markers. Excess sand applied to soak up surface emulsions must be swept clean prior to installation of the markers.

The method of cleaning the pavement surface and removal of detrimental material is subject to approval by the Engineer and shall include sweeping and the use of high-pressure air spray. On portland cement concrete pavement and old asphalt concrete pavements, cleaning shall be accomplished by water blasting, followed by sweeping and/or air blowing. Newly placed asphalt concrete pavement need not be water blasted unless, in the opinion of the Engineer, the surface is contaminated with materials that would adversely affect the bond of the adhesive.

The adhesive shall be placed uniformly on the cleaned pavement surface in an amount sufficient to result in complete coverage of the area of contact of the markers, with no voids present and with a slight excess after the markers have been placed. The markers shall be placed in position and pressure applied until firm contact is made with the pavement. The markers shall be protected against impact until the adhesive has set to the degree acceptable to the Engineer.

Excess adhesive on the pavement and on the exposed surfaces of the markers shall be immediately removed. Thinners or solvents which may be detrimental to either the markers or the bond provided by the adhesive shall not be used in removing excess adhesive.

Markers shall not be installed when the temperature of the pavement surface or the atmosphere is less than 40º F, when the relative humidity is 80 percent or higher or when the pavement surface is not dry.

All markers shall be installed to the line approved by the Engineer and in such manner that the reflective face of the markers is perpendicular to a line parallel to the roadway centerline. Raised Pavement Markers installed next to a solid stripe shall be placed to the side of the stripe with a four inch clear space between the edge of stripe and edge of the marker. Raised Pavement Markers installed in broken or dashed striping shall be centered on the striping and centered in the middle of the striping gap. No pavement markers shall be installed over longitudinal or transverse joints of the pavement surface.

463.4 MEASUREMENT:

Pavement markers will be measured as a unit for each marker furnished and placed.

463.5 PAYMENT:

The accepted quantities of pavement markers, measured as provided above, will be paid for at the contract unit price for the type designated, complete in place, including adhesive and surface preparation.