

Organic yellow, other colors, and tinting as required to meet color standard.
Epoxy resin shall be 75 to 79 percent.

(2) Epoxy Content. Component A. The weight per epoxy equivalent, when tested in accordance with ASTM D 1652 shall be the manufacturer's target plus or minus 50.

(3) Amine Number. Component B. When tested in accordance with ASTM D 2074 shall be the manufacturer's target plus or minus 50.

(4) Prohibited Materials. The manufacturer shall certify that the product does not contain mercury, lead, hexavalent chromium, halogenated solvents, nor any carcinogen, as defined in 29 CFR 1910.1200.

(5) Daylight Directional Reflectance:

(a) White: The daylight directional reflectance of the white paint shall not be less than 75 percent (relative to magnesium oxide), when tested in accordance with Federal Test Method Standard No. 141D/GEN, Method 6121.

(b) Yellow: The daylight directional reflectance of the yellow paint shall not be less than 38 percent (relative to magnesium oxide), when tested in accordance with Federal Test Method Standard No. 141D/GEN. The x and y values shall be consistent with the Federal Hegman yellow color standard chart for traffic yellow standard 33538, or shall be consistent with the tolerance listed below:

x .462	x .470	x .479	x .501
y .438	y .455	y .428	y .452

(6) Accelerated Weathering.

(a) Sample Preparation. Apply the paint at a wet film thickness of 0.013 inch (0.33 mm) to four 3 by 6 inch (8 by 15 cm) aluminum panels prepared as described in Federal Test Method Standard No. 141D/GEN, Method 2013. Air dry the sample 48 hours under standard conditions.

(b) Testing Conditions. Test in accordance with ASTM G 15453 using both Ultra Violet (UV-B) Light and condensate exposure, 72 hours total, alternating 4 hour UV exposure at 60 degree C, and 4 hours condensate exposure at 40 degrees C.

(c) Evaluation. Remove the samples and condition for 24 hours under standard conditions. Determine the directional reflectance and color match using the procedures in paragraph 620-2.2b(5) above. Evaluate for conformance with the color requirements.

(7) Volatile Organic Content. Determine the volatile organic content in accordance with 40 CFR Part 60 Appendix A, Method 24.

(8) Dry Opacity. Use Procedure B, Method B of Method 4121 of Federal Test Method Standard No. 141D/GEN. The wet film thickness shall be 0.015 inch (0.12 mm). The minimum opacity for white and colors shall be 0.92.

(9) Abrasion Resistance. Subject the panels prepared in paragraph 620-2.2b(6) to the abrasion test in accordance with ASTM D 968, Method A, except that the inside diameter of the metal guide tube shall be from 0.747 to 0.750 inch (18.97 to 19.05 mm). Five liters of unused sand shall be used for each test panel. The test shall be run on two test panels. [Note: five liters of sand weighs 17.5 lb. (7.94 kg).] Both baked and weathered paint films shall require not less than 150 liters of sand for the removal of the paint films.

(10) Hardness, Shore. Hardness shall be at least 80 when tested in accordance with ASTM D 2240.

c. **METHACRYLATE.** Paint shall be a two component, minimum 99 percent solids-type system conforming to the following:

(1) **Pigments.** Component A. Percent by weight.

(a) **White:**

Titanium Dioxide, ASTM D 476, type II shall be 6 percent minimum.
Methacrylate resin shall be 18 percent minimum.

(b) **Yellow and Colors:**

Titanium Dioxide, ASTM D 476, type II shall be 6 percent minimum.
Organic yellow, other colors, and tinting as required to meet color standard.
Methacrylate resin shall be 18 percent minimum.

(2) **Prohibited Materials.** The manufacturer shall certify that the product does not contain mercury, lead, hexavalent chromium, halogenated solvents, nor any carcinogen, as defined in 29 CFR 1910.1200.

(3) **Daylight Directional Reflectance:**

(a) **White:** The daylight directional reflectance of the white paint shall not be less than 80 percent (relative to magnesium oxide), when tested in accordance with Federal Test Method Standard No. 141D/GEN, Method 6121.

(b) **Yellow:** The daylight directional reflectance of the yellow paint shall not be less than 55 percent (relative to magnesium oxide), when tested in accordance with Federal Test Method Standard No. 141D/GEN. The x and y values shall be consistent with the Federal Hegman yellow color standard chart for traffic yellow standard 33538, or shall be consistent with the tolerance listed below:

x .462	x .470	x .479	x .501
y .438	y .455	y .428	y .452

(4) **Accelerated Weathering.**

(a) **Sample Preparation.** Apply the paint at a wet film thickness of 0.013 inch (0.33 mm) to four 3 by 6 inch (8 by 15 cm) aluminum panels prepared as described in Method 2013 of Federal Test Method Standard No. 141D/GEN. Air dry the sample 48 hours under standard conditions.

(b) **Testing Conditions.** Test in accordance with ASTM G 53 154 using both Ultra Violet (UV-B) Light and condensate exposure, 72 hours total, alternating 4 hour UV exposure at 60 degree C, and 4 hours condensate exposure at 40 degrees C.

(c) **Evaluation.** Remove the samples and condition for 24 hours under standard conditions. Determine the directional reflectance and color match using the procedures in paragraph 620-2.2c(3) above. Evaluate for conformance with the color requirements.

(5) **Volatile Organic Content.** Determine the volatile organic content in accordance with 40 CFR Part 60 Appendix A, Method 24.

(6) **Dry Opacity.** Use Procedure B, Method B of Method 4121 of Federal Test Method Standard No. 141D/GEN. The wet film thickness shall be 0.015 inch (0.12 mm). The minimum opacity for white and colors shall be 0.92.

(7) **Abrasion Resistance.** Subject the panels prepared in paragraph 620-2.2c(4) to the abrasion test in accordance with ASTM D 968, Method A, except that the inside diameter of the metal guide tube shall be from 0.747 to 0.750 inch (18.97 to 19.05 mm). Five liters of unused sand shall be used for each test panel. The test shall

be run on two test panels. [Note: five liters of sand weighs 17.5 lb. (7.94 kg).] Both baked and weathered paint films shall require not less than 150 liters of sand for the removal of the paint films.

(8) Hardness, Shore. Hardness shall be at least 80 when tested in accordance with ASTM D 2240.

d.SOLVENT-BASE. Paint shall meet the requirements of Federal Specification [A-A-2886A Type I or Type II].

TT-P-85 or TT-P-110 should not be used on bituminous pavement.

e. PREFORMED THERMOPLASTIC AIRPORT PAVEMENT MARKINGS. Must be composed of ester modified rosins in conjunction with aggregates, pigments, and binders which have been factory produced as a finished product. The material must be impervious to degradation by aviation fuels, motor fuels and lubricants.

(1) The markings must be able to be applied in temperatures down to 35°F without any special storage, preheating or treatment of the material before application.

(2) Graded Glass Beads:

(a) The material must contain a minimum of thirty percent (30%) intermixed graded glass beads by weight. The intermixed beads shall be conforming to Federal Specification. TT-B-1325D, with minimum 80% true spheres and minimum refractive index of 1.50.

(b) The material must have factory applied coated surface beads in addition to the intermixed beads at a rate of 1 lb. (± 10%) per 10 sq. ft. These factory applied coated surface beads shall have a minimum of 90% true spheres, minimum refractive index of 1.50, and meet the following gradation.

Size Gradation		Retained, %	Passing, %
US Mesh	µm		
12	1700	0 - 2%	98 - 100%
14	1400	0 - 3.5%	96.5 - 100%
16	1180	2 - 25%	75 - 98%
18	1000	28 - 63%	37 - 72%
20	850	63 - 72%	28 - 37%
30	600	67 - 77%	23 - 33%
50	300	89 - 95%	5 - 11%
80	200	97-100%	0 - 3%

(3) Heating indicators: The top surface of the material (same side as the factory applied surface beads) shall have regularly spaced indents. These indents shall act as a visual cue during application that the material has reached a molten state so satisfactory adhesion and proper bead embedment has been achieved and a post-application visual cue that the installation procedures have been followed.

(4) Pigments: Percent by weight.

(a) White:

Titanium Dioxide, ASTM D 476, type II shall be 10 percent minimum.

(b) Yellow and Colors:

Titanium Dioxide, ASTM D 476, type II shall be 1 percent maximum.

Organic yellow, other colors, and tinting as required to meet color standard.

(5) **Prohibited Materials.** The manufacturer shall certify that the product does not contain mercury, lead, hexavalent chromium, halogenated solvents, nor any carcinogen, as defined in 29 CFR 1910.1200.

(6) **Daylight Directional Reflectance:**

(a) **White:** The daylight directional reflectance of the white paint shall not be less than 80 percent (relative to magnesium oxide), when tested in accordance with Federal Test Method Standard No. 141D/GEN, Method 6121.

(b) **Yellow:** The daylight directional reflectance of the yellow paint shall not be less than 55 percent (relative to magnesium oxide), when tested in accordance with Federal Test Method Standard No. 141D/GEN. The x and y values shall be consistent with the Federal Hegman yellow color standard chart for traffic yellow standard 33538, or shall be consistent with the tolerance listed below:

x .462	x .470	x .479	x .501
y .438	y .455	y .428	y .452

(7) **Skid Resistance:** The surface, with properly applied and embedded surface beads, must provide a minimum resistance value of 45 BPN when tested according to ASTM E303.

(8) **Thickness:** The material must be supplied at a nominal thickness of 65 mils (1.7 mm).

(9) **Environmental Resistance:** The material must be resistant to deterioration due to exposure to sunlight, water, salt or adverse weather conditions and impervious to aviation fuels, gasoline, and oil.

(10) **Retroreflectivity:** The material, when applied in accordance with manufacturer’s guidelines, must demonstrate a uniform level of sufficient nighttime retroreflection when tested in accordance to ASTM E1710.

(11) **Packaging:** A protective film around the box must be applied in order to protect the material from rain or premature aging.

(12) **Manufacturing Control and ISO Certification:** The manufacturer must be ISO 9001:2000 certified and provide proof of current certification. The scope of the certification shall include manufacture of reflective markings.

620-2.3 REFLECTIVE MEDIA. Glass beads shall meet the requirements for []. Glass beads shall be treated with all compatible coupling agents recommended by the manufacturers of the paint and reflective media to ensure adhesion and embedment.

The Engineer should insert all that will be used in the project. When more than one bead type is specified, the plans should indicate the bead type for each marking.

[Federal Specification. TT-B-1325D, Type I, gradation A]

[Federal Specification. TT-B-1325D, Type III]

[Federal Specification. TT-B-1325D, Type IV]

The Engineer should consult with the paint and bead manufacturer on the use of adhesion, flow promoting, and/or flotation additives.

CONSTRUCTION METHODS

620-3.1 WEATHER LIMITATIONS. The painting shall be performed only when the surface is dry and when the surface temperature is at least 45°F (7°C) and rising and the pavement surface temperature is at least 5°F (2.7°C) above the dew point. [Painting operations shall be discontinued when the surface temperature exceeds [] degrees F ([] degrees C.) Markings shall not be applied when the pavement temperature is greater than 120°F.

The Engineer may specify minimum and maximum surface temperatures based on paint manufacturer's recommendations.

620-3.2 EQUIPMENT. Equipment shall include the apparatus necessary to properly clean the existing surface, a mechanical marking machine, a bead dispensing machine, and such auxiliary hand-painting equipment as may be necessary to satisfactorily complete the job.

The mechanical marker shall be an atomizing spray-type or airless type marking machine suitable for application of traffic paint. It shall produce an even and uniform film thickness at the required coverage and shall apply markings of uniform cross sections and clear-cut edges without running or spattering and without over spray.

620-3.3 PREPARATION OF SURFACE. Immediately before application of the paint, the surface shall be dry and free from dirt, grease, oil, laitance, or other foreign material that would reduce the bond between the paint and the pavement. The area to be painted shall be cleaned by sweeping and blowing or by other methods as required to remove all dirt, laitance, and loose materials without damage to the pavement surface. Use of any chemicals or impact abrasives during surface preparation shall be approved in advance by the Engineer. [Paint shall not be applied to Portland cement concrete pavement until the areas to be painted are clean of curing material. Sandblasting or high-pressure water shall be used to remove curing materials.]

The Engineer should specify any additional surface preparation required and should specify the type of surface preparation to be used when existing markings interfere with or would cause adhesion problems with new markings.

620-3.4 LAYOUT OF MARKINGS. The proposed markings shall be laid out in advance of the paint application. The locations of markings to receive glass beads shall be shown on the plans. [The locations of markings to receive silica sand shall be shown on the plans.]

Glass beads improve conspicuity and the friction characteristics of markings. When markings are part of an AIP or PFC funded project, at a minimum, the Engineer shall indicate the following locations to receive glass beads:

1. All runway and taxiway holding position markings.
2. Runway threshold marking.
3. Runway threshold bar.
4. Runway aiming point marking.
5. Runway designation marking.
6. Runway touchdown zone markings.
7. Runway centerline marking.

- 8. Taxiway centerline marking.
- 9. Geographical position marking.
- 10. Surface painted signs.

In addition to the minimum list above, the following locations are recommended to receive glass beads:

- 11. Runway side stripes,
- 12. Taxiway edge markings,
- 13. Non-movement Area boundary markings,
- 14. Displaced threshold markings, and
- 15. Demarcation bar.

620-3.5 APPLICATION. Paint shall be applied at the locations and to the dimensions and spacing shown on the plans. Paint shall not be applied until the layout and condition of the surface has been approved by the Engineer. The edges of the markings shall not vary from a straight line more than 1/2 inch (12 mm) in 50 feet (15 m) and marking dimensions and spacings shall be within the following tolerances:

Dimension and Spacing	Tolerance
36 inches (910 mm) or less	±1/2 inch (12 mm)
greater than 36 inches to 6 feet (910 mm to 1.85 m)	± 1 inch (25 mm)
greater than 6 feet to 60 feet (1.85 m to 18.3 m)	± 2 inches (51 mm)
greater than 60 feet (18.3 m)	± 3 inches (76 mm)

The paint shall be mixed in accordance with the manufacturer's instructions and applied to the pavement with a marking machine at the rate(s) shown in Table 1. The addition of thinner will not be permitted. A period of [] shall elapse between placement of a bituminous surface course or seal coat and application of the paint.

TABLE 1. APPLICATION RATES FOR PAINT AND GLASS BEADS

Paint Type	Paint Square feet per gallon, ft ² /gal (Square meters per liter, m ² /l)	Glass Beads, Type I, Gradation A Pounds per gallon of paint—lb./gal. (Kilograms per liter of paint—kg/l)	Glass Beads, Type III Pounds per gallon of paint—lb./gal. (Kilograms per liter of paint—kg/l)	Glass Beads, Type IV Pounds per gallon of paint—lb./gal. (Kilograms per liter of paint—kg/l)
*	*	*	*	*

The Engineer shall specify the application rates for paint and glass beads from the following table.

APPLICATION RATES FOR PAINT AND GLASS BEADS FOR TABLE 1

Paint Type	Paint Square feet per gallon, ft ² /gal (Square meters per liter, m ² /l)	Glass Beads, Type I, Gradation A Pounds per gallon of paint—lb./gal. (Kilograms per liter of paint—kg/l)	Glass Beads, Type III Pounds per gallon of paint—lb./gal. (Kilograms per liter of paint—kg/l)	Glass Beads, Type IV Pounds per gallon of paint—lb./gal. (Kilograms per liter of paint—kg/l)

Waterborne	115 ft ² /gal. maximum (2.8 m ² /l)	7 lb./gal. minimum (0.85 kg/l)	10 lb./gal. minimum (1.2 kg/l)	--
Waterborne	90 ft ² /gal. maximum (2.2 m ² /l)	--	--	8 lb./gal. minimum (1.0 kg/l)
Solvent Base	115 ft ² /gal. maximum (2.8 m ² /l)	7 lb./gal. minimum (0.85 kg/l)	10 lb./gal. minimum (1.2kg/l)	--
Solvent Base	90 ft ² /gal. maximum (2.2 m ² /l)	--	--	8 lb./gal. minimum (1.0 kg/l)
Epoxy	90 ft ² /gal. maximum (2.2 m ² /l)	14 lb./gal. minimum (1.7 kg/l)	20 lb./gal. minimum (2.4 kg/l)	15 lb./gal. minimum (1.8kg/l)
Methacrylate	45 ft ² /gal. maximum (1.1 m ² /l)	14 lb./gal. minimum (1.7 kg/l)	20 lb./gal. minimum (2.4 kg/l)	15 lb./gal. minimum (1.8 kg/l)

The Engineer shall specify the time period in order to allow adequate curing of the pavement surface. The Engineer should contact the paint manufacturer to determine the wait period.

Due to the increased surface area to cover, the following should be substituted when painting P-402 Porous Friction Course with waterborne or solvent based paints: "The paint shall be mixed in accordance with the manufacturer's instructions and applied to the pavement with a marking machine from two directions at 75 percent of the rate(s) (e.g. rate/0.75 for paint, 0.75×rate for beads and sand)) shown in Table 1 from each direction."

Markings may be required before paving operations are complete. The Engineer may wish to specify waterborne or solvent-based materials for temporary markings at 30-50 percent of the specified application rates (e.g. rate/0.50). No glass beads are required for temporary markings. A-A-2886A, Type III may be used for temporary markings when reflectorized temporary markings are desired

Glass beads shall be distributed upon the marked areas at the locations shown on the plans to receive glass beads immediately after application of the paint. A dispenser shall be furnished which is properly designed for attachment to the marking machine and suitable for dispensing glass beads. Glass beads shall be applied at the rate(s) shown in Table 1. Glass beads shall not be applied to black paint. Glass beads shall adhere to the cured paint or all marking operations shall cease until corrections are made.

All emptied containers shall be returned to the paint storage area for checking by the Engineer. The containers shall not be removed from the airport or destroyed until authorized by the Engineer.

A 24 to 30 day waiting period is recommended for all types of paints to be used for pavement marking. If the airport operations require pavement marking prior to the recommended waiting period, the paint may be applied in a temporary light coat application. Appropriate modifications to paragraph 3.5 should be included to specify a 25% or 33% application rate for temporary markings. Glass beads are not required for temporary markings. The final application should occur after the waiting period has passed. The final marking application

must be at full strength in order to adequately set the glass bead. Avoid specifying a 25-33% first application and then a 66-75% second application. This approach will not adequately set the glass bead.

620-3.6 APPLICATION--PREFORMED AIRPORT PAVEMENT MARKINGS

(a) The markings must be a resilient thermoplastic product with uniformly distributed glass beads throughout the entire cross sectional area. The markings must be resistant to the detrimental effects of aviation fuels, motor fuels and lubricants, hydraulic fluids, de-icers, anti-icers, protective coatings, etc. Lines, legends and symbols must be capable of being affixed to bituminous and/or portland cement concrete pavements by the use of a large radiant heater. Colors shall be available as required.

(b) The markings must be capable of conforming to pavement contours, breaks and faults through the action of airport traffic at normal pavement temperatures. The markings must be capable of fully conforming to grooved pavements, including pavement grooving per FAA AC 150/5320-12C. The markings shall have resealing characteristics, such that it is capable of fusing with itself and previously applied thermoplastic when heated with a heat source per manufacturer's recommendation.

(c) Multicolored markings must consist of interconnected individual pieces of preformed thermoplastic pavement marking material, which through a variety of colors and patterns, make up the desired design. The individual pieces in each large marking segment (typically more than 20 ft. long) must be factory assembled with a compatible material and interconnected so that in the field it is not necessary to assemble the individual pieces within a marking segment. Obtaining multicolored effect by overlaying materials of different colors is not acceptable due to resulting inconsistent marking thickness and inconsistent application temperature in the marking/substrate interface.

(d) The markings must be capable of being successfully applied to Green Concrete (concrete that has set but not appreciably hardened). The application of the markings shall not require the portland cement concrete application areas to be cured or dried out.

(e) The marking material must set up rapidly, permitting the access route to be re-opened to traffic maximum 15 minutes after application.

(f) The marking material shall have an integral color throughout the thickness of the marking material

(g) Asphalt and Portland cement concrete: To ensure minimum single-pass application time and optimum bond in the marking/substrate interface, the materials must be applied using a variable speed self-propelled mobile heater with an effective heating width of no less than 16 ft. (4.88 m) and a free span between supporting wheels of no less than 18 ft. (5.49 m). The heater must emit thermal radiation to the marking material in such a manner that the difference in temperature of 2 in. (5.08 cm) wide linear segments in the direction of heater travel must be within 5% of the overall average temperature of the heated thermoplastic material as it exits the heater. The material must be able to be applied at ambient and pavement temperatures down to 35°F without any preheating of the pavement to a specific temperature. The material must be able to be applied without the use of a thermometer. The pavement shall be clean, dry and free of debris. A non-VOC sealer with a maximum applied viscosity of 250 centi-Poise (ASTM D 2393) must be applied to the pavement shortly before the markings are applied. The supplier must enclose application instructions with each box/package.

620-3.7 PROTECTION AND CLEANUP. After application of the markings, all markings shall be protected from damage until dry. All surfaces shall be protected from excess moisture and/or rain and from disfiguration by spatter, splashes, spillage, or drippings. The Contractor shall remove from the site all debris, waste, loose or unadhered reflective media, and by-products generated by the surface preparation and application operations to the satisfaction of the Engineer. The Contractor shall dispose of these wastes in strict compliance with all applicable state, local, and Federal environmental statutes and regulations.

METHOD OF MEASUREMENT

620-4.1 The quantity of runway and taxiway markings to be paid for shall be [the number of square feet (square meters) of painting and the number of pounds (kilograms) of reflective media] [the number of square feet (square meters) of preformed markings] [one complete item in place] performed in accordance with the specifications and accepted by the Engineer.

BASIS OF PAYMENT

620-5.1 Payment shall be made at the respective contract [price per square foot (square meter)] [lump sum price] for runway and taxiway painting [, and [price per pound (kilogram)] [lump sum price] [,price per square foot (square meter)] [lump sum price] for preformed markings] for reflective media. This price shall be full compensation for furnishing all materials and for all labor, equipment, tools, and incidentals necessary to complete the item.

Payment will be made under:

Item P-620-5.1-1 Runway and Taxiway Painting [per square foot (square meter)] [lump sum]

The Engineer should include a pay item for each paint and bead type material specified.

Item P-620-5.1-2 Reflective Media [per pound (kilogram)] [lump sum]

TESTING REQUIREMENTS

- ASTM C 136 Sieve Analysis of Fine and Coarse Aggregates
- ASTM C 146 Chemical Analysis of Glass Sand
- ASTM C 371 Wire-Cloth Sieve Analysis of Nonplastic Ceramic Powders
- ASTM D 92 Test Method for Flash and Fire Points by Cleveland Open Cup
- ASTM D 711 No-Pick-Up Time of Traffic Paint
- ASTM D 968 Standard Test Methods for Abrasion Resistance of Organic Coatings by Falling Abrasive
- ASTM D 1213-54(1975) Test Method for Crushing Resistance of Glass Spheres
- ASTM D 1652 Test Method for Epoxy Content of Epoxy Resins
- ASTM D 2074 Test Method for Total Primary, Secondary, and Tertiary Amine Values of Fatty Amines by Alternative Indicator Method
- ASTM D 2240 Test Method for Rubber Products-Durometer Hardness
- ASTM G 15453 Operating Light and Water-Exposure Apparatus (Fluorescent Light Apparatus UV-Condensation Type) for Exposure of Nonmetallic Materials.
- Federal Test Method Paint, Varnish, Lacquer and Related Materials; Methods of Inspection,

Standard No. 141D/GEN Sampling and Testing

MATERIAL REQUIREMENTS

ASTM D 476	Specifications for Dry Pigmentary Titanium Dioxide Pigments Products
Code of Federal Regulations	40 CFR Part 60, Appendix A – Definition of Traverse Point Number and Location
Code of Federal Regulations	29 CFR Part 1910.1200 – Hazard Communications
FED SPEC TT-B-1325D	Beads (Glass Spheres) Retroreflective
AASHTO M 247	Glass Beads Used in Traffic Paints
FED SPEC TT-P-1952E	Paint, Traffic and Airfield Marking, Waterborne
Commercial Item Description (CID) A-A-2886B	Paint, Traffic, Solvent Based
FED STD 595	Colors used in Government Procurement

END OF ITEM P-620

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