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USACE / NAVFAC / AFCEC **UFGS-32 17 23.16 (November 2024)**

Preparing Activity: USACE **Superseding**
UFGS-32 17 23 (August 2016)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated April 2026
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DIVISION 32 - EXTERIOR IMPROVEMENTS

SECTION 32 17 23.16

ROAD AND PARKING LOT PAVEMENT MARKINGS

11/24

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SECTION 32 17 23.16

ROAD AND PARKING LOT PAVEMENT MARKINGS
11/24

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NOTE: This guide specification covers pavement marking requirements for roads and parking lots by means of paint and raised pavement markers. This guide specification also covers removal of existing pavement markings on roads and parking lots. If curbs, obstructions, and other appurtenant structures are included in the work area, the same requirements apply, but hand application with spray guns and manual bead dispensers may be required.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project-specific requirements by adding, deleting, or revising text. Choose applicable item(s) or insert appropriate information for bracketed items.

Reference UFC 3-260-04, Airfield and Heliport Marking before editing this specification. Review Chapter 3, Chapter 4, and Appendix B for specific information about paint types, reflective glass beads, and wet film thickness.

Remove information and requirements not required for the project, whether or not brackets are present.

This guide specification includes tailoring options for AIR FORCE, ARMY, and NAVY. Selection or deselection of a tailoring option will include or exclude that option in the section, but editing the resulting section to fit the project is still required.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).

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NOTE: Be specific in identifying existing materials to be removed or prepared for marking on the Contract drawings. On the Contract drawings, show location, width, paint type, color,and raised pavement markers to be used. Indicate whether pavement marking is reflective or non-reflective.

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NOTE: For Air Force applications, coordinate deviations from this guide specification with the Air Force Installation & Mission Support Center.

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PART 1 GENERAL

1.1 UNIT PRICES

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NOTE: Delete this paragraph when pavement marking is included in a lump sum project. Edit the following paragraph when raised pavement markers or paint removal are not included in the scope of work.

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1.1.1 Measurement

1.1.1.1 Surface Preparation

The unit of measurement for surface preparation (cleaning [and paint removal]) is the number of square meters feet of pavement surface prepared for marking and accepted by the Contracting Officer.

1.1.1.2 Pavement Striping and Markings

The unit of measurement for pavement markings is the number of square meters feet of reflective and/or non-reflective striping or markings actually completed and accepted by the Contracting Officer.

[1.1.1.3 Raised Pavement Markers

The unit of measurement for raised pavement markers is the number actually placed as specified and approved by the Contracting Officer.

]1.1.2 Payment

The quantities of surface preparation, [marking removal] pavement striping or markings, [and] [raised pavement markers,] as specified in paragraph Measurement, will be paid for at the contract unit price. The payment constitutes full compensation for furnishing all labor, materials, tools, equipment, appliances, and doing all work involved in preparing and marking the pavements as shown on the drawings. Remove and replace any striping or markings which required reflective media, but are placed without it, do not meet the stated minimum retro-reflective requirements, or with other defects, at no cost to the Government. Remove and replace striping or markings which do not conform to the required physical

characteristics, alignment, or location required at no cost to the Government.

1.2 REFERENCES

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NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a Reference Identifier (RID) outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

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The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 247	(2013) Standard Specification for Glass Beads Used in Pavement Markings
AASHTO M 249	(2012; R2016) Standard Specification for White and Yellow Reflective Thermoplastic Striping Material (Solid Form)

ASTM INTERNATIONAL (ASTM)

ASTM D471	(2016a; R 2021) Standard Test Method for Rubber Property - Effect of Liquids
ASTM D476	(2015) Dry Pigmentary Titanium Dioxide Pigments
ASTM D522/D522M	(2017; R 2021) Mandrel Bend Test of Attached Organic Coatings
ASTM D711	(2010; R 2015) No-Pick-Up Time of Traffic Paint
ASTM D823	(2018) Standard Practices for Producing Films of Uniform Thickness of Paint, Coatings, and Related Products on Test Panels
ASTM D968	(2022) Standard Test Methods for Abrasion

	Resistance of Organic Coatings by Falling Abrasive
ASTM D1652	(2011; E 2012) Standard Test Method for Epoxy Content of Epoxy Resins
ASTM D2074	(2007; R2013) Standard Test Methods for Total, Primary, Secondary, and Tertiary Amine Values of Fatty Amines by Alternative Indicator Method
ASTM D2240	(2015; R 2021) Standard Test Method for Rubber Property - Durometer Hardness
ASTM D2621	(1987; R 2016) Standard Test Method for Infrared Identification of Vehicle Solids from Solvent-Reducible Paints
ASTM D2697	(2003; R 2014) Volume Nonvolatile Matter in Clear or Pigmented Coatings
ASTM D3335	(1985a; R 2020) Low Concentrations of Lead, Cadmium, and Cobalt in Paint by Atomic Absorption Spectroscopy
ASTM D3718	(1985a; R 2015) Low Concentrations of Chromium in Paint by Atomic Absorption Spectroscopy
ASTM D3924	(2016) Standard Specification for Environment for Conditioning and Testing Paint, Varnish, Lacquer, and Related Materials
ASTM D3960	(2005; R 2013) Determining Volatile Organic Compound (VOC) Content of Paints and Related Coatings
ASTM D4280	(2012) Extended Life Type, Nonplowable, Raised, Retroreflective Pavement Markers
ASTM D4383	(2012) Standard Specification for Plowable, Raised Retroreflective Pavement Markers
ASTM D4414	(1995; R 2020) Standard Practice for Measurement of Wet Film Thickness by Notch Gages
ASTM D4505	(2012; R 2017) Standard Specification for Preformed Retroflective Pavement Marking Tape for Extended Service Life
ASTM D4541	(2022) Standard Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers
ASTM E1710	(2011) Standard Test Method for Measurement of Retroreflective Pavement

	Marking Materials with CEN-Prescribed Geometry Using a Portable Retroreflectometer
ASTM E2302	(2003; R 2016) Standard Test Method for Measurement of the Luminance Coefficient Under Diffuse Illumination of Pavement Marking Materials Using a Portable Reflectometer
ASTM G154	(2023) Standard Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Materials

MASTER PAINTERS INSTITUTE (MPI)

MPI 97	(2012) Traffic Marking Paint, Latex

SOCIETY OF AUTOMOTIVE ENGINEERS INTERNATIONAL (SAE)

SAE AMS-STD-595A	(2017) Colors used in Government Procurement

U.S. FEDERAL HIGHWAY ADMINISTRATION (FHWA)

MUTCD	(2023) Manual on Uniform Traffic Control Devices

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS TT-B-1325	(Rev D; Notice 1; Notice 2 2017) Beads (Glass Spheres) Retro-Reflective (Metric)
FS TT-P-1952	(2015; Rev F; Notice 1) Paint, Traffic and Airfield Markings, Waterborne

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1910.1200	Hazard Communication
40 CFR 60	Standards of Performance for New Stationary Sources

1.3 SUBMITTALS

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NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a “G” to an item, if the submittal is sufficiently important or complex in context of the project.

For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy and Air Force projects.

The "S" classification indicates submittals required as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.

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Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-01 Preconstruction Submittals

Quality Control Plan; G, [_____]

Qualifications; G, [_____]

Safety Data Sheets For Each Paint Type; G, [_____]

Safety Data Sheets For Chemicals Used In Surface Preparation; G, [_____]

Data Sheets For Paint Removal Equipment; G, [_____]

Surface Preparation Equipment List; G, [_____]

Marking Applications Equipment List; G, [_____]

Detour Plans; G, [_____]

SD-03 Product Data

Manufacturer Data Sheets for all Marking Materials; G[, [_____]]

Manufacturer Data Sheets for all Reflective Media; G, [_____]

SD-04 Samples

Samples of Marking Materials; G, [_____]

Samples of each Reflective Media; G, [_____]

SD-06 Test Reports

Marking Application Wet Film Thickness Test; G, [_____]

Reflective Media Reflectivity Test; G, [_____]

SD-07 Certificates

Manufacturer Certificate of Compliance for Marking Materials; G, [_____]

Manufacturer Certificate of Compliance for Reflective Materials; G, [_____]

Manufacturer Certificate of Conformance for Volatile Organic Compliance; G[, [_____]]

SD-08 Manufacturer's Instructions

Marking Materials Storage and Application; G, [_____]

Reflective Media Storage and Application; G, [_____]

Chemicals Used in Surface Preparation; G, [_____]

1.4 QUALITY CONTROL

1.4.1 Quality Control Plan

Within [10][_____] calendar days of project award, submit a quality control plan. The plan must state the means, methods, equipment, and materials to be employed for the performance of the surface preparation, existing markings removal, application of reflective and non-reflective marking, and marking layout. At a minimum, provide descriptive criteria for each of the following activities for review and approval by the Contracting Officer:

a. Describe the means and methods used to layout marking geometry and the location of marking elements.

b. Describe the protocol for determination of the operating pressure and speed of the equipment for surface preparation.

c. Describe the protocol for surface preparation when not using water.

d. Describe the protocol for existing markings removal.

e. Define the protocol for the performance of test stripes for each line width, color, and paint type.

f. Provide equipment details to include speed, pressures and application rate for the minimum wet film thickness and the application rate of reflective media to provide the specified glass bead anchoring and reflectivity.

g. Provide and discuss safety directives for maintaining traffic on roads and parking lots.

h. Define communications procedures when operating on roads and parking lots.

1.4.2 Qualifications

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NOTE: The brackets in the paragraph below require the designer to select the years of experience required for those people operating equipment. The years of experience selected is based upon the level of difficulty expected in performing the work.
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Submit documentation certifying that pertinent personnel are qualified for equipment operation and handling of applicable chemicals. The documentation should include experience on five projects of similar size and scope with references for all personnel.

1.4.3 Qualifications For Roads and Parking Marking Personnel

Submit documentation of qualifications in resume format a minimum of [14] [_____] days before pavement marking work is to be performed showing personnel who will be performing the work have experience working on airfields, operating mobile self-powered marking, cleaning, and paint removal equipment and performing these tasks. Include with their resume a list of references complete with points of contact and telephone numbers. Provide certification for pavement marking machine operator and Foreman demonstrating experience successfully completing a minimum of two airfield pavement marking projects of similar size and scope. Provide documentation demonstrating personnel have a minimum of [two] [three] [four] years of experience operating similar equipment and performing the same or similar work in similar environments, similar in size and scope of the planned project. The Contracting Officer reserves the right to require additional proof of competency or to reject proposed personnel.

1.5 DELIVERY, STORAGE, AND HANDLING

[Provide a conditioned storage and staging area located off the installation][A conditioned storage and staging area on the installation will be provided] for all materials intended to be used on the project. Ensure all materials delivered to the storage location are in the original container and clearly marked with the product name, compliance information, batch number, color, manufactured date, instructions for storage, instructions for application, and the name of the manufacturer. All materials are to be stored in conformance with the manufacturer instructions. Provide manufacturer instructions for; marking materials storage and application, reflective media storage and application, and the chemicals used in surface preparation.

1.6 PROJECT/SITE SPECIAL CONDITIONS

1.6.1 Environmental Requirements

Pavement surface must be free of snow, ice, or slush; with a surface temperature of at least 4 degrees C 40 degrees F and rising at the beginning of operations, except those involving shot blasting or grinding. Cease operation during thunderstorms, or during rainfall, except for water blasting and removal of previously applied chemicals. Cease water blasting where surface water accumulation alters the effectiveness of material removal.

1.6.1.1 Weather Limitations for Marking Application

Apply pavement markings to clean, dry surfaces and only when the ambient temperature is at least 3 degrees C 5 degrees F above the dew point and the pavement surface temperatures are within the limits recommended by the manufacturer of the material being used unless otherwise noted. Allow the pavement surface to dry after the water has been used for surface preparation or after a precipitation event. Do not perform marking applications when the wind carries overspray onto locations adjacent to the marking. Provide wind screens to shroud application equipment.

1.6.1.2 Testing Dry Surfaces

Do not commence marking until the pavement surface is dry. Use the plastic wrap method as described in paragraph PRE-APPLICATION TESTING to test the pavement surface for moisture. Do not proceed with marking until the Contracting Officer has observed the moisture test and has accepted the area prepared for marking.

1.6.1.3 Volatile Organic Compounds Compliance

Submit a manufacturer certificate stating that the proposed pavement marking paint meets the Volatile Organic Compound (VOC) regulations of the local Air Pollution Control District having jurisdiction over the geographical area in which the project is located. Submit manufacturer certificate of conformance for volatile organic compliance.

1.6.2 Traffic Control for Roads and Parking Lots

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NOTE: Guidance for traffic control procedures can be obtained from the Manual on Uniform Traffic Control Devices (MUTCD) for Streets and Highways.
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Place approved signs conforming to MUTCD near the beginning of the worksite and well ahead of the worksite to alert approaching traffic from both directions. Place markers along newly painted lines to control traffic and prevent damage to newly painted surfaces [or displacement of raised pavement markers]. Mark painting equipment with warning signs that can be read from a distance of 30 meters 100 feet, indicating slow-moving painting equipment in operation. Provide all lighting and equipment necessary to light the work area during night operations effectively.

When traffic is rerouted or controlled to accomplish the work, provide necessary warning signs, flag persons, and related equipment for the safe passage of vehicles. Submit detour plans to the Contracting Officer for approval before doing the work.

1.7 APPLICATION EQUIPMENT CALIBRATION

Before performing any marking application, calibrate the paint and glass bead application equipment at the necessary speed to execute the application. Calibration and application will be performed using paint that is not diluted or thinned. Paint will be used as formulated by the manufacturer. Calibrate paint and bead guns for each line width and color intended to be applied. Use metal coupons placed in the path of the equipment to capture a test line without glass beads. Use a wet film gauge in accordance with ASTM D4414, to determine if the wet film

thickness is the same at each edge and at the center of the marking. Adjust each paint gun to provide a line of uniform thickness.

Collect a sample of glass beads directly from the glass bead dispenser along a measured distance. Weigh the glass beads captured and determine the coverage by dividing the weight by the area of the line placed during the calibration. Adjust the glass bead dispenser to provide an application rate necessary to meet or exceed the reflectivity specified. After determining the application rate, apply a reflective marking using the wet film thickness to be used for the color and marking element. Using a magnifying glass, examine the distribution and embedment of the glass beads. Beads are to be distributed uniformly for the width of the marking. Adjust the wet film thickness if the beads are submerged or predominantly on the surface of the marking.

PART 2 PRODUCTS

2.1 EQUIPMENT

Submit a surface preparation equipment list by serial number, type, model, and manufacturer. Include descriptive data indicating area of coverage per pass, pressure adjustment range, tank and flow capacities, and safety precautions required for the equipment operation. Mobile equipment must allow for removal of markings without damaging the pavement surface or joint sealant. Maintain machines, tools, and equipment used in the performance of the work in satisfactory operating condition.

2.1.1 Surface Preparation and Paint Removal for Roads and Parking Lots

Submit data sheets for paint removal equipment intended for use in preparation of the pavement surface for marking. In the submittal, include descriptive information on the means for adjusting coverage per each pass, water pressure adjustment range, and tank and flow capacities. The equipment must have a range of adjustments that will provide a clean surface free of dirt, dust, oil, grease, algae, mildew, mold, and loose paint.[When preparing new portland cement concrete for marking, provide equipment capable of removing curing compounds without damage to the concrete surface and joint seal materials.] Submit safety data sheets for chemicals used in surface preparation. Chemicals must be bio-degradable.

2.1.1.1 Water Blasting Equipment

Use mobile water blasting equipment capable of producing a pressurized stream of water that effectively removes paint from the pavement surface without significantly damaging the pavement. Provide equipment, tools, and machinery which are safe and in good working order.

2.1.1.2 Shot Blasting Equipment

Use mobile self-propelled shot blasting equipment capable of producing an adjustable depth of paint removal and propelling abrasive particles at high velocities on the paint for effective removal. Ensure each unit is self-cleaning and self-contained. Use equipment able to confine the abrasive, any dust that is produced, and removed paint and is capable of recycling the abrasive for reuse.

2.1.1.3 Grinding or Scarifying Equipment

Use equipment capable of removing surface contaminates, paint build-up, or

extraneous markings from the pavement surface without leaving any residue. Clean the surface by a hydro blast to remove surface contaminants, and ash after a weed torch is used to remove paint.

2.1.1.4 Chemical Removal Equipment

Use chemical equipment capable of applying and removing chemicals and paint from the pavement surface, leaving only non-toxic biodegradable residue without scarring or other damage to the pavement or joints and joint seals.

2.1.2 Markings Application Equipment

Submit a marking applications equipment list of equipment appropriate for the material(s) to be used. Include the manufacturer's descriptive data and certification for the planned use that indicates the area of coverage per pass, pressure adjustment range, tank and flow capacities, and all safety precautions required for operating and maintaining the equipment. Provide and maintain machines, tools, and equipment used in the performance of the work in satisfactory operating condition, or remove equipment that is not providing satisfactory performance from the work site. Provide mobile and maneuverable application equipment to the extent that straight lines can be followed and normal curves can be made in a true arc.

2.1.2.1 Airless or Atomizing Equipment

Provide mobile airless or pneumatic air-atomized application equipment that is maneuverable to the extent that straight lines can be followed and normal curves can be made in a true arc. Mount equipment on trucks, skids or tractors. Use equipment suitable for application of the marking material specified. Airless systems are used to apply waterborne and epoxy coatings. Pneumatic systems are used only to apply waterborne and solvent based coatings.

Provide equipment capable of applying a marking from 100mm to 300mm 4 inches to 12 inches wide in a single pass and also capable of applying two single solid or intermittent lines using a minimum of two colors. Provide equipment with tanks or reservoirs equipped with mechanical agitators, pressure regulators, and gages in full view of the equipment operator. Use paint strainers suitable to screen paint flowing in all supply lines.

2.1.2.2 Hand-Operated Machines

Provide a hand-operated push-type applicator machine commonly used for the application of water-based paint or two-component, chemically curing paint, thermoplastic, or preformed tape to pavement surfaces for small marking projects, such as legends and cross-walks, parking lots, or surface painted signs. Provide an applicator machine with the necessary tanks and spraying nozzles capable of applying paint uniformly at specified wet film thickness. Provide spray guns for hand application of paint in areas where push-type machines cannot be used.

2.1.2.3 Reflective Media Dispenser

Mount glass bead dispensers that are automatically triggered when paint guns are activated. The dispensers may be pressurized or gravity-drop systems. Pressurized systems require moisture control.

2.1.3 Reflective Thermoplastic Striping Material (Hot Applied) Application Equipment

Apply thermoplastic material with equipment capable of providing continuous uniformity for the dimensional and reflectivity requirements of the marking.

2.1.3.1 Application Equipment

a. Provide application equipment capable of continuous mixing and agitation of the material, with conveying parts that prevent accumulation and clogging between the main material reservoir and the extrusion shoe or spray gun. Ensure all parts of the equipment which come into contact with the material are easily accessible and exposed for cleaning and maintenance. All mixing and conveying parts including the extrusion shoes and spray guns are to maintain the material at the required temperature with heat-transfer oil or electrical-element-controlled heat.

b. Provide application equipment constructed to ensure continuous uniformity in the stripe dimensions. Provide an applicator with a means for cleanly cutting off stripe ends squarely and providing a method of applying skip lines. Provide equipment capable of applying varying widths of traffic markings.

c. Provide mobile application equipment allowing straight lines to be followed and normal curves to be made in a true arc. Provide equipment for the placement of thermoplastic pavement markings of two general types: mobile applicator and hand-operated applicator.

d. Equip the applicator with a pressurized or drop-on type bead dispenser capable of uniformly dispensing reflective glass spheres at controlled flow rates. The bead dispenser must operate automatically to begin flow before the flow of the binder to assure that the strip is fully reflectorized.

2.1.3.2 Mobile Application Equipment

Provide a truck-mounted, self-contained pavement marking machine capable of hot applying thermoplastic by either the extrusion or spray method.

a. Equip the mobile unit with a melting kettle that holds a minimum of 2.7 metric tons 6000 pounds of molten thermoplastic material, capable of heating the thermoplastic composition to temperatures as recommended by the manufacturer. Use a thermostatically controlled heat transfer liquid. Heating the composition by direct flame is not allowed. Oil and material temperature gauges must be visible at both ends of the kettle.

b. Equip mobile units for application of extruded markings with a minimum of two extrusion shoes; located one on each side of the truck, capable of marking simultaneous edge line and centerline stripes, each being a closed, oil-jacketed unit.

c. Equip the mobile unit with an electronic programmable line pattern control system capable of applying skip or solid lines in any sequence, through any and all extrusion shoes, or spray guns, and in programmable cycle lengths. In addition, equip the mobile unit with an automatic counting mechanism capable of recording the number of

lineal meters feet of thermoplastic markings applied to the pavement surface with an accuracy of 0.5 percent.

2.1.3.3 Hand-Operated Machines

Provide portable hand-operated equipment, specifically designed for placing special markings such as crosswalks, stop bars, legends, arrows, and short lengths of the lane, edge, and centerlines; and apply thermoplastic pavement markings by the extrusion method. Equip the hand-operated applicator with all the necessary components, including a materials storage reservoir, bead dispenser, extrusion shoe, and heating accessories.

2.1.3.4 Reflective Media Dispenser

Attach the dispenser for applying the reflective media to the thermoplastic dispenser that is designed to operate automatically and simultaneously with the applicator through the same control mechanism. Provide a bead applicator capable of adjustment and designed to provide a uniform flow of reflective media over the full length and width of the marking.

2.1.4 Preformed Retroreflective Pavement Marking Tape Application Equipment

Provide mechanical application equipment specifically designed for the placement of preformed marking tape. The equipment is specifically designed to apply pressure-sensitive pavement marking tape of varying widths. Equip the applicator with rollers, or other suitable compaction devices to provide initial adhesion of the material with the pavement surface. Use additional tools and devices for properly seating the applied material, as the manufacturer recommends.

2.2 ROAD AND PARKING LOT MATERIALS

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NOTE: For Navy projects, refer to the MPI Manual for recommendations on uses and application rates of paints and select paint systems for the project in accordance with the MPI Architectural Painting Decision Tree available on the Whole Building Design Guide. The MPI Decision Tree identifies paint systems for each interior and exterior coated surface in "Normal" or "Aggressive environmental conditions. It lists the applicable paint systems in descending order of performance. The paint system at the top of each substrate list indicates the highest-performing acceptable coating system.

NOTE: The designer is responsible for preparing drawings identifying where each type, color, and reflective or non-reflective marking is located. The designer is responsible for providing a Table or notes that identifies the paint type, color, and bead type for each marking type. For non-reflective markings, mark the bead type as “NA” or not applicable.

Waterborne paint is usually the material of choice for use on roads and parking lots. Highly durable

materials such as methacrylate, epoxy, and thermoplastic hot applied stripping materials are used on high-volume traffic surfaces such as interstate or primary highways. Durable materials are very difficult to remove, and in northern tiers, snowplows shear off glass beads resulting in a loss of reflectivity. Durable materials have a higher unit cost.

For NAVFAC LANT projects only: When using pavement marking materials (epoxy, thermoplastic, and preformed tape) that perform better than the paint desired for new pavement in Virginia and North Carolina, contact NAVFAC LANT for a sample section.

High Build Acrylic Coating (HBAC) performs similarly to epoxy, thermoplastic compounds, and preformed tape when applied to pavements with high daily vehicular traffic.

Polyurea and urethane are durable marking products that may be used on Roads and Parking Lots only. For designs specifying the use of polyurea or urethane, the respective specifications relating to equipment and materials recognized by local or state agencies in which the project is located must be incorporated herein, and paragraphs appropriately re-numbered.

****

Submit safety data sheets for each paint type[and preformed tape] as well as manufacturer data sheets for all marking materials; include with the submittal a manufacturer certificate of compliance for marking materials and a manufacturer certificate of compliance for reflective materials.

2.2.1 Marking Colors

Provide markings for pavements that conform to SAE AMS-STD-595A color numbers as listed in Table I.

Table I - SAE AMS-STD-595A Color Numbers

Paint Color	SAE AMS-STD-595A Color Number
White	37925
Yellow	33538
Black	37038
Green	34108
Red	33411

2.2.2 Waterborne Paint

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NOTE: Waterborne paint is typically used on roads

and parking lots. Waterborne paints have been known to provide service lives of up to 2 years on low-volume roads, and on higher-volume roads the service life may be reduced to 6 to 12 months. Waterborne paint can be used to restripe over existing waterborne, methacrylate, epoxy paints, thermoplastic stripping material, and high-build acrylic coating.

Specify FS TT-P-1952 for Air Force and Army projects.

Specify MPI 97 for Navy projects. A list of approved products conforming to MPI 97 is on the Master Painters Institute website.

FS TT-P-1952 covers three types of low VOC, ready-mixed, one-component, and 100 percent acrylic waterborne airfield and traffic marking paints.

Type I - For normal weather conditions and not for use at the wet film thickness required for Type IV beads.

Type II - For use under adverse conditions (faster drying for wet film thickness required for Type IV beads.

Type III - For use under normal weather conditions where higher durability and greater adhesion to glass beads is desired. Type III is recommended for use on asphalt pavement because of its higher elasticity which impedes cracking of asphalt at the paint interface.

****

Use FS TT-P-1952, Type [I or II] [III] paint.Use MPI 97 paint.

[2.2.3 Reflective Thermoplastic Striping Material (Hot Applied)

****

NOTE: Thermoplastic striping materials are durable markings used for high-traffic pavements. Caution should be exercised when using thermoplastic stripping material because of a reduction of surface friction, the difficulty of removal, damage from snow removal equipment causing low reflectivity and foreign object debris (FOD), and de-bonding from the pavement surface. Thermoplastic striping materials have intermixed beads and a top dressing of beads applied during placement.

Thermoplastic markings cannot be placed over markings made from materials other than thermoplastic.

Thermoplastic Striping Material is recommended for use on asphalt pavements. The application temperature is about 204.4 degrees C 400 degrees F. Liquid asphalt materials burn at temperatures over

176.7 degrees C 350 degrees F. The bonding between paint and asphalt occurs when the asphalt is liquefied and not when the asphalt is burned.

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2.2.3.1 Composition

Thermoplastic materials must conform to AASHTO M 249. Formulate the binder component as an alkyd resin.

2.2.3.2 Primer

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NOTE: A primer is not required for thermoplastic striping material placed on new asphalt pavement. Specify a primer when thermoplastic is applied to existing asphalt pavements or concrete pavements. Primers are used to reduce the risk of thermoplastic striping material de-bonding from the pavement.

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2.2.3.2.1 Existing Asphalt Primer

Provide thermosetting adhesive primer with a solids content of pigment-reinforced synthetic rubber and synthetic plastic resin dissolved or dispersed in a volatile organic solvent for asphaltic concrete pavements. The solids content must not be less than 10 percent by weight at 21 degrees C 70 degrees F and 60 percent relative humidity. A wet film thickness of 0.13 mm 0.005 inch, plus or minus 0.03 mm 0.001 inch, must dry to a tack-free condition in less than 5 minutes.

2.2.3.2.2 Portland Cement Concrete Primer

Provide an epoxy resin primer for portland cement concrete pavements of the type recommended by the manufacturer of the thermoplastic composition.

][2.2.4 Methacrylate Paint

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NOTE: Methacrylate paint may be used to mark roads and parking lots where cold weather may not allow the use of waterborne paint. Methacrylate paint cannot be placed over markings made from materials other than methacrylate.

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Paint must be a two-component, minimum 99 percent solids type system conforming to the following:

2.2.4.1 Pigments

Titanium dioxide, ASTM D476, Type II must be 10 percent minimum by weight for white paint. Titanium dioxide, ASTM D476, Type II must be one percent minimum for yellow and other colors. Methacrylate resin must be 18 percent minimum for all colors.

2.2.4.2 Prohibited Materials

Provide the manufacturer certification that the product does not contain

mercury, lead, hexavalent chromium, halogenated solvents nor any carcinogen as defined in 29 CFR 1910.1200 in amounts exceeding permissible limits specified in relevant federal regulations.

2.2.4.3 Daylight Directional Reflectance

The daylight directional reflectance must not be less than 80 percent for white paint and 55 percent for yellow paint (relative to magnesium) when tested in conformance with ASTM E2302.

2.2.4.4 Volatile Organic Compounds

Determine the volatile organic compounds in conformance with 40 CFR 60 Appendix A, Method 24.

2.2.4.5 Dry Opacity

When tested at a wet film thickness of 0.38mm 0.015 inches, the minimum opacity for white and colors must be 0.92 when measured in accordance with ASTM E2302.

2.2.4.6 Hardness

Hardness must be at least 80 when tested in accordance with ASTM D2240.

2.2.4.7 Abrasion Resistance

Subject the panels prepared to the abrasion test in accordance with ASTM D968, Method A, except that the inside diameter of the metal guide tube must be from 8.97 to 19.05 mm 0.747 to 0.750 inch. Five liters 17.5 lbs (7.94 kg) of unused sand must be used for each test panel. Run the test on two test panels. Both baked and weathered paint films require not less than 150 liters 525 lbs (239 kg) of sand to remove the paint films.

][2.2.5 Epoxy Paint

****

NOTE: Epoxy pavement markings are a durable, two-component system with exceptional durability on asphalt and concrete surfaces alike. On low to medium volume highways, epoxies have been known to provide service lives in excess of four years. Epoxies often take much longer to dry than other materials. Epoxies also cannot be placed over markings made from other materials. Epoxy can be applied over existing epoxy markings once. After a second application, the old material must be removed.

****

2.2.5.1 Formulation

Epoxy paint must be a two-component, minimum 99 percent solids, material formulated to provide a simple mixing ratio of Component A and Component B as recommended by the manufacturer. Provide the manufacturer certification that the product does not contain mercury, lead, hexavalent chromium, halogenated solvents, nor any carcinogen, as defined in 29 CFR 1910.1200, in amounts exceeding permissible limits specified in federal regulations.

2.2.5.2 Composition (Component A)

The titanium dioxide percent by weight, determined by ASTM D476, of white and yellow paints must be 18 percent minimum and 14 to 17 percent minimum, respectively. The percent by weight of the epoxy resin must be 75 to 79 percent. Tint as required to match Federal Standard No. 595 color number.

2.2.5.3 Epoxide Value

When tested in accordance with ASTM D1652, the epoxide value for white and yellow (Component A) must be within plus or minus 50 of the manufacturer's target value.

2.2.5.4 Total Amine Value

When tested in accordance with ASTM D2074, the curing agent (Component B) must be within plus or minus 50 of the manufacturer's target value.

2.2.5.5 Toxicity

Upon heating to application temperature, the material cannot produce toxic or injurious fumes to persons or property.

2.2.5.6 Daylight Directional

The daylight directional reflectance of the white paint must not be less than 75 percent relative to magnesium oxide when tested to conform to ASTM E1710.

The daylight directional reflectance of the yellow paint must not be less than 55 percent relative to magnesium oxide when tested to conform to ASTM E1710.

2.2.5.7 Hardness

Hardness must be at least 80 when tested in accordance with ASTM D2240.

2.2.5.8 Abrasion Resistance

Subject the panels prepared to the abrasion test in accordance with ASTM D968, Method A, except that the inside diameter of the metal guide tube must be from 18.97 to 19.05 mm 0.747 to 0.750 inch. Five liters 17.5 lbs (7.94 kg) of unused sand must be used for each test panel. Run the test on two test panels. Both baked and weathered paint films must require not less than 150 liters 525 lbs (239 kg) of sand to remove the paint films.

][2.2.6 High Build Acrylic Coating (HBAC)

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NOTE: High Build Acrylic Coating (HBAC): When applied to pavements with high daily vehicular traffic counts, HBAC performs similar to epoxy and thermoplastic striping materials.

HBAC is suitable for reflective and non-reflective use and is applied at approximately twice the thickness of conventional marking paints. The paint produces upraised markings and is appropriate for

use in marking crosswalks, stop legends, railroad crossings, lettering, centerlines, skip lines, and edge lines. HBAC at a thickness beyond conventional marking paints is not intended for use on pavements with snowplow use. However, application at standard thickness, per MPI, is acceptable on surfaces employing snowplows.

Consider either HBAC or thermoplastic stripingmaterials to reduce maintenance costs in desert areas, where painted markings are susceptible to a "sandblasting" effect during high winds.

****

Formulate High Build Acrylic Coating (HBAC) to meet the requirements of Table II.

TABLE II - REQUIREMENTS FOR HIGH BUILD ACRYLIC COATINGS (HBAC)	
TEST	MINIMUM REQUIREMENT (AND MAXIMUM WHERE INDICATED)
Resin System (ASTM D2621)	Waterborne 100 percent Acrylic
Percent Volume Solids (ASTM D2697)	58 percent
Volatile Organic Compound, max. (ASTM D3960)	150 g/l 1.25 lbs/gal
White (SAE AMS-STD-595A)	37925
Yellow (SAE AMS-STD-595A)	33538
Shore D Hardness (ASTM D2240)	45
1/8 inch Mandrel Bend at 5 mils Dry Film Thickness (DFT, one-week cure (ASTM D522/D522M, Method B)	No visual defects at bend (Conditions at ASTM D3924)
Adhesion to Concrete and Asphaltic Pavements (ASTM D4541)	0.97 MPa 140 psi or 100 percent cohesive failure in pavement
Accelerated Weathering, Yellow, 2500 Hours UV Exposure (ASTM G154: see note 1)	Max. color loss to 33655 (SAE AMS-STD-595A)
Water Absorption at 168 Hours Immersion Tap Water (ASTM D471)	9.0 percent max. weight increase (conditions at ASTM D3924)

TABLE II - REQUIREMENTS FOR HIGH BUILD ACRYLIC COATINGS (HBAC)	
TEST	MINIMUM REQUIREMENT (AND MAXIMUM WHERE INDICATED)
Application at 1650 microns 65 mils Wet,One Coat, One-week Cure, (see note 2)	No visual cracking or curling (conditions at ASTM D3924)
No Pick-Up at 630 microns 25 mils (ASTM D711)	Wet 10 minutes max.
Lead (ASTM D3335)	0.06 percent max.
Cadmium (ASTM D3335)	0.06 percent max.
Chromium (ASTM D3718)	0.00 percent

Notes:

(1) Properly mix and apply yellow paint at 250 microns plus or minus 50 microns 10 mils plus or minus 2 mils DFT over a suitably sized, clean aluminum substrate (ASTM D823), and cure for a minimum of 48 hours: prepare four individual yellow samples. Expose three samples to continuous Ultraviolet (UV) light for 2500 hours, without cycles condensation, in accordance to ASTM G154: use UVA-340 lamps in the testing apparatus. Following exposure, compare the three exposed samples to the "one" non-exposed sample using SAE AMS-STD-595A colors 33538 and 33655 as visual references: evaluate exposed samples for degree of visual color loss. Yellow paint is rated as passing if each exposed sample appears equivalent to the non-exposed sample, and in addition, displays color loss no greater than SAE AMS-STD-595A color 33655.

(2) Using double-stick, foam mounting tape (or equal) with a nominal thickness of 1625 microns 65 mils, apply a rectangular mold with inner dimensions of 7.6 cm by 25.5 cm 3 in by 10 in to a clean aluminum sample approximately sized at 15 cm by 30 cm by 0.30 cm 6 in by 12 in by 1/8 in. Do not remove the tape's plastic backing. Mix and apply excess paint into mold. Remove excess paint, by squeegee or other appropriate draw down technique, to a uniform thickness equal to the tape's height. Perform paint application and draw down within a period of no more than 60 seconds. Approximately one to two minutes following the draw down, remove tape from sample and allow coating to cure for a minimum period of one week ASTM D3924. Using a micrometer or other appropriate device, measure cured coating thickness (less sample thickness) to confirm resulting coating application was at or above 950 microns 38 mils DFT. Inspect coating for visual signs of cracking and curling. Following a one week cure, the coating is rated as passing if applied greater than 950 microns 38 mils DFT and visually free of both cracking and curling.

][2.2.7 Preformed Reflective Pavement Marking Tape

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NOTE: Preformed Retroreflective Pavement Marking Tape is normally used for temporary markings when not subject to turning vehicle movements or abrasion. Preformed Marking Tape is usually considered a temporary marking. The expected service life is usually less than a few months. Preformed tape cannot be placed over markings made from other materials nor applied over existing preformed tape markings. All existing markings must be removed when using preformed tape.

****

Provide adherent reflectorized strip preformed tape in accordance with ASTM D4505 Retroreflectivity Level II, Class 1, 2 or 3, Skid Resistance Level B.

][2.2.8 Raised Pavement Markers

****

NOTE: Line marker segments having a 1 to 3 ratio of stripe to gap are standard. Line segments of 3 m 10 feet with gaps of 9 m 30 feet are recommended. When raised pavement markers are used in lieu of striping, make the line marker segments a 3 to 5 ratio of stripe to gap with line segments of 5 m 15 feet with gaps of 8 m 25 feet recommended.

Nonplowable, raised retroreflective pavement markers are specified in ASTM D4280. Plowable, raised retroreflective pavement markers are specified in ASTM D4383.

****

Use either metallic or nonmetallic markers of the button or prismatic reflector type. Provide permanent color markers as specified for pavement marking, which retain the color and brightness under the action of traffic. Provide button markers with a diameter of not less than 100 mm 4 inches, spaced not more than 12 m 40 feet apart on solid longitudinal lines. Make broken centerline marker spacing in segments [of [_____]] [indicated] with gaps [of [_____]] [indicated] between segments. Provide button markers with rounded surfaces presenting a smooth contour to traffic and not projecting more than 19 mm 3/4 inch above level of pavement. Provide [nonplowable] [plowable] pavement markers and adhesive epoxy conforming to [ASTM D4280][ASTM D4383].

]2.2.9 Reflective Media for Roads and Parking Lots

****

The designer should read paragraph 3.1.2., UFC 3-260-04, Airfield and Heliport Marking, Appendix B, before selecting a reflective bead type and gradation.

For Air Force and Army projects, reflective media for roads and parking lots will conform to FS TT

B-1325 Type 1 Gradation A.

Reflective Media for Navy projects will conform to AASHTO M 247, Type I.

****

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NOTE: When selecting retro-reflective media using FS TT-B-1325, refer to the following for the intended uses.

Type I, Coarse (Gradation A), low index recycled glass beads for drop-on applications are intended for marking highways. Type I beads have a low Index of Reflectivity (IOR of 1.5) because the beads return light in a diffused pattern. Type I waterborne marking paint is typically used with Type I beads.

Type III beads are not used on Roads and Parking Lots.

Type IV, Gradation B, large diameter, low index recycled glass beads for drop-on applications intended for highways. The wet film thickness must be increased compared to using Type I beads to provide proper anchoring (between 20 to 22 mils). Type IV beads are used with HBAC, Thermoplastic and Epoxy because of the wet film thickness associated with those materials.

Type I glass beads can be used with Type I, II, or III paint when using waterborne paint. Type IV glass beads can only be used with Type III paint.

****

Provide FS TT-B-1325 [Type I, Gradation A][and][Type III][and][Type IV, Gradation B] glass beads.Provide AASHTO M 247 reflective media. Paint and glass bead types used with markings are designated on the drawings.

Provide glass beads with those coatings to promote adhesion, limit flotation, and absorb moisture to preclude bundling and dual coatings for waterborne materials. Submit manufacturer data sheets for all reflective media used.

PART 3 EXECUTION

3.1 TEST SECTIONS

Before the performance of any marking application, demonstrate to the Government, using the equipment, materials, and personnel identified in the approved quality control plan, that the requirements for acceptance of the final product(s) are attainable. The minimum length of the test section is 15 meters 50 feet of marking for each line width, color, and wet film thickness. Perform demonstrations in a location designated by the Contracting Officer within the project scope of work. Do not perform the test section(s) until the Contracting Officer is present to observe the test. Table III identifies minimum and maximum wet film thickness based on glass bead type. Each test section's result is the standard of

performance for the color, width, wet film thickness, and glass bead application rate for each marking element. Submit the color, line width, wet film thickness, and measured reflectivity.

3.1.1 Surface Preparation and Paint Removal Test Section

****
NOTE: Delete brackets if project does not include removal of existing markings.
****

[Perform a demonstration removal of pavement markings in an area designated by the Contracting Officer.] Prepare an area large enough to determine [cleanliness][, adhesion of remaining markings][, and cleaning rate][and removal rate]. Use the means, methods, and equipment identified in the approved quality control plan. Adjust the means, methods, equipment, or equipment settings until the prepared surface is free of dirt, debris, oils and greases, algae, mold, mildew, and loose or flaking paint without damage to the pavement. Remove any equipment that fails to provide an acceptable product during the demonstration and provide new equipment that will produce an acceptable product.[Approved demonstration area establishes the standard for the work.]

3.1.2 Wet Film Thickness Test Section

****
NOTE: The purpose of providing glass beads embedded in a paint marking is to provide easy sight acquisition for vehicle drivers at night under diffused light. Embedment is critical. If beads are submerged light will not be returned. If there is not enough paint to anchor beads then beads become fugitive materials. Determining proper embedment is critical to the performance and durability of the reflective marking.

Proper embedment is determined by providing a paint mil thickness that allows for the largest diameter bead in the distribution to be embedded to one-half of the bead diameter. The smaller beads will "float" and the wicking of the paint will coat the beads to a range of 50 to 60 percent of the diameter. The minimum wet film thickness threshold in Table III result in glass bead embedment at approximately 50 percent of the glass bead diameter for the specified bead type. Confirm the reflectivity of the marking using a retro-reflectometer at night under diffuse lighting using ASTM E1710 protocol. If the reflectivity exceeds the minimum at three locations from different directions then the embedment is correct.
****

Adjust the marking application rate for equipment speed, operating pressure, and line width, to provide a minimum wet film thickness, full coverage, and reflective media anchoring. Minimum and maximum wet film thickness is identified in Table III. Measure the wet film thickness using a wet film gauge at three points along the test section. Wet film thickness is determined using ASTM D4414 as the performance standard.

When the average of the three readings is less than the minimum specified in Table III, repeat the test section. Submit the results of the marking application wet film thickness test to the Contracting Officer

3.1.3 Reflective Value Test Section

Measure the reflectivity at three points, along the length of the marking placed for wet film thickness. After the application is cured, measure the retro-reflective value using a Retro-Reflectometer with a direct readout in millicandelas per square meter per lux (mcd/m2/lx) using ASTM E1710. Take three readings on each test section. When the average of the three readings is less than the minimum specified in Table V repeat the test section. Document the application rate of the reflective media required to meet the specified minimum reflectivity. Submit the results of the reflective media reflectivity test to the Contracting Officer before proceeding with work on the project.

3.2 SURFACE PREPARATION

Clean surfaces before the application of marking materials. Remove all dust, dirt, scaling or loose paint, algae, oils, and grease and mineral deposits such as iron stains by use of water blasting or chemical removal. Follow the cleaning with sweeping, blowing or using water rinse. Do not begin painting in any location prepared for marking until surfaces are dry and clean.

Scrub areas with oil or grease present with applications of trisodium phosphate solution or other approved detergent or degreaser. Rinse thoroughly after each application to prevent staining of the new marking. After cleaning oil-soaked areas, seal with shellac or primer as the manufacturer recommends to prevent bleeding through the new paint.

3.3 PRE-APPLICATION TESTING

Test the pavement surface for moisture before beginning pavement marking after each period of rainfall, fog, high humidity, or cleaning or when the ambient temperature has fallen below the dew point. Do not commence marking until the pavement is sufficiently dry and the Contracting Officer has approved the pavement condition.

Employ the plastic wrap method, described as follows, to test the pavement for moisture:

a. Cover the pavement with a 300 mm by 300 mm 12 inch by 12 inch section of clear plastic wrap and seal the edges with tape.

b. After 15 minutes, examine the plastic wrap for any visible moisture accumulation. Do not begin marking operations until the test can be performed with no visible moisture accumulation inside the plastic wrap.

c. Re-test surfaces when work has been stopped due to a precipitation event.

3.4 MARKINGS APPLICATION

3.4.1 Marking Materials for Roads and Parking Lots Pavement

3.4.1.1 Waterborne Paint

****

NOTE: Most waterborne paints can be applied at temperatures down to 10 degrees C 50 degrees F. Waterborne paints formulated to be applied at temperatures down to approximately 2 degrees C 35 degrees F are available.

The actual application rate for paint will vary because of the texture, age, and condition of the material being marked. The application rate is determined as a result of the TEST SECTIONS (Wet Film Thickness). The application rate is required to provide a wet film thickness approximately equal to provide a 50 percent embedment of the glass bead diameter being used. Edit Table III to delete content of those cells with paint wet film thickness or bead application rates not applicable to the scope of work.

Type I glass beads can be used with Type I, Type II, or Type III waterborne paint; Type IV glass beads can only be used with Type III waterborne paint. The expected wet film thickness when using Type I glass beads is 14 to 16 mils. When using Type IV gradation B glass beads, the wet film thickness must be increased to the range of 25 to 30 mils because of the larger bead diameter. Type IV beads do not increase the reflectivity because they are low index beads. Type IV beads are only used where Type III paint is used to provide thicker paint.

Application rates for glass beads will vary.

Specify FS TT-P-1952 waterborne paint and FS TT-B-1325 reflective media for Air Force and Army projects.

Specify MPI 97 waterborne paint and AASHTO M 247 reflective media for Navy projects.

Edit the following paragraphs by deleting those that do not apply.

****

The dilution or thinning of paint prior to application is not allowed.

[
Provide FS TT-P-1952waterborne paint and FS TT-B-1325 glass beads. Apply [reflective][and][non-reflective] markings in accordance with Table III. Use the paint type[and bead type] as shown on the drawings.]

[
Provide MPI 97 paint and apply AASHTO M 247 glass beads. Apply [reflective][and][non-reflective] markings in accordance with Table III. Use the paint type[and bead type] as shown on the drawings.]

The paint wet film thickness and glass bead application rate is provided in Table III. Perform the marking and bead application test section beginning at the minimum value and adjust the application rate up or down until the requirements of WET FILM THICKNESS TEST SECTION and REFLECTIVE TEST SECTION are satisfied. The values of wet film thickness and bead application rate established by the test section will be the standard of performance for the respective marking type and color.

Table III. Paint Wet Film Thickness and Bead Application Rate

Paint Type	Non-Reflectorized Marking Wet Film Thickness (mil)	Reflectorized Marking			
		Wet Film Thickness (mil) based on Glass Bead Type		Minimum Bead Application Rate	
		Type I Gradation A	Type IV Gradation B	Type I Gradation A	Type IV Gradation B
Type I	14-16	14-16	--	0.8 kg/L 7 lb/gal	--
Type II	14-16	14-16	--	0.8 kg/L 7 lb/gal	--
Type III	16-20	--	25-30	--	1 kg/L 8 lb/gal

[3.4.1.2 Methacrylate Paint

****

NOTE: Methacrylate paint is used for roads and parking lots and is suitable for use on portland cement concrete, asphalt and brick traffic surfaces. Methacrylate may be applied at temperatures down to -1 degrees C 30 degrees F.

Reference UFC 3-260-04, Appendix B, Best Practices Handbook, prior to selecting bead and paint types.

For Air Force and Army Projects, use either FS TT B 1325 Type I (Gradation 1) for Roadway traffic markings. Use Type IV (Gradation B) for cross walks or markings that require high durability because of traffic abrasion.

For Navy projects use the AASHTO M247 equivalent for glass beads.

The wet film thickness for paint and the application rate for glass beads will be variable because of pavement conditions and ambient temperature at the marking time. The wet film thickness for methacrylate paint and application rate for glass beads must be determined by test section. The

minimum wet film thickness is that required to provide embedment of the glass beads at approximately 50 percent of the glass bead diameter.
****

Apply methacrylate paints at a minimum wet film thickness recommended by the manufacturer, provided it is the wet film thickness required to embed glass beads at approximately 50 percent of the bead diameter. Apply [FS TT-B-1325 [Type I (Gradation A)] [Type IV (Gradation B)]] [AASHTO M 247] glass beads at an application rate that provides the minimum reflectivity in accordance with paragraph TEST SECTION.

Apply methacrylate paint only on surfaces prepared for marking application and free of moisture, dirt, debris, oils and greases, algae, mold, or mildew. Apply methacrylate paint only to dry pavement surfaces. Do not apply methacrylate paint when ambient temperature conditions are outside of the ranges recommended by the manufacturer.]

[3.4.1.3 Reflective Thermoplastic Striping Material (Solid Form)-AASHTO M 249

Place thermoplastic pavement markings upon the dry pavement. The pavement temperature must be at a minimum of 4 degrees C 40 degrees F and rising at the time of application. Apply all centerline, edge, and other longitudinal type markings with a mobile applicator. Place all special markings, stop bars, legends, and similar patterns with a hand-operated applicator.

3.4.1.3.1 Primer

****
NOTE: A primer is not required for thermoplastic striping material placed on new asphalt pavement. Specify a primer when thermoplastic is applied to existing asphalt pavements or concrete pavements. Primers are used to reduce the risk of thermoplastic striping material de-bonding form the pavement.

Use the first and second paragraphs for Air Force, Navy, and Army projects, and delete the third paragraph.
****

[After surface preparation has been completed, prime the asphalt or concrete pavement surface with spray equipment.][Allow primer materials to achieve a tack-free condition.][Allow the asphalt primer to dry to a tack-free condition.][Allow the portland cement concrete primer to dry in accordance with the thermoplastic manufacturer recommendations.][An infrared heating device may be used on the concrete primer.][Apply asphalt primer to all asphalt pavements at a wet film thickness of 0.13 mm 5 mils, plus or minus 0.03 mm 1 mil 6.5 to 9.82 square meters per liter 265 to 400 square feet per gallon.][Apply portland cement concrete primer to all concrete pavements at a wet film thickness of between 1.0 to 1.3 mm 40 to 50 mils 7.85 to 9.82 square meters per liter 320 to 400 square feet per gallon.]
[
After the primer has achieved a tack-free condition, apply the thermoplastic at temperatures no lower than 191 degrees C 375 degrees F nor higher than 218 degrees C 425 degrees F at the point of deposition.

Apply all extruded thermoplastic markings at the specified width and a thickness of not less than 3 mm 0.125 inches nor more than 5 mm 0.190 inches. Apply all sprayed thermoplastic markings at the specified width and thickness designated in the contract plans. If the plans do not specify a thickness, apply centerline markings at a wet film thickness of 2.3 mm 0.090 inches, plus or minus 0.13 mm 0.005 inches, and edgeline markings at a wet film thickness of 1.5 mm 0.060 inches, plus or minus 0.13 mm 0.005 inches.]

[
Extrude or spray thermoplastic reflectorized pavement marking compound in a molten state onto a primed pavement surface. Following a surface application of glass beads and upon cooling to normal pavement temperatures, the marking must be an adherent reflectorized strip of the specified thickness and width that is capable of resisting deformation by traffic.]

3.4.1.3.2 Reflective Media

****

NOTE: For Air Force and Army designs use the first paragraph below and delete the second paragraph. For Navy designs delete the first paragraph below and use the second paragraph.

****

[
Immediately after installation of the thermoplastic material, mechanically apply drop-on reflective glass spheres conforming to FS TT-B-1325 Type I (Gradation A) at the rate of 0.24 kg per square meter one pound per 20 square feet such that the spheres are held by and embedded in the surface of the molten material. Accomplish drop-on application of the glass spheres to ensure uniform distribution.]

[
Immediately after installation of the thermoplastic material, mechanically apply drop-on reflective glass spheres conforming to AASHTO M 247 at the rate of 0.24 kg per square meter one pound per 20 square feet such that the spheres are adhered and embedded in the surface of the molten material. Accomplish drop-on application of the glass spheres to ensure uniform distribution.]

][3.4.1.4 Epoxy Paint

****

NOTE: Epoxy pavement markings are a durable, two-component system with exceptional durability on asphalt and concrete surfaces. Epoxies have been known to provide service lives over four years on low to medium-volume highways, and epoxies often take much longer to dry than other materials. Epoxies cannot be placed over markings made from other materials. Epoxy can be applied over existing epoxy markings once, and after a second application, the old material must be removed.

Reference UFC 3-260-04, Appendix B, Best Practices Handbook, prior to selecting bead and paint types.

For Air Force and Army Projects, use either FS TT B 1325 Type I (Gradation 1) for Roadway traffic

markings. Use Type IV (Gradation B) for crosswalks or markings that require high durability because of traffic abrasion.

For Navy projects use the AASHTO M247 equivalent for glass beads.

The wet film thickness for paint and the application rate for glass beads will be variable because of pavement conditions and ambient temperature at the marking time. The wet film thickness for methacrylate paint and application rate for glass beads must be determined by test section. The minimum wet film thickness is that required to provide embedment of the glass beads at approximately 50 to 60 percent of the glass bead diameter.

****

Apply [FS TT-B-1325 [Type I (Gradation A)]] [Type IV (Gradation B)] [AASHTO M 247] glass beads that provides the minimum or exceeds the reflectivity in accordance with paragraph TEST SECTION. Apply epoxy paint only on surfaces prepared for marking application and free of moisture, dirt, debris, oils and greases, algae, mold, or mildew. Apply epoxy paint only to dry pavement surfaces. Do not apply epoxy paint when ambient temperature conditions are outside of the ranges recommended by the manufacturer. Epoxies cannot be placed over markings made from other materials. Epoxy can be applied over existing epoxy markings once, and after a second application, the old material must be removed.

][3.4.1.5 High Build Acrylic Coating (HBAC)

****

NOTE: FS TT-B-1325 Type IV beads or the equivalent AASHTO M 247 must be used with HBAC paint due to the increased wet film thickness. The expected wet film thickness required for using Type IV glass beads is 20 to 22 mils.

****

Apply [FS TT-B 1325 Type IV] [AASHTO M 247] glass beads at a wet film thickness that provides the retro-reflectivity in accordance with paragraph TEST SECTION. Apply HBAC paint only on surfaces prepared for marking application and free dirt, debris, oils and greases, algae, mold, or mildew. Apply HBAC paint only to dry pavement surfaces. Do not apply HBAC paint when ambient temperature conditions are outside of the ranges recommended by the manufacturer.

][3.4.1.6 Preformed Reflective Pavement Marking Tape

The pavement surface and ambient air temperature must be at a minimum of 15 degrees C 60 degrees F and rising. Place the preformed tape markings according to the written instructions provided by the manufacturer.]

3.4.1.7 Raised Pavement Markers

Align prefabricated markers carefully at the spacing indicated on the

drawings and permanently fix them by using epoxy adhesives. Clean all areas where markers are to be set by water blasting. Markers are not to be set until the pavement surface is dry and contaminant-free.

[3.4.1.8 Polyurea or Urethane

****
NOTE: For designs specifying the use of polyurea or urethane marking products, the respective specifications relating to applications recognized by the local or state agencies in which the project is located must be incorporated herein.
****

[_____]

]3.5 FIELD QUALITY CONTROL AND ACCEPTANCE

3.5.1 Material Inspection

The Contractor is responsible for examining all materials accepted for delivery for compliance with the certificate of compliance.

3.5.2 Sampling and Testing

****
NOTE: It is recommended that samples of all marking materials be collected directly from the application equipment before or during the calibration of the equipment. Taking samples directly from the application equipment will avoid the possibility that marking materials have been thinned or altered from the time of manufacture until the time of application.

Certifications issued by the manufacturer can be used to determine if the marking materials meet the specified criteria. And samples of the materials can be collected and stored in the environment recommended by the manufacturer. Samples can be tested if there are problems with the markings before the end of the warranty period.
****

As soon as the marking materials are available for sampling, obtain materials by random selection directly from equipment already calibrated. Four liters Four quarts of paint are to be collected; two liters two quarts for the Contractor and two liters two quarts for the Government. Samples of marking materials and samples of each reflective media are to be collected by the Contractor in the presence of the Contracting Officer. Identify samples by project name and number, manufacture date, batch number, and the square yards of markings represented by the sample.

The Government will retain samples for the warranty period under storage conditions recommended by the manufacturer. If there is an issue with a material defect during the period of the warranty the Contractor will incur the cost for an accredited independent laboratory to test the

material(s) for conformance with the certifications and the contract specifications. The Government reserves the right to test the samples for verification of materials.

3.5.3 Dimensional Tolerance

The Contractor applies layout markings. All layout markings are placed before the marking material application. The edges of a line must not vary from a straight line drawn between the beginning and end of the line more than 12 mm 1/2-inch to 45 m 50 feet. Marking dimensions and spacing must be within the tolerances provided in Table IV.

TABLE IV - Dimensional Tolerance for Marking Elements

Dimension and Spacing	Tolerance
300 mm 12 inch or less	12 mm +/- 1/2 inch
Greater than 910 mm to 1.85 m 36 inch to 6 feet	25 mm +/- 1 inch
Greater than 1.85 m to 18.3 m 6 feet to 60 feet	50 mm +/- 2 inch
Greater than 18.3 m 60 feet	76 mm +/- 3 inch

3.5.4 Coating and Reflective Media Application Reporting

3.5.4.1 Reporting Wet Film Thickness and Reflectivity

Submit documentation on the wet film thickness and reflectivity for each marking element. Provide a reading at the rate of one reading per 300 linear meters 1000 linear feet of line marking. A reading is the average of 10 measurements at random locations within the marking element area. Submit the results of the marking application wet film thickness test and Reflective Media Reflectivity Test to the Contracting Officer before proceeding with work on the project.

3.5.4.2 Wet Film Thickness

Conduct a marking application wet film thickness test. Provide a wet film thickness gauge to measure the wet film thickness using ASTM D4414 at the edge(s) and one interior location of the marking. When more than 3 in 10 consecutive measurements of wet film thickness are outside of the tolerances in Table III, remove and replace areas not meeting the wet film thickness requirement.

3.5.4.3 Reflectivity

Provide documentation that records the readings for white, yellow and red reflective markings. Conduct a Reflective Media Reflectivity Test. Measure the reflectivity using a Retro-Reflectometer using ASTM E1710. The minimum reading for white, yellow, and red markings is provided in Table V in millicandelas per square meter per lux (mcd/m2/lx) at the time of marking. When more than 3 in 10 consecutive measurements of reflectivity are outside of the minimum in Table V, remove and replace the areas not meeting the minimum reflectivity requirements.

TABLE VI - Minimum Reflectivity (millicandelas per square meter per lux)		
Bead Type	Minimum Reflectivity at Time of Marking	
Type I	White - 300	Yellow - 175
Type IV	White - 300	Yellow - 200

[Preformed Tape pavement markings will yield a minimum of 225 mcd/m2/lux on white markings at installation and a minimum of 100 mcd/m2/lux on yellow markings at installation.]

3.6 CLEANUP AND WASTE DISPOSAL

The worksite and the material staging area must be free of debris, dirt, and items that will blow away during periods of elevated wind speeds. Dispose of all materials at a site approved by the Contracting Officer. Dispose of waste from cleaning the marking equipment at a facility that is permitted to accept the material.

3.6.1 Cleanup Requirements

Provide a vacuum sweeper after each work area when markings are cured. Vacuum sweep the entire pavement surface to provide a clean pavement without fugitive glass beads and debris.

-- End of Section --