

Payment will be made under:

Item No.	Pay Item	Pay Unit
1071000	Traffic Control	Lump Sum

SECTION 604

PERMANENT PAVEMENT MARKINGS

FAST DRY WATERBORNE PAINT

604.01 Description. This work shall consist of furnishing and applying reflectorized, heavy metals free, fast drying, water-borne, paint for pavement markings. The markings shall be of the color (white or yellow) and pattern as indicated in the Pavement Marking Plans, Pavement Marking Typical, or the *South Carolina Manual of Uniform Traffic Control Devices (SCMUTCD)*, latest edition, as applicable. The Contractor shall supply all necessary equipment and materials for the correct application of the marking material to the pavement surface.

This work shall include protection of pavement markings during construction, protection of traffic during installation of pavement markings, determination of no passing zones for two-lane facilities in accordance with the *SCMUTCD*, and providing the Department data used in establishing no passing zones on two-lane facilities.

MATERIAL

604.02 General. The pavement marking shall consist of traffic paint, meeting the requirements given herein, upon which spherical glass beads are applied by dropping immediately following paint application. If required, the pavement surface shall be cleaned in an appropriate manner as described herein

immediately prior to application.

A. Paint. Only paint conforming to the requirements of this specification shall be used for this work. Paint more than 12 months old shall not be used. All paint utilized shall have been tested and shown to be in conformance with all applicable specifications by the SCDOT Research and Materials Laboratory before commencement of work. SCDOT Laboratory approval shall be indicated by the Laboratory Test Number stenciled on the side of each paint container. Each paint batch shall be assigned a unique Laboratory Number by the SCDOT Laboratory upon satisfactory completion of testing. For each shipment, the Contractor shall present the Engineer with documentation containing the information specified in Subsection **604.02A.7.a**. The Engineer shall forward a copy of this information to the SCDOT Research and Materials Laboratory in order to track usage of each paint batch tested.

1. General Requirements. The white and yellow paint shall meet the following general requirements:

- a. Paint shall be formulated and manufactured from first grade materials and shall be free from defects and imperfections that might adversely affect the serviceability of the finished product.
- b. Paint shall be formulated and processed specifically for service as a suitable binder for glass beads for use on traffic-carrying pavements, including portland cement concrete, bituminous concrete, and brick.
- c. Paint shall dry to an elastic adherent finish that will not darken after exposure to sunlight, not show appreciable discoloration with age, or darken under service such that the color or visibility of the reflectorized marking is impaired. They shall further permit ease and uniformity of application and

covering properties.

d. Paint shall be heavy metals free as defined in Subsection **604.02A.4.k**.

e. Paint shall provide 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. Paint shall be manufactured and sealed in containers in such manner that during normal shelf life they do not show evidence of settling or livering that would cause the paint to be unusable or detrimental to the specialized equipment used in application.

g. Paint shall show no evidence of skinning when received in sealed containers.

2. Vehicle. The vehicle portion shall be a combination of 100 percent acrylic emulsion resins and sufficient surfactants, dispersants, defoamers, water, and coalescing agents to produce a pigmented binder that meets the requirements of these specifications.

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

4. Detailed Requirements.

a. **Viscosity.** The viscosity shall be 80 to 95 K.U.

when tested at 77°F in accordance with ASTM D 562.

b. Drying Time. Drying time shall be determined by two methods; Laboratory and Field Application. The paint shall comply with both requirements.

(1) Laboratory Drying Time. The binder shall be tested in accordance with ASTM D 711 at a wet film thickness of 15 mils \pm 1 mil to determine time to no-pickup. The test will be conducted in a standard laboratory atmosphere during which the relative humidity shall be maintained at 50% \pm 5%, and the temperature shall be maintained at 73.5°F \pm 3.6°F and air flow shall be maintained at a rate of 2.2 mph \pm 0.45 mph. The paint described herein shall dry to "no-pickup" in 8 minutes or less.

(2) Field Drying Time. When applied at a wet film thickness of 15 mils and a bead application rate of 6 pounds/gallon, the paint shall dry to a "no-track" condition in the following times under the stipulated conditions:

The paint will be considered to have reached a "no-track" condition when the marking can be 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.

c. Flexibility. A 5 mil wet film of the paint shall be cast on a clean, 30-gage tin panel approximately 3 inches by 6 inches. The panel shall be air-dried at room temperature for 18 \pm 2 hours and then baked at 122°F \pm 4°F for 2 \pm 0.25 hours. The panel shall then be allowed to cool at room temperature for 30 \pm 10

minutes and then bent around a 0.5 inch metal rod. The paint film shall withstand this test with no sign of film failure or loss of adhesion when viewed without the use of magnification.

d. Dry Opacity. The white and yellow paint shall have a minimum contrast ratio of 0.965 when tested at a wet film thickness of 10 mils and tested in accordance with ASTM D 2805.

e. Directional Reflectance. The daylight reflectance of the paint, without drop-on glass spheres, shall be 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

f. Abrasion Resistance. The paint shall pass the following abrasion resistance test:

Four plate samples for each lot shall be prepared for testing on the Taber Abrader. The paint shall be applied by a drawdown blade having a clearance of 26 mils. The paint abrasion samples shall then be dried at room temperature for approximately 30 minutes and then dried at 105°C for 18 ± 0.2 hours. After this time, the plates shall be cleaned, dressed, weighed, and abraded for 1000 cycles. After abrading, the samples shall be cleaned with a soft brush and weighed again. The corresponding loss for the four plates shall not exceed 50 mg per plate. The Taber Abrader shall be operated with a weight of 500 g and CS-10 wheels.

g. Glass Bead Adhesion. Both white and yellow paints shall be formulated and processed specifically for service as a binder of drop-on beads to produce maximum adhesion, refraction, and reflection during

the life of the marking applied at 15 mils wet thickness.

h. Bleeding. The paint shall have 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.

i. Total Non-Volatile, Vehicle Solids, Flash

Point. Volatile organic compounds (VOC) for the paint shall not exceed 100 grams/liter. The non-volatile vehicle shall be greater than or equal to 42% when the whole paint is ashed for one hour at 877 F \pm 45°F. The white and yellow paints shall have a 75% to 80% total non-volatiles when tested in accordance with ASTM D 3723. Closed cup flash point shall be greater than or equal to 140°F.

j. Composition. White paint shall contain a minimum of 1.0 pound/gallon of titanium dioxide in the white pigment. For all colors, the titanium dioxide shall conform to ASTM D 476, Types II, III, or IV.

k. Lead Content. For heavy metals free yellow paint, the lead content of the finished binder shall not exceed the legal limit of 0.06 percent maximum when tested for lead content. The yellow pigments shall be organic yellows containing no lead, chromium, or other heavy metal containing pigments. The color shall be established 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. Small quantities of tinting aids may be used as needed to establish an acceptable color.

l. Color. The paint shall be capable of maintaining its original color throughout the life of the line (approximately 2 years). The color of the white paint shall be a clean, bright, untinted white that provides

maximum opacity and visibility under daylight and artificial light. The color of the yellow paint shall match color 33538, Federal Standard 595B. The following CIE chromaticity coordinates describe the instrumental boundaries of the required yellow color match:

<u>X</u>	<u>Y</u>
.475	.455
.506	.452
.484	.455
.460	.438

m. Distinguishable Color. The yellow color shall be very distinguishable from white markings under day or night conditions when applied on the roadway and be capable of remaining distinguishable during the life of the marking.

n. Grind and Freedom from Lumps. The pigmented binder shall have a grind of not less than 3 on the Hegman-Grind Gauge and shall pass a No. 50 mesh sieve at the time of packaging.

o. Settling. The pigmented binder shall be tested for settling in full pint, triple-sealed friction top paint cans. The cans used for testing shall be lined with an appropriate material designed to be non-reactive with waterborne paints. When these cans are stored free of vibration at an air temperature of $122\text{ F} \pm 2\text{ F}$ for a period of five days, the paint shall exhibit no dense or hard settling. The degree of settling shall have a rating of 6 or better when evaluated in accordance with ASTM D 869. In making the tests, the cans shall be filled to the bottom of the friction seal lip and placed in an inverted position for one hour to insure a complete seal between the cover and the body of the can. At the end of one hour, the filled can shall be placed in an upright position for at least

one hour before being placed in an air temperature of 122 F \pm 2 F. The can or cans shall be placed in a single tier. After a heating period of 5 days, the cans shall be cooled at room temperature for four to five hours and the degree of settling evaluated.

p. pH Factor. The pH factor of the pigmented binder as packaged without thinning or diluting shall be 9.5 minimum. This specification is intended to require the use of Rohm and Haas E-2706 Resin, Dow DT211, or an approved equal, for enhancing the time to "no-track." Any substitute resin other than the two expressly mentioned here must be approved by the Engineer before its use. The manufacturer must inform the Department which resin it intends to use when supplying bid award samples. The supplier may not change resins during the life of the contract without prior approval by the Engineer. 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.

q. Solvents. The manufacturer shall use only potable water from a public water supply as the solvent for the binder manufactured by these specifications.

r. Maximum Temperature and Heat Exchanger Dwell Time. Temperatures at the heat exchanger of the paint truck shall not exceed 150°F. Paint shall not dwell in the exchanger for more than 2 hours.

(Note: It is strongly recommended that the exchanger temperature be reduced to 120°F or that the heat to the exchanger and lines be turned off if the material is not to be applied within one hour.)

5. Control Tolerances. Binder materials shipped under these specifications shall conform to the samples submitted for tests and performance in accordance with

the following tolerances:

a. Percent Pigment. Total pigment solids shall be 58% to 63% by weight when tested in accordance with ASTM D 3723.

b. Volumetric Weight. The density of the pigmented binders shall be 14.0 ± 0.3 pounds/gallon for white and 13.7 ± 0.3 pounds/gallon for yellow. Weight per gallon shall be determined in accordance with ASTM D 1475.

c. Vehicle Solids and Total Non-Volatile. All paint submitted for approval must meet the requirements given in Subsection **604.02A.4.i** of these specifications

*(Note: As noted in Subsection **604.02A.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.)*

d. Viscosity. All paint submitted for approval must meet the requirements given in Subsection **604.02A.4.a** of these specifications.

e. Drying Time. All paint submitted for approval must meet the requirements for Laboratory Drying time given in Subsection **604.02A.4.b.(1)** of these specifications

6. Samples Required.

a. Qualification Samples. Before shipment, manufacturers supplying paint under these

specifications, shall submit the following items for each type and color of paint supplied:

- (1) A sample consisting of two 1-quart cans of paint which the manufacturer proposes to furnish.
- (2) Manufacturer's testing results for the samples. These testing results shall minimally

include the items given in Subsection **604.02A.5** of these specifications and the brand and type of resin used.

- (3) Manufacturer's statement of compliance with all requirements of these specifications. This statement must explicitly state that the paint provided is essentially free of lead, cadmium, and other heavy metals.

- (4) *Material Safety Data Sheets*, essentially similar to Form OSHA-20, for the material provided.

The items listed above shall be furnished to the following address:

Dr. Andrew M. Johnson, PE
State Materials Engineer
SCDOT Research
and Materials Laboratory
1406 Shop Road
Columbia, SC 29201

The shipping of paint shall not be made until testing indicates that the material proposed is in conformance with these specifications.

b. Production Control Tests. The manufacturer

shall perform laboratory tests on each batch of paint produced under these specifications to ensure compliance with these specifications. Results of these tests shall be included with departmental samples as given in Subsection **604.02A.6.c**.

c. Departmental Samples. After shipping, 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 by the contractor. During packaging operations for each batch and at the time the manufacturer obtains retain samples for each batch, 2 one-quart samples shall be obtained, 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 SCDOT Research and Materials Laboratory at the address shown in Subsection **604.02A.6.a** of these specifications. The samples will be tested by the Department in whatever manner is deemed necessary. Performance of all sampling shall be observed by Department inspectors or their designated agents. Samples taken by the manufacturer without supervision are not acceptable without permission of the Engineer. The inspectors shall designate at random two containers from each batch to be sampled for testing and enclose a copy of the sampling inspection with the samples.

7. Material Acceptance Criteria.

a. Shipping Records. Once a batch of paint has been approved for shipment, a form to include the following information shall be sent to the Engineer for each shipment:

- (1) Date

(2) Consignee

(3) Shipped To

(4) Purchase Order Number

(5) Type of Paint

(6) No. of Gallons Shipped

(7) Batch Number

(8) Laboratory Number furnished by SCDOT-
Research & Materials Lab for approved batch(es)

8. Packing and Marking.

a. New Containers. All paint shall be shipped only in new containers that can be properly sealed.

b. Five (5) Gallon Containers: When 5 gallon containers are used, the bucket shall be an ICC approved container for shipping liquids conforming to and this specification. It shall be made of not less than 26-gage steel or may be a plastic bucket with 90 mils minimum wall thickness, a 26-gage metal lid, and shall be of open-head design with lug cover and flowed-in gasket. Metal pails shall have at least one reinforcing bead at the upper end.

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

c. Fifty-Five (55) Gallon Containers. When 55

gallon drums are used, the drum shall be an open-head type conforming with ICC regulation 17 H as amended by this specification. It shall be constructed of not less than 18 gage steel and with a removable head that is solid and contains no bungs. The bolt used on the ring clamp for securing the removable head bolt shall be 5/8 inches minimum diameter. The ring clamp shall be tightened to prevent spillage when the drum is tilted during unloading.

d. Fill Level. Each 55 gallon drum shall be filled with 52 gallons of paint to provide an air space at the top. This space is to reduce spillage when stirring is required. One to two quarts of water shall be added to the top of the paint in each filled drum to retard evaporation.

e. Container Marking. All containers shall be plainly marked or labeled to show the following information as appropriate: "Waterborne Lead Free - White", or "Waterborne Lead Free - Yellow". Other information which shall be shown is net gallons and/or liters, name of manufacturer, batch number, date of manufacture (month and year), purchaser's order number, and the type of resin used. For large containers, this legend shall be stenciled on the head and at one point on the side of the container. For smaller pails, the information shall be stenciled at one point on the side of the containers. The printed legend shall be the color of the contents.

f. Container Color. Containers provided under these specifications shall be painted or otherwise colored blue. Other colors may be used with prior approval of the Engineer. Yellow, white, and black are not acceptable container colors.

g. Container Lining. Each drum or metal pail shall

have a baked-on epoxy lining on the inside of the container. The coating shall be phenolic epoxy or equal coating.

B. Glass Beads. Only glass beads meeting the requirements of this specification shall be used in the performance of this work. The beads shall be manufactured from 100% recycled cullet glass. This may include window pane glass, architectural glass, automotive glass, or other glass sources.

The beads shall meet all requirements of AASHTO M 247-81, Type 1 with moisture resistant coating, with the following exceptions:

Packaging: Section 5.1 of AASHTO M 247-81 shall be replaced by the following:

The beads shall be packed in 50 or 55 pound waterproof multiple-layer type treated paper bags with a sheet of plastic moisture barrier between paper layers. Including the plastic moisture barrier, the bags shall be of not less than five-ply construction. All pallets must be furnished with the same quantity of bags and each pallet must be secured with shrink-wrap.

Each package shall be marked with the following information: name and address of manufacturer, shipping point, trademark or name, the wording "glass beads", number of pounds, the lot or batch number, and the month and year of manufacture.

Other larger containers may be used subject to approval by the Engineer.

The Department reserves the right to perform sampling of the packaged or unpackaged material at the point of manu-

ufacture, the Contractor's facilities, or at the job site. These samples will be tested in the manner deemed appropriate by the Engineer. Before commencement of the work, the Contractor shall provide to the Engineer a Certification of Compliance for the glass beads as specified herein. At least one, 50 or 55 pound bag of beads shall be sampled by the Engineer at random for each 44,000 pounds of beads used. The bead samples and a copy of the certification information shall be forwarded to the SCDOT Research and Materials Laboratory in Columbia for testing.

EQUIPMENT

604.03 Application Equipment.

A. Traveling Applicator. The traveling traffic marking applicator shall be adaptable to traveling at a uniform, predetermined rate of speed both uphill and downhill in order to produce a uniform application of paint. The paint machine shall be of the spray type, capable of satisfactorily applying the paint under pressure with a uniformity of feed through nozzles spraying directly upon the pavement. Each machine shall be 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. Each paint tank shall be equipped with satisfactory cutoff valves, which will apply broken, or skip lines automatically. The controls shall allow the operator to override set automatic cycles to extend a line or to begin a new cycle at any selected point. Each nozzle shall have a mechanical bead dispenser that will operate simultaneously and in coordination with the spray nozzle and distribute the beads in a uniform pattern at the rate specified. Each nozzle shall be equipped with suitable line guides. The traveling applicator shall also be equipped with paint meters that will indicate the amount of paint dispensed from each tank.

B. Cleaning Equipment. Cleaning equipment shall consist 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. Cleaning shall be conducted in such a manner that the underlying pavement is not damaged.

C. Hand Painting. Hand painting equipment shall consist of suitable applicators, templates, and guides necessary to produce satisfactory results. This equipment will be limited to smaller areas such as traverse lines and stenciled symbols.

CONSTRUCTION REQUIREMENTS

604.04 Application of Markings.

A. Cleaning of Surface. All surfaces to be painted shall be thoroughly cleaned of all dust, dirt, grease, oil, and all other foreign matter before application of the marking paint.

B. Maximum Temperature and Heat Exchanger Dwell Time (Waterborne Paint). When waterborne paint is utilized, temperatures at the heat exchanger of the paint truck shall not exceed 150°F. Paint shall not dwell in the exchanger for more than two hours.

(Note: It is strongly recommended that the exchanger temperature be reduced to 120°F or that heat to the exchanger and lines be turned off if the material is not to be applied within one hour.)

C. Alignment of Markings. The markings shall be straight or of uniform curvature and shall conform uniformly to tangents, curves, and transitions. Symbols shall be of dimensions shown in the *SCMUTCD*. Markings shall be of the dimensions as shown on the Pavement Marking Plans or as directed by the Engineer. The Contractor shall provide, at his own expense, sufficient control points to serve as guides for the application of markings.

The finished line markings shall be free from waviness and the lateral deviations shall not exceed 2 inches in 15 feet. Any greater deviation shall be sufficient cause for requiring the Contractor to remove and correct such markings at his own expense. The Contractor shall also be required to remove and correct, at his expense, any symbol markings not meeting the dimensional requirements shown in the *SCMUTCD*.

D. Applicator Type. All longitudinal markings (see page 3-103, *1994 SCMUTCD*) shall be placed with a truck-mounted applicator except when approved by the Engineer. Such a case 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 (see page 3-106, *1994 SCMUTCD*) may be applied with a portable unit.

E. Application Restrictions. Unless otherwise permitted by the Engineer, no markings shall be applied to areas of pavement when any of the following conditions are present:

1. Any moisture or foreign matter is present on the surface.
2. The air temperature is below 50°F.
3. The relative humidity is above 85%.

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

F. Hours of Operation. Marking operations shall be conducted only during daylight hours, unless nighttime operations are required by the contract. All markings shall be sufficiently dry before opening to traffic.

G. Rate of Application. The wet film thickness for all

markings shall be 15 mils. Place glass beads at a minimum rate of 6 pounds per gallon of paint.

H. Protective Measures. When marking operations are conducted under traffic, the Contractor shall take protective measures as outlined in the Traffic Control Plan. At the discretion of the Engineer, markings damaged by traffic, or markings tracked by crossing traffic, shall be repaired and corrected as specified in Subsection **622.04J** and at the Contractor's expense.

I. Tolerance and Appearance. Markings shall be of the dimensions shown on the Pavement Marking Plans. No marking shall be less than the specified width. The length of the 10 foot painted segment of skip lines shall be a minimum of 10 foot, and the gaps between the painted segments shall vary no more than ± 6 inches from the specified dimensions. All markings shall present a clean-cut, uniform, and workmanlike appearance. The Contractor at his expense shall correct all markings that fail to have a uniform, satisfactory appearance, either 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 **604.04J**.

J. Corrective Measures. All work shall be subject to checks of dimensions and application rates for beads and paint. All traffic markings that fail to meet the requirements given herein shall be corrected at the Contractor's expense. All areas of misted, dripped, and/or splattered paint shall be removed to the satisfaction of the Engineer. In all instances, when it is necessary to remove paint, it shall be done by means satisfactory to the Engineer and which do not damage the underlying pavement.

604.05 Method of Measurement. Pavement markings, except arrows, words, and railroad crossing symbols shall be measured on a linear foot basis for each width and color of fast dry painted pavement marking in place and accepted, meas-

ured along the center of the lines. The measurement shall include the length of the painted marking only and conversely shall exclude spaces between broken lines.

Measurement for payment of arrows, words, and railroad crossing symbols shall be for each arrow, word, or railroad crossing. A railroad crossing shall consist of one "X" and two "R"s as shown on the plans.

604.06 Basis of Payment. Accepted lengths of pavement markings will be paid for at the contract unit price for fast dry painted pavement markings of each width, color, and type, which price and payment shall be full compensation for all materials, labor, equipment, and all incidentals necessary to satisfactorily complete the work.

Traffic control for application and/or removal of pavement markings shall be included in the bid item, Traffic Control, unless separate bid items for traffic control devices are included in the proposal.

The cost of determining the no passing zones for two-lane facilities and providing the Department with the data used in establishing the zones shall be considered incidental to the other items of work, and no separate payment will be made for this work.

Payment for each item includes all direct and indirect costs and expenses required to complete the work.

Payment will be made under:

Item No.	Pay Item	Pay Unit
6040X0X	<i>(width)</i> " <i>(color)</i> Broken Lines (Gaps Excluded) - Fast Dry Paint	Linear Foot

6040X1X	<i>(width)</i> " <i>(color)</i> Solid Lines (Pavement Edge Lines) - Fast Dry Paint	Linear Foot
6040015	8" White Solid (Crosswalk & Channelization) - Fast Dry Paint	Linear Foot
6040020	12" White Solid Lines (Stop Lines) - Fast Dry Paint	Linear Foot
6040025	24" White Solid Lines (Stop Lines / Diagonal Lines) - Fast Dry Paint	Linear Foot
6040030	White Single Arrow (Left, Straight, or Right) - Fast Dry Paint	Each
6040031	White Single Bike Lane Arrow (Left, Straight, or Right) - Fast Dry Paint	Each
6040035	White Word Message ("Only") - Fast Dry Paint	Each
6040043	White Lane Drop Arrow (Right or Left) - Fast Dry Paint	Each
6040045	Railroad Crossing Symbol - Fast Dry Paint	Each
6040050	Handicap Symbol - Fast Dry Paint	Each
6040055	Bike Lane Symbol - Fast Dry Paint	Linear Foot
6040112	6" Yellow Solid Lines on Curb / Median - Fast Dry Paint	Linear Foot
6040113	6" Yellow Solid Lines on 6" Concrete Curb (Top & Side) - Fast Dry Paint	Linear Foot
6040115	24" Yellow Diagonal Lines - Fast Dry Paint	Linear Foot

THERMOPLASTIC PAVEMENT MARKINGS

604.07 Description. This work shall consist of furnishing and

application of permanent thermoplastic pavement markings within the limits of the project to delineate the travel lanes and channelize traffic.

This work shall include protection of pavement markings during construction, protection of traffic during installation of pavement markings, determination of no passing zones for two-lane facilities in accordance with the *South Carolina Manual of Uniform Traffic Control Devices (SCMUTCD)*, and providing the Department data used in establishing no passing zones on two-lane facilities.

MATERIAL

604.08 Thermoplastic Pavement Marking Material. The thermoplastic pavement marking material shall be a reflectorized mixture of thermoplastic binder and spherical glass beads upon which additional glass beads are applied by dropping immediately following application. If recommended by the thermoplastic manufacturer, the pavement surface shall be coated with a primer-sealer material before application of the thermoplastic binder material.

A. Thermoplastic Compound. The thermoplastic binder compound shall meet all requirements of AASHTO M 249 with the following adjustments:

1. The material may be shipped in the granulated form or the block form.
2. For longitudinal long line and channelization markings, including gore markings on interstate routes, the material may be either hydrocarbon or Alkyd based.
3. All handwork consisting of stop-bars, crosswalks, legends, and symbols shall be Alkyd Based material only.

B. Glass Beads. The drop-on glass beads shall meet the

requirements of AASHTO M 247, Type 1.

C. Primer-Sealer. A primer-sealer as recommended by the manufacturer of the thermoplastic pavement marking material shall be used on all portland cement pavement surfaces and all bridge surfaces that have not been overlaid with asphalt. The primer-sealer also shall be used on any type of pavement before the placing of any pavement symbols. Primer-sealer shall be used on asphaltic concrete pavement surfaces if recommended by the manufacturer of the thermoplastic pavement marking material. The primer-sealer shall form a continuous film that will mechanically adhere to the pavement and shall neither discolor nor cause any noticeable change in the pavement outside of the finished pavement markings. The primer-sealer shall be applied in accordance with the manufacturer's recommendations.

D. Certification. The Contractor shall obtain from the manufacturer of the thermoplastic binder test results of all requirements of AASHTO M 249 for each batch of material furnished along with a final certification that the material furnished meets the requirements of the Department's specifications. The Contractor shall also obtain from the manufacturer of the drop-on glass beads a certification stating that the material furnished meets all the requirements of the contract specifications. Copies of the above-described affidavits shall be furnished to the Engineer.

EQUIPMENT

604.09 Equipment for Thermoplastic Pavement Markings. The application properties of AASHTO M 249 are expanded as follows:

1. Material shall be prepared only by means of an insulated batching machine recommended or furnished by the manufacturer of the compound and shall consist of a special kettle for melting and heating the composition.

Applicators may be either a truck-mounted liner or a portable unit. "Truck-mounted" shall be defined as a self-propelled vehicle with six or more wheels and an enclosed cab for housing a driver.

2. If the contract requires extruded application, the material shall be applied to the pavement by an extrusion method herein one side of the shaping die is the

pavement surface and the other three sides are contained by, or are part of, suitable equipment for heating and controlling the flow of the material.

3. The batching machine shall be constructed to provide continuous mixing and agitation of the material. All parts of the equipment which come in contract with the material shall be easily accessed and exposed for cleaning and maintenance and designed to prevent accumulation and clogging.

4. The equipment shall be constructed to ensure that all mixing and conveying parts up the final dispensing nozzle/shaping die maintain the material at the appropriate temperature.

5. The controls shall be such that the operator can override set automatic cycles in order to extend a line or to begin a new cycle at any selected point.

6. The applicators shall provide a means for cleanly cutting off square ends. The truck mounted liner shall provide a method of automatically applying "skip" or solid longitudinal lines, including right and left edge lines, or any combination of single or double line configurations (color and pattern) as illustrated in the latest edition of the *SCMUTCD*. The marking machine shall travel only in the direction of normal traffic flow during marking operations. The use of pans, aprons, or similar

appliances with the nozzle/die overruns will not be permitted.

7. Glass beads applied to the surface of the completed marking shall be applied by an automatic bead dispenser attached to the applicator in such a manner

that the beads are dispensed almost instantly following application of the marking material.

8. The applicators shall be constructed to produce varying width of traffic markings as indicated in the in the latest edition of the *SCMUTCD* and/or in the plans.

9. Kettles and melters must be such that heating is done by controlled heat transfer systems that are oil jacketed or indirect flame air jacketed. Direct flame equipment will not be allowed. All kettles and melters must be equipped with an automatic thermostatic control device and proper thermometers to control the temperature of the material at the manufacturer's recommended application temperature range.

10. The applicator and kettle must be equipped and arranged as to satisfy the requirements of the National Fire Underwriters, and all state and local requirements.

11. The applicators shall be mobile and maneuverable to the extent that straight lines can be followed and normal curves can be made in a true arc.

APPLICATION

604.10 Application of Thermoplastic Pavement Makings.

A. Preparation of Surface. The pavement shall be dry and free of glaze, oil, dirt, grease, or other foreign contaminants. Where directed by the Engineer, the Contractor shall remove any existing markings that conflict with the

Pavement Marking Plans by an approved method before the application of thermoplastic material.

On portland cement concrete surfaces including bridge decks, the Contractor shall be required to remove at least 80% of any existing markings by an approved method to provide for adequate bonding of the thermoplastic material. The width of the removal should be 2 inches wider than the line to be applied. A primer sealer recommended by the thermoplastic manufacturer shall be applied to the prepared surface before the application of the thermoplastic material.

When it is necessary to remove old markings from the pavement surface, it shall be the Contractor's responsibility to capture the removed material utilizing a vacuum or other approved system to prevent its dispersal and to properly dispose of this material. The Contractor shall also be responsible for clean-up, removal, and proper disposal of excess or waste thermoplastic materials from the project site.

B. Application of the Primer-Sealer. Where used, the primer-sealer shall be sprayed on the pavement surface where the lines are to be applied. The application thickness and curing time on the pavement before thermoplastic application shall be governed by the recommendations of the manufacturer of the primer sealer.

C. Application of the Pavement Marking Material. All longitudinal markings shall be placed with a truck-mounted applicator except when approved by the Engineer. Such a case may occur where the length of a particular marking is too short, or the curvature too great, to permit efficient use of the liner. Transverse markings may be applied with a portable unit.

The markings shall be straight or of uniform curvature and shall conform uniformly with tangents, curves and transitions. Symbols shall be of dimensions shown in the

SCMUTCD. Markings must be of the dimensions and placed as shown on the Pavement Marking Plans or as directed by the Engineer. The Contractor shall provide, at his own expense, sufficient control points to serve as guides for the application of markings.

The finished line pavement markings shall be free from waviness and the lateral deviations shall not exceed two inches in fifteen feet. Any greater deviation shall be sufficient cause for requiring the Contractor to remove and correct such markings at his own expense. The Contractor shall also be required to remove and correct, at his expense, any symbol pavement markings not meeting the dimensional requirements shown in the *SCMUTCD*.

The Contractor shall protect the pavement markings until dry by placing guarding or warning devices as necessary. In the event, any vehicle should cross the wet marking, such a pavement marking shall be re-applied and any tracking lines made by the moving vehicle shall be removed by the Contractor at no additional expense to the Department.

To avoid poor quality, pavement markings shall be placed only when the surface of the pavement is surface dry as determined by visual inspection and the pavement temperature is minimum 55°F and the air temperature is minimum 50°F. No work will be allowed when any moisture is visible on the pavement surface. The Contractor shall provide each work crew with a hand-held infrared non-contact thermometer with a temperature range of 0°F to 1000°F (Baxter Scientific Products Model No. T 2940-2 or equivalent) to verify the minimum surface temperature and a pocket thermometer capable of accurately measuring air temperature (ERTCO 532PS or equivalent). Air temperature shall be measured away from heat generating equipment.

No thermoplastic pavement markings shall be applied between December 15 and March 15, inclusive. Addition-

ally, the Engineer may disallow application on any days when the weather is cold and/or rainy, and there is some question as to whether the surface temperature will be above 55°F for a period of time adequate to obtain quality pavement markings. The Engineer may also disallow application on any day when, in the Engineer's opinion, moisture conditions are not satisfactory for obtaining quality pavement markings.

New asphalt concrete surfaces shall be in place a minimum of twenty (20) days before marking application. On new portland cement concrete surfaces, the curing compound shall be removed before application.

An adequate number of personnel experienced in the handling and application of this type of material shall be provided by the Contractor to assure the work is done properly.

Work shall be done only during daylight hours unless specified otherwise, and all markings shall be sufficiently dry, before sunset, to permit crossing by traffic. All protective devices shall be removed before sunset to allow free movement of traffic at night.

The pavement marking material shall be applied at a temperature that will provide best adhesion to the pavement and shall be between 390°F and 420°F as recommended by the manufacturer. The material shall be heated uniformly throughout and shall have a uniform

disbursement of binder, pigment, and glass beads when applied to the surface of the pavement.

All extruded lines 12 inches or less in width, shall be applied with a die that equals the width of the line. All extruded lines greater than 12 inches may be applied with two dies whose combined widths equal the width of the line.

D. Rates of Application.

1. Thermoplastic Material. The thermoplastic material shall be applied at the specified widths and at a rate to result in a new material thickness as specified below:

90 mils for Edge Lines and Median Lines including:

- 4 inch solid white lines,
- 4 inch solid yellow lines,
- 4 inch broken yellow lines,
- 6 inch solid white lines, and
- 6 inch solid yellow lines.

90 mils for Lane Lines including:
4 inch broken white lines and
6 inch broken white lines.

90 mils for Center Lines on Two Lane Roads including:
4 inch broken yellow lines, and
4 inch solid yellow lines.

125 mils for all other lines not listed above.

2. Glass Beads. Drop-on glass beads shall be mechanically applied to the surface of the pavement marking material immediately after the material is applied to the pavement surface, and while the pavement marking material is still molten to ensure that the beads will be held by and mechanically embedded in the surface of the material. The beads shall be uniformly distributed over the entire surface of the marking and shall be applied at a minimum rate of 12 pounds per 100 square feet of stripe.

E. Warranty. The Contractor shall transfer to the Depart-

ment the warranty on thermoplastic materials issued by the manufacturer. The Contractor shall also furnish the Department the normal warranty for material for a stated period beginning with the last date of marking application on the project. Work will not be allowed to commence until the warranties have been received by the Department.

F. Departmental Sampling. In addition to the initial acceptance of the thermoplastic material, a representative of the Department will sample each batch or lot scheduled for shipment for SCDOT projects for testing. Additional sampling and testing at the job site may occur at the discretion of the Department. A certification from the manufacturer must be submitted for each shipment for each project, certifying that the thermoplastic meets the requirements of AASHTO 249 as amended herein for each type of thermoplastic material. No thermoplastic material shall be used nor will payment be made for thermoplastic until the thermoplastic certification is received and accepted by the Engineer. The Department reserves the right to sample and test any thermoplastic material supplied for any SCDOT use at any time.

G. Inspection and Acceptance of Work. All thermoplastic pavement markings shall be inspected for proper line thickness and width, proper adhesion, and proper cycle length. The markings shall also be observed both day and night to determine whether all requirements of the Contract have been met. Any markings failing to have satisfactory appearance, either day or night shall be re-applied by the Contractor at his expense.

The final acceptance of the thermoplastic pavement markings will be delayed for a period of 180 days after the last date of marking on the project to permit observation of performance. The Contractor shall be required to replace any markings or markers that, in the opinion of the Engineer, have not performed satisfactorily during this 180-day period due to defective materials and/or workmanship.

604.11 Method of Measurement. Measurement, except for arrows, words, and railroad crossing symbols, shall be on a linear foot basis for each width and color of thermoplastic pavement marking in place and accepted by the Engineer. The measurement shall be along the center of the lines and shall include the length of the marking only, excluding spaces between broken lines.

Measurement of arrows, words, and railroad crossing symbols shall be for each arrow, word, or railroad-crossing symbol. A railroad-crossing symbol consists of one "X" and two "R"s.

604.12 Basis of Payment. Thermoplastic pavement markings will be paid for at the contract unit price for Thermoplastic Pavement Marking of each width, color, and type, which price and payment shall be full compensation for all materials, labor, equipment, and all incidentals necessary to satisfactorily complete the work.

The cost of removing pavement markings shall be considered incidental to the other items of work and no separate payment will be made therefor, unless separate bid items have been included in the proposal.

Traffic control for application and/or removal of pavement markings shall be included in the bid item, Traffic Control, unless separate bid items are included in the plans and special provisions.

The cost of determining the no passing zones for two-lane facilities and providing the Department with the data used in establishing the zones shall be considered incidental to the other items of work, and no separate payment will be made for this work.

Payment for each item includes all direct and indirect costs and expenses required to complete the work.

Payment will be made under:

Item No.	Pay Item	Pay Unit
6041X0X	<i>(width)</i> " <i>(color)</i> Broken Lines (Gaps Excluded) - Thermoplastic - 90 mil.	Linear Foot
6041X1X	<i>(width)</i> " <i>(color)</i> Solid Lines (Pavement Edge Lines) - Thermoplastic - 90 mil.	Linear Foot
6041X15	<i>(width)</i> " <i>(color)</i> Solid Lines - Thermoplastic - 125 mil	Linear Foot
6041020	12" White Solid Lines (Stop Lines) - Thermoplastic - 125 mil.	Linear Foot
6041025	24" White Solid Lines (Stop Lines / Diag. Lines) - Thermoplastic - 125 mil.	Linear Foot

Item No.	Pay Item	Pay Unit
6041035	White Word Message "Only" - Thermoplastic - 125 mil.	Each
6041040	White Combination Arrows (Straight & Right or Straight & Left) - Thermoplastic - 125 mil.	Each
6041045	Railroad Crossing Symbols - Thermoplastic - 125 mil.	Each
6041050	Handicap Symbol - Thermoplastic - 125 mil.	Each

EPOXY PAVEMENT MARKINGS

604.13 Description. This item of work consists of the furnishing and application of permanent epoxy pavement markings within the limits of the project to delineate the travel lanes and channelize traffic.

This work shall include protection of pavement markings during construction, protection of traffic during installation of pavement markings, determination of no passing zones for two-lane facilities in accordance with the *South Carolina Manual on Uniform Traffic Control Devices (SCMUTCD)*, and providing the Department data used in establishing no passing zones on two-lane facilities.

MATERIAL

604.14 Epoxy Pavement Marking Material. Epoxy pavement markings are permanent retro-reflective (white or yellow) and non-retro-reflective (black) pavement marking materials of the color and pattern indicated on the plans or special provisions. The Contractor shall supply all the necessary equipment and materials for proper surface preparation and correct application of the pavement marking material.

The markings applied shall consist of a two component, 100% solids epoxy coating material capable of being applied by truck-mounted spray equipment. The material shall be capable of being applied at a minimum ambient air temperature of 40°F. The material shall be capable of retaining glass spheres and shall be suitable for application to all types of bituminous and concrete pavement surfaces.

A. Epoxy Coating Material. Epoxy marking materials shall comply with the following requirements:

1. Formulation. The epoxy material shall consist of a two-part system formulated and designed to provide a simple volumetric mixing ratio of two components (such as two volumes of Part A and one volume of Part B). Part B shall be common to all colors.

2. Composition. Component A shall be within the following limits:

Pigments:	White	Yellow
Titanium Dioxide ¹	18-25%	-----
Chrome Yellow ²	-----	23-30%
Organic Yellow	-----	-----
Black	-----	-----
Binder:		
Epoxy Resin	75-82%	70-77%

Pigments:	Non Lead Yellow	Black
Titanium Dioxide ¹	14-17%	-----
Chrome Yellow ²	-----	-----
Organic Yellow	7-8%	-----
Black	-----	18-25%
Binder:		
Epoxy Resin	75-79%	75-82%

Notes:

1. ASTM D 476, Type II & III
2. ASTM D 211, Type III

3. Color. The epoxy marking materials, without drop-on beads, shall visually match the color chips that visually correspond to the Federal Standard Number 595B for the following colors:

White
Yellow
Black

The mixed epoxy compound, white, yellow and black, must be applied to 2 sets of 3 inch x 6 inch steel plates at 20 ± 1 mil in thickness, one set with glass beads and one set with no glass beads as specified. Expose the prepared samples as per ASTM G 53. The test shall be conducted for 75 hours at 122°F, four hours of humidity, and four hours of UV in alternating cycles. The color of the epoxy materials shall be within 5 units of the Federal Standards shown above.

4. Yellowness Index (ASTM D 1925).

Cure 72 hours after sample preparation.

Take yellow index reading, XYZ C/2°, following the 72-hour cure and preceding QUV (ASTM G 53).

Maximum before QUV 10.0

Place sample in QUV for 72 hours.

Maximum after QUV 15.0

Typical White <u>Standard</u>	Typical Yellow <u>Standard</u>
X 78.5	X 52.7
Y 81.8	Y 48.1
Z 90.4	Z 7.6
YI 4.7	

5. Directional Reflectance (ASTM E 97). The Directional Reflectance after QUV using XYZ Scale D65/10° is as follows:

White	75 Minimum
Yellow	38 Minimum

6. Epoxide Number. The WPE of the epoxy resin shall be 250 ± 50 as determined by ASTM D 1652 for white, yellow, and black Component A on a pigment free basis.

7. Amine Number. The amine number of the curing agent (Component B) shall be 450 ± 50 as per ASTM D 2074.

8. Toxicity. Upon heating to application temperature, the material shall not exude fumes that are toxic or injurious to persons or property.

9. Viscosity. Formulations of each component shall be such that the viscosity of both components shall coincide (within 10%) at the spray temperature recommended by the manufacturer. Component B shall be formulated to have a steady and constant viscosity at temperatures recommended for spray application.

10. Drying Time. The epoxy marking material, when mixed in the proper ratio and applied at 20 mils \pm 0.5 mil wet film thickness at 75°F \pm 2°F and with the proper saturation of glass spheres, shall exhibit no tracking time when tested according to ASTM D 711 in less than 15 minutes.

11. Curing. The epoxy materials shall be capable of fully curing under a constant pavement surface temperature of 32°F or above.

12. Adhesion to Concrete. The catalyzed epoxy pavement marking materials, when tested according to ACI Method 503, shall have such a higher degree of adhesion to the specified concrete (4000 psi minimum) surface that there shall be a 100% concrete failure in the performance of this test. The prepared specimens shall be conditioned at room temperature for a minimum of 24 hours and a maximum of 72 hours before the performance of the tests indicated.

13. Hardness. The epoxy pavement marking materials, when tested according to ASTM D 2240, shall have a Shore D Hardness greater than 80. Samples shall be allowed to cure at room temperature for a minimum of 24 hours and a maximum of 72 hours before performing the tests indicated.

14. Abrasion Resistance. The abrasion resistance shall be evaluated on a Taber Abrader with a 1000-gram load and CS-17 wheels. The duration of the test shall be 1000 cycles. The wear index shall be calculated based

on ASTM C-501 and the wear index for the catalyzed material shall not be more than 80. The tests shall be run on cured samples of material which have been applied at a film thickness of 15 ± 0.5 mil to code S-16 stainless steel plates (to be run without glass spheres). Samples shall be allowed to cure at room temperature for a minimum of 24 hours and a maximum of 72 hours before performing the tests indicated.

15. Tensile Strength. When tested according to ASTM D 638, the epoxy pavement marking materials shall have an average tensile strength of not less than 6000 psi. The Type IV specimens shall be cast in a suitable mold and pulled at rate of 0.25 inch per minute by a suitable dynamic testing machine. Samples shall be allowed to cure at room temperature for a minimum of 24 hours and a maximum of 72 hours before performing the tests indicated.

16. Compressive Strength. When tested according to ASTM D 695, the catalyzed epoxy marking materials shall have a compressive strength of not less than 12,000 psi. The cast sample shall be conditioned at room temperature for a minimum of 72 hours before performing the indicated tests. The rate of compression of these samples should be no more than 0.25 inch per minute.

B. Glass Beads. Glass beads having a spherical geometry shall be injected or dropped on the white or yellow lines immediately after application to give retroreflectivity to the newly applied lines. A mixture of large beads and small beads shall be used.

1. Composition. The silica content of the beads should be no less than 60%.

2. Physical Characteristics. The glass spheres shall be colorless, clean, transparent, and free from milkiness

or excessive air bubbles. The glass beads shall have a minimum refractive index of 1.5 when tested by the liquid immersion method at 77°F. The beads shall be essentially free of sharp angular particles and particles showing surface scarring or scratching.

3. Gradation. The glass spheres shall have the following gradation when tested in accordance with ASTM D 1214:

Large Beads	
<u>Sieve Number</u>	<u>% Retained</u>
10	0
12	0-5
14	5-20
16	40-80
18	10-400
20	0-5
Pan	0-2

Small Beads	
<u>Sieve Number</u>	<u>% Retained</u>
20	0-5
30	5-20
50	30-75
80	9-32
100	0-5
Pan	0-5

4. Roundness. The large beads shall have a minimum of 80% rounds per screen on the two highest sieve quantities. The remaining sieve fractions shall

have no less than 75% rounds. The small beads shall be 70% rounds overall when tested in accordance with ASTM D 1155, Procedure A.

5. Angularity. Angular beads (beads with an aspect

ratio of greater than 1.2:1, twins, satellites, agglomerates, angular or fire polished particles) shall not exceed 5% overall when examined visually for the small beads. For the large beads, the angulars shall not exceed 3% per screen when tested by the following method:

a. Scope:

A specimen of the material is visually examined using a Bell and Howell Microfiche Reader (with a 20 mm lens) and a number, or count percentage, of angular spheres is obtained for each of the two largest (quantity) sieve fractions.

b. Equipment and Chemicals:

(1) Bell and Howell Microfiche reader, Model ABR VIII, or equivalent with a 20 mm lens.

(2) Transparencies for +14, +16, +18, and +20 mesh spheres defining 1.2:1 aspect ratio.

(3) Mini- splitter.

(4) Clear, transparent tape.

(5) Syringe (3cc) with a 23 gage needle.

(6) Microscope slide.

(7) Cooking oil, Wesson Oil or equivalent, with an approximate 1.5 refractive index. A standard 1.5 refractive index liquid can also be used.

c. Safety Concerns:

(1) It is recommended that safety glasses be worn whenever testing is performed using chemi-

cals, solvents, or glass spheres.

(2) Be sure to immediately sweep up any beads dropped on the floor to avoid slipping.

d. Procedure:

(1) All testing is to be performed on properly split or riffled specimens.

(2) During the gradation of normal testing, retain separately those fractions that contain the two largest quantities of particles. This will usually be at least 75%-80% of the material.

(3) Using the mini-splitter, reduce each fraction to just enough beads to cover a microscope slide when they are adhered to the clear tape. Retain each reduced specimen separately.

(4) Place a piece of clear transparent tape, adhesive side up, over the open side of the mini-splitter pan (lengthwise).

(5) Carefully pour one of the specimens over the tape to adhere the beads to the tape. Any particles that fall into the pan should be recovered

and again poured onto the tape until all particles have adhered to the tape.

(6) A microscope slide is then placed on top of the beads and the tape secured to the slide by bringing the ends of the tape over the top of the slide. This is repeated for the other mesh size retained.

(7) The beads are next slightly wet with Wesson Oil by injecting a few drops onto the beads (under

the tape) using the syringe and needle. Use only a few drops to avoid excess from running off the slide.

(8) Place the slide (beads up) between the two glass plates on the sample tray of the microfiche reader.

(9) Turn on the light and move the sample tray so that the beads are visible on the screen. Focus in on the beads and count the number of non-round beads in the field. Keep track of the number of angular particles in order to determine their concentration.

(10) In order to assist in determining whether a sphere has an aspect ratio greater than 1.2:1, transparencies shall be provided by the manufacturer being examined, select the proper transparency and determine which of the inner circles best matches the width of the sphere in question. Then slide the overlay so that the end of the bead lines up with the outer circle. If the other end of the bead protrudes beyond the opposite edge of the outer circle, the particle aspect ratio is greater than 1.2:1 and the particle is counted as non-round.

(11) If the edge of the particle does not protrude beyond the opposite edge of the outer circle, its shape is either spherical or slightly oval, it will be counted as a round particle.

(12) As was mentioned earlier, excluded from the category of round particles, regardless of aspect ratio, are twins, satellites, angulars, and fire polished particles.

(13) At least 200 beads shall be counted on each

slide. More than one field should be used on a slide to make up the 200 count in order to ensure that the count is representative of the entire specimen.

(14) Calculate the percentage of angular particles at each sieve fraction as follows:

$$\% \text{ Angulars} = \frac{(\text{Total No. of angular particles}) \times 100\%}{(\text{Total No. of particles counted})}$$

(15) If the angular content is greater than 3% for any screen fraction, a second bag from the same lot is to be analyzed. If any of the fractions again fall outside the specification limits for angular content, the lot is rejected. If the second bag is found to be within the specification limits, the lot is accepted.

6. Bead Coatings. All beads shall be embedded and moisture proof coated with Potters Industries AC-100 series or an equivalent performance insuring coating. The embedment coating shall be tested by the Dansyl Chloride Method. The moisture proof coating shall be tested by the following method:

a. Equipment:

(1) Teaspoon

(2) 500 ml Beaker

b. Procedure:

(1) Put about 400 ml of cold water in the beaker.

(2) Fill a spoon with the coated beads and gently immerse them into the water.

(3) Tap the spoon to force the mass of beads to fall to the bottom to the beaker. The material should maintain its initial shape for at least one hour. Some beads may fall from the agglomerated mass, however, there should not be considerable dropping of beads before one hour.

C. Certification. The Contractor shall obtain from the manufacturer of the epoxy material, final certification that each batch of material furnished meets the requirements of the special provisions. The Contractor shall also obtain from the manufacturer of the glass beads certifications that each batch of material furnished meets special provisions. The certifications provided by the Contractor for the marking material or glass beads shall indicate the batch numbers utilized and include the manufacturer's production control tests for each batch. Certifications shall also include the manufacturer's material safety data sheets. Copies of the above affidavits shall be furnished to the Engineer.

D. Department Samples. The Department reserves the right to perform in-plant sampling of the finished epoxy paint components or glass beads during packaging operations and/or sampling of the packaged epoxy paint components of glass beads after they are received by the Contractor. The samples may be tested by the Department in whatever manner is deemed necessary. Performance of all sampling shall be observed by Department inspectors or their designated agents. The inspectors shall designate at random two containers from each batch to be sampled for testing and enclose a copy of the sampling inspection with the samples.

E. Marking and Packaging. All materials utilized in the performance of this work shall be provided in the manufacturer's original, undamaged packaging. This packaging shall clearly indicate the name of the manufacturer, the type of material packaged, the weight or volume of the material

enclosed and the batch or lot numbers. All packaging shall also indicate the date of manufacture and, if applicable, color.

EQUIPMENT

604.15 Equipment for Epoxy Pavement Markings. Equipment for applying the epoxy material shall be truck mounted and capable of mixing the two material components in the proportions recommended by the manufacturer. The equipment shall also be capable of applying the material at the manufacturer's recommended application temperature. The equipment shall be capable of automatically dispensing beads immediately following application of the epoxy material using a double drop system.

The marking equipment shall be capable of applying the epoxy material at a uniform thickness up to 25 mils. In addition, the equipment shall be capable of dispensing beads at a constant rate of 25 pounds per gallon of marking material.

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 shall be constructed to assure continuous uniformity in the dimensions of the applied markings.

The equipment shall be capable of cleanly cutting off square stripe ends. The equipment shall also provide a method of automatically applying "skip" or longitudinal lines, including right and left edge-lines, or any combination of single or double line configurations (color and pattern) as illustrated in the latest edition of the *SCMUTCD*. In addition, the controls shall be such that the operator can override set automatic cycles in order to extend a line or to begin a new cycle at any selected point.

The equipment shall also be capable of producing markings of varying widths as indicated in the Pavement Marking Plans,

the *SCMUTCD*, or the contract specifications.

The equipment shall travel only in the direction of normal traffic flow during marking operations.

The equipment shall have such a design that the pressure gauges for each type of proportioning pump are constantly visible to the operator at all times so that any fluctuation or pressure difference can be detected immediately.

Electrical foot counters shall be installed on the marking equipment. The counters shall individually tabulate the amount of footage applied by each striping gun. The counters shall have 6 digits with a reset feature.

The marking equipment shall be equipped with a pressure regulated air jet that will spray all debris from the pavement in advance of the applicator guns. The air jet shall operate when marking material is being applied and shall be synchronized with marking material application or remain “on” at all times.

APPLICATION

604.16 Application of Epoxy Pavement Markings.

A. General Requirements. All longitudinal markings shall be placed with a truck-mounted applicator except where approved by the Engineer. Such a case may occur where the length of a particular marking is too short, or the curvature too great, to permit efficient use of the liner. Such markings, as well as transverse markings may be applied with a portable unit.

Markings shall be sharp, well defined, and uniformly retroreflective (except black markings). Pavement markings shall be free of uneven edges, overspray or other readily visible defects which, in the opinion of the Engineer, detract from the appearance or function of the pavement markings. Non-retroreflective lines are unacceptable with the exception

of black pavement markings. Pavement markings which are improperly applied, improperly located or are not of uniform retroreflectivity shall be reapplied. Improperly located markings shall be removed at the contractor's expense and reapplied in the correct location at the contractor's expense, including furnishing of materials.

The markings shall be straight or of uniform curvature and shall conform uniformly with tangents, curves and transitions. Symbols shall be of dimensions shown in the *SCMUTCD*. Markings shall be of the dimensions shown on the pavement marking plans or as directed by the Engineer. The contractor shall provide, at his own expense, sufficient control points to serve as guides for the application of markings.

The finished line markings shall be free from waviness and lateral deviations shall not exceed 2 inches in 100 feet. Any deviation greater than 3 inches will not be acceptable. Any greater deviation shall be sufficient cause for requiring the Contractor to remove and correct such markings at his own expense. The Contractor shall also be required to remove and correct, at his expense, any symbol markings not meeting the dimensional requirements of the *SCMUTCD*.

The Contractor shall protect the markings until dry by placing guarding or warning devices as necessary. In the event any vehicle should cross the wet marking, such a marking shall be re-applied and any tracking lines made by the moving vehicle removed by the Contractor.

In the event that the contract includes sections of roadway where raised pavement markers are installed on the surface, marking material shall not be applied onto the reflective surface of the raised markers. If marking material is applied to the reflective marker surface, the Engineer shall suspend the work and the Contractor shall, at his expense, either remove all marking material from the reflector unit; or he shall remove and replace in kind the raised marker.

B. Surface Preparation. The Contractor shall clean all visible loose or foreign material from the surface to be marked. The Contractor shall power broom clean all surfaces where gore markings or edge-lines are to be marked before marking application. In addition, all surfaces shall be cleaned by a jet of compressed air immediately before material application. At the time of marking application, the pavement surface shall be free of dirt, dust, oil, grease, and other contaminants.

C. Rate of Application. The epoxy marking materials shall be applied at the rate specified in Table 1 below to produce a uniform wet film thickness of 20 mils, calculated without drop-on beads.

Table 1 Gallons of Material per Mile of Line		
Line Width (inches)	Material for Solid Line (gallons)	Material for Broken Line (gallons)
4	22	5.5
6	33	8.25
8	44	---
12	66	---
24	88	---

Application rates for solid lines in gore areas shall not be less than one gallon per 80 square foot of marking surface (20 mil thickness). Table 2 gives the application rate on a linear foot basis for shorter lengths of markings (gore markings and stop bars.)

Table 2 Linear Foot of Line Per Gallon of Material	
Line Width (inches)	Solid Line Length (feet)
8	120
12	80
24	40

The epoxy shall be heated to the manufacturer's recommended temperature before application to the pavement surface.

Epoxy pavement markings shall be applied only when the surface of the pavement is dry as determined by visual inspection. The minimum required pavement surface temperature for application shall be 45°F. The ambient air temperature shall be at least 40°F during marking operations.

The Contractor shall provide each work crew with a hand held infrared non-contact thermometer with a temperature range of 0°F to 1000°F (Baxter Scientific Products Model No. T 2940-2 or equivalent) to verify the minimum surface temperature and a pocket thermometer capable of accurately measuring the air temperature (ERTCO 532PS or equivalent). Air temperature shall be measured away from heat generating equipment.

No application of markings will be permitted between January 1 and March 1 inclusive.

The Engineer may disallow application of markings on any day when, in the Engineer's opinion, moisture or temperature conditions are not satisfactory.

An adequate number of personnel experienced in the handling and application of this type of material shall be provided by the Contractor to assure that the work is done

properly.

D. Glass Beads. Two sizes of glass beads shall be applied by the double drop method. This method requires that the large and small glass spheres be injected into or dropped onto the liquid epoxy marking. Each type of bead shall be applied simultaneously at a minimum rate of 12 pounds per gallon of marking material (24 pounds per gallon total). The large beads shall be applied first immediately followed by the application of the small beads. The beads shall adhere to the cured epoxy or all marking operation shall cease until corrections are made.

New asphalt concrete surfaces shall be in place a minimum of two weeks before marking application. On new portland cement concrete surfaces, the curing compound shall be removed before application.

E. Warranty. The Contractor shall furnish to the Department the warranty of the epoxy materials issued by the manufacturer. Work will not be allowed to commence until the warranty has been received by the Department.

F. Inspection and Acceptance of Work. All epoxy markings shall be inspected for proper line thickness and width, proper adhesion and proper cycle length. The markings shall also be observed both day and night to determine whether all the requirements of the contract have been met. Any markings failing to have satisfactory appearance, either day or night, shall be reapplied by the Contractor at his own expense.

The final acceptance of the epoxy material shall be delayed for a period of 180 days after the last day markings are applied on the project to permit observation of performance. The Contractor shall be required to replace any markings that, in the opinion of the Engineer, have not performed satisfactorily during this 180-day period due to defective materials and workmanship in manufacture or appli-

cation.

604.17 Method of Measurement. Measurement, except for arrows, words, and railroad crossing symbols, shall be on a linear foot basis for each width and color of epoxy pavement marking in place and accepted by the Engineer. The measurement shall be along the center of the lines and shall include the length of the marking only, excluding spaces between broken lines.

Measurement of arrows, words, and railroad crossing symbols shall be for each arrow, word, or railroad-crossing symbol. A railroad crossing symbol consists of one "X" and two "R"s.

604.18 Basis of Payment. Epoxy pavement markings will be paid for at the contract unit price for Epoxy Pavement Marking of each width, color, and type, which price and payment shall be full compensation for all materials, labor, equipment, and all incidentals necessary to satisfactorily complete the work.

The cost of removing pavement markings shall be considered incidental to the other items of work and no separate payment will be made therefor, unless separate bid items have been included in the proposal.

Traffic control for application and/or removal of pavement markings shall be included in the bid item, Traffic Control, unless separate bid items are included in the plans and special provisions.

The cost of determining the no passing zones for two-lane facilities and providing the Department with the data used in establishing the zones shall be considered incidental to the other items of work, and no separate payment will be made therefor.

Payment for each item includes all direct and indirect costs and expenses required to complete the work.

Payment will be made under:

Item No.	Pay Item	Pay Unit
6042X0X	<i>(width)" (color)</i> Broken Lines (Gaps Excluded) - Epoxy Paint	Linear Foot
6042X1X	<u><i>(width)" (color)</i></u> Solid Lines (Pavement Edge Lines) - Epoxy Paint	Linear Foot
6042021	12" White Solid Lines (Diagonal Lines) - Epoxy Paint	Linear Foot
6042015	8" White Solid (Crosswalk & Channelization) - Epoxy Paint	Linear Foot
6042020	12" White Solid Lines (Gore Markings) - Epoxy Paint	Linear Foot
6042021	12" White Solid Lines (Diagonal Lines) - Epoxy Paint	Linear Foot
6042025	24" White Solid Lines (Stop Lines / Diagonal Lines) - Epoxy Paint	Linear Foot
6042030	White Single Arrows (Left, Straight, or Right) - Epoxy Paint	Each

Item No.	Pay Item	Pay Unit
6042035	White Word Message ("Only") - Epoxy Paint	Each
6042040	White Combination Arrows (Straight & Right or Straight & Left) - Epoxy Paint	Each

6042043	White Lane Drop Arrow (Right or Left) - Epoxy Paint	Each
6042045	Railroad Crossing Symbol - Epoxy Paint	Each
6042114	12" Yellow Solid Lines (Diagonal Line) - Epoxy Paint	Linear Foot
6042115	24" Yellow Diagonal Line - Epoxy Paint	Linear Foot

SECTION 605

PERMANENT RAISED PAVEMENT MARKERS

605.01 Description. This work shall consist of furnishing and installing durable, abrasion-resistant retroreflective pavement markers at locations designated on the plans and as directed by the Engineer. The pavement markers shall be as specified herein and shall be installed as shown in the plans.

MATERIAL

605.02 Pavement Markers.

A. Shape and Color. The base of the marker shall be approximately 4 inch x 4 inch with 30 degree sloping sides approximately 5/8 inches in height (nominal dimensions). The outer surface of the marker shall be smooth and all corners and edges exposed to traffic must be rounded. Pavement markers may be of various colors or combination of colors and have one or two reflective faces as shown on the Plans. When illuminated by automobile headlights, the reflective faces shall redirect light of the color indicated and as specified in these specifications. The color of the reflectors when illuminated and when not illuminated shall be subject to the approval of the Department. The color of samples will be evaluated, and off-colors will constitute