SECTION 1048

PAVEMENT MARKING MATERIAL

1048.1 Scope. This specification covers Type 1 and Type 2 preformed pavement marking tape, preformed removable pavement marking tape, preformed short-term pavement marking tape, drop-on glass beads, temporary raised pavement markers, epoxy pavement marking paint, acrylic copolymer fast dry pavement marking paint and acrylic waterborne pavement marking paint.

1048.1.1 Certification and Acceptance. All material contained in Sec 1048 shall be in accordance with the following requirements.

1048.1.1.1 To obtain approval of the material, the manufacturer shall submit material and application specifications, samples of the material, and a history of satisfactory use to Construction and Materials for testing and evaluation. The sample quantity submitted shall be at the discretion of Construction and Materials. The approval process shall not be initiated prior to obtaining the concurrence of Construction and Materials. Following testing and evaluation, satisfactory material will be placed on a qualified list.

1048.1.1.2 For acceptance on a project, the contractor shall furnish to the engineer a manufacturer's certification stating the manufacturer and trade name, lot or batch number and that all material furnished is similar to the material originally qualified. For extruded or hot-spray thermoplastic, the certification shall state the specific gravity of the lot or batch. Acceptance of the material will be based on the manufacturer's certification, the results of such tests that may be performed by the engineer and satisfactory performance in the field.

1048.1.1.3 The material may be inspected and sampled at the point of manufacture, at an intermediate shipping terminal or at destination. The engineer shall be allowed access to all facilities and records as required to conduct inspection and sampling. The contractor shall adequately mix the contents of all shipping containers prior to obtaining samples or transferring partial containers of material to tanks on the striping equipment.

SECTION 1048.10 PREFORMED PAVEMENT MARKING TAPE

1048.10.1 Type 1 Preformed Pavement Marking Tape.

1048.10.1.1 Application. On bituminous surfaces, Type 1 preformed pavement marking tape shall be capable of being installed onto wearing surfaces during the final roller operation. Application on concrete surfaces shall be in accordance with the manufacturer’s application recommendations. After application, the tape shall be immediately ready to receive traffic.

1048.10.1.2 Composition. The tape shall consist of a mixture of polymeric material, pigments and glass beads distributed throughout the cross-sectional area, with a reflective layer of glass beads embedded in the top surface. The tape shall be sufficiently flexible to conform to the roadway without cracking or breaking.

1048.10.1.3 Dimensions. The tape, without adhesive, shall have a minimum thickness of 60 mils (1.5 mm). A patterned surface will be allowable but the tape shall have a minimum thickness of 60 mils (1.5 mm) over at least 50 percent of the tape’s surface. The edges of the tape shall not be tapered.

1048.10.1.4 Adhesive. The tape shall be supplied with a precoated factory-applied adhesive for immediate application to bituminous pavement without the use of heat, solvent or other adhesive operations. The tape and adhesive shall be of a type that water used on the compaction roller will not be detrimental to successful application. On concrete surfaces, application shall be in accordance with the manufacturer's recommendations.

1048.10.1.5 Reflectance. The tape shall have a minimum specific luminance as shown for White and Yellow per ASTM D 4505, expressed as millicandelas/m^2/lux. The tape shall be applied to an 8 x 36-inch (200 x 900 mm) panel per instrument recommendation for pavement marking tape and measured in accordance with MoDOT Test Method TM 8 at prescribed CEN geometry.

1048.10.2 Type 2 Preformed Pavement Marking Tape.

1048.10.2.1 Application. After application, the tape shall be immediately ready to receive traffic.

1048.10.2.2 Composition. Type 2 preformed pavement marking tape shall consist of a mixture of polymeric material and pigments with beads distributed throughout the cross-sectional area and with a reflective layer of ceramic beads embedded in the embossed, patterned surface. The patterned surface shall have 50 percent ± 15 percent of the surface area raised and presenting a near vertical face (angle of 0 degrees to 60 degrees from vertical) to traffic from any direction. The channels between the raised areas shall be substantially free of exposed beads or particles. The marking shall be capable of adhering to bituminous or concrete surfaces by a flexible conforming backing. A primer may be required to precondition the pavement surface.

1048.10.2.3 Dimensions. The tape, without adhesive, shall have a patterned surface with a minimum thickness of 65 mils (1.65 mm) in the raised (thickest) area of the cross section and a minimum thickness of 20 mils (0.5mm) in the depressed (thinnest) areas of the cross section.

1048.10.2.4 Adhesive. The tape shall be supplied with a precoated factory-applied pressure sensitive adhesive.

1048.10.2.5 Reflectance. The tape shall have a minimum specific luminance as shown for White and Yellow per ASTM D 4505, expressed as millicandelas /m^2/lux. The tape shall be applied to an 8 x 36-inch (200 x 900 mm) panel per instrument recommendation for pavement marking tape and measured in accordance with MoDOT Test Method TM 8 at prescribed CEN geometry.

1048.10.2.6 Index of Refraction. The ceramic beads on the raised, patterned surface of the material shall have a minimum index of refraction of 1.70 when tested using the liquid oil immersion method. Ceramic beads with an index of refraction greater than 1.80 shall not be used. The beads mixed into the pliant polymer shall have a minimum index of refraction of 1.50 when tested by the oil immersion method.

SECTION 1048.20 PREFORMED REMOVABLE PAVEMENT MARKING TAPE

1048.20.1 General. Preformed removable pavement marking tape shall be capable of being removed and shall leave no objectionable or misleading image or damage to the pavement after removal.

1048.20.2 Reflectance. The tape shall have a minimum specific luminance as shown for White and Yellow per ASTM D 4592, expressed as millicandelas/m^2/lux. The tape shall be applied to an 8 x 36-inch (200 x 900 mm) panel per instrument recommendation for pavement marking tape and measured in accordance with MoDOT Test Method TM 8 at prescribed CEN geometry.

1048.20.3 Adhesive. Tape shall have a pre-coated pressure sensitive adhesive requiring no activation procedures. The adhesive shall be resistant to normal roadway chemicals or materials.

1048.20.4 Durability. The tape shall be weather-resistant and show no appreciable fading, lifting or shrinkage during the tape's useful life. Samples of the tape applied to standard specimen plates and tested in accordance with Federal Test Method No. 141, Method 6192, for 1000 cycles, using a CS-17 wheel and 1000-gram load shall not expose the backing material over more than five percent of the abraded area.

SECTION 1048.30 PREFORMED SHORT TERM PAVEMENT MARKING TAPE

1048.30.1 Reflectance. The tape shall have minimum specific luminance as shown for White and Yellow per ASTM D 4592, expressed as millicandelas/m^2/lux). The tape shall be applied to an 8 in. x 36 in. (200 mm x 900 mm) panel per instrument recommendation for pavement marking tape and measured in accordance with MoDOT Test Method TM 8 at prescribed CEM geometry.

1048.30.2 Adhesive. Tape shall have pre-coated pressure sensitive adhesive requiring no activation procedures. The adhesive shall be resistant to normal roadway chemicals or materials.

1048.30.3 Durability. The tape shall be weather-resistant and show no appreciable fading, lifting or shrinkage during the tape's useful life. Samples of the tape applied to standard specimen plates and tested in accordance with Federal Test Method No. 141, Method 6192, for 1000 cycles, using a CS-17 wheel and 1000-gram load shall not expose the backing material over more than five percent of the abraded area.

SECTION 1048.40 DROP-ON GLASS BEADS

1048.40.1 General. When tested in accordance with MoDOT Test Method TM 70 for water resistance, the beads shall show no readily discernible dulling and the amount of 0.1 normal hydrochloric acid needed to titrate the filtrate shall not exceed 4.5 mL. When tested in accordance with MoDOT Test Method TM 70 for calcium chloride and sodium sulfide resistance, the beads shall show no readily discernible darkening or dulling.

1048.40.2 Type 1 Drop-On Glass Beads. Type 1 beads shall be moisture-resistant and manufactured from glass of a composition that is highly resistant to traffic wear and to the effects of weathering. Glass beads shall be in accordance with AASHTO M 247, Type 1.

1048.40.3 Type L Drop-On Glass Beads. Type L beads shall be embedment coated and manufactured from glass of a composition that is highly resistant to traffic wear and to the effects of weathering. The beads shall be in accordance with AASHTO M 247, Type 1, except as follows.

1048.40.3.1 Coating. The beads shall be coated to ensure satisfactory embedment and adhesion when applied to uncured traffic marking material. The coating shall be tested in accordance with MoDOT Test Method TM 70.

1048.40.3.2 Roundness. Type L beads shall have a minimum of 80 percent rounds per screen for the two highest sieve quantities, and no more than 3 percent angular particles per screen, as determined by visual inspection. The remaining sieve fractions shall be determined visually per aspect ratio using microfiche reader to be no less than 75 percent rounds. The tests shall be in accordance with Federal Lands Highway - Test Method T520-93.

1048.40.3.3 Gradation. Type L beads shall meet the following gradation requirements when tested in accordance with ASTM D 1214:

Type L Bead Gradation Requirements	
Sieve Size	**Percent Passing**
No. 12 (1.7 mm)	100
No. 14 (1.4 mm)	95 - 100
No. 16 (1.18 mm)	80 - 98
No. 18 (1.00 mm)	10 - 42
No. 20 (850 μm)	0 - 7
No. 25 (710 μm)	0 - 2

1048.40.4 Intermix Beads. Intermix beads shall be uncoated, and in accordance with AASHTO M 247, Type 1. Intermix beads shall be uniformly mixed throughout the thermoplastic material at the rate of no less than 30 percent, by weight (mass) of the thermoplastic material.

1048.40.5 Type P Drop-On Glass Beads. Type P beads shall be manufactured from glass of a composition that is highly resistant to traffic wear and to the effects of weathering. If coating is required to meet the performance requirements for the specific marking material used, the beads shall be coated to ensure satisfactory embedment and adhesion.

1048.40.5.1 Refractive Index. Type P beads shall have a minimum refractive index of 1.51 when tested in accordance with AASHTO M 247.

1048.40.5.2 Roundness. All Type P beads passing the No. 30 sieve shall have a minimum of 75 percent true spheres when tested in accordance with ASTM D 1155. All Type P beads retained on the No. 20 and No. 30 sieves shall have a minimum of 80 percent true spheres (determined visually per aspect ratio using microfiche reader); testing to be in accordance with Federal Lands Highway (FLH) Test Method T520-93.

1048.40.5.3 Gradation. Type P beads shall meet the following gradation requirements when tested in accordance with ASTM D 1214.

U. S. Standard Sieve No.	Percent Retained
20	3-10
30	15-35
50	45-75
70	0-10
Pan	0-5

SECTION 1048.50 TEMPORARY RAISED PAVEMENT MARKERS

1048.50.1 General. The brand name and manufacturer shall be stamped or indelibly printed on each container.

1048.50.2 Type 1 Temporary Raised Pavement Markers. Markers shall consist of an L-shaped or T-shaped flexible polymer body with prismatic reflective tape on both faces of the

vertical section. The prismatic reflective faces shall be a minimum of 0.38 square inches (0.0002 m^2) for each face. The marker base shall have affixed a pressure-sensitive adhesive, protected by a release paper, for application to the pavement surface. A protective sleeve that prevents contamination of the reflective faces during pavement surface treatment operations shall be affixed to each marker. The protective sleeve shall be easily removable after the work is complete.

1048.50.3 Type 2 Temporary Raised Pavement Markers. Markers shall consist of a plastic shell with prismatic reflective faces with a minimum of 0.38 square inches (0.0002 m^2) of reflective surface for each face. If reflective faces are specified on both sides, the faces shall be 180 degrees opposed. The marker shall be fitted with a pressure-sensitive adhesive for application to a primed surface or may be applied to the pavement surface with a bituminous adhesive material.

SECTION 1048.60 EPOXY PAVEMENT MARKING MATERIAL

1048.60.1 General. Epoxy pavement marking material shall not contain toxic heavy metals. The material shall be two-component, 100 percent solids and formulated and tested to perform as a pavement marking material with glass beads applied to the surface. The two components shall be epoxy resin and an amine curing agent.

1048.60.2 Toxicity. Upon heating to application temperature, the material shall not release fumes that are toxic to persons or property. Upon curing, the material shall be completely inert, with all components fully reacted and environmentally benign.

104860.3 No Track Time. The material shall have a no-track time of 10 minutes or less, when mixed in the proper proportions and applied at a 25-mil (0.635 mm) wet film thickness at 75 ± 2 F (24 ± 1 C) with the proper application of glass beads and when tested in accordance with ASTM D 711. The material shall fully cure under a constant surface temperature of 32 F (0 C) or above.

1048.60.4 Adhesion to Concrete. The pavement marking material shall have a high degree of adhesion to the concrete surface such that there is a 100 percent concrete failure when tested in accordance with ACI 503, Appendix A.1. The prepared specimens shall have a film thickness of 15 ± 1 mil (0.381 ± □0.025 mm) and shall be applied to concrete with a minimum compressive strength of 4000 psi (28 MPa). The concrete surface shall be 90 ± 2 F (32 ± 1 C) when the material is applied. The applied material shall be cured for 72 hours at 75 ± 2 F (24 ± 1 C) before performing the test.

1048.60.5 Hardness. The material shall have a minimum Shore D Hardness of 75 when tested in accordance with ASTM D 2240.

1048.60.6 Tensile Strength. The material shall have a minimum tensile strength of 5000 psi (34 MPa) after 72 hours of cure at 75 ± 2 F (24 ± 1 C) when tested in accordance with ASTM D 638.

1048.60.7 Compressive Strength. The material shall have a minimum compressive strength of 10,000 psi (69 MPa) after 72 hours of cure at 75 ± 2 F (24 ±1 C) when tested in accordance with ASTM D 695.

1048.60.8 Abrasion Resistance. The material shall have a maximum abrasion resistance of 150 mg at 15 ± 1 mil (0.375 ± 0.025 mm) thickness after 72 hours of cure and with a CS-17 wheel under a load of 1000 grams for 1000 cycles, when tested in accordance with ASTM C 501.

1048.60.9 Yellowness Index. The material shall have a maximum yellowness index of 6 before the QUV test and a maximum of yellowness index of 23 after the 72-hour QUV test, when tested in accordance with ASTM D 1925.

1048.60.10 Color. The finished white color shall be free from tint, furnishing good opacity and visibility under both daylight and artificial light. The finished yellow color shall closely match Federal Test Standard 595 - Color Chip Number 13538.

1048.60.11 Drop-on Glass Beads. Type P glass beads shall be in accordance with Sec 1048.40.5.

1048.60.12 Qualification. In addition to the requirements of Sec 1048.1.1, the material shall have been field tested at NTPEP test decks in a northern, wet climate region for a minimum of six months. The maintained retroflectivity and durability shall be in accordance with the following requirements after being installed on at least one NTPEP test deck for a minimum of six months, including December, January and February.

1048.60.12.1 Maintained Retroreflectivity. Photometric quantity to be measured will be the coefficient of retroreflective luminance (R_L) in accordance with ASTM E 1743 for 15-meter geometry or ASTM E 1710 for 30-meter geometry. The average R_L for concrete and asphalt surfaces shall be expressed in millicandelas per footcandle per square foot (millicandelas/lux/m^2) and shall be at least 125 for 15-meter geometry or 100 for 30-meter geometry, when measured in the wheel path area.

1048.60.12.2.2 Durability. Paint shall have a durability rating of at least 5 for both concrete and asphalt surfaces when tested in the wheel path area of the NTPEP test deck.

1048.60.13 Packaging. The manufacturer's name and address, product name, color, manufacturing date, date of expiration and if the material is Part A or B shall be visible on the containers. In addition to the requirements of Sec 1048.1.1, the certification supplied by the manufacturer shall include reference to the specific NTPEP test deck to which the paint formulation was applied, including NTPEP identification numbers and report numbers.

Section 1048.70 Polyurea Pavement Marking Material

1048.70.1 Polyurea Pavement Marking Material. Polyurea pavement marking material shall not contain toxic heavy metals. It shall be two component, 100 percent solids, and formulated and tested to perform as a pavement marking material with glass beads applied to the surface.

1048.70.2 Toxicity. Upon heating to application temperature, the material shall not release fumes that are toxic to persons or property. Upon curing, the material should be completely inert, with all components fully reacted and environmentally benign.

1048.70.3 No Track Time. The material shall have a no-track time of 10 minutes or less when mixed in the proper proportions and applied at 20 mils (0.508 mm) wet film thickness at 75 ± 2 F (24 ± 1 C) with the proper application of glass beads and when tested in accordance with ASTM D 711. The material shall fully cure under a constant surface temperature of 32 F (0 C) or above.

1048.70.4 Adhesion to Concrete. The pavement marking material shall have a high degree of adhesion to the concrete surface such that there is a 100 percent concrete failure when tested in accordance with ACI 503, Appendix A.1. The prepared specimens shall have a film thickness of 15 ± 1 mils (0.375 ± 0.025 mm) and be applied to concrete with a minimum compressive strength of 4000 psi (28 MPa). The concrete surface shall be 90 ± 2 F (32 ± 1 C)

when the material is applied. The applied material shall be cured for 72 hours at 75 ± 2 F (24 ± 1 C) before performing the test.

1048.70.5 Hardness. The material shall have a minimum Shore D Hardness of between 70 and 100 when tested in accordance with ASTM D 2240.

1048.70.6 Abrasion Resistance. The material shall have a maximum abrasion resistance of 150 mg at 15 ± 1 mils (0.375 ± 0.025 mm) thickness after 72 hour curing time and with a CS-17 wheel under a load of 1000 grams for 1000 cycles, when tested in accordance with ASTM C 501.

1048.70.7 Yellowness Index. The material shall have a maximum yellowness index of 6 before the QUV test and a maximum of 23 after the 72 hour QUV test, when tested in accordance with ASTM D 1925.

1048.70.8 Color. The finished white color shall be free from tint, furnishing good opacity and visibility under both daylight and artificial light. The finished yellow color shall be defined by Federal Test Standard 595 - Color Chip Number 13538, using Federal Tests Standard 141 (Method 4252).

1048.70.9 Accelerated Weathering. The material shall have been field tested at NTPEP test decks for a minimum of six months. The material shall have satisfactory results from the NTPEP test deck.

1048.70.10 Drop-on Glass Beads. Type P moisture-resistant glass beads shall be in accordance with Sec 1048.40.5 Type P Drop-On Glass Beads.

1048.70.11 Qualification. In addition to the requirements of Sec 1048.1.1, the material shall have been field tested at NTPEP test decks in a northern, wet climate region for a minimum of six months. The maintained retroflectivity and durability shall be in accordance with the following requirements after being installed on at least one NTPEP test deck for a minimum of six months, including December, January and February.

1048.70.11.1 Maintained Retroreflectivity. Photometric quantity to be measured will be the coefficient of retroreflective luminance (R_L) in accordance with ASTM E 1743 for 15-meter geometry or ASTM E 1710 for 30-meter geometry. The average R_L for concrete and asphalt surfaces shall be expressed in millicandelas per footcandle per square foot (millicandelas/lux/m^2) and shall be at least 125 for 15-meter geometry or 100 for 30-meter geometry, when measured in the wheel path area.

1048.70.11.2 Durability. Paint shall have a durability rating of at least 5 for both concrete and asphalt surfaces when tested in the wheel path area of the NTPEP test deck.

1048.70.12 Packing. The pavement marking material shall be shipped to the job site in strong, substantial containers. The manufacturer shall include the MSDS with each shipment. The manufacturer's name and address, name of the product, lot number and/or batch number, color, tare weight, manufacturing date, date of expiration, mixing proportions and if it is Part A or B shall be contained on a label and/or painted on the containers.

SECTION 1048.80 ACRYLIC COPOLYMER FAST DRY PAVEMENT MARKING PAINT

1048.80.1 Description. Acrylic copolymer fast dry pavement marking paint shall be capable of receiving and holding glass beads for producing retroreflective pavement marking.

1048.80.2 Material. The paint shall contain no more than 3200 ppm lead or more than 800 ppm chromium based on dry weight, and shall have limited VOC content as noted herein.

1048.80.2.1 General. The finished paint shall be formulated and manufactured from first-grade material and shall be a fast drying, solvent-based, acrylic copolymer resin type paint capable of withstanding air and roadway temperatures without bleeding, staining, discoloring or deforming. The dried paint film shall be capable of maintaining original dimensions and placement without chipping, spalling or cracking. The dry paint film shall not deteriorate because of contact with normal roadway chemicals or materials.

1048.80.2.2 Durability Testing. Determination of conformance to this specification will include, but will not be limited to, the evaluation of test data from NTPEP or other MoDOT approved facilities. The maintained retroreflectivity and durability shall be in accordance with the following requirements after being installed on at least one NTPEP test deck in a northern, wet climate region for at minimum of six months, including December, January and February.

1048.80.2.2.1 Maintained Retroreflectivity. Photometric quantity to be measured will be the coefficient of retroreflective luminance (R_L) in accordance with the requirements of ASTM E 1743 for 15-meter geometry or ASTM E 1710 for 30-meter geometry. The average R_L for concrete and bituminous surfaces shall be expressed in millicandelas per footcandle per square foot (millicandelas/lux/m^2) and shall be at least 100 for 15-meter geometry or 75 for 30-meter geometry, when measured in the wheel path area.

1048.80.2.2.2 Durability. Paint shall have a durability rating of at least 4 for both concrete and bituminous surfaces when tested in the wheel path area of the NTPEP test deck.

1048.80.2.3 Mixed Paint.

1048.80.2.3.1 The mixed paint shall be strained before filling, using a screen or a sieving device no coarser than 40 mesh.

1048.80.2.3.2 The VOC content of the finished paint shall be less than 1.25 pounds of volatile organic matter per gallon (150 g/L) of total non-volatile paint material when tested in accordance with ASTM D 3960.

1048.80.2.3.3 The paint shall have the following physical properties.

Property	Requirement
Viscosity, KU	80 - 95
Laboratory Dry Time, ASTM D 711, minutes, max.	10

1048.80.2.3.3.1 Color. For white, the color shall closely match Color Chip 37925 of Federal Standard 595b. For yellow, the color shall closely match Color Chip 33538 of Federal Standard 595b. Color determination will be made for markings and the diffuse daytime color of the markings shall be in accordance with the below CIE Chromaticity coordinate limits. Color determination for liquid marking materials will be made over the black portion of a 2A or 5C Leneta Chart or equal, at least 24 hours after application of a 15-mil (380 µm) wet film. Color readings will be determined in accordance with the requirements of ASTM E 1349 using CIE 1931 2-degree standard observer and CIE standard illuminant D65.

CIE Chromaticity Coordinate Limits (Initial)								
	1		2		3		4	
Color	x	y	x	y	x	y	x	y
White	0.334	0.357	0.334	0.317	0.297	0.357	0.297	0.317

Yellow	0.531	0.483	0.531	0.429	0.471	0.483	0.471	0.429

1048.80.2.3.3.2 Contrast Ratio. The contrast ratio shall be a minimum of 0.98 when drawn down as a 15-mil (380 µm) wet film on a 2A or 5C Leneta Chart or equal, and air-dried for 24 hours. The contrast ratio shall be calculated as follows: Contrast ratio = Black/White.

1048.80.2.3.3.4 Reflectance. The daylight directional reflectance of a 15-mil (380 µm) wet film applied to a 2A or 5C Leneta Chart or equal and dried for a minimum of 24 hours shall be 84% minimum for the white paint and 50% minimum for the yellow paint.

1048.80.3. Acceptance.

1048.80.3.1 Except as noted, each batch or lot of paint shall be sampled and approved by the engineer prior to use.

1048.80.3.2 No paint shall be used that is more than 15 months old.

1048.80.3.3 In addition to the requirements of Sec 1048.1.1, the certification supplied by the manufacturer shall include reference to the specific NTPEP test deck to which the paint formulation was applied, including NTPEP identification numbers and report numbers.

SECTION 1048.90 HIGH BUILD ACRYLIC WATERBORNE PAVEMENT MARKING PAINT

1048.90.1 Description. Acrylic waterborne pavement marking paint shall be capable of receiving and holding glass beads for producing retroreflective pavement marking.

1048.90.2 Material. The paint shall contain no more than 3200 ppm lead or more than 800 ppm chromium, based on dry weight.

1048.90.2.1 General. The finished paint shall be formulated and manufactured from quality material and shall be a fast-drying, water-based, acrylic resin-type paint capable of withstanding air and roadway temperatures without bleeding, staining, discoloring or deforming. The dried paint film shall be capable of maintaining original dimensions and placement without chipping, spalling or cracking. The dry paint film shall not deteriorate from contact with normal roadway chemicals or materials.

1048.90.2.2 Acrylic Emulsion Polymer. The acrylic emulsion polymer used in the manufacture of the paint shall be Rohm & Haas HD-21, Dow DT400 or equal.

1048.90.2.3 Durability Testing. Determination of conformance to this specification will include, but will not be limited to, the evaluation of test data from NTPEP or other MoDOT approved facilities. The maintained retroreflectivity and durability shall be in accordance with the following requirements after being installed on at least one NTPEP test deck in a northern climate region for at minimum of six months, including December, January and February.

1048.90.2.3.1 Maintained Retroreflectivity. Photometric quantity to be measured will be the coefficient of retroreflective luminance (R_L) in accordance with the requirements of ASTM E 1743 for 15-meter geometry or ASTM E 1710 for 30-meter geometry. The average R_L for concrete and bituminous surfaces shall be expressed in millicandelas per footcandle per square foot (millicandelas/lux/m^2) and shall be at least 100 for 15-meter geometry or 75 for 30-meter geometry, when measured in the wheel path area.

1048.90.2.3.2 Durability. Paint shall have a durability rating of at least 4 for both concrete and bituminous surfaces when tested in the wheel path area of the NTPEP test deck.

1048.90.3 Mixed Paint.

1048.90.3.1 The paint shall be strained before filling using a screen or a sieving device no coarser than 40 mesh or equivalent.

1048.90.3.2 The volatile content of the finished paint shall contain less than 150 grams of volatile organic matter per liter in accordance with ASTM D 3960.

1048.90.3.3 The paint shall have the following physical properties:

Acrylic Waterborne Pavement Marking Paint Physical Properties	
Property	**Requirement**
Viscosity, 77 F (25 C), KU	83-98
Grind (Hegman Gage), minimum	3
Laboratory Dry Time, ASTM D 711, @ 15 mil, minutes, max.	10
Laboratory Dry Time, ASTM D 711, @ 25 mil, minutes, max.	25
Dry Through Time, minutes, max.	150

1048.90.3.3.1 Color. For white, the color shall closely match Color Chip 37925 of Federal Standard 595b. For yellow, the color shall closely match Color Chip 33538 of Federal Standard 595b. Color determination will be made for markings and the diffuse daytime color of the markings shall be in accordance with the below CIE Chromaticity coordinate limits. Color determination for liquid marking material will be made over the black portion of a 2A or 5C Leneta Chart or equal, at least 24 hours after application of a 15-mil wet film. Color readings will be determined in accordance with the requirements of ASTM E 1349 using CIE 1931 2-degree standard observer and CIE standard illuminant D65.

CIE Chromaticity Coordinate Limits (Initial)								
Color	1		2		3		4	
	x	y	x	y	x	y	x	y
White	0.334	0.357	0.334	0.317	0.297	0.357	0.297	0.317
Yellow	0.531	0.483	0.531	0.429	0.471	0.483	0.471	0.429

1048.90.3.3.2 Flexibility. The paint shall show no cracking or flaking when tested in accordance with Federal Specification TT-P-1952B.

1048.90.3.3.3 Water Resistance. The paint shall conform to Federal Specification TT-P-1952B. There shall be no blistering or appreciable loss of adhesion, softening or other deterioration after examination.

1048.90.3.3.4 Freeze-Thaw Stability. The paint shall show no coagulation or change in consistency greater than 10 Kreb Units when tested in accordance with Federal Specification TT-P-1952B.

1048.90.3.3.5 Heat Stability. The paint shall show no coagulation, discoloration or change in consistency greater than 10 Kreb Units when tested in accordance with Federal Specification TT-P-1952B.

1048.90.3.3.6 Dilution Test. The paint shall be capable of dilution with water at all levels without curdling or precipitation such that the wet paint can be readily cleaned up with water only.

1048.90.3.3.7 Storage Stability. After 30 days of storage in a 3/4 filled, closed container, the paint shall show no caking that cannot be readily remixed to a smooth, homogeneous state, and shall show no skinning, livering, curdling or hard settling. The viscosity shall change no more than 5 Kreb Units from the viscosity of the original sample.

1048.90.3.3.8 Contrast Ratio. The minimum contrast ratio (hiding power) shall be 0.96 when drawn down with a 0.005 bird film applicator on a 2A or 5C Leneta Chart or equal and air-dried for 24 hours. The contrast ratio shall be calculated as follows: Contrast Ratio = Black/White.

1048.90.3.3.9 Reflectance. The daylight directional reflectance of a 15-mil (380 µm) wet film, applied to a 2A or 5C Leneta Chart or equal and dried for a minimum of 24 hours, shall be no less than 84 percent for the white paint and no less than 50 percent for the yellow paint.

1048.90.3.3.10 Bleeding. The paint shall have a minimum bleeding ratio of 0.97 when tested in accordance with Federal Specification TT-P-1952B. The asphalt saturated felt shall be in accordance with ASTM D 226 for Type I.

1048.90.3.3.11 Dry Through Time. The paint shall be applied to a non-absorbent substrate at a wet film thickness of 15 ± 1 mil and placed in a humidity chamber controlled at 90 ± 5 percent relative humidity and 72.5 ± 2.5 F (22.5 ± 1.4 C). The dry through time shall be determined in accordance with ASTM D 1640, except that the pressure exerted shall be the minimum needed to maintain contact with the thumb and film.

1048.90.4 Acceptance.

1048.90.4.1 Except as noted, each batch or lot of paint shall be sampled and approved by the engineer prior to use.

1048.90.4.2 No paint shall be used that is more than 15 months old.

1048.90.4.3 In addition to the requirements of Sec 1048.1.1, the certification supplied by the manufacturer shall include reference to the specific NTPEP test deck to which the paint formulation was applied, including NTPEP identification numbers and report numbers.

1048.100 STANDARD ACRYLIC WATERBORNE PAVEMENT MARKING PAINT.

1048.100.1 Description. Standard acrylic waterborne pavement marking paint shall be capable of receiving and holding glass beads for producing retroreflective pavement marking.

1048.100.2 Material. The paint shall contain on more than 3200 ppm lead or more than 800 ppm chromium, based on dry weight.

1048.100.2.1 General. The finished paint shall be formulated and manufactured from quality material and shall be a fast-drying, water-based, acrylic resin-type paint capable of withstanding air and roadway temperatures without bleeding, staining, discoloring or deforming. The dried paint film shall be capable of maintaining original dimensions and placement without chipping, spalling or cracking. The dry paint film shall not deteriorate from contact with normal roadway chemicals or materials.

1048.100.2.2 Acrylic Emulsion Polymer. The acrylic emulsion polymer used in the manufacture of the paint shall be Rohm & Haas E-2706, Dow DT211 or equal. Later generation acrylic emulsions may be substituted as approved by the engineer.

1048.100.2.3. Durability Testing. The provisions of section 1048..90.2.3 will apply.

1048.100.2.3.1 Maintained Retroreflectivity. Photometric quantity to be measured will be the coefficient of retroreflective luminance (R_L) in accordance with the requirements of ASTM E 1743 for 15-meter geometry or ASTM E 1710 for 30-meter geometry. The average R_L for concrete and bituminous surfaces shall be expressed in millicandelas/lux/m^2 and shall be at least 100 for 15-meter geometry or 75 for 30-meter geometry, when measured in the wheel path area.

1048.100.2.3.2 Durability. Paint shall have a durability rating of at least 4 on both concrete and bituminous surfaces when tested in the wheel path area of the NTPEP test deck..

1048.100.3 Mixed Paint The provisions of Sec 1048.90.3 shall apply.

1048.100.4 Acceptance.

1048.100.4.1 Except as noted, each batch or lot of paint shall be sampled and approved by the engineer prior to use.

1048.100.4.2 No paint shall be used that is more than 15 months old.

1048.100.4.3 In the addition to the requirements of Sec 1048.1.1, the certification supplied by the manufacture shall include reference to specific NTPEP test deck to which the paint formulation was applied, including NTPEP identification numbers and report numbers.