
USACE / NAVFAC / AFCEC / NASA UFGS-32 17 23.00 20 (April 2006)

Preparing Activity: NAVFAC Replacing without change
UFGS-02761N (January 2006)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated October 2013

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SECTION 32 17 23.00 20

PAVEMENT MARKINGS

04/06

NOTE: This guide specification covers marking and remarking requirements for airfields, heliports, roads, streets, and parking areas by means of painting. Where curbs, obstructions, and other appurtenant structures are included in the work, the same general requirements will apply but hand application with pneumatic spray guns will be used in these areas.

Criteria and standard requirements for pavement markings are provided in the following publications:

1. American National Standards Institute (ANSI)

D6.1d-1986 - Uniform Traffic Control Devices for Streets and Highways

2. Naval Air System Command Publication:

NAVAIR 51-50AAA-2 - Shorebased Airfield Marking and Lighting.

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 items(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 \(CCR\)](#).

NOTE: On the project drawings, show location, width, type, and color of the paint markings to be used.

NOTE: 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.

NOTE: Delete notes, explanations, or elective guidance enclosed by parentheses or bordered by dotted lines before publishing this document as a project specification.

For Air Force applications, coordinate other deviations from this guide specification with the MAJCOM Pavements Engineer prior to advertising a request for bids.

The use of the name or mark of any specific manufacturer, commercial product, commodity, or service in this publication does not imply endorsement by any Branch of the U.S. Military.

PART 1 GENERAL

1.1 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 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.

ASTM INTERNATIONAL (ASTM)

ASTM D2240	(2005; R 2010) Standard Test Method for Rubber Property - Durometer Hardness
ASTM D2621	(1987; R 2011) Infrared Identification of Vehicle Solids from Solvent-Reducible Paints
ASTM D2697	(2003; R 2008) Volume Nonvolatile Matter in Clear or Pigmented Coatings
ASTM D3335	(1985a; R 2009) Low Concentrations of Lead, Cadmium, and Cobalt in Paint by Atomic Absorption Spectroscopy
ASTM D3718	(1985a; R 2010) Low Concentrations of Chromium in Paint by Atomic Absorption Spectroscopy
ASTM D3924	(1980; R 2011) Standard Environment for Conditioning and Testing Paint, Varnish, Lacquer, and Related Materials
ASTM D3960	(2005) Determining Volatile Organic Compound (VOC) Content of Paints and Related Coatings
ASTM D4280	(2012) Extended Life Type, Nonplowable, Raised, Retroreflective Pavement Markers
ASTM D4505	(2012) Preformed Retroreflective Pavement Marking Tape for Extended Service Life
ASTM D4541	(2009; E 2010) Pull-Off Strength of Coatings Using Portable Adhesion Testers
ASTM D471	(2012a) Standard Test Method for Rubber Property - Effect of Liquids
ASTM D522	(1993a; R 2008) Mandrel Bend Test of Attached Organic Coatings
ASTM D711	(2010) No-Pick-Up Time of Traffic Paint
ASTM D792	(2008) Density and Specific Gravity (Relative Density) of Plastics by Displacement
ASTM D823	(1995; E 2012; R 2012) Producing Films of Uniform Thickness of Paint, Varnish, and Related Products on Test Panels.
ASTM E28	(1999; R 2009) Softening Point of Resins Derived from Naval Stores by Ring and Ball

Apparatus

ASTM G154

(2012a) Standard Practice for Operating
Fluorescent Light Apparatus for UV
Exposure of Nonmetallic Materials

INTERNATIONAL CONCRETE REPAIR INSTITUTE (ICRI)

ICRI 03732

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

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

CID A-A-2886

(Rev B) Paint, Traffic, Solvent Based

FED-STD-595

(Rev C; Notice 1) Colors Used in
Government Procurement

FS TT-B-1325

(Rev D; Notice 1) Beads (Glass Spheres)
Retro-Reflective (Metric)

FS TT-P-1952

(Rev E) Paint, Traffic and Airfield
Markings, Waterborne

1.2 SUBMITTALS

NOTE: Review Submittal Description (SD) definitions
in Section 01 33 00 SUBMITTAL PROCEDURES and edit
the following list to reflect only the submittals
required for the project.

The Guide Specification technical editors have
designated 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 submittals requiring Government approval on Army
projects, a code of up to three characters within
the submittal tags may be used following the "G"
designation 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
projects.

Submittal items not designated with a "G" are
considered as being for information only for Army
projects and for Contractor Quality Control approval
for Navy projects.

Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are for information only or as otherwise designated. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government. The following shall be submitted in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-03 Product Data

Reflective media for airfields

Reflective media for roads and streets

Paints for airfields

Paints for roads and streets

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

Thermoplastic compound

Raised Pavement Markers and Adhesive

Equipment [; G] [; G, [____]]

Lists of proposed equipment, including descriptive data, and notifications of proposed Contractor actions as specified in this section. List of removal equipment shall include descriptive data indicating area of coverage per pass, pressure adjustment range, tank and flow capacities, and safety precautions required for the equipment operation.

Qualifications

Documentation on personnel qualifications, as specified.

SD-06 Test Reports

Reflective media for airfields

Reflective media for roads and streets

Paints for airfields

Paints for roads and streets

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

Thermoplastic compound

Raised Pavement Markers and Adhesive

Certified reports from sampling and testing made in accordance with paragraph entitled "Sampling and Testing" prior to the use of the materials at the jobsite. Testing shall be performed in an approved independent laboratory.

SD-07 Certificates

Reflective media for airfields

Reflective media for roads and streets

Paints for airfields

Paints for roads and streets

Volatile Organic Compound, (VOC)

Certificate stating that the proposed pavement marking paint meets the VOC regulations of the local Air Pollution Control District having jurisdiction over the geographical area in which the project is located.

Thermoplastic compound

Construction equipment list

SD-08 Manufacturer's Instructions

Paints for airfields

Paints for roads and streets

Thermoplastic compound

Submit manufacturer's Material Safety Data Sheets.

1.3 DELIVERY AND STORAGE

Deliver paints, paint materials and thermoplastic compound materials 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 or authorized representative,] 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.]

1.4 WEATHER LIMITATIONS

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."

NOTE: For Air Force marking operations change the
lower limit to be above 7 degrees C 45 degrees F .

Apply paint to clean, dry surfaces, and unless otherwise approved, only when the air and pavement surface temperature is at least 2.7 degrees C 5 degrees above the dew point and the air and pavement temperatures are above 5 degrees C 40 degrees F and less than 35 degrees C 95 degrees F for oil-based materials; above 10 degrees C 50 degrees F and less than 43 degrees C 110 degrees F for water-based materials. Maintain paint temperature within these same limits.

1.5 EQUIPMENT

Machines, tools, and equipment used in the performance of the work shall be approved by the Contracting Officer and maintained in satisfactory operating condition. Submit construction equipment list for approval by the Contracting Officer.

1.5.1 Mobile and Maneuverable

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

1.5.2 Paint Application Equipment

NOTE: Where pavement marking is limited to small street and parking areas, use the paragraph entitled "Hand-Operated, Push-Type Machines."

NOTE: Select the applicable paragraph(s) from the following:

1.5.2.1 [Hand-Operated, Push-Type Machines

[Provide hand-operated push-type applicator machine of a type commonly used for application of paint to pavement surfaces. Paint applicator machine shall be acceptable for marking small street and parking areas. Applicator machine shall be equipped with the necessary paint tanks and spraying nozzles, and shall be capable of applying paint uniformly at coverage specified.] Applicator for water-based markings shall be equipped with non-stick coated hoses; metal parts in contact with the paint material shall be constructed of grade 302, 304, 316, or equal stainless steel.]

1.5.2.2 [Self-Propelled or Mobile-Drawn Pneumatic Spraying Machines

NOTE: For Air Force applications use the bracketed option with the smaller width of 102 mm 4 inches for Navy and Army applications use the bracketed option with the larger width of 150 mm 6 inches.

[Provide self-propelled or mobile-drawn pneumatic 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.] [Provide equipment used for marking streets and highways 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.] [The equipment for applying the paint for airfield pavements shall be a self-propelled or mobile-drawn pneumatic spraying machine with an arrangement of atomizing nozzles capable of applying a width of line at any one time in multiples of [150 mm 6 inches, from 150 to 900 mm 6 to 36 inches][102 mm 4 inches, from 102 mm to 1m 4 inches to 3 feet at a speed of at least 5 miles per hour] .] 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 air-driven 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 shall be readily adaptable for attachment of an air-actuated dispenser for the reflective media approved for use. Provide pneumatic spray guns for hand application of paint in areas where the mobile paint applicator cannot be used.] Applicator for water-based markings shall be equipped with non-stick coated hoses; metal parts in contact with the paint material shall be constructed of grade 302, 304, 316, or equal stainless steel.

1.5.3 Thermoplastic Application Equipment

1.5.3.1 Thermoplastic Material

Thermoplastic material shall be applied to the primed pavement surface by spray techniques or by the extrusion method, wherein one side of the shaping die is the pavement and the other three sides are contained by, or are part of, suitable equipment for heating and controlling the flow of material. By either method, the markings shall be applied with equipment that is capable of providing continuous uniformity in the dimensions of the stripe.

1.5.3.2 Application Equipment

- a. Application equipment shall provide continuous mixing and agitation of the material. Conveying parts of the equipment between the main material reservoir and the extrusion shoe or spray gun shall prevent accumulation and clogging. All parts of the equipment which come into contact with the material shall be easily accessible and exposable for cleaning and maintenance. All mixing and conveying parts up to and including the extrusion shoes and spray guns shall maintain the material at the required temperature with heat-transfer oil or electrical-element-controlled heat.
- b. The application equipment shall be constructed to ensure continuous uniformity in the dimensions of the stripe. The applicator shall provide a means for cleanly cutting off stripe ends squarely and shall provide a method of applying "skiplines". The equipment shall be capable of applying varying widths of traffic markings.
- c. The applicator shall be equipped with a drop-on type bead dispenser capable of uniformly dispensing reflective glass spheres at controlled rates of flow. The bead dispenser shall be automatically operated and shall begin flow prior to the flow of composition to assure that the

strip is fully reflectorized.

1.5.3.3 Mobile and Maneuverable

Application equipment shall be mobile and maneuverable to the extent that straight lines can be followed and normal curves can be made in a true arc. The equipment used for the placement of thermoplastic pavement markings shall be of two general types: mobile applicator and portable applicator.

1.5.3.4 Mobile Application Equipment

The mobile applicator shall be defined as a truck-mounted, self-contained pavement marking machine that is capable of hot applying thermoplastic by either the extrusion or spray method. The unit shall be equipped to apply the thermoplastic marking material at temperatures exceeding 190 degrees C 375 degrees F, at widths varying from 75 to 300 mm 3 to 12 inches and in thicknesses varying from 1.0 to 5.0 mm 0.040 to 0.200 inch and shall have an automatic drop-on bead system. The mobile unit shall be capable of operating continuously and of installing a minimum of 6 km 20,000 lineal feet of longitudinal markings in an 8-hour day.

The mobile unit shall be equipped with a melting kettle which holds a minimum of 2.7 metric tons 6000 pounds of molten thermoplastic material. The kettle shall be capable of heating the thermoplastic composition to temperatures of 190 to 218 degrees C 375 to 425 degrees F. A thermostatically controlled heat transfer liquid shall be used. Heating of the composition by direct flame shall not be allowed. Oil and material temperature gauges shall be visible at both ends of the kettle. [The mobile unit shall be equipped with a minimum of two extrusion shoes located one on each side of the truck, and shall be capable of marking simultaneous edgeline and centerline stripes. Each extrusion shoe shall be a closed, oil-jacketed unit; shall hold the molten thermoplastic at a temperature of 190 to 218 degrees C 375 to 425 degrees F; and shall be 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, and of generally uniform cross section.] [The mobile unit shall be equipped with a spray gun system. The spray system shall consist of a minimum of four spray guns, located two on each side of the truck, and shall be capable of marking simultaneous edgeline and centerline stripes. The spray system shall be surrounded (jacketed) with heating oil to maintain the molten thermoplastic at a temperature of 190 to 218 degrees C 375 to 425 degrees F; and shall be capable of spraying a stripe of 75 to 300 mm 3 to 12 inches in width, and in thicknesses varying from 1.5 mm 0.060 inch to 2.5 mm 0.098 inch, and of generally uniform cross section.]

The mobile unit shall be equipped with an electronic programmable line pattern control system. The control system shall be 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, the mobile unit shall be equipped 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.

1.5.3.5 Portable Application Equipment

The portable applicator shall be defined as hand-operated equipment,

specifically designed for placing special markings such as crosswalks, stopbars, legends, arrows, and short lengths of lane, edge and centerlines. The portable applicator shall be capable of applying thermoplastic pavement markings by the extrusion method. The portable applicator shall be loaded with hot thermoplastic composition from the melting kettles on the mobile applicator. The portable applicator shall be equipped with all the necessary components, including a materials storage reservoir, bead dispenser, extrusion shoe, and heating accessories, so as to be capable of holding the molten thermoplastic at a temperature of 190 to 218 degrees C 375 to 425 degrees F, of extruding a line of 75 to 300 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.

1.5.4 Reflective Media Dispenser

The dispenser for applying the reflective media shall be attached to the paint dispenser and shall operate automatically and simultaneously with the applicator through the same control mechanism. The dispenser shall 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, at all operating speeds of the applicator to which it is attached.

1.5.5 Preformed Tape Application Equipment

Mechanical application equipment shall be used for the placement of preformed marking tape. Mechanical application equipment shall be defined as a mobile pavement marking machine specifically designed for use in applying precoated, pressure-sensitive pavement marking tape of varying widths, up to 300 mm 12 inches. The applicator shall be equipped with rollers, or other suitable compactive device, to provide initial adhesion of the preformed, pressure-sensitive marking tape with the pavement surface. Additional hand-operated rollers shall be used as required to properly seat the thermoplastic tape.

1.5.6 Surface Preparation Equipment

1.5.6.1 Sandblasting Equipment

Sandblasting equipment shall include an air compressor, hoses, and nozzles of proper size and capacity as required for cleaning surfaces to be painted. The compressor shall be capable of furnishing not less than 70.8 L/sec 150 cfm of air at a pressure of not less than 620 kPa 90 psi at each nozzle used, and shall be equipped with traps that will maintain the compressed air free of oil and water.

1.5.6.2 Waterblast Equipment

The water pressure shall be specified at 17.9 MPa 2600 psi at 60 degrees C 140 degrees F in order to adequately clean the surfaces to be marked. [Water will be furnished at no cost to the Contractor from a fire hydrant designated by the Contracting Officer or authorized representative and located within a reasonable proximity to the work area. The Contractor shall install a gate valve and a back-flow prevention device on the fire hydrant tap. The Contractor shall furnish all equipment, material, and labor required to obtain and deliver water from the designated fire hydrant to the work area(s).]

1.5.7 Marking Removal Equipment

Equipment shall be mounted on rubber tires and shall be capable of removing markings from the pavement without damaging the pavement surface or joint sealant. Waterblasting equipment shall be capable of producing an adjustable, pressurized stream of water. Sandblasting equipment shall include an air compressor, hoses, and nozzles. The compressor shall be equipped with traps to maintain the air free of oil and water.

1.5.7.1 Shotblasting Equipment

Shotblasting equipment shall be capable of producing an adjustable depth of removal of marking and pavement. Each unit shall be self-cleaning and self-contained, shall be able to confine dust and debris from the operation, and shall be capable of recycling the abrasive for reuse.

1.5.7.2 Chemical Equipment

Chemical equipment shall be capable of application and removal of chemicals from the pavement surface, and shall leave only non-toxic biodegradable residue.

1.5.8 Traffic Controls

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

Suitable warning signs shall be placed near the beginning of the worksite and well ahead of the worksite for alerting approaching traffic from both directions. Small markers shall be placed 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. Painting equipment shall be marked with large warning signs indicating slow-moving painting equipment in operation.

1.6 MAINTENANCE OF TRAFFIC

1.6.1 Airfield

The performance of work in the controlled zones of airfields shall be coordinated with the Contracting Officer and with the Flight Operations Officer. Verbal communications shall be maintained with the control tower before and during work in the controlled zones of the airfield. The control tower shall be advised when the work is completed. A radio for this purpose [will be provided by the Government. The Contractor shall assume responsibility for the radio and shall reimburse the Government for repair or replacement of the radio if it is lost, damaged, or destroyed] [shall be provided by the Contractor and approved by the Contracting Officer].

1.6.2 Lighting

When night operations are necessary, all necessary lighting and equipment shall be provided. Lighting shall be directed or shaded to prevent interference with aircraft, the air traffic control tower, and other base operations. All lighting and related equipment shall be capable of being

removed from the runway within 15 minutes of notification of an emergency. Night work must be coordinated with the Airfield Manager and approved in advance by the Contracting Officer or authorized representative. The Government reserves the right to accept or reject night work on the day following night activities by the Contractor.

1.6.3 Roads, Streets, and Parking Areas

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

1.7 WEATHER LIMITATIONS FOR REMOVAL

Pavement surface shall be free of snow, ice, or slush. Surface temperature shall be at least 5 degrees C 40 degrees F and rising at the beginning of operations, except those involving shot or sand blasting. Operation shall cease during thunderstorms. Operation shall cease during rainfall, except for waterblasting and removal of previously applied chemicals. Waterblasting shall cease where surface water accumulation alters the effectiveness of material removal.

1.8 QUALIFICATIONS

The Contractor shall submit documentation certifying that pertinent personnel are qualified for equipment operation and handling of chemicals.

PART 2 PRODUCTS

2.1 MATERIALS

NOTE: Use Either FS TT-P-1952, a water-emulsion marking paint, or High Build Acrylic Coating (HBAC) on asphaltic pavement and pavements in areas where air pollution by organic solvents is a problem. On concrete pavements where air pollution by organic solvents is not a problem, FS TT-P-1952 or CID A-A-2886 paint may be used.

HBAC is suitable for reflective and nonreflective use and can be applied at 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 is acceptable on surfaces employing snowplows.

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

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.

2.1.1.1 Paints for Airfields

[CID A-A-2886] [FS TT-P-1952], color as [indicated] [selected].

2.1.1.2 Paints for Roads and Streets

[CID A-A-2886] [FS TT-P-1952] [High Build Acrylic Coating (HBAC)] , color as [indicated] [selected].

2.1.1.3 Reflective Media for Airfields

FS TT-B-1325, Type I, Gradation A.

2.1.1.4 Reflective Media for Roads and Streets

FS TT-B-1325, Type I, Gradation A.

2.1.1.5 Thermoplastic Compound

The thermoplastic reflectorized pavement marking compound shall be extruded or sprayed 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 shall be an adherent reflectorized strip of the specified thickness and width that is capable of resisting deformation by traffic.

2.1.5.1 Composition Requirements

The binder component shall be formulated as a hydrocarbon resin. The pigment, beads and filler shall be uniformly dispersed in the binder resin. The thermoplastic composition shall be free from all skins, dirt, and foreign objects and shall comply with the following requirements:

<u>Component</u>	<u>Percent by Weight</u>	
	<u>White</u>	<u>Yellow</u>
Binder	17 min	17 min
Titanium dioxide	10 min	-
Glass beads	20 min	20 min
Calcium carbonate and	49 min	*
Yellow pigments	-	*

<u>Component</u>	<u>Percent by Weight</u>	
	<u>White</u>	<u>Yellow</u>
*Amount and type of yellow pigment, calcium carbonate and inert fillers shall be at the option of the manufacturer, providing the other composition requirements of this specification are met.		

2.1.5.2 Physical Properties

- a. Drying time: When installed at 21 degrees C 70 degrees F and in thicknesses between 3 and 5 mm 0.120 and 0.190 inch, the composition shall be completely solid and shall show no damaging effect from traffic after curing 15 minutes.
- b. Softening point: The composition shall have a softening point of not less than 90 degrees C 194 degrees F when tested in accordance with ASTM E28.
- c. Specific gravity: The specific gravity of the composition shall be between 1.9 and 2.2 as determined in accordance with ASTM D792.

2.1.5.3 Primer

- a. Asphalt concrete primer: The primer for asphalt concrete pavements shall be a thermosetting adhesive with a solids content of pigment reinforced synthetic rubber and synthetic plastic resin dissolved or dispersed in a volatile organic solvent. The solids content shall 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, shall dry to a tack-free condition in less than 5 minutes.
- b. Portland cement concrete primer: The primer for portland cement concrete pavements shall be an epoxy resin primer. The primer shall be of the type recommended by the manufacturer of the thermoplastic composition.

2.1.6 PREFORMED TAPE

The preformed tape shall be an adherent reflectorized strip in accordance with ASTM D4505 Type I or IV, Class optional.

2.1.7 Raised Pavement Markers

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

Either metallic or nonmetallic markers of the button or prismatic reflector

type may be used. Markers shall be of permanent colors as specified for pavement marking, and shall retain the color and brightness under the action of traffic. Button markers shall have a diameter of not less than 100 mm 4 inches, and shall be spaced not more than 12 meters 40 feet apart on solid longitudinal lines. Broken centerline marker spacings shall be in segments [of [____]] [indicated] with gaps [of [____]] [indicated] between segments. Button markers shall have rounded surfaces presenting a smooth contour to traffic and shall not project more than 3/4 inch above level of pavement. Pavement markers and adhesive epoxy shall conform to ASTM D4280

2.1.8 High Build Acrylic Coating (HBAC)

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

NOTE: Tables are located at the end of Part 3.

2.1.8.1 Preapproved HBAC Vendors and Materials

Table II presents a partial list of HBAC vendors and materials. Up to specifications's date of issue, preapproved materials met specification requirements. It is the user's responsibility to confirm preapproved material formulations have not changed and specification requirements will be met. Other products may meet HBAC requirements.

PART 3 EXECUTION

3.1 SURFACE PREPARATION

NOTE: Newly laid 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 before application of marking materials. When earlier application of paint is necessary because of operations requirements, the maximum period practicable should be specified.

Removal of rubber is generally accomplished by water blasting. Few approved chemical are effective and sandblasting is not permitted by air pollution regulations at some locations. Mechanical abrasion generally causes damage to the pavement.

Detailed procedures for conducting rubber and paint removal from airfield pavements are contained in Section 32 01 11.51 RUBBER AND PAINT REMOVAL FROM AIRFIELD PAVEMENTS.

Existing marking paints with paint build-up greater than 1 mm 40 mils shall be completely removed in accordance with Section 32 01 11.51, unless crack free and determined sound. 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]. For Portland Cement Concrete pavement, grinding, light shot blasting, and 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, to either remove existing coatings or for surface preparation on most pavements: shot blasting shall not be used 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.

[3.1.1 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.

] [3.1.2 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.

] 3.2 APPLICATION

3.2.1 Testing for Moisture

Apply pavement markings to dry pavement only. The Contractor shall test the pavement surface for moisture before beginning work 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 CO 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.

3.2.2 Rate of Application

NOTE: On new asphaltic surfaces, two coats of

marking paint at half the normal application thickness and with a waiting period of two or more weeks between coats may be required to reduce surface cracking, paint curling, and marking paint discoloration.

To reduce FS TT-P-1952 and High Build Acrylic Coating (HBAC) discoloration on uncoated asphaltic wearing surfaces, apply a pre-stripe of the above paint at 6.13 square meters per liter 250 square feet per gallon. Pre-stripe shall cure to a tack-free state prior to paint application at the specified rate.

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.

3.2.2.1 Reflective Markings

Apply paint evenly to the pavement area to be coated at a rate of 2.5 plus or minus 0.10 square meter per liter 105 plus or minus 5 square feet per gallon. [Apply High Build Acrylic Coating (HBAC) at a rate of 1.3 square meters per liter 50 square feet per gallon.]Apply glass spheres uniformly to the wet paint [on airfield pavement at a rate of (1198)] [on road and street pavement at a rate of (719)] plus or minus (60) g of glass spheres per liter [on airfield pavement at a rate of (10)] [on road and street pavement at a rate of (6)] plus or minus (0.5) pounds of glass spheres per gallon. Collect and record readings for white and yellow retroreflective markings at the rate of one reading per 300 linear meters 1000 linear feet. The minimum acceptable average for white markings is 200 millicandelas per square meter per lux (mcd/m²/lx) (measured with Mirolux 12 Retroreflectometer or similar instrument as agreed). The minimum acceptable average for yellow markings is 175 millicandelas per square meter per lux (mcd/m²/lx). Readings shall be computed by averaging a minimum of 10 readings taken within the area at random locations. Areas not meeting the retroreflective requirements stated above shall be re-marked.

3.2.2.2 Nonreflective Markings

Apply paint evenly to the pavement surface to be coated at a rate of 2.5 plus or minus 0.10 square meter per liter 105 plus or minus 5 square feet per gallon. [Apply High Build Acrylic Coating (HBAC) at a rate of 1.3 square meters per liter 50 square feet per gallon.]

3.2.2.3 Thermoplastic Compound

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 10.0 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 7.8 to 10.0 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. Immediately after installation of the marking, apply drop-on reflective glass spheres mechanically 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. 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.

3.2.3 Painting

Apply paint pneumatically 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. Discontinue painting operations if there is a deficiency in drying of the markings until cause of the slow drying is determined and corrected.

3.2.4 Reflective Media

Application of reflective media shall immediately follow the application of paint. Accomplish drop-on application of the glass spheres to ensure even distribution at the specified rate of coverage. Should there be malfunction of either paint applicator or reflective media dispenser, discontinue operations until deficiency is corrected.

3.2.5 Thermoplastic Compound

Place thermoplastic pavement markings upon dry pavement. At the time of installation the pavement surface temperature shall be a minimum of 5 degrees C 40 degrees F and rising. Thermoplastics, as placed, shall be free from dirt or tint. 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.

3.2.6 Raised Pavement Markers

Prefabricated markers shall be aligned carefully at the required spacing or as directed and permanently fixed in place by means of epoxy adhesives. To ensure good bond, areas where markers will be set shall be thoroughly cleaned by water blasting and use of compressed air prior to applying adhesive.

3.3 FIELD TESTING, INSPECTION, AND DEMONSTRATIONS

3.3.1 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 3500 square meters 4000 square yards in painted surface area, requirements for Contractor's testing should be used ad the next to last bracketed sentence should be left in. For projects less that 3500 square meters 4000 square yards, delete the next to last sentence and include the last bracketed sentence that will allow for Government testing is the Contracting Officer deems it necessary.

As soon as the paint [and reflective] [and thermoplastic] materials are available for sampling, obtain by random selection from the sealed containers, two quart samples of each batch in the presence of the Contracting Officer. 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 copy of the test results to the Contracting Officer. 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.]

3.3.2 Inspection

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 3500 square meters 4000 square yards in painted surface area, requirements for Contractor's testing should be used. For small projects, use Government test option.

Examine material at the job site to determine that it is the material referenced in the report of test results or certificate of compliance. A certificate of compliance shall be accompanied by test results substantiating conformance to the specified requirements.

3.3.3 Surface Preparations and Application Procedures

Surface preparations and application procedures will be examined by the Contracting Officer to determine conformance with the requirements specified. Approve each separate operation prior to initiation of subsequent operations.

[3.3.3.1 Surface Preparation Demonstration

Prior to [surface preparation] [coating removal] [rubber removal], demonstrate surface preparation using the proposed [materials,] [methods] and equipment according to the procedures outlined in Section 32 01 11.51. Prepare areas large enough to determine [cleanliness] [, adhesion of remaining coating] and rate of cleaning.

] [3.3.3.2 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. The test stripes shall be long enough to determine the proper speed and operating pressures for the vehicle(s) and machinery, but not less than 15 meters 50 feet long.

] [3.3.3.3 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 or authorized representative [days]prior to proceeding with the work.

] [3.3.3.4 Retroreflective Value Demonstration

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 Mirolux 12 Retroreflectometer, or similar instrument with the same measuring geometry and direct readout in millicandelas per square meter per lux (mcd/m²/lx).

] [3.3.3.5 Level of Performance Demonstration

The Contracting Officer or authorized representative will be present 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 or authorized representative, the test stripe shall be the measure of performance required for this project. Work shall not proceed until the demonstration results are satisfactory to the Contracting Officer or authorized representative.

] 3.4 TRAFFIC CONTROL AND PROTECTION

Place warning signs near the beginning of the work site and well ahead of

the work site for alerting approaching traffic from both directions. Place small markers along newly painted lines to control traffic and prevent damage to newly painted surfaces. Mark painting equipment with large warning signs indicating slow-moving painting equipment in operation. Do not use foil-backed material for temporary pavement marking because of its potential to conduct electricity during accidents involving downed power lines.

3.5 QUALITY ASSURANCE

Demonstrate success of bond of reflective media, new paint marking and the pavement surface, vacuum cured surface of new marking after a seven (7) day dry time. Inspect newly applied markings for signs of bond failure based on visual inspection and comparison to results from Test Stripe Demonstration paragraph.

3.5.1 Reflective Media and Coating Bond Verification

Within seven (7) days after pavement marking application, use industrial vacuum to sweep new markings. 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.

3.5.2 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 beads embedded and 50 percent of the beads exposed.

TABLE I - REQUIREMENTS FOR HIGH BUILD ACRYLIC COATINGS (HBAC)	
TEST	MINIMUM REQUIREMENT (AND MAXIMUM WHERE INDICATED)
Resin System (ASTM D2621)	Waterborne 100 percent Acrylic
Percent Volume Solids (ASTM D2697)	58 percent
Volatile Organic Compound, max. (ASTM D3960)	150 g/l 1.25 lbs/gal
White (FED-STD-595)	37925
Yellow (FED-STD-595)	33538
Shore D Hardness (ASTM D2240)	45
1/8 inch Mandrel Bend at 5 mils Dry Film Thickness (DFT, one-week cure (ASTM D522, 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 (FED-STD-595)
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

TABLE I - REQUIREMENTS FOR HIGH BUILD ACRYLIC COATINGS (HBAC)	
TEST	MINIMUM REQUIREMENT (AND MAXIMUM WHERE INDICATED)
Notes:	
<p>(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: four individual yellow samples shall be prepared. Expose three samples to continuous Ultraviolet (UV) light for 2500 hours, without cycles condensation, in accordance to ASTM G154: UVA-340 lamps shall be used in the testing apparatus. Following exposure, compare the three exposed samples to the "one" non-exposed sample using FED-STD-595 colors 33538 and 33655 as visual references: evaluate exposed samples for degree of visual color loss. Yellow paint shall receive a passing rating if each exposed sample appears equivalent to the non-exposed sample, and in addition, displays color loss no greater than FED-STD-595 color 33655.</p>	
<p>(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. Paint application and draw down shall be performed 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, coating shall receive a passing rating if applied greater than 950 microns 38 mils DFT and visually free of both cracking and curling.</p>	

TABLE II - PREAPPROVED HBACs	
MANUFACTURER	PRODUCTS
TMT-Pathway 1021 North Mission Road Los Angeles, CA 90033 (800) 338-7680	Legend Build, #2712A9, White
	Legend Build, #2713A9, Yellow
Pervo Paints 6624 Stanford Avenue Los Angeles, CA 90001 (323) 758-1147	Pervo 6050, White
	Pervo 6053, Yellow
Vogel Traffic Services 1920 Albany Place South PO Box 140 Orange City, IA 51041 (712) 737-4016	UC-1516, White
	UC-3588, Yellow

-- End of Section --