
USACE / NAVFAC / AFCESA / NASA UFGS-32 01 24 (August 2008)

Preparing Activity: USACE Superseding
UFGS-32 01 24 (April 2006)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated April 2009

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SECTION 32 01 24

HOT IN-PLACE RECYCLING OF BITUMINOUS PAVEMENTS
08/08

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

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 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).

PART 1 GENERAL

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.

1.1 MEASUREMENT AND PAYMENT PROCEDURES

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.

1.1.1 In-Place Recycled Mixture

The quantity of hot in-place recycling paid for will 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.

1.1.2 New Asphalt Concrete

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

1.1.3 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.

1.2 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 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 within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM C 117	(2004) Standard Test Method for Materials Finer than 75-um (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C 136	(2006) Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM D 140	(2001; R 2007) Sampling Bituminous Materials
ASTM D 1856	(1995a; R 2003) Recovery of Asphalt from Solution by Abson Method
ASTM D 2041	(2003a) Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures
ASTM D 2170	(2007) Kinematic Viscosity of Asphalts (Bitumens)
ASTM D 2171	(2007) Viscosity of Asphalts by Vacuum Capillary Viscometer
ASTM D 2172	(2005) Quantitative Extraction of Bitumen from Bituminous Paving Mixtures
ASTM D 2726	(2008) Bulk Specific Gravity and Density of Non-Absorptive Compacted Bituminous Mixtures
ASTM D 3381	(2005) Viscosity-Graded Asphalt Cement for Use in Pavement Construction
ASTM D 3665	(2007) Random Sampling of Construction Materials
ASTM D 4552	(1992; R 2004) Classifying Hot-Mix Recycling Agents
ASTM D 75	(2003) Standard Practice for Sampling Aggregates
ASTM D 946	(1982; R 2005) 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
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1.3 SYSTEM DESCRIPTION

1.3.1 Equipment, Tools, and Machines

Maintain equipment, tools, and machines used in the performance of the work in a satisfactory working condition at all times, and in conformance with applicable governing regulations for local air pollution controls. Provide equipment capable of performing recycling operations at a minimum rate of 600 square meters 720 square yards per hour to the depth required.

1.3.2 Heating

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

1.3.3 Scarifying/Milling

Provide scarifying or hot milling equipment that is 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. Provide equipment with height adjustments to clear obstacles in the pavement.

1.3.4 Distribution and Mixing

Provide at least one unit of the recycling equipment 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 L/square meter 0.05 gallons/square yard. Heat the recycling agent, at the time of application, to within plus or minus 14 degrees C 25 degrees F of the temperature of the recycled mixture.

1.3.5 Placement

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.

Provide a unit capable of spreading and leveling the recycled mixture uniformly across the processed width and with a vibratory or tamping screed to finish the recycled mixture surface.

1.3.6 Straightedge

Furnish and maintain at the site, in good condition, one 3.66 meter 12 foot straightedge for each finishing unit (paver) for testing the finished surface. Make straightedges available for Government use. Straightedges shall be constructed of aluminum or other lightweight metal, with blades of box or box-girder cross section with flat bottom, reinforced to insure rigidity and accuracy and with handles to facilitate movement on the pavement.

1.4 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. Submittals should be kept to the minimum required for adequate quality control.

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, Air Force, and NASA projects.

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" designation; submittals not having a "G" designation are for [Contractor Quality Control approval.] [information only. When used, a designation following the "G" designation identifies the office that will review the submittal for the Government.] Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-04 Samples

Samples

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 gal sample of recycling agent. Submit all samples not less than [30] [_____] days before the material is required in the work.

SD-06 Test Reports

Field Testing and Sampling

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. Include with the test reports 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 QUALITY ASSURANCE

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.

1.5.1 Initial Sampling and Testing

Perform sampling and testing using a commercial testing laboratory or 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 will 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.

1.5.2 Samples

Take recyclable asphalt pavement for laboratory tests 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, obtain samples from the existing pavement from at least two locations to provide materials representative of the pavement. Use these samples 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).] Furnish the JMF to the Contracting Officer within 30 days after the award of the contract and prior to the start of recycling operations.

1.6 ENVIRONMENTAL REQUIREMENTS

Perform hot in-place recycling procedures only when the existing pavement

is dry and the pavement surface temperature is above 15 degrees C 60 degrees F.

PART 2 PRODUCTS

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 32 10 00 BITUMINOUS CONCRETE PAVEMENT or Section 32 12 15 HOT-MIX ASPHALT (HMA) FOR AIRFIELDS.

2.1 RECYCLING AGENTS

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

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

2.2 JOB-MIX FORMULA

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 32 10 00 BITUMINOUS CONCRETE PAVEMENT or Section 32 12 15 HOT-MIX ASPHALT (HMA) FOR AIRFIELDS 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.

a. [The Government will provide information on the existing asphalt concrete pavement to allow the Contractor to develop a JMF for the recycled mixture.] [Furnish, for acceptance, a JMF to the Contracting Officer meeting the requirements of Section [32 10 00 BITUMINOUS CONCRETE PAVEMENT] [32 12 15 HOT-MIX ASPHALT (HMA) FOR AIRFIELDS].] The Contracting Officer will verify this JMF through samples of materials submitted by the Contractor.

b. 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.

c. Develop the JMF by combining various percentages of the selected recycling agent with the existing pavement material. Increase the amount of recycling agent in the recycled mixture 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, extract the asphalt cement from the samples made and recovered according to ASTM D 2172 and ASTM D 1856, respectively.

d. Obtain the viscosity of the recovered asphalt cements 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.

e. 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 [32 10 00 BITUMINOUS CONCRETE PAVEMENT] [32 12 15 HOT-MIX ASPHALT (HMA) FOR AIRFIELDS]].

PART 3 EXECUTION

3.1 PREPARATION OF SURFACE

Prior to recycling, clean the pavement surface 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

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.

Provide heating units of sufficient number and size to heat the pavement surface as required for successful scarifying and/or hot milling to the required depth. Do not allow these units to overheat the existing pavement. Generate sufficient heat 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

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.

3.3.1 Single-Pass Method

Perform the single-pass method consisting 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). Automatically feed the reclaimed material into a mixing unit. Add a recycling agent and, when required, new asphalt concrete to the reclaimed material at the mixer. Specify the type and quantity of the new asphalt concrete and the proportion of new material and reclaimed material in the JMF. Thoroughly mix all materials while maintaining the minimum temperature of 115 degrees C 240 degrees F. After [mixing, the combined bituminous material] [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)]. Place a layer of new hot bituminous pavement material conforming to the JMF 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 has 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

Perform the multiple-pass method consisting 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. Control the heating 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. Apply a wearing

course meeting the requirements of Section [32 10 00 BITUMINOUS CONCRETE PAVEMENT] [32 12 15 HOT-MIX AASPHALT (HMA) FOR AIRFIELDS] following completion of the recycling process.

3.4 JOINTS

Heat the existing pavement 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

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.

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

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.

Prior to the start of the recycling, recycle a length of pavement at least 15 meters 50 feet long to the depth required in the project. At the direction of the Contracting Officer, place this test section 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. Begin full production if tests

results are satisfactory, and as approved by the Contracting Officer. If the test section was constructed within the project boundaries, keep it in place as part of the completed pavement. If tests indicate that the pavement does not conform to specification requirements, make necessary adjustments to operations and procedures immediately, and construct another test section, all at no additional cost to the Government. Construct additional test sections, as necessary and as directed by the Contracting Officer, to be sampled and tested for conformance with specification requirements. Do not start full production without test section approval by the Contracting Officer.

3.7 ACCEPTABILITY OF WORK

3.7.1 Field Testing and Sampling

Perform field tests in sufficient numbers to ensure that the specifications are being met. Testing is the Contractor's responsibility to be performed by an approved commercial laboratory. Perform the following tests at the appropriate time; they will be the minimum acceptable for each type of operation.

3.7.1.1 Mixture Properties

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.

[Obtain a sample of the recycled mixture for every [_____] hours of mix production. Extract the asphalt cement 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. Determine the gradation of the extracted aggregate according to [ASTM C 117](#) and [ASTM C 136](#). The extracted gradation shall meet the JMF and the corresponding tolerances.]
[Record the amount of recycling agent used per day along with the square meter yard area recycled. Use these values to verify that the correct amount of recycling agent is being added to the recycled mixture.]

3.7.1.2 Density Testing

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.

Obtain one [150 mm 6 inches](#) core sample for each [_____] square [meters yards](#) of hot in-place recycled mixture. Determine the location of the core

samples 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

NOTE: For pavements in aircraft traffic areas, such as airfield runways and taxiways, lines of levels to determine elevation of the planed pavement will be run longitudinally and transversely at intervals not exceeding 7.62 meters (25 feet).

Test the finished surface of the recycled pavement, 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. Correct surface irregularities that depart from the testing edge by more than 6 mm 1/4 inch as directed.

-- End of Section --