

**TEMPORARY PAVEMENT MARKINGS
FAST DRY, HIGH BUILD
HIGH DURABILITY WATERBORNE PAINT
with WET REFLECTIVE ELEMENTS**

SECTION 612

612.1 Description

This section contains specifications for the materials, equipment, construction, measurement and payment for furnishing and applying heavy metals free, fast drying high build, waterborne paint reflectorized with Type I glass beads, a glass bead intermix system supplemented with a drying agent to accelerate dry time and wet reflective elements for temporary pavement markings applied within the limits of a construction or maintenance project to produce temporary pavement markings that are retroreflective during both dry and wet conditions. Apply these pavement markings in conformity with the plans, the *2007 Standard Specifications for Highway Construction*, these supplemental specifications and the RCE. These temporary pavement markings shall provide delineation for the travel lanes during all stages of the work.

Supply all necessary equipment and materials for application of the fast dry, high build, high durability waterborne paint at a minimum wet film thickness of 25 mils. Apply a glass bead intermix system supplemented with a drying agent to accelerate dry time and drop-on wet reflective elements and Type I glass beads applied from a single truck in a single pass operation.

612.2 Materials

612.2.1 General

Apply a pavement marking that consists of a heavy metals free, fast drying, waterborne traffic paint in compliance with these specifications. These pavement markings shall have a minimum thickness of 25 mils when applied from a single truck in a single pass operation. These pavement markings shall be retroreflective during both dry and wet conditions.

Achieve the retroreflectivity of these pavement markings by employing a double drop bead system. Use 3M Series 50 Wet Reflective Elements or an approved equal for the initial drop followed immediately by a subsequent drop of Type I glass beads to produce a uniformly retroreflective pavement marking. Reduce the drying time of the pavement markings by injecting a glass bead intermix system supplemented with a drying agent directly into the paint stream as described in **Subsection 612.2.3.2**.

612.2.2 Paint

Use paint conforming to the requirements of this specification for this work. Do not use paint that is more than 12 months old. Use paint that is in conformance with all applicable specifications and has been tested by the Office of Materials and Research before commencement of work. Upon satisfactory completion of testing, the Office of Materials and Research will assign a unique Laboratory Number to each paint batch. Stencil the Laboratory Test Number on the side of each paint container to indicate Office of Materials and Research approval. Provide documentation to the RCE with each batch containing the information specified in **Subsection 612.2.2.7**. The RCE will forward a copy of this information to the Office of Materials and Research in order to track usage of each paint batch tested.

612.2.2.1 General Requirements

Provide white and yellow paint that meets the following requirements:

- a. Formulated and manufactured from top grade materials and free from defects and imperfections that might adversely affect the serviceability of the finished product.
- b. Formulated and processed specifically for service as a suitable binder for Type I glass beads and wet reflective elements for use on traffic-carrying pavements, including Portland cement concrete, asphalt pavement and brick.
- c. Dries to an elastic adherent finish that does not darken after exposure to sunlight, does not show appreciable discoloration with age or darken under service such that the color or visibility to the reflectorized marking is impaired. Apply evenly and uniformly.
- d. Free of heavy metals as defined in **Subsection 612.2.2.4.11**.
- e. Provides the proper anchorage and refraction for glass beads when both binder and spheres are applied in the stipulated quantities with specialized equipment using pressurized bead guns.
- f. Manufactured and sealed in containers in such manner that during normal shelf life does not show evidence of settling or livering that causes the paint to be unusable or is detrimental to the specialized equipment used in application.
- g. Does not show evidence of skinning when received in sealed containers.

612.2.2.2 Vehicle

Use a vehicle portion that has a combination of 100% acrylic emulsion resins (Rohm and Haas HD 21A or Dow DT 400 or approved equal) and sufficient surfactants, dispersants, defoamers, water, and coalescing agents that produce a pigmented binder meeting the requirements of these specifications.

612.2.2.3 Testing and Production Variation

When minimum or maximum values are given in these specifications, they represent values that are reliably obtained from testing. They do not represent acceptable mean production values. It is the responsibility of the manufacturer to consider variations in production and between testing laboratories when setting manufacturing tolerances.

612.2.2.4 Detailed Requirements**612.2.2.4.1 Viscosity**

Use paint with a viscosity of 80 to 95 K.U. when tested at 77° F in accordance with ASTM D 562.

612.2.2.4.2 Drying Time**612.2.2.4.2.1 Laboratory Drying Time**

Test paint in accordance with ASTM D 711 at a wet film thickness of 25 mils (± 1 mil) to determine time to "no-pickup" condition. Conduct the test in a standard laboratory atmosphere during which the relative humidity is maintained at 50% ($\pm 5\%$), and the temperature is maintained at 73.5°F (± 3.5 °F) and air flow is maintained at a rate of 2.2 mph (± 0.45 mph). Use paint that will dry to a "no-pickup" condition in 8 minutes or less.

612.2.2.4.2 Field Drying Time

Provide paint that when applied for a 6 inch wide line at a wet film thickness of 25 mils with an intermix glass bead system supplemented with a drying agent injected directly into the paint stream at an application rate of 3.00 pounds per gallon, a wet reflective element application of 0.0165 pounds per 6 inch linear foot and a subsequent application of AASHTO M247 Type I standard beads at a rate of 6.4 – 10.0 pounds/gallon dries to a “no-track” condition under the stipulated conditions stated below. The supplemental drying agent will accelerate drying time typical for paint with a wet film thickness of 25 mils and inclusive of all reflective elements listed hereto by 50% to 60% to achieve a “no track” condition in compliance with those times listed below. See *Table 1*.

Table 1

Relative Humidity \leq 80%, Surface Temperature \geq 50°F , Dry Pavement	
Paint Temperature at Tip	Maximum "No-Track" Time
77°F	6 minutes
78°F – 120°F	4 minutes

Consider paint to have reached a "no-track" condition when the marking is traversed by a standard automobile simulating a passing maneuver at a speed of approximately 40 mph without visible tracking of the reflectorized line. Tracking is defined to be visible if it is discernable when viewed at a distance of 50 feet.

612.2.2.4.3 Flexibility

Cast a 5 mil wet film of the paint on a clean 30-gauge tin panel approximately 3 inches by 6 inches. Air-dry the panel at room temperature for 18 hours (\pm 2 hours), and then, bake at 122°F (\pm 4°F) for 2 hours (\pm 0.25 hour). Allow the panel to cool at room temperature for 30 minutes (\pm 10 minutes), and then, bend around a 0.5 inch metal rod. Use paint that withstands this test with no sign of film failure or loss of adhesion when viewed without the use of magnification.

612.2.2.4.4 Dry Capacity

Provide white and yellow paint that has a minimum contrast ratio of 0.965 when tested at a wet film thickness of 15 mils in accordance with ASTM D 2805.

612.2.2.4.5 Directional Reflectance

Use paint that has daylight reflectance, without drop-on glass spheres or other retroreflective elements, of not less than 86% for white paint, and not less than 50% for yellow paint relative to magnesium oxide when tested in accordance with ASTM E 1347.

612.2.2.4.6 Glass Bead Adhesion

Use paint that is formulated and processed as both white and yellow colors specifically for service as a binder of drop-on beads and wet reflective elements, to produce maximum adhesion, refraction, and reflection during the life of the marking applied at 25 mils wet film thickness.

612.2.2.4.7 Bleeding

Use a paint that has a minimum bleeding ratio of 0.98 when tested in accordance with the method given in Federal Specification TT-P-1952B, paragraph 4.5.13.

612.2.2.4.8 Total Non-Volatile, Vehicle Solids and Flash Point

Provide paint with volatile organic compounds (VOC) that does not exceed 100 grams/liter. Use a non-volatile vehicle that is greater than or equal to 42.00%, reported to the nearest one hundredth of a percent, when the whole paint is ashed for one hour at 877°F ($\pm 45^\circ\text{F}$). Use white and yellow paints that have 75.00% to 80.00% total non-volatiles, reported to the nearest one hundredth of a percent, when tested in accordance with ASTM D 3723. Provide paint that has a closed cup flash point that is greater than or equal to 140°F.

612.2.2.4.9 Composition

Use a white paint that contains a minimum of 1.0 pound/gallon of titanium dioxide in the white pigment. For all colors, conform the titanium dioxide to ASTM D 476, Types II, III, or IV.

612.2.2.4.10 Lead Content

For yellow heavy metals free binder, use a finished binder that does not exceed the legal limit of 0.06% maximum when tested for lead content. Use yellow pigments that are organic yellows containing no lead, chromium, or other heavy metal containing pigments. Establish the color using a blend of Color Index PY 75 and Rutile Titanium Dioxide Type II or blends of CI PY 75, CI PY 65, and Rutile Titanium Dioxide Type II. Use only small quantities of tinting aids if needed to establish an acceptable color.

612.2.2.4.11 Color

Use paint that is capable of maintaining its original color throughout the life of the line (up to approximately 2 years). Use paint with color that meets the requirements of 23CFR, Part 655, Table 1. The following CIE chromaticity coordinates describe the instrumental boundaries of the required color match. See *Table 2*.

Table 2

Chromaticity Coordinates				
	White		Yellow	
	x	y	x	y
1	0.303	0.300	0.498	0.412
2	0.368	0.366	0.557	0.442
3	0.393	0.340	0.520	0.479
4	0.274	0.329	0.438	0.472

612.2.2.4.12 Distinguishable Color

Use yellow color that is very distinguishable from white markings under day and night conditions when applied on the roadway and is capable of remaining distinguishable during the life of the marking.

612.2.2.4.13 Grind and Freedom from Lumps

Use pigmented binder that has a grind of not less than 3 on the Hegman Grind Gauge and that passes a No. 50 mesh sieve at the time of packaging.

612.2.2.4.14 Settling

Test the pigmented binder for settling by the following method:

- a. Use full pint, triple-sealed, friction top paint cans lined with an appropriate material designed to be non-reactive with waterborne paints.
- b. Fill the cans to the bottom of the friction seal lip and place in an inverted position for one hour to ensure a complete seal between the cover and the body of the can.
- c. At the end of one hour, place the filled can in an upright position for at least one hour before being placed in an air temperature of 122°F ($\pm 2^\circ\text{F}$). Place the can or cans in a single tier.
- d. Store these cans free of vibration at an air temperature of 122°F ($\pm 2^\circ\text{F}$) for a period of 5 days.
- e. After a heating period of 5 days, cool the cans at room temperature for 4 to 5 hours and evaluate the degree of settling in accordance with ASTM D 869.

Provide paint that exhibits no dense or hard settling and has a degree of settling rating of 6 or better when evaluated in accordance with ASTM D 869.

612.2.2.4.15 pH Factor

Provide a pigmented binder that has a pH factor of 9.6 minimum as packaged without thinning or diluting. Use the following resins; Rohm and Haas HD 21A or Dow DT 400 or approved equal for enhancing the time to "no track". Request approval by the OMR of any substitute resin other those expressly mentioned here before its use. Inform the OMR of the resin intended for use when supplying samples. Ensure that the supplier does not change resins during the life of the Contract without prior approval from the OMR. In the event that low pH water is used to manufacture the finished binder, pH buffers may be used to obtain the minimum pH factor.

612.2.2.4.16 Solvents

Use potable water from a public water supply as the solvent for the binder manufactured by these specifications.

612.2.2.5 Control Tolerances**612.2.2.5.1 Percent Pigment**

Use total pigment solids that are 58.00 to 63.00 percent by weight, reported to the nearest one hundredth of a percent, when tested in accordance with ASTM D 3723.

612.2.2.5.2 Volumetric Weight

Use pigmented binders that have a density of 14.0 pounds/gallon (± 0.3 pound/gallon) for white and 13.5 pounds/gallon (± 0.3 pound/gallon) for yellow. Determine weight per gallon in accordance with ASTM D 1475.

612.2.2.5.3 Vehicle Solids and Total Non-Volatile

As noted in **Subsection 612.2.2.3**, it is the manufacturer's responsibility to consider testing and production variation when selecting mean production values. It is strongly recommended that the vehicle solids be one to two percent higher than the specified minimum values.

612.2.2.5.4 Viscosity

Use paint that meets the requirements given in **Subsection 612.2.2.4.1**.

612.2.2.5.5 Field Drying Time

Use paint that meets the requirements given in **Subsection 612.2.2.4.2.2**.

612.2.2.6 Samples and Tests Required**612.2.2.6.1 Qualifications of Samples**

Before shipment or use, submit the following items for each type and color of paint supplied:

- Two samples consisting of one-quart cans of paint that the manufacturer proposes to furnish.
- Manufacturer's testing results for the samples. Provide testing results that minimally include the items given in **Subsection 612.2.2.5** and the brand and type of resin used.
- Manufacturer's statement of compliance with all requirements of these specifications. This statement explicitly states that the paint provided is essentially free of lead, cadmium, and other heavy metals.
- *Material Safety Data Sheets*, essentially similar to *Form OSHA-20*, for the material provided.

Furnish the items above to the following address:

SCDOT Office of Materials and Research
1406 Shop Road
Columbia, SC 29201

Do not ship or use paint until testing indicates that the material proposed is in conformance with these specifications.

612.2.2.6.2 Production Control Tests

Perform laboratory tests on each batch of paint produced under these specifications to ensure compliance with these specifications. Include the results of these tests with samples provided as specified in **Subsection 612.2.2.6.1**.

612.2.2.6.3 Department Samples

After award of the contract, the Department reserves the right to perform in-plant sampling of the finished paint during packaging operations and/or sampling of the packaged paint after it is received. During packaging operations for each batch and at the time the manufacturer obtains samples for each batch, obtain two one-quart samples, sealed properly, and forwarded along with the results of the manufacturer's production control tests and a certification of compliance with these specifications to the OMR at the address shown in **Subsection 612.2.2.6.1**. The samples are tested by the Department in whatever manner is deemed necessary. Department inspectors or their designated agents observe the performance of all sampling. Samples taken by the manufacturer without supervision are not acceptable without permission of the OMR. The inspectors will designate at random two containers from each batch to be sampled for testing and enclose a copy of the sampling inspection with the samples.

612.2.2.7 Materials Acceptance Criteria

612.2.2.7.1 Shipping Records

Once a batch of paint has been approved for shipment, send a form with the following information to the RCE for each shipment:

- Date
- Consignee
- Shipped To
- Type of Paint
- No. of Gallons Shipped
- Batch Number
- Laboratory Number furnished by OMR for approval batch(es).

612.2.2.8 Packing and Marking

612.2.2.8.1 Bulk Containers

Supply paint in an intermediate bulk container capable of holding 250 gallons. Provide a container that is new or reconditioned, stainless steel, and conforms to Federal DOT Specification 57 from 49 CFR, Part 178.251, or 49 CFR, Part 178 Subpart O and all other appropriate rules and regulations. Provide a container that has a certificate of construction compliance with 49 CFR, Part 178.2(C), (1), (i) and (ii) or Part 178 Subpart O regarding drop test requirements. Use a container that is equipped with disposable airtight bladders (not liners), minimum 5 mil thickness, constructed of polyethylene or similar flexible materials that will not react with the specified waterborne paint. Provide a bladder that has a minimum working volume of 250 gallons. Use a bladder that is designed to allow for valve access and proper drainage of the container contents, while minimizing air space around the paint during storage and use. Use a bladder that completely encapsulates the paint within the container and that can be easily opened for field sampling and easily closed to remain airtight. Do not allow direct air to contact paint between the bladder and the container. Reuse of the bladder is prohibited.

Use containers that comply with the following specifications:

- a. Capable of holding approximately 250 gallons.
- b. Designed to accommodate lifting and transporting with forklift or front-end loader.
- c. Stackable, at least two high.
- d. Has either a hinged or bolted hatch and/or screw top opening that is at least 16 inches in diameter. Use containers with a bolt-down hatch that have an additional screw top opening of 6 inch minimum diameter.
- e. Has a 2 inch ball valve fitted with a male quick disconnect and valves that are 100% compatible with waterborne paint. Has a valve that no portion, including the in-place cap assembly, extends beyond the vertical plane of the forklift. No galvanized, copper, chrome, or brass valves allowed.
- f. Has a security feature that protects the valve from being opened by accident or by vandals.
- g. 100% compatible with waterborne paint.
- h. Has proper venting of the tank by either a vacuum relief valve or an access port that can be opened. Opening the container for vacuum relief will not cause the paint to come in direct contact with air.

612.2.2.8.2 Fill Level for Bulk Containers

Fill each bulk container with 250 gallons of paint to provide an air space at the top. This space is to reduce spillage when stirring is required. Add several liters of an appropriate floating ammonia solution to the top of the paint to retard evaporation and skinning.

612.2.2.8.3 Five Gallon Containers

When 5 gallon containers are used, use buckets that are USDOT hazmat certified containers for shipping liquids conforming to this specification. Ensure that they are made of not less than 26 gauge steel or plastic buckets with 90 mil minimum wall thickness, a 26 gauge metal lid, and are open-head design with lug cover and flowed-in gasket. Ensure that metal pails have at least one reinforcing bead at the upper end.

If a tapered design is used, provide two beads; one above and one below the point at which the handle is attached to the side of the metal buckets. Provide a suitable wire bail-type handle.

612.2.2.8.4 Fifty-Five Gallon Containers

Use open-head type 55 gallon drums conforming to USDOT 1A1 hazmat approved containers, as amended by this specification. Ensure that they are constructed of not less than 18 gauge steel and have a removable head that is solid and contains no bungs. Use a 5/8" bolt to secure the ring clamp that secures the removable head. Tighten the ring clamp to prevent spillage when the drum is tilted during unloading.

612.2.2.8.5 Container Marking

Plainly mark or label all containers to show the following information as appropriate: "Waterborne High-Build Lead Free - White," or "Waterborne High-Build Lead Free - Yellow." Also, show the following:

- Net gallons and/or liters
- Name of manufacturer
- Batch number
- Date of manufacture (month and year)
- Type of resin used

Use containers that are labeled with the information listed above in a method that is able to withstand exposure to elements for up to one year and retain all of the required information. The Department reserves the right to require an improved marking/labeling method in the event that the identifying information is not retained on the container during the storage period to the satisfaction of the RCE.

612.2.2.8.6 Container Color

Use containers provided under these specifications that are painted or otherwise colored blue. Other colors may be used with prior approval of the RCE. Yellow, white, and black are not acceptable container colors.

612.2.2.8.7 Container Lining

Ensure that each drum or metal pail has a baked-on epoxy lining on the inside of the container. Provide containers with a coating of phenolic epoxy or equal coating.

612.2.2.8.8 Alternative Method of Packaging**612.2.2.8.8.1 General**

At the Contractors option, an alternative method of packaging may be used. This alternative packing consists of caged bottle paint totes also known as composite intermediate bulk containers (IBCs). If totes are used, make certain that containers consist of blow-molded, high molecular, high density polyethylene (HDPE) enclosed by a galvanized square tubular steel cage and have a capacity of 275 gallons.

612.2.2.8.8.2 Materials

Ensure that the HDPE resin is certified by the tote manufacturer to contain a U.V. stabilizer compounded by the resin manufacturer. Make certain that the frame is zinc-galvanized tubular steel and the pallet is either plastic (HDPE) or zinc-galvanized tubular steel.

Make certain totes are equipped with disposable airtight bladders (not liners), minimum 127-micron (5 mil) thickness, constructed of polyethylene or similar flexible materials that will not react with the specified waterborne traffic paint.

612.2.2.8.8.3 Requirements

Use reusable HDPE totes capable of handling bulk liquids with 1.9 specific gravity. Make certain containers have a footprint dimensions that does not exceed 48 inches for either width or depth.

Ensure that totes are UN/DOT certified for shipping and handling of bulk liquids with a maximum of 1.9 specific gravity as required by 49 CFR, Part 178. Use totes that have a base that allows four-way forklift and pallet jack handling. Make certain that the totes are capable of being stacked a minimum of two high when completely filled with paint.

Ensure that the minimum working volume of the bladder is 275 gallons and that the bladder is designed to allow for valve access and proper drainage of the container contents, while minimizing air space around the paint during storage and use. Ensure that the bladder completely encapsulates the paint within the container and does not allow any direct air to paint contact between the bladder and the container. Reuse of the bladder is prohibited.

Ensure that the finished tank wall is as free, as commercially practicable, of visual defects such as foreign inclusions, dried paint, air bubbles, pinholes, pimples, crazing, cracking and delaminations that will impair the serviceability of the vessel. Fine bubbles are acceptable with tanks to the degree in which they do not interfere with proper fusion of the resin melt.

612.2.2.8.8.4 Tank Fittings and Attachments

Make certain that a bottom drain ball valve is recessed 2 inches with a 2 inch male quick disconnect fitting. Ensure that the fill port and disconnect are leak free and compatible with waterborne paint. No galvanized, copper, chrome, or brass valves are allowed. Make certain that no portion of the valve, including the in-place cap assembly, extends beyond the vertical plane of the forklift.

Ensure that the top lid is a 6 inch screw cap style lid, and is easily opened by hand, and the screw cap has a 2 inch bung incorporated into it to provide a vacuum vent.

612.2.2.8.8.5 Markings and Certifications

Use totes that have a molded-in gallon marker for at-a-glance monitoring.

Make certain that totes have the following markings required by 49 CFR, Part 178.703:

- UN/DOT shipping classification
- Capacity
- Tare mass
- Month, day and year of manufacture
- Manufacturer's name, city and state

Use totes that have either a document holder attached or direct stenciling to the side that clearly convey the following information:

- Company name
- Color of paint
- Quantity of paint contained
- Batch number
- Formula Code
- Other information as may be specified/requested by the Department

612.2.2.9 Supplier Qualification**612.2.2.9.1 Supplier Experience**

The firm or corporation that supplies paint is required to have a history of production and sales of the material furnished under these specifications. If requested by the Department and before use, have the supplier meet in person and/or furnish a statement to the satisfaction of the Department of the above history along with the names of other government agencies that have successfully used its products.

612.2.2.9.2 Laboratory Facilities

Ensure that the supplier possesses or has sufficient access to laboratory facilities capable of assuring accuracy and quality of formulation by performing laboratory tests as required in these specifications.

612.2.2.9.3 Service Technician

Proper application is deemed essential to the success of this process. To ensure proper usage of material provided under these specifications, provide at least one technician to instruct in the application of materials when requested by the Department. Provide a technician that is familiar with marking application equipment and has had successful experience in the placing of reflective markings and the use of reflective marking materials.

612.2.3 Glass Beads

612.2.3.1 Type I Glass Beads

Utilize Type I glass beads with a Refractive Index greater than 1.9 with minimum 80% rounds that meet the requirements of **Subsection 627.2.3** of the *2007 Standard Specifications for Highway Construction*.

The Department reserves the right to perform sampling of the packaged or unpackaged material at the point of manufacture, the Contractor's facilities or at the job site. These samples will be tested in the manner deemed appropriate by the RCE. Before commencement of the work, provide a Certification of Compliance to the RCE for the glass beads as specified herein. At least one 50 or 55 pound bag of beads will be sampled by the RCE at random for each 44,000 pounds of beads used. Forward the bead samples and a copy of the certification information to the OMR in Columbia for testing.

612.2.3.2 VISILOK Glass Beads

Use Potters Industries VISILOK glass bead intermix system or an approved equal supplemented with a drying agent designed to accelerate the dry time of fast drying waterborne paint applied at a wet film thickness of 25 mils (± 1 mil) in a single pass operation from a single truck to less than 6 minutes. Submit all requests for approval equals to the Director of Traffic Engineering no less than 30 days prior to conducting the work.

Apply the glass bead intermix system supplemented with a drying agent by either of the following methods:

- 1.) Single paint gun - Inject the glass bead intermix system directly into the paint stream immediately prior to contact of the paint with the roadway surface.
- 2.) Tandem paint guns - Apply the glass bead intermix system to the paint surface in between two paint guns operating in tandem from the same truck in a single pass operation. Apply the glass bead intermix system to the paint surface immediately after application of paint from the first paint gun in front and prior to application of paint from the second paint gun in the rear of the tandem pair of paint guns.

Apply the glass bead intermix system to a 4 inch wide line at a minimum rate of 2.0 pounds/gallon (75 pounds/mile) and to a 6 inch wide line at a minimum rate of 3.0 pounds/gallon (112 pounds/mile).

The glass bead system supplemented with a drying agent and the wet reflective elements will be accepted under manufacturer's certification and will not require laboratory testing.

612.2.4 Wet Retroreflective Elements

Use 3M Series 50 Wet Reflective Elements or an approved equal. Submit all requests for approval equals for wet reflective elements to the Director of Traffic Engineering no less than 30 days prior to conducting the work.

The wet reflective elements shall contain either clear or yellow tinted microcrystalline ceramic beads bonded to an opacified core. The use of lead, chromate or arsenic during the manufacturing process is prohibited.

All "dry-performing" microcrystalline ceramic beads bonded to the core shall have a minimum index of refraction of 1.80 when tested using the liquid oil immersion method. All "wet-performing" microcrystalline ceramic beads bonded to the core shall have a minimum index of refraction of 2.30 when tested using the liquid oil immersion method.

The glass bead system supplemented with a drying agent and the wet reflective elements will be accepted under manufacturer's certification and will not require laboratory testing.

612.2.5 Reflectance Requirements

All fast dry waterborne high build high durability paint (25 mils thick) with wet reflective elements shall meet minimum initial retroreflectance values as obtained with a LTL-X Retroreflectometer. The Contractor shall conduct measurements of the retroreflectivity of the pavement markings to ensure the pavement markings meet the minimum initial retroreflectance values required of the pavement markings as shown in the table below.

Table 3

Initial Retroreflectivity (mcd/lux/m ²) Requirements	
White	Yellow
400	300

Prior to conducting the initial application of pavement marking to any roadway of the project, the RCE may require the Contractor to conduct a test strip application of the fast dry waterborne high build high durability paint (25 mils thick) with wet reflective elements at a location approved by the RCE. Utilize the test strip to obtain retroreflectivity measurements and ensure proper calibration of all application equipment to meet the minimum initial retroreflectance values.

Conduct measurements of the retroreflectivity of the pavement markings after the pavement markings have been exposed to traffic operating at speeds sufficient to remove excess unattached beads that can impact retroreflectance values from the newly applied pavement markings. Conduct these measurements no later than 10 days after application of the pavement markings. However, prior to conducting any work activities that will generate a need for pavement markings, conduct retroreflectance measurements of any pavement markings applied the previous day or work shift to ensure those pavement markings meet the minimum initial retroreflectance values. If the initial retroreflectance values of those pavement markings do not meet the minimum requirements, those pavement markings shall require replacement and the Contractor shall not conduct any further work activities that will generate a need for pavement markings until the pavement marking application process that generated the substandard condition is corrected.

Obtain retroreflectivity measurements for each 5000 feet of each color of pavement markings applied each day or work shift. Solid lines and broken lines of the same color do not require individual retroreflectivity measurements due to variation in the type of line unless visual observations suggest a need to conduct individual measurements of each type of line. The Contractor shall submit the retroreflectivity measurement data relative to the pavement markings applied the previous day or work shift to the RCE each day prior to beginning any work activities that will generate a need for pavement markings.

Conduct measurements of the retroreflectivity of the pavement markings after 90 days after the time of application of the pavement marking. A pavement marking found to have retroreflectance values less than 200 mcd/lux/m² for white or 150 mcd/lux/m² for yellow will require replacement. The RCE may conduct random retroreflectivity measurements of the pavement markings to gather retroreflectance value data.

Ensure all fast dry waterborne high build high durability paint (25 mils thick) with wet reflective elements are uniformly retroreflectorized.

612.3 EQUIPMENT

612.3.1 Traveling Applicator

Apply longitudinal pavement markings using a truck mounted applicator. Transverse lines or symbols may be applied using a portable unit. A truck mounted unit is defined as a self-propelled vehicle with six or more wheels and having an enclosed cab for housing the driver.

Use a traveling pavement marking applicator that is adaptable to traveling at a uniform, predetermined rate of speed both uphill and downhill in order to produce a uniform application of paint. Use a spray-type paint machine that is capable of satisfactorily applying the paint under pressure with a uniformity of feed through nozzles spraying directly upon the pavement. Use a machine that is capable of applying at least two separate stripes, either solid or skip, in any specified pattern by using at least two adjacent spray nozzles simultaneously. Use paint tanks equipped with satisfactory cutoff valves, which can apply broken, or skip lines automatically. Make certain that the controls allow the operator to override set automatic cycles to extend a line or to begin a new cycle at any selected point. Use nozzles with mechanical bead dispensers that operate simultaneously and in coordination with the spray nozzle and distributes the beads in a uniform pattern at the rate specified. Ensure each nozzle is equipped with suitable line guides. Use a traveling applicator equipped with paint meters that will indicate the amount of paint dispensed from each tank.

612.3.2 Cleaning Equipment

Use pavement cleaning equipment consisting of the necessary brushes, brooms, scrapers, grinders, high-pressure water jets and air blast equipment required to satisfactorily remove all foreign matter from the surfaces to be painted. Conduct cleaning in such a manner so that the underlying pavement is not damaged.

612.3.3 Hand Painting Equipment

Use hand painting equipment consisting of suitable applicators, templates and guides necessary to produce satisfactory results. Limit the use of this equipment to smaller areas such as transverse lines and stenciled symbols.

612.3.4 Equipment on Site

Ensure that the equipment necessary for the proper construction of the work is on site, in acceptable working condition, and approved by the RCE as to both type and condition before the start of work under this section. Provide sufficient equipment to enable prosecution of the work in accordance with the project schedule and completion of the work in the specified time.

612.4 CONSTRUCTION

612.4.1 Use and Coordination of Traffic Control

Install and maintain the proper traffic control for long line application as directed by the typical traffic control standard drawings for mobile operations, the *2007 Standard Specifications for Highway Construction*, and the RCE. Install and maintain the proper traffic control for handwork and application of pavement markings at signalized intersections as directed by the typical traffic control standard drawings, the *2007 Standard Specifications for Highway Construction* and the RCE.

612.4.2 Surface Preparation

Ensure that the pavement is dry and free of glaze, oil, dirt, grease, or other foreign contaminants. Prior to application of the temporary pavement markings, clean the roadway surface by sweeping or high-pressure air to ensure a clean surface for proper adhesion of the markings. Remove any existing markings that conflict with the traffic control staging plans. Conduct all pavement marking removal operations in accordance with **Subsection 609.4.1.2** of the *2007 Standard Specifications for Highway Construction*.

612.4.3 Application of Markings

612.4.3.1 Maximum Temperature and Heat Exchanger Dwell Time (Waterborne Paint)

When waterborne paint is utilized, do not allow the temperature at the heat exchanger of the paint truck to exceed 120°F. Do not allow paint to dwell in the exchanger for more than 2 hours.

It is strongly recommended that the exchanger temperature be reduced to 100°F or that heat to the exchanger and lines be turned off if the material is not to be applied within one hour.

612.4.3.2 Alignment of Markings

Ensure that the markings are straight or uniform in curvature and conform uniformly to tangents, curves, and transitions. Make certain that all pavement markings and symbols are of dimensions shown in the plans, the Standard Drawings for Road Construction and the MUTCD.

Ensure that the finished line markings are free from waviness and the lateral deviations do not exceed 2 inches in 15 feet. Any greater deviation will be sufficient cause for requiring the removal and correction of the markings.

612.4.3.3 Applicator Type

Place all longitudinal markings with a truck-mounted applicator except when approved by the RCE. Such an exception may occur where the length of a particular marking is too short or the curvature too great to permit efficient use of a truck-mounted applicator. Transverse markings may be applied with a portable unit.

612.4.3.4 Application Restrictions

Unless otherwise permitted by the RCE, no markings may be applied to areas of pavement when any of the following conditions are present:

- a. Moisture or foreign matter is present on the surface.
- b. The air temperature is below 50°F
- c. The relative humidity is above 85%

The RCE may waive the temperature and humidity requirements on newly placed pavement when markings are immediately required for safe conduct of traffic.

612.4.3.5 Hours of Operation

Conduct marking operations in accordance with all hourly restrictions as directed by the special provisions, the plans, and the RCE. Ensure that all markings are sufficiently dry before opening to traffic.

612.4.3.6 Rate of Application

Provide all pavement markings with a wet film thickness of 25 mils. Apply the wet reflective elements to 4 inch wide lines at an application rate of 0.011 pounds per 4 inch linear foot and to 6 inch wide lines at an application rate of 0.0165 pounds per 6 inch linear foot. Apply a subsequent application of AASHTO M247 Type I standard beads at a rate of 6.4 – 10.0 pounds/gallon.

Apply the wet reflective elements and the AASHTO M247 Type I standard beads at the rates listed below as recommended by the manufacturer. See *Tables 3, 4 and 5*.

Table 4

Wet Reflective Element Application Rate Per Linear Foot		
Units	Minimum for Smooth Surface	Improved Durability and/or Rough Pavement Surfaces
Pounds per 4-Inch Linear Foot	0.011 lbs.	0.022 lbs.
Pounds per 6-Inch Linear Foot	0.0165 lbs.	0.033 lbs.
Pounds per 8-Inch Linear Foot	0.022 lbs.	0.044 lbs.
Pounds per 12-Inch Linear Foot	0.033 lbs.	0.066 lbs.
Pounds per 24-Inch Linear Foot	0.066 lbs.	0.132 lbs.

Table 5

Wet Reflective Element Application Rate Per Mile		
Units	Minimum for Smooth Surface	Improved Durability and/or Rough Pavement Surfaces
Pounds per Mile 4-Inch Width	58.2 lbs.	116.4 lbs.
Pounds per Mile 6-Inch Width	87.3 lbs.	174.6 lbs.
Pounds per Mile 8-Inch Width	116.4 lbs.	232.8 lbs.
Pounds per Mile 12-Inch Width	174.6 lbs.	349.2 lbs.
Pounds per Mile 24-Inch Width	349.2 lbs.	698.4 lbs.

Table 6

AASHTO M247 Type I Standard Beads Application Rate	
Units	Application Rate
Pounds per Gallon 25 mils ~ 190 ft/gal	6.4 to 10.0 Pounds / Gallon

612.4.3.7 Protective Measures

When marking operations are conducted under traffic, install and maintain the proper traffic control for long line application as directed by the typical traffic control standard drawings for mobile operations, the *2007 Standard Specifications for Highway Construction*, and the RCE. Install and maintain the proper traffic control for handwork and application of pavement markings at signalized intersections as directed by the typical traffic control standard drawings, the *2007 Standard Specifications for Highway Construction*, and the RCE.

At the discretion of the RCE, repair and correct markings damaged by traffic, or markings tracked by crossing traffic as specified in **Subsection 612.4.3.10**.

612.4.3.8 Tolerance and Appearance

Ensure that markings are applied at the dimensions and rates required by the plans, these specifications, the Standard Drawings for Road Construction, and the MUTCD. Markings less than the specified width will not be accepted. Markings that are applied at a rate outside the acceptable tolerances will not be accepted. Lengths of painted segment of skip lines less than 10 feet will not be accepted. Gaps between the painted segments that vary more than ± 6 inches from the specified dimensions will not be accepted. Ensure that all markings present a clean-cut, uniform, and workmanlike appearance. Correct all markings that fail to have a uniform, satisfactory appearance during day or night. Continued deviation from required dimensions will be cause for stopping the work and correcting the non-conforming markings as specified in **Subsection 612.4.3.10**.

612.4.3.9 Corrective Measures

All work will be subject to checks of dimensions and application rates for wet reflective elements, beads and paint. Correct all traffic markings that fail to meet the requirements given herein. Remove all areas of misted, dripped, and/or splattered paint to the satisfaction of the RCE. In all instances, when it is necessary to remove paint, remove it in accordance with **Subsection 609.4.1.2** of the *2007 Standard Specifications for Highway Construction* and as directed by the RCE.

612.5 MEASUREMENT

The quantity for these temporary pavement markings, including width, color and line type, is the length of the temporary pavement marking line excluding spaces between broken lines and is measured by the linear foot (LF) along the center of the pavement marking line in place, complete and accepted.

The quantity for temporary pavement markings White Single Arrow and Combination Arrows, the word "ONLY", and Railroad Crossing Symbol is measured by each (EA) symbol and word in place, complete and accepted. A railroad crossing symbol consists of "X RR".

No separate measurement is made for the removal of pavement markings unless the Contract includes the pay items Removal of Pavement Markings or Removal of Pavement Markings (High Pressure Water). In the absence of such a pay item, the cost of the pavement marking removal is considered incidental to the pavement marking items.

No separate measurement is made for traffic control during application and removal of pavement markings. The cost of the traffic control during application and removal of pavement markings is included in the contract lump sum item Traffic Control. In the absence of the pay item Traffic Control, traffic control for application and removal of pavement markings is considered incidental to the pavement marking bid items.

612.6 PAYMENT

Payment for the accepted quantities, measured in accordance with **Subsection 612.5 Measurement** of these supplemental specifications, is determined using the contract unit bid price for the applicable pay item and includes all direct and indirect costs and expenses necessary to fulfill the requirements of the pay item.

Payment for+ temporary pavement markings, including width, color and line type and symbols and words to include White Single Arrows and Combination Arrows, the word "ONLY" and Railroad Crossing Symbols, is full compensation for furnishing, installing and replacing (if necessary) pavement markings meeting the reflectivity requirements as specified or directed and removing of temporary and existing pavement markings unless a separate bid item for removal of pavement markings is included in the Contract. Also, payment for temporary pavement markings is full compensation for preparing the pavement surface, applying the pavement markings at the correct thickness, applying the Type I glass beads, an approved glass bead intermix system for improving drying time to less than 6 minutes and the wet reflective elements at the correct amounts, maintaining the temporary pavement markings until they are removed, replaced or covered by the permanent pavement markings or a subsequent pavement surface and all other materials, labor, hardware, equipment, tools, supplies, transportation, incidentals and any miscellaneous items necessary to fulfill the requirements of the pay item in accordance with the plans, the standard specifications, these supplemental specifications and other terms of the Contract.

Pay items under this section include the following:

Item No.	Pay Item	Unit
609105O	Pvmt. Markings (Temporary-High Build Paint with Wet Reflective Elements) 4" White Broken Lines	LF
609110O	Pvmt. Markings (Temporary-High Build Paint with Wet Reflective Elements) 6" White Broken Lines	LF
609115O	Pvmt. Markings (Temporary-High Build Paint with Wet Reflective Elements) 4" White Solid Lines	LF
609120O	Pvmt. Markings (Temporary-High Build Paint with Wet Reflective Elements) 6" White Solid Lines	LF
609125O	Pvmt. Markings (Temporary-High Build Paint with Wet Reflective Elements) 8" White Solid Lines	LF
609130O	Pvmt. Markings (Temporary-High Build Paint with Wet Reflective Elements) 12" White Solid Lines	LF
609135O	Pvmt. Markings (Temporary-High Build Paint with Wet Reflective Elements) 24" White Solid Lines	LF
609160O	Pvmt. Markings (Temporary-High Build Paint with Wet Reflective Elements) White Single Arrow	EA
609165O	Pvmt. Markings (Temporary-High Build Paint with Wet Reflective Elements) White Combination Arrow	EA
609180O	Pvmt. Markings (Temporary-High Build Paint with Wet Reflective Elements) White Word "ONLY"	EA
609185O	Pvmt. Markings (Temporary-High Build Paint with Wet Reflective Elements) White RR Crossing Symbols	EA
609105P	Pvmt. Markings (Temporary-High Build Paint with Wet Reflective Elements) 4" Yellow Broken Lines	LF
609110P	Pvmt. Markings (Temporary-High Build Paint with Wet Reflective Elements) 6" Yellow Broken Lines	LF
609115P	Pvmt. Markings (Temporary-High Build Paint with Wet Reflective Elements) 4" Yellow Solid Lines	LF
609120P	Pvmt. Markings (Temporary-High Build Paint with Wet Reflective Elements) 6" Yellow Solid Lines	LF
609125P	Pvmt. Markings (Temporary-High Build Paint with Wet Reflective Elements) 8" Yellow Solid Lines	LF
609130P	Pvmt. Markings (Temporary-High Build Paint with Wet Reflective Elements) 12" Yellow Solid Lines	LF
609135P	Pvmt. Markings (Temporary-High Build Paint with Wet Reflective Elements) 24" Yellow Solid Lines	LF