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USACE / NAVFAC / AFCEC / NASA | UFGS-32 17 23 (August 2016)
Change 5 - 11/18

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UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2023
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SECTION 32 17 23

PAVEMENT MARKINGS
08/16, CHG 5: 11/18

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NOTE: This guide specification covers pavement marking requirements for airfields, heliports, in hangars, roads and Automotive Parking areas by means of paint, raised pavement markers (RPM), preformed tapes or plastics. If curbs, obstructions, and other appurtenant structures are included in the work area, the same general requirements apply, but hand application with spray guns and manual bead dispensers may be required. This guide specification also covers removal of existing pavement markings on roads and Automotive Parking areas. UFGS 32 01 11.51 covers removal of rubber and pavement markings on airfield pavements. Removal of raised pavement markers or reflectors is not covered in this section.

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.

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

This guide specification includes tailoring options for AIR FORCE, NASA, NAVY and ARMY. 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.
****

****
NOTE: On the project drawings, show location, width, type, and color of the paint, epoxy, thermoplastic, or preformed tape to be applied, and raised pavement markers (RPM) to be used. Indicate whether pavement marking must be reflectorized or non-reflectorized.

On the project drawings, show the pavement markings to be removed and the minimum percentage of removal required.
****

****
NOTE: Pavement markings are usually removed by hydro-blasting. Few chemical methods are effective, except those specifically formulated for some specialty paints.

For Army and Air Force, sand or shot blasting may be prohibited by higher headquarters due to the potential for residual foreign object damage (FOD) material being left behind, or due to local air pollution regulations. Show on the drawings the extent of pavement to have markings removed.
****

****
NOTE: For Air Force applications, coordinate other deviations from this guide specification with the AFIMSC prior to advertising a request for bids.
****

PART 1 GENERAL

1.1 UNIT PRICES

****
NOTE: Delete this paragraph when pavement marking is included in a lump sum project.
****

1.1.1 Measurement

1.1.1.1 Surface Preparation

The unit of measurement for surface preparation (cleaning) 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 nonreflective 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.

1.1.1.4 Removal of Pavement Markings on Roads and Automotive Parking Areas

The unit of measurement for removal of pavement markings is the number of square meters feet of pavement markings removed as specified and accepted by the Contracting Officer.

1.1.2 Payment

The quantities of surface preparation, pavement striping or markings, raised pavement markers, and removal of pavement markings determined 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

****

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 248	(1991; R 2012) Standard Specification for

	Ready-Mixed White and Yellow Traffic Paints
AASHTO M 249	(2012; R2016) Standard Specification for White and Yellow Reflective Thermoplastic Striping Material (Solid Form)

ASTM INTERNATIONAL (ASTM)

ASTM D471	(2016a) Standard Test Method for Rubber Property - Effect of Liquids
ASTM D476	(2015) Dry Pigmentary Titanium Dioxide Pigments
ASTM D522/D522M	(2017) Mandrel Bend Test of Attached Organic Coatings
ASTM D638	(2014) Standard Test Method for Tensile Properties of Plastics
ASTM D695	(2010) Standard Test Method for Compressive Properties of Rigid Plastics
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 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; E 2017) 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 D4060	(2019) Abrasion Resistance of Organic Coatings by the Taber Abraser
ASTM D4061	(2013) Standard Test Method for Retroreflectance of Horizontal Coatings
ASTM D4280	(2012) Extended Life Type, Nonplowable, Raised, Retroreflective Pavement Markers
ASTM D4383	(2012) Standard Specification for Plowable, Raised Retroreflective Pavement Markers
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 D6628	(2003; R 2015) Standard Specification for Color of Pavement Marking Materials
ASTM D7234	(2012) Standard Test Method for Pull-Off Adhesion Strength of Coatings on Concrete Using Portable Pull-Off Adhesion Testers
ASTM E1347	(2006; R 2020) Standard Test Method for Color and Color Difference Measurement by Tristimulus (Filter) Colorimetry
ASTM E1710	(2011) Standard Test Method for Measurement of Retroreflective Pavement Marking Materials with CEN-Prescribed Geometry Using a Portable Retroreflectometer
ASTM E2177	(2011) Standard Test Method for Measuring the Coefficient of Retroreflected Luminance (RL) of Pavement Markings in a Standard Condition of Wetness
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

INTERNATIONAL CONCRETE REPAIR INSTITUTE (ICRI)

ICRI 03732	(1997) Selecting and Specifying Concrete Surface Preparation for Sealers, Coatings, and Polymer Overlays

MASTER PAINTERS INSTITUTE (MPI)

MPI 32	(2012) Traffic Marking Paint, S.B.
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 AVIATION ADMINISTRATION (FAA)

FAA AC 150/5370-10	(2018; Rev H; Errata 1 2019) Standard Specifications for Construction of Airports

U.S. FEDERAL HIGHWAY ADMINISTRATION (FHWA)

MUTCD	(2009; Rev 2012) 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

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, Air Force, and NASA 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.

Choose the first bracketed item for Navy, Air Force and NASA projects, or choose the second bracketed item for Army projects.

****

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.][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-03 Product Data

Surface Preparation Equipment List; G[, [_____]]

Application Equipment List; G[, [_____]]

Exterior Surface Preparation

Safety Data Sheets; G[, [_____]]

Reflective media for airfields; G[, [_____]]

Reflective media for roads; G[, [_____]]

Waterborne Paint; G[, [_____]]

Solventborne Paint; G[, [_____]]

Thermoplastic compound; G[, [_____]]

Raised Pavement Markers Primers and Adhesives; G[, [_____]]

SD-06 Test Reports

Reflective Media for Airfields; G[, [_____]]

Reflective Media for Roads; G[, [_____]]

Waterborne Paint; G[, [_____]]

Solventborne Paint; G[, [_____]]

High Build Acrylic Coating (HBAC); G[, [_____]]

Thermoplastic Compound; G[, [_____]]

Raised Pavement Markers Primers and Adhesives; G[, [_____]]

Test Reports

SD-07 Certificates

Qualifications; G[, [_____]]

Reflective Media for Airfields

Reflective Media for Roads

Waterborne Paint

Solventborne Paint

Volatile Organic Compound, (VOC); G[, [_____]]

Thermoplastic Compound

SD-08 Manufacturer's Instructions

Waterborne Paint; G[, [_____]]

Solventborne Paint; G[, [_____]]

Thermoplastic Compound; G[, [_____]]

1.4 QUALITY ASSURANCE

1.4.1 Regulatory Requirements

Submit 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 Safety Data Sheets for each product.

1.4.2 Qualifications

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 Airfield 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 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 AND STORAGE

Deliver paint materials, thermoplastic compound materials, and reflective media in original sealed containers that plainly show the designated name, specification number, batch number, color, date of manufacture, manufacturer's directions, and name of manufacturer.

Provide storage facilities at the job site[, only in areas approved by the Contracting Officer,] for maintaining materials at temperatures recommended by the manufacturer. [Make available paint stored at the project site or segregated at the source for sampling not less than 30 days prior to date of required approval for use to allow sufficient time for testing. Notify the Contracting Officer when paint is available for sampling.]

1.6 PROJECT/SITE CONDITIONS

1.6.1 Environmental Requirements

1.6.1.1 Weather Limitations for Application

****

NOTE: If emergency marking at temperatures from minus 1 degrees C 30 degrees F to 5 degrees C 40 degrees F is required, follow the requirements of Air Force Engineering Technical Letter (ETL) 97-16 "Pavement Marking System for Low Temperature Applications."

Allowable air and pavement temperature for application varies with type of pavement marking material and manufacturer.

****

Apply pavement markings to clean, dry surfaces, and unless otherwise approved, only when the air and pavement surface temperature is at least 3 degrees C 5 degrees F above the dew point and the air and pavement temperatures are within the limits recommended by the pavement marking manufacturer. Allow pavement surfaces to dry after water has been used for cleaning or rainfall has occurred prior to striping or marking. Test the pavement surface for moisture before beginning work each day and after cleaning. Do not commence marking until the pavement is sufficiently dry and the pavement condition has been approved by the Contracting Officer. Employ the "plastic wrap method" to test the pavement for moisture as specified in paragraph TESTING FOR MOISTURE.

1.6.1.2 Weather Limitations for Removal of Pavement Markings on Roads and Automotive Parking Areas

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 or sand blasting or grinding. Cease operation during thunderstorms, or during rainfall, except for waterblasting and removal of previously applied chemicals. Cease waterblasting where surface water accumulation alters the

effectiveness of material removal.

1.6.2 Traffic Controls

****
NOTE: Guidance for traffic control procedures can be obtained from the Manual on Uniform Traffic Control Devices (MUTCD) for Streets and Highways.
****

Place warning signs conforming to MUTCD near the beginning of the worksite and well ahead of the worksite for alerting approaching traffic from both directions. Place small markers along newly painted lines or freshly placed raised markers to control traffic and prevent damage to newly painted surfaces or displacement of raised pavement markers. Mark painting equipment with large warning signs indicating slow-moving painting equipment in operation.

When traffic must be rerouted or controlled to accomplish the work, provide necessary warning signs, flag persons, and related equipment for the safe passage of vehicles.

1.6.3 Airfield Traffic Control

Coordinate performance of all work in the controlled zones of the airfield with the Contracting Officer and with the [Flight Operations Officer or Airfield Manager] [control tower]. Neither equipment nor personnel can use any portion of the airfield without permission of these officers unless the runway is closed. Runways will be closed during the following times:

Day or Date	Runway Closing Time	Runway Opening Time	Important Notes
[_____]	[_____]	[_____]	[_____]

1.6.4 Airfield Radio Communication

No personnel or equipment will be allowed in the controlled zones of the airfield until radio contact has been made with the control tower and permission is granted by the control tower. A radio for this purpose [will be provided by the Government. The Contractor is responsible for the radio and must reimburse the Government for repair or replacement of the radio if it is lost, damaged, or destroyed] [is to be provided by the Contractor as approved by the Contracting Officer]. Maintain contact with the control tower at all times during work in vicinity of the airfield. Notify the control tower when work is completed and all personnel, equipment and materials have been removed from all aircraft operating surfaces.

1.6.5 Airfield Emergency Landing and Takeoff

Emergencies take precedence over all operations. Upon notification from the control tower of an emergency landing or imminent takeoff, stop all operations immediately and evacuate all personnel and equipment to an area not utilized for aircraft traffic which is at least 75 m 250 feet measured perpendicular to and away from the near edge of the runway unless otherwise authorized by the Contracting Officer. Equipment and chemicals

or detergents as well as excess water must be able to be removed from the work area within 3 minutes.

1.6.6 Lighting

When night operations are necessary, provide all necessary lighting and equipment. [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 notification of an emergency. Night work must be coordinated with the Flight Operations Manager or Airfield Manager and approved in advance by the Contracting Officer.] The Government reserves the right to accept or reject night work on the day following night activities by the Contractor.

PART 2 PRODUCTS

2.1 EQUIPMENT

2.1.1 Surface Preparation and Paint Removal

2.1.1.1 Surface Preparation and Paint Removal Equipment for Airfield Pavements

Prepare all airfield surfaces and remove paint from airfield surfaces in accordance with UFGS 32 01 11.51 Rubber and Paint Removal From Airfield Pavements. Provide submittals in accordance with UFGS 32 01 11.51 Rubber and Paint Removal From Airfield Pavements.

2.1.1.2 Surface Preparation Equipment for Roads and Automotive Parking Areas

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.

2.1.1.2.1 Sandblasting Equipment

****
NOTE: Delete paragraph for Navy projects.
****

Use mobile sandblasting equipment capable of producing a pressurized stream of sand and air that effectively removes paint from the surface without filling voids with debris in asphalt or tar pavements or removing joint sealants in Portland cement concrete pavements. Include with the equipment and air compressor, hoses, and nozzles of adequate size and capacity for removing paint. Equip the compressor with traps and coalescing filters that maintain the compressed air free of oil and water.

2.1.1.2.2 Waterblasting Equipment

Use mobile waterblasting 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 at all times.

2.1.1.2.3 Shotblasting Equipment

****
NOTE: Delete paragraph for Air Force, Army, and Navy airfield projects.
****

Use mobile self propelled shotblasting equipment capable of producing an adjustable depth of paint removal and of 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.

2.1.1.2.4 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 hydro blast to remove surface contaminates and ash after a weed torch is used to remove paint.

2.1.1.2.5 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 Application Equipment

Submit application equipment list appropriate for the material(s) to be used. Include manufacturer's descriptive data and certification for the planned use that indicates 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 them 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 Paint Application Equipment

2.1.2.1.1 Hand-Operated, Push-Type Machines

****
NOTE: Where pavement marking is limited to small street legends and/or Automotive Parking areas, use the paragraph entitled "Hand-Operated, Push-Type Machines."
****

Provide hand-operated push-type applicator machine of a type commonly used for 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, automotive parking areas, or surface painted signs. Provide applicator machine equipped with the necessary tanks and spraying nozzles capable of applying paint

uniformly at coverage specified. Hand operated spray guns may be used in areas where push-type machines cannot be used.

2.1.2.1.2 Self-Propelled or Mobile-Drawn Spraying Machines

Provide self-propelled or mobile-drawn spraying machine with suitable arrangements of atomizing nozzles and controls to obtain the specified results. Provide machine having a speed during application capable of applying the stripe widths indicated at the paint coverage rate specified herein and of even uniform thickness with clear-cut edges.

2.1.2.1.2.1 Road Marking

Provide equipment used for marking roads capable of placing the prescribed number of lines at a single pass as solid lines, intermittent lines, or a combination of solid and intermittent lines using a maximum of three different colors of paint as specified.

2.1.2.1.2.2 Airfield Marking

Provide self-propelled or mobile-drawn spraying machine for applying the paint for airfield pavements with an arrangement of atomizing nozzles capable of applying the specified line width in a single pass. Provide paint applicator with paint reservoirs or tanks of sufficient capacity and suitable gages to apply paint in accordance with requirements specified. Equip tanks with suitable mechanical agitators. Equip spray mechanism with quick-action valves conveniently located, and include necessary pressure regulators and gages in full view and reach of the operator. Install paint strainers in paint supply lines to ensure freedom from residue and foreign matter that may cause malfunction of the spray guns. The paint applicator must be readily adaptable for attachment of a dispenser for the reflective media approved for use.

2.1.2.1.2.3 Hand Application

Provide spray guns for hand application of paint in areas where the mobile paint applicator cannot be used.

2.1.2.2 Thermoplastic Application Equipment

2.1.2.2.1 Thermoplastic Material

Apply thermoplastic material with equipment that is capable of providing continuous uniformity in the dimensions and reflectorization of the marking.

2.1.2.2.2 Application Equipment

a. Provide application equipment capable of continuous mixing and agitation of the material, with conveying parts which prevent accumulation and clogging between the main material reservoir and the extrusion shoe or spray gun. All parts of the equipment which come into contact with the material must be easily accessible and exposed for cleaning and maintenance. All mixing and conveying parts up to and including the extrusion shoes and spray guns must 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 dimensions of the stripe. Provide an applicator with a means for cleanly cutting off stripe ends squarely and providing a method of applying "skiplines." Provide equipment capable of applying varying widths of traffic markings.

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

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

2.1.2.2.3 Mobile Application Equipment

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

a. Equip the unit to apply the thermoplastic marking material at temperatures according to the manufacturer's instructions, at widths varying from 75 to 300 mm 3 to 12 inches, with an automatic pressurized or drop-on bead dispensing system, capable of operating continuously, and of installing a minimum of 6 lineal km 20,000 lineal feet of longitudinal markings in an 8-hour day.

b. Equip the mobile unit with a melting kettle which 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 of the composition by direct flame is not allowed. Oil and material temperature gauges must be visible at both ends of the kettle.

c. 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; holding the molten thermoplastic at a temperature as recommended by the manufacturer; and capable of extruding a line of 75 to 200 mm 3 to 8 inches in width; and at a thickness of not less than 3 mm 0.120 inch nor more than 5.0 mm 0.190 inch, of generally uniform cross section.

d. Equip mobile units for application of spray markings with a spray gun system capable of marking simultaneous edgeline and centerline stripes. Surround (jacket) the spray system with heating oil to maintain the molten thermoplastic at a temperature of 191 to 218 degrees C 375 to 425 degrees F, capable of spraying a stripe of 75 to 305 mm 3 to 12 inches in width, and in thicknesses varying from 1.52 mm 0.060 inch to 2.49 mm 0.098 inch, of generally uniform cross section.

e. 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 of the extrusion shoes, or the 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.

2.1.2.2.4 Portable Application Equipment

Provide portable hand-operated equipment, specifically designed for placing special markings such as crosswalks, stop bars, legends, arrows, and short lengths of lane, edge and centerlines; and capable of applying thermoplastic pavement markings by the extrusion method. Equip the portable applicator with all the necessary components, including a materials storage reservoir, bead dispenser, extrusion shoe, and heating accessories, capable of holding the molten thermoplastic at the temperature recommended by the manufacturer, and of extruding a line of 75 to 305 mm 3 to 12 inches in width, and in thickness of not less than 3 mm nor more than 5 mm 0.120 inch nor more than 0.190 inch and of generally uniform cross section.

2.1.2.3 Reflective Media Dispenser

Attach the dispenser for applying the reflective media to the [paint] [thermoplastic] dispenser and designed to operate automatically and simultaneously with the applicator through the same control mechanism. The bead applicator must be capable of adjustment and designed to provide uniform flow of reflective media over the full length and width of the stripe at the rate of coverage specified in paragraph APPLICATION.

2.1.2.4 Preformed Tape Application Equipment

Provide and use mechanical application equipment for the placement of preformed marking tape which is a mobile pavement marking machine specifically designed for use in applying pressure-sensitive pavement marking tape of varying widths. Equip the applicator with rollers, or other suitable compaction device to provide initial adhesion of the material with the pavement surface. Use additional tools and devices as needed to properly seat the applied material as recommended by the manufacturer.

2.2 MATERIALS

****

NOTE: For Navy and NASA 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: Volatile Organic Content (VOC) of pavement markings used must conform to state and local regulations. The EPA's national volatile organic

compound emission standards defines pavement markings as either "Traffic Marking Coating" or "Zone Marking Coating". VOC content of traffic marking coatings may not exceed 150 grams per liter. VOC content of zone marking coatings many not exceed 450 grams per liter. Zone marking coatings can only be sold in containers with a volume of five gallons or less. Most states follow the EPA requirements. Some states and localities have more stringent requirements.

****

[Use waterborne or methacrylate paint for airfield markings.] [Use [waterborne paint] [epoxy paint] [thermoplastic] [high build acrylic] [raised pavement markers] [preformed tape] for roads.] [Use non-reflectorized waterborne [or solventborne] paint for automotive parking areas.] The maximum allowable VOC content of pavement markings is [150] [____] grams per liter. Color of markings are indicated on the drawings and must conform to ASTM D6628 for roads and automotive parking areas and SAE AMS-STD-595A for airfields. Provide materials conforming to the requirements specified herein.

****

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

When applied to pavements with high daily vehicular traffic, High Build Acrylic Coating (HBAC) performs similar to epoxy, thermoplastic, and preformed.

****

2.2.1 Waterborne Paint

****

NOTE: Airfields, roads, and Automotive Parking areas should typically be marked using waterborne paint. On low volume roads, waterborne paints have been known to provide service lives of up to 2 years. 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, solventborne, methacrylate, epoxy paints, thermoplastic compounds, and high-build acrylic.

Specify TT-P-1952 for Air Force and Army projects. Specify MPI 97 for Navy and NASA projects.

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

Type I - For normal weather conditions

Type II - For use under adverse conditions (faster drying for high humidity environments). Not for use at the greater 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. Applied at a thicker wet film thickness than Type I or II.

A list of approved products conforming to MPI 97 is located on the Master Painters Institute website.

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

****

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

2.2.2 Solventborne Paint

****

NOTE: The use of solventborne paint may be warranted in cool, humid environments, because in such environments, application restrictions are not as critical as with waterborne paints. Solventborne paint is sold in small containers and should only be used for marking areas where hand-operated, push-type application equipment is used, such as Automotive Parking lots. Solventborne paint cannot be used to restripe over existing waterborne paint. Solventborne paint can be used to restripe over existing solventborne, methacrylate, epoxy paints, thermoplastic compounds, and high-build acrylic. Do not specify solventborne paint for Air Force projects.

This paint typically contains VOCs exceeding 150 grams/liter. However, low VOC solventborne paints are also available.

Solventborne paints can be applied at temperatures down to 3 degrees C 35 degrees F, but the solvents they contain will cause asphaltic pavements to bleed through the paint, especially in cases where the asphalt is less than 30 days old, or is otherwise not completely cured.

Specify AASHTO M 248 for Air Force and Army projects. Specify MPI 32 for Navy and NASA projects.

AASHTO M 248 covers three types of solventborne (alkyd resin) type traffic marking paint.

Type S - Slow drying paint (1 hr or more)

Type N - Intermediate drying paint (15 to 30 min)

Type F - Fast drying paint (3 to 6 min)

****

[AASHTO M 248][MPI 32].

2.2.3 Methacrylate Paint

****

NOTE: Methacrylate paint may potentially be used to mark airfields where cold weather may not allow the use of waterborne paint. Methacrylate paint cannot be placed over markings made from other materials.

FAA AC 150-5370-10, Item P-620.2, Methacrylate marking paint is a two-component, low volatile organic compound (VOC) airfield and roadway marking paint suitable for use on Portland Cement concrete, bituminous pavements, and plain or vitrified brick traffic-bearing surfaces at temperatures down to -1 degrees C 30 degrees F.

****

Formulate methacrylate paint to meet the requirements of FAA AC 150/5370-10, Item P-620.2, Methacrylate.

2.2.4 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.

****

2.2.4.1 Formulation

Epoxy pavement marking material will be a two component, 100 percent solids, material formulated to provide simple volumetric mixing ratio of two volumes of component A and one volume of component B unless otherwise recommended by the manufacturer.

2.2.4.2 Composition

The component A of both white and yellow must be within the following limits:

TABLE I		
	White	Yellow
Pigments	Minimum 18 percent by weight Titanium Dioxide (ASTM D476, Type II)	21-27 percent by weight
Epoxy Resin	75-82 percent	73-79 percent

The epoxy resin must be free of lead, cadmium, mercury, hexavalent chromium and other toxic heavy metals as defined by the Environmental Protection Agency. Submit a manufacturer's certification of compliance with this requirement.

2.2.4.3 Epoxide Value

Determine epoxide epoxy number of the epoxy resin in accordance with ASTM D1652 for white and yellow component A on pigment free basis. The epoxide number must be within plus or minus 50 of the published manufacturer's standard.

2.2.4.4 Total Amine Value

Determine the amine number on the curing agent (component B) in accordance with ASTM D2074. The amine number must be within plus or minus 50 of the published manufacturer's standard.

2.2.4.5 Toxicity

Upon heating to application temperature, the material must not produce fumes which are toxic or injurious to persons or property.

2.2.4.6 Daylight Directional Reflectance

Directional reflectance of white and yellow paint (without glass beads) in accordance with ASTM E1347: White 84 percent Yellow 55 percent.

2.2.4.7 Laboratory Drying Time

The epoxy pavement marking material must have a maximum no-pick-up time of 30 minutes when tested in accordance with ASTM D711.

2.2.4.8 Curing

The epoxy material must be capable of fully curing under a constant surface temperature of 7 Degrees C 45 Degrees F or above.

2.2.4.9 Adhesion to Concrete

The catalyzed epoxy pavement marking material must have a high degree of adhesion to the specified concrete surface (100 percent concrete failure) when tested according to ASTM D7234. The concrete substrate must have a minimum compressive strength of 27.5 MPa 4,000 psi. Condition prepared specimens at a temperature of 23.9 plus or minus 1.1 Degrees C 75 plus or minus 2 Degrees F for a minimum of 24 hours and a maximum of 72 hours prior to performance of the test.

2.2.4.10 Hardness

Epoxy pavement marking materials must have a Shore D Hardness between 75 and 100 when tested in accordance with ASTM D2240. Cure the samples at 23.9 plus or minus 1.1 Degrees C 75 plus or minus 2 Degrees F for a minimum of 72 hours and a maximum of 96 hours prior to performing the tests.

2.2.4.11 Abrasion Resistance

The wear index for a catalyzed sample must not exceed 82 when tested in accordance with ASTM D4060 using a 1000 gram load, CS-17 wheels and a test duration of 1000 cycles. Run the test on cured samples of material which have been applied at a film thickness of 15 plus or minus 0.5 mils to code S-16 stainless steel plates. Cure the samples at 23.9 plus or minus 1.1 Degrees C 75 plus or minus 2 Degrees F for a minimum of 48 hours prior to performing the tests.

2.2.4.12 Tensile Strength

Epoxy pavement marking materials must have a tensile strength of at least 41,370 kPA 6,000 psi when tested in accordance with ASTM D638. Cast the Type IV specimens in a suitable mold and pull at the rate of 6 mm 1/4 inch per minute using a suitable dynamic testing machine. Cure the samples at 23.9 plus or minus 1.1 Degrees C 75 plus or minus 2 Degrees F for a minimum of 12 hours and a maximum of 48 hours prior to performing the tests.

2.2.4.13 Compressive Strength

Catalyzed epoxy pavement marking materials must have a compressive strength of at least 82,700 kPA 12,000 psi when tested in accordance with ASTM D695. Condition the cast sample at 23.9 plus or minus 1.1 Degrees C 75 plus or minus 2 Degrees F for a minimum of 12 hours and a maximum of 48 hours prior to performing the tests. The rate of compression of these samples must not exceed 6 mm 1/4 inch per minute.

2.2.5 Thermoplastic Compound

****

NOTE: Thermoplastic pavement markings are durable markings used for marking roadways. Thermoplastic pavement markings should not be used on airfield runways. Thermoplastic markings have intermixed beads in the material and a top dressing of beads is applied during placement.

****

2.2.5.1 Composition Requirements

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

2.2.5.2 Primer

****

NOTE: A primer is not required for thermoplastic placed on new asphalt pavement. A primer should be

specified when thermoplastic will be applied to existing asphalt pavements or concrete pavements.
****

a. Asphalt concrete 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.

b. 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.

2.2.6 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, thermoplastic, and preformed materials.

HBAC is suitable for reflective and nonreflective use and can be 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 that of 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 markings 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

TABLE II - REQUIREMENTS FOR HIGH BUILD ACRYLIC COATINGS (HBAC)	
TEST	MINIMUM REQUIREMENT (AND MAXIMUM WHERE INDICATED)
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)
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:	

TABLE II - REQUIREMENTS FOR HIGH BUILD ACRYLIC COATINGS (HBAC)	
TEST	MINIMUM REQUIREMENT (AND MAXIMUM WHERE INDICATED)
(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 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 Primers and Adhesives

****

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

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For Airfields Only: 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 and 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 life cycle costs are assessed as stated above.

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

TT-B-1325, Beads (Glass Spheres) Retroreflective:

Type I, Gradation A, coarse - low-index recycled glass beads for drop-on applications are intended for marking highways and any airfield markings. 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 I, Gradation B, fine - low-index glass beads for premixed paint are intended for marking highways, or for use in applying temporary airport

of airfield markings. 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 - NOT USED.

Type III - High index glass beads for drop-on applications are intended for applications where increased retroreflectivity is needed or where life-cycle costs are less than other bead types.

Type IV Gradation A - Large coarse, direct-melt, low-index glass beads for drop-on applications are intended for highways and all airfield markings (the wet film thickness of paint must be increased to properly bind these beads to the pavement). 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 IV Gradation B - Medium coarse, direct-melt, low index glass beads for drop-on applications are intended for highways and all airfield markings (the wet film thickness of paint must be increased to properly bind these beads to the pavement). 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.

NOTE: Type I or III glass beads can be used with Type I, Type II, or Type III paint. Type IV glass beads can only be used with Type III paint.

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2.2.9.1 Reflective Media for Airfields

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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.
****

FS TT-B-1325, [Type I, [Gradation A,] Type III,] [or] [Type IV, Gradation A or B].

2.2.9.2 Reflective Media for Roads

****
NOTE: Reflective media for Air Force and Army projects must conform to TT-B-1325. Reflective media for Navy and NASA projects must conform to AASHTO M 247.

Coordinate type of beads with pavement markings being used.

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

[FS TT-B-1325, [Type I, Gradation A] [or] [Type IV, Gradation A or B]] [AASHTO M 247, Type 1].

PART 3 EXECUTION

3.1 EXAMINATION

3.1.1 Testing for Moisture

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 pavement condition has been approved by the Contracting Officer or authorized representative.

Employ the "plastic wrap method" to test the pavement for moisture as follows: 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. After 15 minutes, examine the plastic wrap for any visible moisture accumulation inside the plastic. Do not begin marking operations until the test can be performed with no visible moisture accumulation inside the plastic wrap. Re-test surfaces when work has been stopped due to rain.

3.1.2 Surface Preparation Demonstration

Prior to surface preparation, demonstrate the proposed procedures and equipment. Prepare areas large enough to determine [cleanliness][, adhesion of remaining coating] and rate of cleaning. [Perform a demonstration removal of pavement marking in an area designated by the Contracting Officer.] [Approved demonstration area establishes the standard for the remainder of the work.]

3.1.3 Test Stripe Demonstration

Prior to paint application, demonstrate test stripe application within the work area using the proposed materials and equipment. Apply separate test stripes in each of the line widths and configurations required herein using the proposed equipment. Make the test stripes long enough to determine the proper speed and operating pressures for the vehicle(s) and machinery, but not less than 15 m 50 feet long.

3.1.4 Application Rate Demonstration

During the Test Stripe Demonstration, demonstrate compliance with the application rates specified herein. Document the equipment speed and operating pressures required to meet the specified rates in each configuration of the equipment and provide a copy of the documentation to the Contracting Officer prior to proceeding with the work.

3.1.5 Retroreflective Value Demonstration

****

NOTE: Delete paragraph if reflective markings are not specified.

****

After the test stripes have cured to a "no-track" condition, demonstrate compliance with the average retroreflective values specified herein. Take a minimum of ten readings on each test stripe with a Retroreflectometer with a direct readout in millicandelas per square meter per lux (mcd/m2/lx). Perform testing in accordance with ASTM D4061, ASTM E1710, ASTM E2177, and ASTM E2302.

3.1.6 Level of Performance Demonstration

The Contracting Officer will be present at the application demonstrations to observe the results obtained and to validate the operating parameters of the vehicle(s) and equipment. If accepted by the Contracting Officer, the test stripe is the measure of performance required for this project. Do not proceed with the work until the demonstration results are satisfactory to the Contracting Officer.

3.2 EXTERIOR SURFACE PREPARATION

****

NOTE: Newly placed flexible and rigid pavements require aging prior to painting in order to obtain satisfactory paint performance. If practicable, all new pavement surfaces should be at least 30 days old. All curing materials should be completely removed before application of marking materials. When earlier application of paint is necessary because of operations requirements, the maximum period practicable should be specified, and the initial application should be applied at half the normal rate, with a follow-up application after the pavements has completed curing.

Rubber and paint removal from airfield pavements should be specified in Section 32 01 11.51 RUBBER

AND PAINT REMOVAL FROM AIRFIELD PAVEMENTS.

When tested for adhesion (ASTM D4541), a sound marking paint must exhibit greater than 0.97 MPa 140 psi adhesion and/or produce 100 percent cohesive failures within the pavement.

****

Allow new pavement surfaces to cure for a period of not less than [30] [_____] days before application of marking materials. Thoroughly clean surfaces to be marked before application of the paint. Remove dust, dirt, and other granular surface deposits by sweeping, blowing with compressed air, rinsing with water, or a combination of these methods as required. Remove [rubber deposits,] [existing paint markings,] [residual curing compounds,] and other coatings adhering to the pavement by [water blasting][approved chemical removal method][according to the removal requirements and procedures outlined in Section 32 01 11.51].

a. For Portland Cement Concrete pavement, grinding, light shot blasting, or light scarification, to a resulting profile equal to ICRI 03732 CSP 2, CSP 3, and CSP 4, respectively, can be used in addition to water blasting on most pavements, to either remove existing coatings, or for surface preparation.

b. Do not use shot blasting on airfield pavements due to the potential of Foreign Object Damage (FOD) to aircraft. Scrub affected areas, where oil or grease is present on old pavements to be marked, with several applications of trisodium phosphate solution or other approved detergent or degreaser and rinse thoroughly after each application. After cleaning oil-soaked areas, seal with shellac or primer recommended by the manufacturer to prevent bleeding through the new paint. Do not commence painting in any area until pavement surfaces are dry and clean.

3.2.1 Early Painting of Rigid Pavements

Pretreat rigid pavements that require early painting with an aqueous solution containing 3 percent phosphoric acid and 2 percent zinc chloride. Apply the solution to the areas to be marked.

3.2.2 Early Painting of Asphalt Pavements

For asphalt pavement systems requiring painting application at less than 30 days, apply the paint and beads at half the normal application rate, followed by a second application at the normal rate after 30 days.

3.3 APPLICATION

Apply pavement markings to dry pavements only.

3.3.1 Paint

Apply paint with approved equipment at rate of coverage specified herein. Provide guidelines and templates as necessary to control paint application. Take special precautions in marking numbers, letters, and symbols. Manually paint numbers, letters, and symbols. Sharply outline all edges of markings. The maximum drying time requirements of the paint specifications will be strictly enforced, to prevent undue softening of bitumen, and pickup, displacement, or discoloration by tires of traffic.

If there is a deficiency in drying of the markings, painting operations must cease until the cause of the slow drying is determined and corrected.

3.3.1.1 Waterborne Paint

3.3.1.1.1 Airfields

****

NOTE: For Army and Air Force projects, specify paint conforming to TT-P-1952 and glass beads conforming to TT-B-1325. Edit and retain Table IV for reflectorized markings. Delete reference to MPI 97.

TT-P-1952 Type I or II paint should be applied at a rate of 3.0 plus or minus 0.15 square meter per liter 121 plus or minus 6 square feet per gallon for reflectorized and non-reflectorized markings. For reflectorized markings, the application rate for Type I (Gradation A) beads should be 960 plus or minus 120 grams of glass spheres per liter 8 plus or minus 1 pounds of glass spheres per gallon. 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, Type I beads 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. The application rate for Type III beads should be 1,200 plus or minus 120 grams of glass spheres per liter 10 plus or minus 1 pounds of glass spheres per gallon.

TT-P-1952 Type III paint should be applied at a rate of 2.7 plus or minus 0.20 square meter per liter 108 plus or minus 8 square feet per gallon for non-reflectorized markings. For reflectorized markings, Type III paint should be applied at a rate of 3 plus or minus 0.15 square meter per liter 121 plus or minus 6 square feet per gallon for Type I (Gradation A) or Type III beads, 1.9 plus or minus 0.30 square meter per liter 76 plus or minus 12 square feet per gallon for Type IV (Gradation A) beads and 2.4 plus or minus 0.23 square meter per liter 98 plus or minus 9 square feet per gallon for Type IV (Gradation B) beads. 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, Type I or IV beads 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 I or III glass beads can be used with Type I, Type II, or Type III paint. Type IV glass beads can only be used with Type III paint.
****

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NOTE: For Navy and NASA projects, specify paint conforming to MPI 97 and glass beads conforming to TT-B-1325 and delete Table III.

MPI 97 paint should be applied at a rate of 2.5 plus or minus 0.10 square meter per liter 105 plus or minus 5 square feet per gallon for reflectorized and non-reflectorized markings.
****

For non-reflectorized [and reflectorized] markings, apply paint conforming to [FS TT-P-1952 [Type I or II at a rate of 3.0 plus or minus 0.15 square meter per liter 121 plus or minus 6 square feet per gallon] [Type III at a rate of 2.7 plus or minus 0.20 square meter per liter 108 plus or minus 8 square feet per gallon]] [MPI 97 at a rate of 2.5 plus or minus 0.10 square meter per liter 105 plus or minus 5 square feet per gallon].

****
NOTE: Delete first sentence in brackets for Air Force and Army projects. Delete second sentence in brackets and Table III for Navy and NASA projects.
****

[For reflectorized markings, apply FS TT-B-1325 beads at a rate of 834 plus or minus 60 grams of glass spheres per liter 7 plus or minus 0.5 pounds of glass spheres per gallon.] [For reflectorized markings, apply paint and glass spheres at the following rates:]

TABLE III

Bead Type	Paint Type	Paint Application Rate	Bead Application Rate
Type I (Gradation A)	Type I, II, III	3 plus or minus 0.15 Sq M/Liter	960 plus or minus 120 g/Liter
Type III	Type I, II, III	3 plus or minus 0.15 Sq M/Liter	1,200 plus or minus 120 g/Liter
Type IV (Gradation A)	Type III	1.9 plus or minus 0.30 Sq M/Liter	960 plus or minus 120 g/Liter
Type IV (Gradation B)	Type III	2.4 plus or minus 0.23 Sq M/Liter	960 plus or minus 120 g/Liter

Bead Type	Paint Type	Paint Application Rate	Bead Application Rate
Type I (Gradation A)	Type I, II, III	121 plus or minus 6 Sq Ft/Gallon	8 plus or minus 1 lb/gallon
Type III	Type I, II, III	121 plus or minus 6 Sq Ft/Gallon	10 plus or minus 1 lb/gallon
Type IV (Gradation A)	Type III	76 plus or minus 12 Sq Ft/Gallon	8 plus or minus 1 lb/gallon
Type IV (Gradation B)	Type III	98 plus or minus 9 Sq Ft/Gallon	8 plus or minus 1 lb/gallon

3.3.1.1.2 Roads

****

NOTE: Use TT-B-1325 Type I (Gradation A) beads for Air Force and Army projects. Use AASHTO M 247 Type 1 beads for Navy and NASA projects.

****

Apply paint at a rate of 2.6 plus or minus 0.1 square meter per liter 105 plus or minus 5 square feet per gallon. Apply [FS TT-B-1325 Type I (Gradation A)] [AASHTO M 247 Type 1] beads at a rate of 834 plus or minus 60 grams of glass spheres per liter 7 plus or minus 0.5 pounds of glass spheres per gallon.

3.3.1.2 Solventborne Paint

****

NOTE: Use TT-B-1325 Type I (Gradation A) beads for Air Force and Army projects road or automotive parking areas. Use AASHTO M 247 Type 1 beads for Navy and NASA projects on road or automotive parking areas. 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, Type I beads 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.

****

Apply paint at a minimum wet film thickness of 0.381 mm 15 mils. Apply [FS TT-B-1325 Type I (Gradation A)] [AASHTO M 247 Type 1] beads at a minimum rate of 715 grams of glass spheres per liter 6 pounds of glass spheres per gallon.

3.3.1.3 Methacrylate Paint

****

NOTE: 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, Type I or Type IV beads 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.

****

Apply paint evenly to the pavement surface at a maximum rate of 1.1 square meters per liter 45 square feet per gallon. Apply glass spheres conforming to FS TT-B-1325 uniformly to the wet paint on airfield pavement. Use either Type I (Gradation A), Type III, or Type IV (Gradation A or B) beads. Apply Type I (Gradation A) beads at a minimum rate of 1.8 kilograms of glass spheres per liter 15 pounds of glass spheres per gallon. Apply Type III beads at a minimum rate of 2.4 kilograms of glass spheres per liter 20 pounds of glass spheres per gallon. Apply Type IV (Gradation A or B) beads at a minimum rate of 1.8 kilograms of glass spheres per liter 16 pounds of glass spheres per gallon.

3.3.1.4 Epoxy Paint

****

NOTE: 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, Type I or Type IV beads 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.

****

Apply paint evenly to the pavement surface at a wet film thickness of 0.508 mm plus or minus 0.025 mm 20 mils plus or minus 1 mil to cover 2.0 plus or minus 0.1 square meters per liter 80 plus or minus 4 square feet per gallon. Apply glass spheres uniformly to the wet paint on road and street pavement at a rate of 834 plus or minus 60 grams of glass spheres per liter 7 plus or minus 0.5 pounds of glass spheres per gallon.

3.3.1.5 High Build Acrylic Coating

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NOTE: TT-B-1325 Type IV beads must be used with HBAC paint due to the increased thickness to provide initial retroreflectivity.

NOTE: The High Build Acrylic Coating (HBAC) can require two or more consecutive coats to meet the specified rate of application when using an airless spray gun. 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, Type I or Type IV beads 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.
****

Apply High Build Acrylic Coating (HBAC) at a rate of 1.3 square meters per liter 50 square feet per gallon. Apply Type IV (Gradation A) beads at a minimum rate of 1.8 kilograms of glass spheres per liter 16 pounds of glass spheres per gallon.

3.3.2 Thermoplastic Compound

Place thermoplastic pavement markings, free from dirt or tint, upon dry pavement. The temperature must be a minimum of 4.4 degrees C 40 degrees F and rising at the time of installation. Apply all centerline, skipline, edgeline, and other longitudinal type markings with a mobile applicator. Place all special markings, crosswalks, stop bars, legends, arrows, and similar patterns with a portable applicator, using the extrusion method.

3.3.2.1 Primer

****
NOTE: Use the first two paragraphs (tailored Air Force, Navy, Army) for Air Force, Navy, and Army projects, and delete (deselect tailoring for NASA)the third paragraph. Use the third paragraph for NASA projects.

A primer is not required for thermoplastic placed on new asphalt pavement. A primer should be specified when thermoplastic will be applied to existing asphalt pavements or concrete pavements.
****

After surface preparation has been completed, prime the asphalt or concrete pavement surface with spray equipment. Allow primer materials to "set-up" prior to applying the thermoplastic composition. [Allow the asphalt concrete primer to dry to a tack-free condition, usually occurring in less than 10 minutes.] [Allow the Portland cement concrete primer to dry in accordance with the thermoplastic manufacturer recommendations. To shorten the curing time of the epoxy resins, an infrared heating device may be used on the concrete primer.] [Apply asphalt concrete primer to all asphalt concrete pavements at a wet film thickness of 0.13 mm 0.005 inch, plus or minus 0.03 mm 0.001 inch (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 (including concrete bridge decks) at a wet film thickness of between 1.0 to 1.3 mm 0.04 to 0.05 inch 7.85 to 9.82 square meters per liter 320 to 400 square feet per gallon.]

After the primer has "set-up", 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 at a thickness of not less than 3 mm 0.125 inch nor more than 5 mm 0.190 inch. Apply all sprayed thermoplastic markings at the specified width and the thickness designated in the

contract plans. If the plans do not specify a thickness, apply centerline markings at a wet thickness of 2.3 mm 0.090 inch, plus or minus 0.13 mm 0.005 inch, and edgeline markings at a wet thickness of 1.5 mm 0.060 inch, plus or minus 0.13 mm 0.005 inch.

[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.]

3.3.2.2 Reflective Media

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NOTE: 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, Type I or Type IV beads 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.

****

Immediately after installation of the thermoplastic material, mechanically apply drop-on reflective glass spheres conforming to [FS TT-B-1325 Type I (Gradation A)] [AASHTO M 247 Type 1] at the rate of 0.24 kg per square meter one pound per 20 square feet such that the spheres are held by and imbedded in the surface of the molten material. Accomplish drop-on application of the glass spheres to ensure even distribution at the specified rate of coverage. If there is a malfunction of either thermoplastic applicator or reflective media dispenser, discontinue operations until deficiency is corrected.

3.3.3 Raised Pavement Markers

Align prefabricated markers carefully at the spacing indicated on the drawings and permanently fix in place by means of epoxy adhesives. To ensure good bond prior to applying adhesive, thoroughly clean all areas where markers are to be set by water blasting and use of compressed air.

3.3.4 Preformed Tape

The pavement surface and ambient air temperature must be a minimum of 15 degrees C 60 degrees F and rising. Place the preformed markings in accordance with the manufacturer's written instructions.

3.3.5 Cleanup and Waste Disposal

Keep the worksite clean and free of debris and waste from the removal and application operations.[Immediately cleanup following removal operations in areas subject to aircraft traffic.] Dispose of debris at approved sites.

3.4 FIELD QUALITY CONTROL

3.4.1 Sampling and Testing

****

NOTE: The material specifications do not provide for obtaining certified production data, and the importance of verification testing for each batch where appreciable quantities are involved is emphasized. Only when the factors of time, value of material, and its application versus cost of testing and end use of the material justify a waiver of testing will certification be acceptable.

For projects more than 3345 square meters 4,000 square yards in painted surface area, use the requirements for Contractor's testing as stated in the next to last bracketed sentence. Four quart samples will be taken. For projects less than 3345 square meters 4,000 square yards, delete the next to last sentence and include the last bracketed sentence. Two quart samples will be taken.

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As soon as the paint [and thermoplastic] materials [and reflective media] are available for sampling, obtain by random selection from the sealed containers, [two] [four] quart samples of each batch in the presence of the Contracting Officer. [Two quarts will be for sampling and testing by the Contractor and two quarts will be for retention by the Government.] Accomplish adequate mixing prior to sampling to ensure a uniform, representative sample. A batch is defined as that quantity of material processed by the manufacturer at one time and identified by number on the label. Clearly identify samples by designated name, specification number, batch number, project contract number, intended use, and quantity involved.

[Test samples by an approved laboratory. If a sample fails to meet specification, replace the material in the area represented by the samples and retest the replacement material as specified above. Submit certified copies of the test reports, prior to the use of the materials at the jobsite. Include in the report of test results a listing of any specification requirements not verified by the test laboratory.] [At the discretion of the Contracting Officer, samples provided may be tested by the Government for verification.]

3.4.2 Material Inspection

Examine material at the job site to determine that it is the material referenced in the report of test results or certificate of compliance. Provide test results substantiating conformance to the specified requirements with each certificate of compliance.

3.4.3 Dimensional Tolerances

Apply all markings in the standard dimensions provide in the drawings. New markings may deviate a maximum of 10 percent larger than the standard dimension. The maximum deviation allowed when painting over an old marking is up to 20 percent larger than the standard dimensions.

3.4.4 Bond Failure Verification

Inspect newly applied markings for signs of bond failure based on visual inspection and comparison to results from Test Stripe Demonstration paragraph.

3.4.5 Reflective Media and Coating Application Verification

Use a wet film thickness gauge to measure the application of wet paint. Use a microscope or magnifying glass to evaluate the embedment of glass beads in the paint. Verify the glass bead embedment with approximately 50 percent of the individual bead spheres embedded and 50 percent of the individual bead spheres exposed.

3.4.6 Retroreflective Markings

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NOTE: Delete paragraph if reflective markings are not specified. Delete paragraph for small road and street projects.

****

Collect and record readings for white and yellow retroreflective markings at the rate of one reading per 305 linear m 1000 linear feet. The minimum acceptable average for white markings is 200 millicandelas per square meter per lux (mcd/m2/lx) (measured with Retroreflectometer). The minimum acceptable average for yellow markings is 175 millicandelas per square meter per lux (mcd/m2/lx). Compute readings by averaging a minimum of 10 readings taken within the area at random locations. Re-mark areas not meeting the retroreflective requirements stated above.

3.4.7 Material Bond Verification and Operations Area Cleanup for Airfields

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NOTE: Delete paragraph for non-airfield projects.

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Vacuum sweep the aircraft operating area before it is opened for aircraft operations to preclude potential foreign object damaged to aircraft engines. Visually inspect the pavement markings and the material captured by the vacuum. Verify that no significant loss of reflective media has occurred to the pavement marking due to the vacuum cleaning.

-- End of Section --