
USACE / NAVFAC / AFCEC UFGS-32 17 23.19 (November 2024)

Preparing Activity: USACE

Superseding
UFGS-32 17 23 (August 2016)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated April 2025

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11/24

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SECTION 32 17 23.19

AIRFIELD PAVEMENT MARKINGS 11/24

NOTE: This guide specification covers pavement marking requirements for airfields, heliports, and hangar floors by means of paint with spray guns and glass bead dispensers. This guide specification includes only those requirements for surface preparation. Where the removal of rubber build up and existing pavement markings is specified, use Section 32 01 11.51 RUBBER AND PAINT REMOVAL FROM AIRFIELD PAVEMENTS.

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. For bracketed items, choose applicable item(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

This guide specification includes tailoring options for AIR FORCE, NAVY, and ARMY. Selection or deselection of a tailoring option will include or exclude that option in the section. 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 \(CCR\)](#).

NOTE: Be specific in the identification of existing

materials to be removed or prepared for marking on the Contract drawings. On the Contract drawings, show location, width, paint type, and paint color to be used for new markings. Indicate whether new markings are to be reflective or non-reflective.

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

PART 1 GENERAL

1.1 UNIT PRICES

NOTE: Delete this paragraph when pavement marking is included in a lump sum project. Edit items in brackets to provide the type of pavement to be prepared and type of marking to be placed.

1.1.1 Measurement

1.1.1.1 Surface Preparation

The unit of measurement for surface preparation is the number of square ~~meters~~ ~~feet~~ for [new][existing][and existing] surface preparation completed and accepted by the Contracting Officer.

1.1.1.2 Pavement Markings

NOTE: Delete subparagraph c when the project does not include temporary pavement markings. Temporary pavement markings are used where construction or repair of pavements requires aircraft operations coincident with the work effort.

a. Reflective Pavement Markings

The unit of measurement for reflective pavement markings is the number of square ~~meters~~ ~~feet~~ completed at the application rate that provides the specified wet film thickness for markings and application rates of reflective media accepted by the Contracting Officer.

b. Non-reflective Pavement Markings

The unit of measurement for non-reflective pavement markings is the number of square ~~meters~~ ~~feet~~ completed at the same wet film thickness as that used for reflective markings accepted by the Contracting Officer.

[

c. Temporary Pavement Markings

The unit of measurement for temporary pavement markings is the number of square ~~meters~~ ~~feet~~ completed at the application rate that provides the specified wet film thickness for markings accepted by the Contracting Officer.]

1.1.2 Payment

The quantity of surface preparation, applied reflective and non-reflective markings[,][and][temporary markings] will be paid for at the measured quantity Contract unit prices. Payment constitutes full compensation for furnishing all labor, materials, tools, and equipment for preparing and marking pavements shown on the Contract drawings and as specified. Remove and replace any markings, specified to have reflective media, but are placed without it, do not meet the standard minimum retro-reflective requirements, or with other defects, at no cost to the Government. Remove and replace markings not conforming to the required physical characteristics, alignment, or location required at no cost to the Government.

1.2 REFERENCES

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.

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

ASTM INTERNATIONAL (ASTM)

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 Retroreflective Pavement Marking
Tape for Extended Service Life

ASTM E1710 (2011) Standard Test Method for
Measurement of Retroreflective Pavement

Marking Materials with CEN-Prescribed
Geometry Using a Portable
Retroreflectometer

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. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 300 (1990) Specifications for Membrane-Forming
Compounds for Curing Concrete

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

1.3 SUBMITTALS

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.

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 Surface Preparation Equipment; G, [_____]

Marking Applications Equipment List; G, [_____]

SD-03 Product Data

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

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

SD-04 Samples

Samples Of Marking Materials; G, [_____]

Samples Of Each Reflective Media; G, [_____]

SD-06 Test Reports

Marking Application Wet Film Thickness; 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 performance of the marking layout, surface preparation, and application of reflective and non-reflective markings. 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. Define the protocol for the performance of test sections for each line width, color, and paint type.
- e. 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. The information will be presented in a table format for each type of marking, width and color.
- f. Provide and discuss safety directives for vehicle operations on the airfield.
- g. Define communications procedures when operating on the airfield.

1.4.2 Personnel Qualifications for Airfield Pavement Marking

Submit documentation, within [10][_____] calendar days of project award, that describes the training and experience of each person performing work on the project.

1.4.2.1 Qualifications of Airfield Marking Personnel

NOTE: The brackets in the paragraph below requires the designer to select the years of experience required for those people operating equipment. The years of experience selected should be based upon the level of difficulty expected in performing the work.

Submit documentation of [qualifications](#) for personnel performing work on the airfield and operating mobile self-powered or drawn marking equipment, hand-operated equipment, hand application equipment and surface preparation equipment. The minimum experience is operating similar equipment in a similar environment, size and scope of work as the project. [Two][Three][Four] years of experience are required for

operators of equipment used for centerline or edge markings with a demonstrated proficiency in meeting dimensional tolerance of markings. The Contracting Officer reserves the right to require additional proof of competency or to reject proposed personnel.

1.5 DELIVERY, STORAGE AND HANDLING

NOTE: Edit the brackets below as required to represent the location of the marking materials storage location.

[Provide a conditioned storage and staging area located off the installation][A conditioned storage space 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 SPECIAL CONDITIONS

1.6.1 Environmental Requirements

1.6.1.1 Weather Limitations for Markings Application

Apply pavement markings to clean, dry surfaces 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 limits recommended by the manufacturer unless otherwise noted. Allow the pavement surfaces 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 in accordance with 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 Airfields

NOTE: Edit the brackets in the paragraph below to identify the government representatives responsible for access to and operations of vehicles on the airfield. Provide proposed runway or helipad closures if known. Edit brackets and delete Table I when closure schedules are not available.

Coordinate performance of all work in the controlled zones of the airfield with the Contracting Officer and with the [Airfield Manager][Air Traffic Control Tower]. Neither equipment nor personnel can use any portion of the airfield without permission of the [Airfield Manager][and Air Traffic Control Tower] unless the feature is closed.[The runway(s) are scheduled for closure during the times provided in Table I.]

Table 1 - Scheduled Runway(s) Closure			
Day or Date	Runway Closing Time	Runway Opening Time	Notes
[_____]	[_____]	[_____]	[_____]

1.6.2.1 Radio Communications

NOTE: Edit the brackets below to identify the entity responsible to provide radios, or other means of communication, and those responsible to provide direction to the Contractor.

No entry of equipment or personnel is allowed into controlled zones of the airfield until radio contact is established with the Air Traffic Control Tower and the Air Traffic Control Tower has granted permission.[When the Air Traffic Control Tower is closed, radio communication can be established with the Airfield Manager.] Radio contact with the [Air Traffic Control Tower][Airfield Manager] is to be maintained whenever the Contractor is on the active airfield. Notify the [Air Traffic Control Tower][Airfield Manager] when work is completed and all equipment, materials, and personnel are clear of the aircraft operating surface(s).
[The Government will provide the radio(s). The Contractor is responsible for the radio(s) and must reimburse the Government for repair or replacement of the radio(s) if lost, damaged, destroyed, or stolen.]
[Provide a minimum of three radios; one for the Air Traffic Control Tower, one for the Airfield Manager, and one for the Contractor. The radio frequency used is to be approved by the [Airfield Manager][Installation Communications Officer].]

1.6.2.2 Emergency Operations on the Airfield

Aircraft emergencies take precedence over all operations. Upon notification from the Air Traffic Control Tower of an emergency, stop all operations immediately and evacuate all personnel and equipment to an area

not utilized for aircraft traffic. The evacuation point must be at least 75 m 250 feet measured perpendicular to the near edge of any runway or taxiway or as directed by the Air Traffic Control Tower. All personnel and equipment must be clear of the work area and at a designated evacuation location within 15 minutes.

1.6.2.3 Night Operations

Provide all lighting and equipment necessary to light the work area during night operations effectively. Direct or shade lighting to prevent interference with aircraft, the Air Traffic Control Tower, and other base operations. Provide lighting and related equipment capable of being removed from the runway within 15 minutes of an emergency notification. Coordinate night work with the [Flight Operations Manager][Airfield Manager]. The Government reserves the right to accept or reject material applications during night work on the day following night activities.

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 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 uniform wet film thickness for the width of the marking.

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

2.1.1 Surface Preparation for Airfields

**NOTE: Edit the brackets in the following paragraph
to delete or incorporate provision for new concrete
pavement.**

Submit data sheets for surface preparation equipment the Contractor intends to use to prepare 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, when used, result in an existing surface that is clean and free of dirt, dust,

oil, grease, algae, mildew, mold, and loose paint. The equipment is not intended to be used to remove stable existing markings intentionally.[When preparing new portland cement concrete for marking, the equipment must be capable of removing the curing compound without damage to the concrete surface and joint seal materials.] Submit [safety data sheets for chemicals used in surface preparation](#).

2.1.1.1 Water Blasting Equipment

Use mobile water blasting equipment capable of producing a pressurized stream of water that effectively cleans existing markings and pavement surfaces without damage to stable markings, pavement, or joint seals. Provide equipment, tools, and machinery which are safe and in good working order.

2.1.2 Markings Application Equipment

Submit a [marking applications equipment list](#) appropriate for the material(s) to be used. Include 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 only apply waterborne coatings. Pneumatic systems are used to apply waterborne coatings and durable materials. Provide equipment capable of applying a marking from [100mm to 900mm 4 inches to 36 inches](#) wide in a single pass and 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 for applying water-based paint, or preformed tape, to pavement surfaces for small marking projects such as surface painted signs. Provide an applicator machine with the necessary tanks and spraying nozzles to apply paint uniformly at the 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.

2.2 AIRFIELD MATERIALS

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. Use this interactive paint system for the project. The MPI Decision Tree identifies paint systems for each interior and exterior coated surface in "Normal" or "Aggressive environmental conditions and 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 should review the Airfield Marking Handbook (Best Practices) in UFC 3-260-04, Appendix B1. The Designer is responsible for preparing drawings identifying where each marking element is located. The Designer is responsible for providing a table or notes that identify each marking element's paint type, color, and glass bead type. For non-reflective markings, mark the bead type as "NA" or not applicable. Refer to UFC 3-260-04 (2018) for more information in Paragraph 3-1.5 CONTRASTING MARKINGS to increase conspicuity; Paragraph 3-2 COLORS FOR PAVEMENT AND OBSTRUCTION MARKINGS; and Paragraph 3-3 for RETRO-REFLECTIVE PAVEMENT MARKINGS.

Waterborne paint is the most common material used on DoD and domestic airfields. Preformed Reflective Pavement Marking Tape is not permitted for application on airfield runways and helipad pavements due to FOD risk. Contact the Corps of Engineers Transportation Systems Center (TSMCX), the Air Force Civil Engineer Center (AFCEC) pavement Subject Matter Expert (SME) or Naval Facilities Engineering Command (NAVFAC) for guidance on interpreting and editing this specification section with regard to the use of preformed tape on airfield pavements other than areas specifically excluded.

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

Submit safety data sheets for each paint type[and preformed tape] as well as manufacturer data sheets for all marking materials and manufacturer data sheets for all reflective 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 Airfield Marking Colors

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

Table II - 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

NOTE: Waterborne paint can be applied to restripe over existing waterborne, solventborne, and thermoplastic paints. Do not restripe over preformed tape.

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. Not for use at the wet film thickness required for Type IV beads.

Type II - For use under adverse conditions (faster drying for high humidity environments). Not for use at the 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 surface.

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

[2.2.3 Preformed Reflective Pavement Marking Tape

NOTE: Preformed tape is not allowed for use on airfield runways and helipad pavements. It is not recommended for use on other airfield pavements unless the Designer coordinates with those entities with flying safety responsibilities. Preformed tape cannot be placed over markings made from other materials nor applied over existing preformed tape markings, and all existing markings must be removed when using preformed tape.

Delete this paragraph if preformed marking tape will not be incorporated into the project.

Provide adherent reflectorized strip preformed tape in accordance with [ASTM D4505](#) Retro-reflectivity Level II, Class 1, 2 or 3, Skid Resistance Level B.

]2.2.4 Reflective Media for Airfields

NOTE: The installation facility management group(i.e. Director of Public Works, Base Civil Engineer, etc.) determines the type of beads used on DOD airfields taking into consideration local conditions, life-cycle cost maintenance, environmental impact, operational requirements, and the safety of flight in the life cycle cost analysis of the pavement markings.

The designer should read paragraph 3.4.2 of the Airfield Marking Handbook included as Appendix B1 in UFC 3-260-4, Marking Airfields and Heliports.

In accordance with Section 2872(b) of the 2018 National Defense Authorization Act, the Secretary of the Air Force has submitted a certification to the congressional defense committees that states whenever a proposed contract for airfield pavement markings includes the use of Type I or Type III glass beads, the assessment of the life-cycle costs associated with the use of such beads appropriately considers the local site conditions, life-cycle cost maintenance, environmental impact, operational requirements, and the safety of flight. Therefore, Type I glass beads or any glass beads with a 1.6 refractive index or less may be used on the airfield provided the lifecycle costs are assessed as stated above.

When selecting reflective media using FS TT-B-1325, use the following and consider the intended use. There are four bead types. Type I and Type IV each have two gradations of beads. The Type I and Type IV beads have a low Index of Reflectivity (IOR of 1.5) because both bead types return light in a

diffused pattern. The Type I beads are the smallest diameter of the bead types.

Type I, (Gradation A), low-index recycled glass beads for drop-on applications are intended for marking highways and any airfield markings. Type I beads require the lowest wet film thickness.

In accordance with Section 2872 of the 2018 National Defense Authorization Act and the Secretary of the Air Force certification to the congressional defense committees, this type of bead can be utilized on airfield markings provided assessment of the life-cycle costs associated with the use of such beads appropriately considers the local site conditions, life-cycle cost maintenance, environmental impact, operational requirements, and the safety of flight has been performed.

Type II beads are not used.

Type III, high index virgin material glass beads for drop-on applications are used where increased reflectivity is required, such as runways and high-speed turn-off taxiways, or where life-cycle costs are less than other beads. Type III beads may be used with any of the waterborne paint. The wet film thickness of the paint will be thicker than paint used with Type I beads because of the Type III bead size.

Type IV, Gradation B, large diameter, low index recycled glass beads for drop-on applications may be used on airfields. The wet film thickness must be increased compared to using Type I or Type III beads to provide proper anchoring (between 25 and 30mils). Type IV beads are not usually used on airfields.

In accordance with Section 2872 of the 2018 National Defense Authorization Act and the Secretary of the Air Force certification to the congressional defense committees, this type of bead can be utilized on airfield markings provided assessment of the life-cycle costs associated with the use of such beads appropriately considers the local site conditions, life-cycle cost maintenance, environmental impact, operational requirements, and the safety of flight has been performed.

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

Specify AASHTO M247 reflective media for Navy projects.

Edit the following sentence to delete those bead types that will not be used for the project.

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 that promote adhesion, limit flotation, and absorb moisture to preclude bundling and dual coatings for waterborne materials.

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 width, color, wet film thickness, and measured reflectivity.

3.1.1 Surface Preparation Test Section

NOTE: Delete bracketed text 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. 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 aircraft pilots at night using diffused light. Embedment is critical. If beads are submerged (covered in paint) 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 before proceeding with work on the project.

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 dirt, dust, oil, grease, algae, mildew, mold, loose paint 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 TEMPORARY MARKINGS

NOTE: New portland cement concrete and asphalt pavements require curing prior to the application of permanent markings. For permanent markings, a new asphalt pavement surface should be at least 30 days old. Markings applied before the cure period will result in asphalt bleed-through or poor bonding. All curing materials need to be completely removed from new concrete pavement before the application of marking materials.

Temporary pavement markings are applied conforming to the phasing plan provided in the Contract drawings.

Select the first set of brackets for temporary markings that do not require reflective media. Both location and flying safety must be considered.

Select the second set of brackets for temporary markings applied in airfield locations where there is aircraft traffic subject to jet blasts, turning movements and requirements for reflective media.

Select the third set of brackets in airfield locations not subject to jet blasts, turning movements, or Foreign Object Debris (FOD) risk.

Delete the bracketed paragraphs not used.

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

[Use FS TT-P-1952 [Type I] [Type II] paint to apply temporary pavement markings. Apply paint at one-half the wet film thickness used for permanent markings. Reflective media is not used with temporary markings. Apply a coat of wax-based curing compound conforming to COE CRD-C 300 prior to paint application.]

[
Use **FS TT-P-1952** Type I waterborne paint applied at a wet film thickness of 14 to 16 mils. Apply beads at the rate of application required to provide the minimum specified reflectivity for the color being applied. Apply a coat of wax-based curing compound conforming to **COE CRD-C 300** prior to paint application.]

[
Apply Preformed Retroreflective Pavement Marking Tape conforming to the specified materials and application requirements.]

3.4.1 New Portland Cement Concrete Pavement (PCC)

Regardless of concrete age, permanent markings may be placed when the concrete passes the pre-application test (plastic wrap test), after a 24 hour period. Temporary markings are to be used for concrete pavement that fails the plastic wrap test.

3.4.2 New Hot Mix Asphalt Pavement (HMA)

Temporary markings are to be used on HMA pavement less than 30 days old.

3.5 MARKINGS APPLICATION

3.5.1 Marking Materials for Airfield Pavement

3.5.1.1 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 or Type III 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. The expected wet film thickness when using Type III glass beads is 16 to 20 mils. When using Type IV glass beads, the wet film thickness must be increased to the range of 25 to 30 mils because of the larger bead diameter.

Type I paint and Type I reflective media (subject to an economic analysis) are used on airfield pavements

such as taxiways (non-primary), aprons, holding pads, and maintenance pads. Type II paint and Type III reflective media are recommended for use on airfield runways, high-speed taxiways, and primary taxiways where flying safety is of primary concern. Type III waterborne paint must be used with Type IV reflective media. 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.

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.

Dilution or thinning of paint prior to application is not allowed.

[Provide FS TT-P-1952 waterborne 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 waterborne paint and 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 paragraphs WET FILM THICKNESS TEST SECTION and REFLECTIVE VALUE 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 III	Type IV Gradation B	Type I Gradation A	Type III	Type IV Gradation B
Type I	14-16	14-16	--	--	0.8kg/L 7 lb/gal	--	--
Type II	14-16	14-16	16-20	--	0.8kg/L 7 lb/gal	1.2 kg/L 10 lb/gal	--

Table III. Paint Wet Film Thickness and Bead Application Rate							
Type III	16-20	--	16-20	25-30	--	1.2 kg/L 10 lb/gal	1 kg/L 8 lb/gal

[3.5.1.2 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.

]3.6 FIELD QUALITY CONTROL AND ACCEPTANCE

3.6.1 Material Inspection

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

3.6.2 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. If a sample fails to meet the specification, replace the material in the area represented by the sample and retest the replacement material as specified above. The Government reserves the right to test the samples for verification of materials.

3.6.3 Dimensional Tolerance

The Contractor responsible for layout markings. All layout markings are placed before the marking material application. The edges of markings will not vary from a straight line drawn between the beginning and end of the marking by more than 12 mm 1/2 inch in 15 meters 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
910 mm 36 inches or less	12 mm +/- 1/2 inch
Greater than 910 mm to 1.85 m 36 inches to 6 feet	25 mm +/- 1 inch
Greater than 1.85 m to 18.3 m 6 feet to 60 feet	50 mm +/- 2 inches
Greater than 18.3 m 60 feet	76 mm +/- 3 inches

3.6.4 Coating and Reflective Media Application Reporting

NOTE: When remove and replace is required use the protocol and provisions of UFGS Section 32 01 11.51 RUBBER AND PAINT REMOVAL FROM AIRFIELD PAVEMENTS.

3.6.4.1 Reporting Wet Film Thickness, Glass Bead Distribution, 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. For airfield marking elements, such as runway threshold bars or numerals, provide a reading for every 50 square meters 500 square feet of marking area. 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.

3.6.4.2 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.

3.6.4.3 Reflectivity

Conduct a Reflective Media Reflectivity Test. Provide documentation that records the readings for white, yellow and red reflective markings. 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 V - Minimum Reflectivity (millicandelas per square meter per lux)			
	Minimum Reflectivity at Time of Marking by Paint Color		
Bead Type	White	Yellow	Red
Type I	300	175	35
Type III	600	350	35
Type IV	300	200	35

[

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.]

3.7 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.

3.7.1 Cleanup Requirements

Provide a vacuum sweeper at 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 --