April 19, 2005 Matls. IM 504
Supersedes April 20, 2004

# COLD-IN-PLACE HOT MIX ASPHALT (HMA) RECYCLING

## GENERAL

Cold-in-place recycling is a method of reusing the HMA surface. No material is wasted or removed. All work takes place on the existing roadway. The existing HMA surface material is scarified to the specified depth, sized to the specified gradation (or maximum particle size) mixed with the specified additives and deposited to the specified width and depth. This shall be accomplished in a continuous movement with the appropriate equipment. The spread material shall be compacted to the required density with rubber-tired and steel-wheeled rollers.

This procedure should be limited to projects with low volume traffic (i.e., under 2000 vpd and a structurally adequate road). (**NOTE:** Projects with insufficient subgrade support should not be candidates for this type of rehabilitation.) A minimum 2-inch (50-mm) wearing surface should be placed over this base to preserve its integrity.

This IM supports Standard Specification 2318. It is not compatible with DS-01024.

## JOB MIX FORMULA

The emulsion added is to be approximately 0.3 gal/yd.²/in. (1.4 L/m²/25 mm) of compacted thickness as a starting point. Final adjustment of asphalt content is to be made to obtain a durable base (based on the need to minimize deformation and cracking).

## CALIBRATING & MONITORING REJUVENATING AGENT RATE OF FLOW

The contactor shall provide a positive means of accurately metering the rate of flow and total delivery of the rejuvenating agent. This shall be monitored by yield checks during construction to verify the rate of application.

The contractor may use the delivery pump as one of the options to determine total gallons of rejuvenating agent used on the project.

Pump accuracy is determined by comparing a metered volume or weight, correcting for temperature, against a known volume or weight. The pump must consistently deliver within ± 1.5% of the required gallons delivered.

If the contractor elects to use delivery ticket quantities, calibration of the pump would not be necessary.

The yield is determined by comparing the number of gallons of rejuvenating agent used to that required for the square yards per inch of compacted thickness as measured. Yield shall be within ± 0.5% of the rate as determined by the Engineer. Use Form #CIR-1, Yield Check to verify the rate of application by yield check.

## EMULSION SAMPLING

A one-quart (one-liter) sample of emulsion shall be obtained each day. The sample from the first day and each third day shall be forwarded to the District Laboratory for testing. The other samples shall be retained for submission in the event of a failing test.

1. The laboratory will determine the percent residue of the emulsion sample. The Central Materials Laboratory may conduct further qualifying tests.

## MIXTURE SAMPLING

Sample recycled material from the roadway using sampling methods described in Materials IM 322. Three 30-lb. (15-kg) samples placed in separate airtight bags or containers will be required per day. The sample must be taken from the roadway after the material has been mixed and leveled by the screed and before rolling.

The first sample of the day shall be promptly delivered to the appropriate District Laboratory for Marshall Density determination. The remaining two samples of the day may be sent the following day as "back-up."

## LABORATORY TESTING PROCEDURE

1. The appropriate laboratory receives a 30-lb. (15-kg) sample and removes a 2000 -2500-gram sample for determining the maximum specific gravity (Rice Method IM 350).

2. The moisture content of the Maximum Specific Gravity sample is determined by drying the entire sample to a constant dry mass in an oven at a temperature not to exceed 275°F (135°C).

   Moisture determination will be calculated using the following formula:

$$\%\,\text{MOISTURE} = \frac{(\text{WET MASS RICE SAMPLE - DRY WT. RICE SAMPLE})(100)}{\text{DRY MASS RICE SAMPLE}}$$

   **NOTE:** All weighing of the sample shall be recorded to the nearest 0.5 gm.

   Example:

   Given Wet Mass Rice Sample = 2250 gms
   Given Dry Mass Rice Sample = 2185 gms

$$\%\ \text{MOISTURE} = \frac{(2250 - 2185)(100)}{2185} = 3.0\%$$

The materials used in determining the moisture content will also be used to determine the Maximum Specific Gravity (Rice Method IM 350).

3. The remainder of this 30-lb. (15-kg) sample shall be used to compact Marshall Density specimens using the Marshall hammer. Molds shall be at room temperature. Do not use paper disks. Plastic or wax paper disks will work, or the base and pounding head may be coated with a thin layer of light oil and no disks used.

4. Marshall molds shall be pre-measured and pre-weighed. Determine the mass of each mold to be used to the nearest 0.5 gram. Determine the inside diameter of each mold to the nearest 0.001 in. (0.025 mm). (The Central Laboratory can do this.) Prepare volume tables from the diameter measurement of each mold for heights of the specimen ranging from 2.40 in. (60 mm) to 2.60 in. (65 mm) in 0.01 in. (0.25 mm) increments.

5. Prepare three specimens by using the Marshall hammer and applying 75 blows to each side. Remove the mold from the base and weigh the mold and specimen to the nearest 0.5 gram. Determine the mass of the specimen by subtracting the mass of the mold. Remove the specimen from the mold and measure the height to the nearest 0.001 in. (0.025 mm) using a dial indicator or suitable caliper. Take a minimum of four measurements, average them, and round the average to the nearest 0.01 in. (0.25 mm).

   If the specimen is too tender to handle or distorts when removed from the mold, the following alternate procedure may be used to determine the height of the specimen:

   Determine the height of the plateau on the base (This is the area of the base that the mold fits over.) to the nearest 0.001 in. (0.025 mm). While pounding, the collar must be kept firmly in place on top of the mold for both sides in order to keep the mold firmly against the base. When compaction is completed, remove the collar, but do not remove the mold from the base. Using a straightedge of known thickness laid across the mold measure down to the specimen avoiding any surface voids that would affect the readings. Take a minimum of four measurements. The height of the specimen can be determined by subtracting the height of the plateau and the average of the measurements from the height of the mold used, then adding the thickness of the straightedge.

6. Determine the bulk volume of the Marshall specimens using the volume tables prepared for the particular mold used.

$$\text{Laboratory Wet Density (kg/m}^3\text{)} = \frac{\text{Specimen Mass (grams)}}{(\text{Specimen Volume, m}^3\text{})(1000)}$$

$$\text{Laboratory Wet Density (lb./ft.}^3\text{)} = \frac{\text{Specimen Mass (grams)}}{(453.6\ \text{gms/lb.})(\text{Specific Volume, ft.}^3\text{})}$$

Calculate the Dry Marshall Density and the laboratory specific gravity using the following formulas:

$$\text{Dry Marshall Density kg/m}^3\ (\text{lb./ft.}^3) = \frac{\text{Laboratory Wet Density (100)}}{100 + \text{Percent Moisture}}$$

$$\text{Laboratory sp gr} = \frac{\text{Dry Marshall Density (kg/m}^3)}{1000\ (\text{kg/m}^3)} = \frac{\text{Dry Marshall Density (lb./ft}^3)}{62.4\ (\text{lbs./ft.}^3)}$$

$$\text{Percent Voids} = 100 - \frac{(100)(\text{Laboratory sp gr})}{\text{RICE sp gr}}$$

**NOTE:** The terms RICE Sp.Gr. and Maximum Sp.Gr. are synonymous. Variations in Laboratory Sp.Gr. of more than 0.050 between successive samples shall be investigated promptly. Testing of backup samples shall be included in the investigation and test results averaged for the day.

## ROADWAY TESTING PROCEDURE

1. The project inspection personnel shall select and mark the field density test locations by dividing the day's run into seven equal subsections. A random spot in each subsection shall be selected for moisture and density testing. Determine the in-place density using the nuclear gauge in direct transmission mode. (Determine moisture in accordance with Materials IM 334.) During the first two day's testing, sample approximately 1000 grams of recycled HMA at each test location to determine the in-place moisture content. Using the nuclear gauge moisture content measurements and the in-place moisture content measurements, determine a correction factor to apply to the subsequent nuclear gauge moisture measurements after at least 10 tests are taken.

   Determine correction factor in kg/m³ (lb./ft.³) using the following formulas:

   Actual in-place moisture in kg/m³ (lb./ft.³) (minimum of 10 sites):

$$\text{Actual Moisture} = \frac{(\text{OVEN DRY \% MOISTURE})(\text{GAUGE WET DENSITY})}{\text{OVEN DRY \% MOISTURE} + 100}$$

   Example:

   Gauge Wet Density = 2090.6 kg/m³ (130.5 lb./ft.³)
   Oven Dry % Moisture = 2.3%

$$\text{Actual In-Place Moisture} = \frac{(2.3)(2090.6)}{2.3 + 100} = \frac{4808.38}{102.3} = 47\ \text{kg/m}^3 = \frac{(2.3)\ \text{x}\ (130.5)}{2.3 + 100} = \frac{300.2}{102.3} = 2.9\ \text{lb./ft.}^3$$

Correction factor in kg/m³ (lb./ft.³):

Determine the average of ten (or more) actual moisture contents obtained using the above equation.

Determine the average of ten (or more) gauge moisture readings obtained at moisture sample sites.

CORRECTION FACTOR = AVG GAUGE MOISTURE - AVG ACTUAL MOISTURE

| | | |
|---|---|---|
| Average of Gauge Moisture | 177.8 | 11.1 |
| Average of Actual In-Place Moisture | - 57.7 | - 3.6 |
| Correction Factor: | 120.1 kg/m³ | 7.5 lb./ft.³ |

This correction factor may seem large due to the fact that the nuclear gauge measures both asphalt and water in the moisture reading. Use Form #CIR-2, Determination of Moisture Correction Factor for showing the determination of a correction factor:

**NOTE:** Any significant change in the characteristics or components of the surface being recycled requires a new correction factor to be established.

2. Determine the dry density of each subsequent test location using the formula:

DRY DENSITY=GAUGE WET DENSITY - GAUGE MOISTURE + CORRECTION FACTOR

**Example:**

| | | | |
|---|---|---|---|
| Field Compacted Gauge Wet Density | 2090.6 | = | 130.5 lb./ft.³ |
| Gauge Moisture | -168.2 | = | -10.5 lb./ft.³ |
| Correction Factor | +120.2 | = | 7.5 lb./ft.³ |

**FIELD COMPACTED DRY DENSITY** 2042.6 kg/m³ = 127.5 lb./ft.³

3. Determine the percent of Dry Marshall Density by the following formula:

$$\%\,\text{Marshall Density} = \frac{\text{Field Compacted Dry Density (100)}}{\text{Marshall Dry Density}}$$

Report percent of density to three significant figures to the right of the decimal.

4. Sections that do not satisfy the minimum density criteria should be immediately re-rolled to achieve the required density.

**DETERMINE IN-PLACE MOISTURE CONTENT**

The in-place moisture content must comply with specifications prior to applying a subsequent surface treatment or HMA overlay. Two samples will be selected within each day's production. The Engineer will select the sample locations. Inclement weather or project conditions may require additional samples representing questionable areas to determine acceptable moisture levels.

Moisture content of the material may be determined by one of the following methods.

1. Nuclear Gauge

Use the same nuclear gauge as was used for density determination taking into account the moisture correction factor.

Nuclear gauge moisture reading is normally indicated in pounds per cubic foot. The following formula will convert that reading to percent moisture. When the nuclear gauge indicates a higher moisture content at some locations, it may be advantageous to use method 2 at those locations to confirm the moisture content.

$$\% \text{ Moisture} = \frac{(\text{gauge moisture lb./ft.}^3 - \text{correction factor lb./ft.}^3)}{\text{Dry Density lb./ft.}^3} \text{ x } 100$$

Example:

$$\% \text{ Moisture} = \frac{(9.1 \text{ lb./ft.}^3 - 7.5 \text{ lb./ft.}^3)}{127.5 \text{ lb./ft.}^3} \text{ x } 100 = 1.3$$

When a different nuclear gauge is used, a new correction factor must be established using the procedure previously noted under roadway testing.

2. Actual In-Place Moisture

Extract 1000 grams of material from the sample location. Dry the entire sample to a constant dry mass in an oven at a temperature not to exceed 275°F (135°C) or on a hot plate at a low temperature setting. Calculate the percent moisture as per IM 501.

**REPORT**

Report daily results on Form #CIR-3, Daily Cold-In-Place Asphalt Recycling Report. All CIR forms can be found in the Asphalt Section of the DOT Web Page.