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USACE / NAVFAC / AFCEA UFGS-02966 (August 2004)  
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Preparing Activity: USACE Superseding  
UFGS-02966A (August 1997)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated 25 June 2004

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SECTION TABLE OF CONTENTS

DIVISION 02 - SITE CONSTRUCTION

SECTION 02966

HOT IN-PLACE RECYCLING OF BITUMINOUS PAVEMENTS

08/04

PART 1 GENERAL

- 1.1 REFERENCES
- 1.2 MEASUREMENT
  - 1.2.1 In-Place Recycled Mixture
  - 1.2.2 New Asphalt Concrete
- 1.3 PAYMENT
- 1.4 SUBMITTALS
- 1.5 EQUIPMENT, TOOLS, AND MACHINES
  - 1.5.1 General
  - 1.5.2 Heating
  - 1.5.3 Scarifying/Milling
  - 1.5.4 Distribution and Mixing
  - 1.5.5 Placement
- 1.6 STRAIGHTEDGE
- 1.7 WEATHER
- 1.8 INITIAL SAMPLING AND TESTING
  - 1.8.1 General Requirements
  - 1.8.2 Samples

PART 2 PRODUCTS

- 2.1 RECYCLING AGENTS
- 2.2 JOB-MIX FORMULA

PART 3 EXECUTION

- 3.1 PREPARATION OF SURFACE
- 3.2 HEATING
- 3.3 RECYCLING PROCEDURE
  - 3.3.1 Single-Pass Method
  - 3.3.2 Multiple-Pass Method
- 3.4 JOINTS
- 3.5 COMPACTION
- 3.6 TEST SECTION
- 3.7 ACCEPTABILITY OF WORK

- 3.7.1 Field Testing and Sampling
  - 3.7.1.1 Mixture Properties
  - 3.7.1.2 Density Testing
- 3.7.2 Grade Conformance
- 3.7.3 Surface-Smoothness

-- End of Section Table of Contents --

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### SECTION 02966

#### HOT IN-PLACE RECYCLING OF BITUMINOUS PAVEMENTS 08/04

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NOTE: This guide specification covers the requirements for the hot in-place recycling of existing bituminous pavement using either single or multiple pass methods.

Comments and suggestions on this guide specification are welcome and should be directed to the technical proponent of the specification. A listing of technical proponents, including their organization designation and telephone number, is on the Internet.

Recommended changes to a UFGS should be submitted as a Criteria Change Request (CCR).

Use of electronic communication is encouraged.

Brackets are used in the text to indicate designer choices or locations where text must be supplied by the designer.

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#### PART 1 GENERAL

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NOTE: Experience and data indicate that scarifying is feasible only on existing asphalt concrete pavements which are structurally sound but in need of surface leveling or which exhibit superficial distresses. In the single pass method, new asphalt concrete is either added to or placed over the existing recycled asphalt concrete. An asphalt overlay or surface treatment should be applied to the recycled pavement when a multiple-pass recycling (heater-scarifying) process is to be used.

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#### 1.1 REFERENCES

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NOTE: Issue (date) of references included in project specifications need not be more current than provided by the latest guide specification. Use of SpecsIntact automated reference checking is recommended for projects based on older guide specifications.

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

ASTM INTERNATIONAL (ASTM)

ASTM C 117	(2003) Materials Finer Than 75 micrometer (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C 136	(2001) Sieve Analysis of Fine and Coarse Aggregates
ASTM D 140	(2001) Sampling Bituminous Materials
ASTM D 1856	(1995a) Recovery of Asphalt from Solution by Abson Method
ASTM D 2041	(2003) Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures
ASTM D 2170	(2001a) Kinematic Viscosity of Asphalts (Bitumens)
ASTM D 2171	(2001) Viscosity of Asphalts by Vacuum Capillary Viscometer
ASTM D 2172	(2001e1) Quantitative Extraction of Bitumen from Bituminous Paving Mixtures
ASTM D 2726	(2000) Bulk Specific Gravity and Density of Non-Absorptive Compacted Bituminous Mixtures
ASTM D 3381	(1992; R 1999) Viscosity-Graded Asphalt Cement for Use in Pavement Construction
ASTM D 3665	(2002) Random Sampling of Construction Materials
ASTM D 4552	(1992; R 1999) Classifying Hot-Mix Recycling Agents
ASTM D 75	(2003) Sampling Aggregates
ASTM D 946	(1982; R 1999) Penetration-Graded Asphalt Cement for Use in Pavement Construction

U.S. ARMY CORPS OF ENGINEERS (USACE)

COE CRD-C 649	(1995) Standard Test Method for Unit Weight, Marshall Stability, and Flow of Bituminous Mixtures
COE CRD-C 650	(1995) Standard Test Method for Density and Percent Voids of Compacted Bituminous Paving Mixtures

1.2 MEASUREMENT

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NOTE: When other methods of measurement are desired or are necessary, this paragraph will be modified accordingly. Delete the second paragraph when new asphalt concrete is not added to the mixture. The term "recycling agent" is used herein to describe any manufacturer certified material that is used to rejuvenate or lower the viscosity of the existing asphalt cement to the required levels.  
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1.2.1 In-Place Recycled Mixture

The quantity of hot in-place recycling paid for shall be the number of square meters yards completed and accepted as determined by the Contracting Officer. The number of square meters yards of planed pavement will be determined by measuring the length and width of the specified work area. Measurements will be along the surface of the pavement and will be to the closest 0.01 meter inch for width and the closest meter foot for length. Recycling agent will be paid for by the number of liters gallons of material used in the accepted work.

1.2.2 New Asphalt Concrete

New asphalt concrete mixture will be paid for by the number of metric tons 2000-pound tons of material used in accepted work.

1.3 PAYMENT

The quantities of recycled mixture, [new asphalt concrete], [and recycling agent] determined as provided above, will be paid for at contract unit prices per square meter yard for recycled mixture [and per metric ton ton for new asphalt concrete] [and per liter gallon for recycling agent]. If deficiencies in the finished product exceed specified tolerances, no payment will be made for such areas of pavement until the defective areas are corrected and accepted by the Contracting Officer.

1.4 SUBMITTALS

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NOTE: Submittals must be limited to those necessary for adequate quality control. The importance of an item in the project should be one of the primary factors in determining if a submittal for the item should be required.

A "G" following a submittal item indicates that the

submittal requires Government approval. Some submittals are already marked with a "G". Only delete an existing "G" if the submittal item is not complex and can be reviewed through the Contractor's Quality Control system. Only add a "G" 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.

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Government approval is required for submittals with a "G" designation; submittals not having a "G" designation are [for Contractor Quality Control approval.] [for information only. 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 01330 SUBMITTAL PROCEDURES:

#### SD-04 Samples

##### Recycled Mixture.

A 200 kg 400 lb sample of existing asphalt concrete. Where a single-pass remix process is used, a 100 kg 200 lb sample of each new aggregate stockpile to make blended samples for the mix design, a 20 liter 5 gal sample of asphalt cement, and a 20 liter 5 galsample of recycling agent. All samples shall be submitted not less than [30] [\_\_\_\_\_] days before the material is required in the work.

#### SD-06 Test Reports

##### Scheduling of Reports and Testing.

Copies of test results within 24 hours of material sampling. Copies of test reports on material properties of existing asphalt pavement [and new asphalt concrete], not less than [30] [\_\_\_\_\_] days before the material is required in the work. The test reports shall include information establishing compliance with the specifications detailed herein and in referenced publications. Certified copies of the recycling agent manufacturer's test reports indicating compliance with applicable specified requirements, not less than [30] [\_\_\_\_\_] days before the material

is required in the work.

## 1.5 EQUIPMENT, TOOLS, AND MACHINES

### 1.5.1 General

Equipment, tools, and machines used in the performance of the work shall be maintained in a satisfactory working condition at all times. All equipment used shall conform to applicable governing regulations for local air pollution controls. The equipment used shall be capable of performing recycling operations at a minimum rate of 600 square meters 720 square yards per hour to the depth required.

### 1.5.2 Heating

Heating units shall use radiant heat with no flame directly on the pavement. The combustion chamber shall be insulated and totally enclosed. The heating units shall be shielded with an enclosed hood to hold in the heat and to protect workers and surrounding obstacles.

### 1.5.3 Scarifying/Milling

Scarifying or hot milling equipment shall be able to penetrate the pavement surface so as to cut to the specified depth without tensile fracturing the aggregate in the pavement. When used for this purpose, the scarifiers or hot milling heads shall be able to thoroughly mix the recycled mixture with any material that is added as part of the recycling process. The equipment shall be capable of height adjustments to clear obstacles in the pavement.

### 1.5.4 Distribution and Mixing

At least one unit of the recycling equipment shall be capable of uniformly distributing and mixing the recycling agent [and new asphalt concrete] with the recycled material. Distribution of the added material shall have a positive feed and shut-off linked to the movement of the unit. The range of application shall be within that required for the project and should be controllable to plus or minus 0.023 liters per square meter.0.05 gallons per square yard. The recycling agent, at the time of application, shall be heated to within plus or minus 14 degrees C 25 degrees F of the temperature of the recycled mixture.

### 1.5.5 Placement

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**NOTE: Units used in single-pass method recycling  
should have automated grade and cross-slope  
controls. Multiple-pass method units  
(heater-scarifying) generally do not have automated  
controls.**  
\*\*\*\*\*

The unit shall be capable of spreading and leveling the recycled mixture uniformly across the processed width. The unit shall have a vibratory or tamping screed to finish the recycled mixture surface.

## 1.6 STRAIGHTEDGE

The Contractor shall furnish and maintain at the site, in good condition, one 3.66 meter (12 foot) 12 foot straightedge for each finishing unit

(paver) for testing the finished surface. Straightedge shall be made available for Government use. Straightedges shall be constructed of aluminum or other lightweight metal, and shall have blades of box or box-girder cross section with flat bottom, reinforced to insure rigidity and accuracy. Straightedges shall have handles to facilitate movement on the pavement.

#### 1.7 WEATHER

Hot in-place recycling procedures shall be performed only when the existing pavement is dry and the pavement surface temperature is above 15 degrees C. 60 degrees F.

#### 1.8 INITIAL SAMPLING AND TESTING

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NOTE: The amount of sampling and testing required will depend upon the type of hot in-place recycling performed. Multiple-pass or heater-scarifying processes do not add any additional materials and will only require testing for the amount of recycling agent to be added to the mixture. The single-pass remix processes may require job-mix-formula tests when new asphalt concrete is to be combined with the recycled mixture.  
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##### 1.8.1 General Requirements

Sampling and testing shall be performed by a commercial testing laboratory or by Contractor's facilities upon approval by the Contracting Officer. No work requiring testing will be permitted until the testing facilities have been inspected and approved. The first inspection shall be at the expense of the Government. Cost incurred by the government for any subsequent inspection required because of failure of the facilities to pass the first inspection will be charged to the Contractor.

##### 1.8.2 Samples

Recyclable asphalt pavement for laboratory tests shall be taken in accordance with ASTM D 75. Samples of recycling agents shall be taken in accordance with ASTM D 140. Prior to the start of the work, samples from the existing pavement shall be obtained from at least two locations to provide materials representative of the pavement. These samples shall be used to determine [the amount of recycling agent required to achieve the mixture properties as provided in paragraph JOB-MIX FORMULA.] [the specified job-mix formula (JMF).] The JMF shall be furnished to the Contracting Officer within 30 days after the award of the contract and prior to the start of recycling operations.

#### PART 2 PRODUCTS

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NOTE: Designer will delete the inapplicable paragraphs and renumber all subsequent paragraphs accordingly. For single-pass remix methods, a mix design or JMF containing the type and amount of new aggregates and asphalt cement should be developed. The material requirements for the new aggregates and



asphalt cement used to produce the new asphalt concrete should be listed below. The requirements listed should be as given in Section 02741A BITUMINOUS PAVING FOR ROADS, STREETS AND OPEN STORAGE AREAS or Section 02556A ASPHALTIC BITUMINOUS HEAVY-DUTY PAVEMENT (CENTRAL-PLANT HOT MIX).

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## 2.1 RECYCLING AGENTS

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NOTE: The appropriate type of recycling agent (rejuvenator) should be selected depending on the type and method of recycling to be accomplished.

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The recycling agent shall be [a hot-mix recycling agent of Grade [\_\_\_\_], conforming to ASTM D 4552] [the rejuvenator [\_\_\_\_]].

## 2.2 JOB-MIX FORMULA

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NOTE: Only a single-pass remix process will allow the use of a JMF that requires a given gradation. This single-pass process involves the addition of new asphalt concrete and provides a method of improving the gradation and mixture properties of the recycled mixture. When the remix process is utilized, the Government will have to sample and provide information concerning the material properties (asphalt content and gradation) of the existing pavement to the bidding parties. An edited version of either Section 02741A BITUMINOUS PAVING FOR ROADS, STREETS AND OPEN STORAGE AREAS or Section 02556A ASPHALTIC BITUMINOUS HEAVY-DUTY PAVEMENT (CENTRAL-PLANT HOT MIX) should be added to the project specifications indicating material and mixture properties required in the JMF. Include the sections in brackets when the single-pass remix process is specified. A suitable paragraph concerning mixture and individual component tolerances must be added. These tolerances must allow for variations in the existing pavement and will generally be less stringent than those usually applied to new hot-mix asphalt concrete. Typical tolerance requirements are given in the previously listed Sections. The grade of asphalt specified should be that which is generally specified for that location.

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[The Government will provide information on the existing asphalt concrete pavement to allow the Contractor to develop a JMF for the recycled mixture.] [The Contractor shall furnish, for acceptance, a JMF to the Contracting Officer meeting the requirements of Section [02741 BITUMINOUS PAVING FOR ROADS, STREETS AND OPEN STORAGE AREAS] [02556A ASPHALT CONCRETE HEAVY-DUTY PAVEMENT (CENTRAL PLANT HOT MIX)].] The Contracting Officer will verify this JMF through samples of materials submitted by the Contractor. No payment will be made for hot in-place recycled mixtures

produced prior to the completion and acceptance of the JMF. The JMF will indicate [the gradation of the aggregate] [and] [a definite percentage of [asphalt and] recycling agent to be added to the mixture]. The amount of [asphalt and] recycling agent shall be given as per square meter yard of recycled material. The JMF shall be developed by combining various percentages of the selected recycling agent with the existing pavement material. The amount of recycling agent in the recycled mixture shall be increased until the void content of specimens made according to COE CRD-C 649 decreases below 3.5 percent. This will provide the maximum amount of recycling agent that can be added to the mixture. At this maximum amount, and at least one lower percentage of recycling agent, the asphalt cement shall be extracted from the samples made and recovered according to ASTM D 2172 and ASTM D 1856, respectively. The viscosity of the recovered asphalt cements shall be obtained in accordance with either ASTM D 2170 or ASTM D 2171. The amount of recycling agent used in the recycled mixture shall be the amount that results in an asphalt viscosity equivalent to [ASTM D 946] [ASTM D 3381], Grade [\_\_\_\_\_] or that which results in a minimum void content of 3.5 percent. The JMF will allow an asphalt content tolerance of plus or minus 10 percent of the amount specified in the JMF. [New asphalt concrete, to be placed on top of the recycled mixture, shall have a JMF meeting the requirements given in Section [02741 BITUMINOUS PAVING FOR ROADS, STREETS AND OPEN STORAGE AREAS] [02556A ASPHALTIC BITUMINOUS HEAVY-DUTY PAVEMENT (CENTRAL-PLANT HOT MIX)]]].

### PART 3 EXECUTION

#### 3.1 PREPARATION OF SURFACE

Prior to recycling, the pavement surface shall be cleaned of all loose and foreign or objectionable material with brooms or other suitable methods. Localized patching, structural corrections, and adjustments to existing structures (i.e., manhole covers) should be completed prior to the recycling process.

#### 3.2 HEATING

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NOTE: The amount of heat applied to the pavement should be controlled to avoid damaging the heated pavement. Excess heat will burn and therefore damage the asphalt binder. Experience has shown that dense graded asphalt concrete pavements that are relatively lean in asphalt cement content are easiest to heat.  
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The heating units provided shall be of sufficient number and size to heat the pavement surface as required for successful scarifying and/or hot milling to the required depth. These units shall not be allowed to overheat the existing pavement. Sufficient heat shall be generated to result in a minimum recycled mixture temperature of 115 degrees C 240 degrees F as the mixture is being placed. The maximum temperature of the recycled mixture should not exceed 143 degrees C 290 degrees F at any time during the recycling process.

#### 3.3 RECYCLING PROCEDURE

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NOTE: Based on the requirements of the project, the

specifier will select either a single- or multiple-pass method of recycling. The single pass method is further broken down into remix and repave procedures. The multiple-pass method requires a wearing surface which can normally be applied anywhere from immediately prior to compaction of the recycled mixture to several weeks later.

The following paragraphs should be edited according to the type of recycling to be accomplished.

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#### 3.3.1 Single-Pass Method

The single-pass method shall consist of self-contained, self-propelled, automated units capable of heating, scarifying and/or hot rotary mixing and redistributing the recycled mixture. [The mixture shall consist of the existing pavement, recycling agent, and new asphalt concrete to the specified depth and design (Remixing). The reclaimed material shall be automatically fed into a mixing unit. A recycling agent and, when required, new asphalt concrete shall be added to the reclaimed material at the mixer. The type and quantity of the new asphalt concrete and the proportion of new material and reclaimed material shall be specified in the JMF. All materials shall then be thoroughly mixed while maintaining the minimum temperature of 115 degrees C.240 degrees F. After mixing, the combined bituminous material] [After the addition of the recycling agent, the reclaimed material shall be gathered by a leveling device equipped with augers for mixing and placement to a uniform depth over the width being processed (Repaving). A layer of new hot bituminous pavement material conforming to the JMF shall be placed over the recycled mix while it still has a residual minimum temperature of 107 degrees C.225 degrees F. This layer] shall be automatically fed into a finishing unit (paver) which shall have automatic screed control for longitudinal leveling of the homogeneous recycled mixture to the required thickness in conformance with the specified cross-section.

#### 3.3.2 Multiple-Pass Method

The multiple-pass method shall consist of self-contained, self-propelled or towed, automated units capable of heating, scarifying and/or hot rotary mixing, redistributing, and screeding. The equipment used in the method shall also provide for controlled leveling at the crown and across the screed to insure a cross-section that conforms to the pavement profile specified. The heating shall be controlled to provide a minimum recycled mixture temperature of 115 degrees C 240 degrees F behind the screed. The unit shall be able to uniformly distribute the specified amount of recycling agent throughout the recycled mixture. A wearing course meeting the requirements of Section [02741 BITUMINOUS PAVING FOR ROADS, STREETS AND OPEN STORAGE AREAS] [02556A ASPHALTIC BITUMINOUS HEAVY-DUTY PAVEMENT (CENTRAL-PLANT HOT MIX)] shall be applied following completion of the recycling process.

#### 3.4 JOINTS

The existing pavement shall be heated a minimum of 100 mm 4 inches beyond the width of the recycling. When recycling adjacent to an existing hot-mix recycled pavement mat, the heating shall extend 150 mm 6 inches into the existing mat and at least 100 mm 4 inches of this mat shall be recycled with the new mat.

### 3.5 COMPACTION

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NOTE: The compaction required will depend on the pavement application. Pavements subjected to high tire pressure (over 690 kPa (100 psi)) vehicles, heavy loads, or numerous application of loads will require a minimum density or degree of compaction of 94 percent of the theoretical maximum specific gravity of the recycled mixture. Pavements subjected to low tire pressure (equal to or less than 690 kPa (100 psi)) vehicles, lighter loads, or fewer applications of loads will require a minimum density or degree of compaction of 91 percent of the theoretical maximum specific gravity of the recycled mixture.

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The density achieved during compaction shall be [94] [91] percent of the theoretical maximum specific gravity as determined according to ASTM D 2041.

Conventional asphalt concrete rollers and procedures can be used for compaction; however, a pneumatic roller should be used in the process because it can improve compaction where odd size particles or variations in lift thickness exist.

### 3.6 TEST SECTION

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NOTE: Use of a test section is recommended for all hot in-place recycling projects, especially for single-pass methods of construction. Placement of test sections in two adjacent paving lanes should be required for recycling of pavement areas where extensive longitudinal construction joints will be required, i.e. parking lots.

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Prior to the start of the recycling, a length of pavement at least 15 meters 50 feet long shall be recycled to the depth required in the project.

At the direction of the Contracting Officer, this test section shall be placed in two adjacent paving lanes to demonstrate joint construction. Recycled mixture shall be placed or spread and rolled with the equipment to be used in the project and in accordance with requirements specified above.

This test section will be tested and evaluated as a full days production and shall conform to all specification requirements. The test section may be located in one of the less critical areas of the project pavement construction, as directed by the Contracting Officer. Full production shall begin if tests results are satisfactory, and as approved by the Contracting Officer. If the test section was constructed within the project boundaries, it shall remain in place as part of the completed pavement. If tests indicate that the pavement does not conform to specification requirements, necessary adjustments to operations and procedures shall be made immediately, and another test section constructed, all at no additional cost to the Government. Additional test sections, as necessary and as directed by the Contracting Officer, shall be constructed and will be sampled and tested for conformance with specification requirements. The Contractor shall not start full production without test section approval by the Contracting Officer.

### 3.7 ACCEPTABILITY OF WORK

#### 3.7.1 Field Testing and Sampling

Field tests shall be performed in sufficient numbers to ensure that the specifications are being met. Testing shall be the Contractor's responsibility and shall be performed by an approved commercial laboratory. The following tests shall be performed at the appropriate time, and will be the minimum acceptable for each type of operation.

##### 3.7.1.1 Mixture Properties

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NOTE: Select the information in the first set of brackets when the single-pass remix process is used and select the information in the second set of brackets when the multiple pass process is used. The mixture should normally be sampled and tested twice a day or once for every 4 hours of production or placement.  
\*\*\*\*\*

[A sample of the recycled mixture shall be obtained for every [\_\_\_\_\_] hours of mix production. The asphalt cement shall be extracted from the mix according to ASTM D 2172. The asphalt content of the recycled material shall be within the tolerance given in paragraph JOB-MIX FORMULA. The gradation of the extracted aggregate shall be determined in according to ASTM C 117 and ASTM C 136. The extracted gradation shall meet the JMF and the corresponding tolerances.] [The amount of recycling agent used per day shall be recorded along with the square meter yard area recycled. These values shall be used to verify that the correct amount of recycling agent is being added to the recycled mixture.]

##### 3.7.1.2 Density Testing

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NOTE: A 150 mm (6 in.) core sample is required where the depth of recycling is less than 38 mm (1.5 in.). When the total depth of recycling exceeds 38 mm (1.5 in.) a 100 mm (4 in.) core sample will be sufficient. The percentage of density required should be based on the depth and degree of mixture control of the recycling process used. Generally, the percentage of density should range from 91 to 94 percent of the theoretical maximum specific gravity.  
\*\*\*\*\*

One 150 mm 6 inches core sample shall be obtained for each [\_\_\_\_\_] square meters yards of hot in-place recycled mixture. The location of the core samples shall be determined according to ASTM D 3665. The density of the cores shall be determined according to either COE CRD-C 650 or ASTM D 2726. The cores shall have a minimum density equal to [\_\_\_\_\_] percent of the theoretical maximum specific gravity determined according to ASTM D 2041.

##### 3.7.2 Grade Conformance

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NOTE: For pavements in aircraft traffic areas, such

as airfield runways and taxiways, lines of levels to determine elevation of the planned pavement will be run longitudinally and transversely at intervals not exceeding 7.62 meters (25 feet).

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The finished surface of the recycled pavement shall be tested, for conformance with the plan-grade requirements and acceptance in the presence of the Contracting Officer, by running lines of levels at intervals of [\_\_\_\_\_] meters feet longitudinally and [\_\_\_\_\_] meters feet transversely to determine the elevation of the completed pavement. The finished surface shall not vary more than 15 mm 0.05 foot from the established plan grade line and elevation. Finished surfaces at junctures with other pavements shall coincide with finished surfaces of abutting pavements.

### 3.7.3 Surface-Smoothness

After completion of the recycling operation, the finished surface will be tested by the Government using the straightedge. Location and deviation from straightedge of all measurements will be recorded. Other approved devices may be used provided that, when satisfactorily and properly operated, such devices reveal all surface irregularities exceeding the tolerances specified. Surface irregularities that depart from the testing edge by more than 6 mm 1/4 inch shall be corrected as directed.

-- End of Section --