SPECIAL PROVISIONS
FOR
HOT IN-PLACE RECYCLING

Keokuk County
STP-022-1(11)--2C-54
STP-149-1(84)--2C-54

Effective Date
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THE STANDARD SPECIFICATIONS, SERIES 2015, ARE BY THE FOLLOWING MODIFICATIONS AND ADDITIONS. THESE ARE SPECIAL PROVISIONS AND THEY SHALL PREVAIL OVER THOSE PUBLISHED IN THE STANDARD SPECIFICATIONS.

150472.01 DESCRIPTON.

Recycle the existing asphalt pavement surface by Hot In-Place Recycling (HIR), and place surfacing materials per plan.

A. Prepare the existing asphalt surface.

B. Soften the surface by uniform heating, scarify, and thoroughly mix with an asphalt rejuvenating agent (ARA).

C. Spread, level, and compact the mixture in preparation for surfacing.

D. Furnish and place surfacing material.

150472.02 MATERIALS.

A. Asphalt Rejuvenating Agent.

1. General Requirements.
Perform inspection and acceptance of emulsified asphalt according to Materials I.M. 437.

2. Material Properties.
Use an asphalt rejuvenating agent composed of a polymer modified asphalt emulsion. Modify the asphalt base stock with a minimum of 1.5% styrene-butadiene solution polymer. Blend the polymer modified base stock with process oils or other additives before emulsification to achieve the desired finished product properties. The material must comply with the following physical and chemical requirements in Table SP-150472.02-1. The Engineer may verify SB content with FTIR or other analyses.

Table SP-150472.02-1: ARA Properties

Property	ARA	
	Min.	Max.
Viscosity, Saybolt-Furol @ 25°C	15	100
Residue from distillation[1], percent	60	--
Storage Stability Test, 24 hour, percent	---	1
Sieve Test, 850 µm mesh (No. 20), percent	---	0.10
Oil distillate by volume of emulsion, percent	---	2
Tests on Residue from Distillation:		
Penetration @ 4°C, 100 g, 5 seconds, dmm	50	150
Elastic Recovery, AASHTO T301, 4ºC, percent	60	
% Asphaltenes, ASTM D3279, D4124 or D6560	---	15

1. Use modified AASHTO T 59 procedure – distillation temperature of 350°F with a 20 minute hold.

B. HIR Mixture.

1. Estimated Application Rate.
See Table SP-150472.02-2 for estimating quantities.

Table SP-150472.02-2: Estimated ARA Application Rates

HIR Plan Thickness (inches)	ARA[1] Application Rate (gallons per square yard)
1.5	0.26
2.0	0.35

1. Use 8.35 pounds per gallon (at 60°F) to estimate ARA by weight. Production application rate is determined by the approved mix design.

2. Contractor Mix Design.

a. When the specified thickness of the HIR is greater than or equal to 2 inches, perform and submit a mix design according to Appendix A.
b. The Contractor is responsible for the mix design.
c. The contractor is responsible for obtaining samples from the existing pavement which includes providing traffic control approved by the Engineer. The Engineer may restrict lane closure times based on traffic volumes.
d. Submit a completed mix design for approval to the materials lab designated by the Contracting Authority (normally District Materials). Submit supporting documentation demonstrating the design process was followed and how the recommended ARA content was determined. Include trial and final proposed proportions and corresponding performance testing data. In addition, submit upon request sufficient loose mixture and individual material samples for approval of the design.
e. Personnel preparing the mix design shall be Iowa DOT certified in HMA Level II.
f. An approved mix design will be required prior to beginning HIR production.

150472.03 Construction.

A. Equipment.

1. **Pre-heating Milling Unit.**
   Use a self-propelled heating unit, adjustable in width, with ports permitting fuel and forced air injection for proper combustion without excessive smoke. The unit shall be under a closed or shielded hood, capable of heating asphalt pavement to a temperature that allows milling or scarifying to the specified depths at a rate of at least 1500 square yards per hour over a minimum one lane width of 12 feet. Equip each unit with a water spray system used to wet the adjacent vegetation. Where milling/scarifying to an existing curb and gutter line is required, equip the unit to mill/scarify, and move away from gutter aprons. Ensure continuous and undiminished pavement contact without damaging utility accesses and valve boxes.

2. **Heating Milling Unit.**
   Use a self-propelled unit capable of milling, heating and windrowing the asphalt pavement that is being processed, and meeting Article SP-150472.03, A, 1.

3. **Heating Scarifying Unit.**
   Use a self-propelled unit capable of heating and scarifying the asphalt pavement with pressure loaded rakes or scarifiers, and meeting Article SP-150472.03, A, 1.

4. **Tunnel Heater.**
   Use a self-propelled unit capable of heating the underlying pavement while shielding previously milled material from direct flame, preventing the material from catching fire and meeting Article SP-150472.03, A, 1.

5. **Distributor-Paving Unit.**
   Use a single unit that uniformly distributes the rejuvenator at the stipulated rate onto the scarified or milled material and mixes them together using a minimum of 2 telescopic milling heads. Screed and finish the scarified or milled material similar to an asphalt paver specified in Article 2001.19 of the Standard Specifications.

6. **Milling-Mixing-Paving Unit.**
   Use a unit complying with Article SP-150472.03, A, 2. Add rejuvenator uniformly at the stipulated rate onto the scarified or milled material and mix with a minimum of two telescopic milling heads. Alternatively, the rejuvenator may be added directly to the milling heads provided the applied rate is uniform across the width of the HIR material. The equipment shall also screed and finish the scarified or milled material similar to an asphalt paver specified in Article 2001.19 of the Standard Specifications. Alternatively, a self-propelled independent paver complying with the asphalt paver specification in Article 2001.19 of the Standard Specifications may be used after the mixing operation.

7. **Construction Equipment for Placing Surface Material.**
   Use equipment complying with the Article which matches the intended use.

B. Preparation.

1. Complete base repair, if required, according to Section 2212 of the Standard Specifications.

2. Clean surface such that it is free of trash, debris, earth, fabric, oils or other deleterious substances present in sufficient quantity to interfere with the work

C. Heating and Scarification / Milling.

1. Provide adequate provisions for equipment calibration.

2. Uniformly heat the existing pavement to a minimum of 190°F and recycle to the specified depth in a continuously moving operation for the full width designated in the contract documents.

3. Use a series of heaters and milling/scarifying units to ensure the existing pavement does not char or become damaged.

4. When the depth of the HIR is more than 1 inch, heat the material in lifts not more than 3/4 inches.

5. When heating in multiple lifts, remove each lift at a uniform depth across the full width of the recycled pavement. This material may be windrowed when heating the next lift.

6. For equipment breakdowns, remove from the roadway milled or scarified material that cannot be placed with a paving unit. Bring these removed areas to grade using HMA approved by the Engineer.

7. Maintain temperature of the HIR directly behind the paver, between 190°F and 300°F. HIR temperatures taken within 2 feet of each other, transverse to the roadway, shall not vary by more than 30°F. HIR temperatures taken within 10 feet of each another, transverse to the roadway, shall not vary by more than 50°F.

8. If the Contractor can't meet the temperature requirements within 1 hour after the discrepancy is discovered, the HIR train will be stopped and the Engineer and Contractor will determine a course of action to correct the deficiency before the HIR train proceeds.

9. Control the heating operation to prevent open flames from exiting from under the heater.

10. The Engineer may require that the operation be stopped when:
- **a.** The prevailing wind velocity exceeds approximately 10 mph and a potential hazard exists.
- **b.** Smoke is being produced continuously (except when passing over a maintenance patch).
- **c.** Flaming on the roadway or in the windrow that does not extinguish on its own within 10 seconds.
- **d.** Temperature uniformity is not continuously achieved.
- **e.** The Engineer determines flaming is detrimental to the final product.

11. When production is stopped, operations will resume when the Contractor modifies the operation and can demonstrate acceptable results without excessive smoke or flames on the pavement or in the windrows.

D. Mixing the HIR Material.

1. Immediately following heating and scarifying, apply the ARA to the material at the specified rate. The Engineer may vary the application rate as required by existing conditions.

2. Mix the material to achieve uniform coating.

E. Placement of the HIR Material.

1. Following the heater scarification, level the surface to provide a uniform cross slope.

2. Use an asphalt paving machine meeting the requirements of Article 2001.19 of the Standard Specifications. Follow the scarifier as closely as possible to redistribute and level the scarified material.

F. Compaction and Density.

1. Comply with the following minimum field densities:

- Interstate and Primary Roads: 95% of laboratory density based on the dry weight of the compacted material according to Appendix A.
- All other roads: 93%

2. Complete a test strip to establish an effective rolling pattern resulting in complying densities. Limit the test strip to ½ day's production.

G. Opening HIR Layer to Traffic.

1. Do not open to traffic until the mat has cooled to ambient temperatures.

2. The Contractor has 14 days after the HIR layer is complete and initially cured to place the first lift of HMA overlay or specified surface treatment. If the first lift is placed after the 14 calendar day period and the HIR layer shows damage, correct the damage, at no additional cost to the Contracting Authority, before placing the lift.

H. Placement of Surface Course.

1. Allow minimum 1 week prior to placing surface material.

2. Place surface material in accordance with Iowa DOT specifications.

3. Ensure finished cross slope is a plane surface with a slope as shown.

4. Ensure all edges, radii, and handwork have a neat and finished appearance.

I. Quality Control.

1. The Contractor is responsible for quality control of the materials and HIR process. Perform testing according to Appendix C. Take samples and deliver them to the District Materials Laboratory according to Appendix A. A lot, for quality control sampling and testing, is defined as each day of HIR operation.

2. Sample and test the ARA according to Appendix C.

3. Apply ARA at the target application rate within ± 0.06 gallon per square yard per inch.

4. If required by the Engineer, measure the profile of the center of each lane of the compacted HIR mat with a profilograph. Correct, at no additional cost to the Contracting Authority, bumps and dips in the profile greater than 1 inch in 25 feet. Ensure the cross-slope of the compacted HIR mat is within 0.4% of the desired slope. Payment will be $400 per lane-mile for profiling the length directed by the Engineer.

5. Perform nuclear gauge moisture and density tests according to Appendix A within 24 hours of completing each lot at locations determined by the Engineer. During each lot of HIR production, furnish a 40 pound sample of loose HIR mixture, sealed in plastic, from a location the Engineer determines. Repair sampling areas by placing and compacting HMA or other material approved by the Engineer. Each day, deliver the sample as soon as possible after sampling to the District Materials Laboratory for density determination. The Quality Index for density does not apply. Recompact sublots that do not achieve the minimum required density. Recompact them within 2 calendar days after the HIR layer was placed to meet the target density.

6. Achieve the maximum density before the temperature of the HIR falls below 160°F. Do not crush the aggregate. When the mat temperature falls below 160°F, roller marks may be removed from the mat with a self-propelled Smooth-Faced Steel Roller operated in static

mode. If there is a significant change in factors affecting density, such as weather or compaction equipment, the Engineer will reevaluate and modify the rolling procedure as required. Stop the HIR operation whenever rolling is not being performed according to the approved rolling procedure.

7. The Engineer will check the thickness of the recycling process immediately behind the paver with a maximum of one test per lane/station. The Engineer shall determine the location of the testing not to exceed the one test per lane/station. The Contractor shall provide the Engineer with a probe to measure the thickness of the mat. The probe will be of such a design and length to facilitate the Engineer the ability to check the mat thickness behind the paver without walking on the mat. The moving average of three consecutive tests shall equal or exceed the contract depth. Any three consecutive tests can be considered a moving average. If the 3-point moving average is less than the contract depth, The Engineer will assess a price reduction using the Equation 1. The price reduction will correspond to those square yards within the 3-point moving average that were deficient in depth. If the Contracting Authority determines that recycling to the contract depth would be detrimental to the project the unit price will be negotiated for the reduced depth before proceeding with the project.

Equation 1: $P = X (S) [1-M/T]$
Where:
P is the Penalty (negative penalty shall be considered as 0)
S is the number of square yards
M is the measured depth
T is the Plan Depth
X is the unit bid price for Hot-In-Place Recycling plus the design Asphalt Rejuvenating Agent cost per square yard of roadway.

If the next two depth checks are below the plan thickness after a failing moving average, the Contractor shall stop production and evaluate the process with the Engineer. Adjustments to the process shall be made to the satisfaction of the Engineer before production resumes.

J. Safety Procedures.

1. Prior to construction in cities, towns, or built up areas; contact the fire chief to solicit a recommended safety procedure to be followed. In addition to any other recommendations, follow the procedure below:
- **a.** Ensure owners of underground utilities in the areas have checked the areas for possible gas leaks in or around their lines.
- **b.** Ensure the city has checked storm sewers and sanitary sewers in the area for accumulations of sewer gas.
- **c.** Ensure service stations and other businesses handling flammable fuels have been advised not to dispense these fuels while the heater burner is being operated within 100 feet of their business places.
- **d.** Plan the operation so as to be as safe as possible for persons and property adjacent to the work, including the traveling public. Keep this route open to traffic. Limit the operation so as to provide for this traffic. Work may need to be conducted during periods of light traffic.

2. The Contractor shall hold the Contracting Authority and State harmless for any damage or loss resulting from an accident, during the heating operation, caused by failure to fulfill the obligations as outlined in these requirements.

K. Limitations.

1. HIR shall only take place between May 1 and September 30.

2. Do not perform HIR operations when the roadway surface is wet, frozen or if the weather conditions prevent proper handling, finishing and compacting of the asphalt mixture.

3. Do not perform HIR operations until the minimum ambient air temperature is 50°F and the minimum surface temperature is 55°F.

4. Cover HIR surfaces with at least one full lift of the specified surfacing material prior to winter shutdown.

L. Pavement Smoothness.
Section 2317 of the Standard Specifications applies to the HMA finished surface.

150472.04 Method of Measurement.

A. Hot In-Place Recycling Asphalt Pavement.
Square yards computed from the measured longitudinal length of pavement and the width of the pavement specified in the contract documents.

B. Asphalt Rejuvenating Agent.
Tons through a calibrated pump used for metering the total delivery of the Asphalt Rejuvenating Agent or through delivery ticket quantity.

150472.05 Basis of Payment.

A. Hot In-Place Recycling Asphalt Pavement.

1. Per square yard for Hot In-Place Recycled Asphalt Pavement.

2. The payment is full compensation for all labor, material, heating, scarifying/milling, processing, addition and mixing of the asphalt rejuvenating agent asphalt, shaping, compaction, finishing, vegetation removal, roadway sweeping, obtaining and delivering bulk sample for mix design, quality control, tests strips, equipment, tools and incidentals for the completed Hot In-Place Recycled Asphalt Pavement.

B. Asphalt Rejuvenating Agent.

1. Per ton of Asphalt Rejuvenating Agent.

2. Payment is for full compensation for all labor, materials and equipment necessary for furnishing the asphalt rejuvenating agent.

APPENDIX A - HOT IN-PLACE RECYCLING OF FLEXIBLE PAVEMENT

GENERAL

Hot in-place recycling (HIR) is a method of rehabilitating the existing flexible pavement surface. As an “in-place” technology, all work takes place on the roadway using the existing asphalt pavement. Generally, material is not wasted or removed. The existing asphalt surface material is softened by uniform heating, scarified to the specified depth, mixed with an asphalt rejuvenating agent, spread, leveled, and compacted to the specified depth, profile, and cross-slope. This is accomplished in a continuous single-pass operation with the appropriate equipment. The HIR layer is compacted to the required density. As part of the project, the HIR layer is covered with a new surface that may be an HMA overlay or thin surface treatment.

MATERIAL SAMPLING FOR MIX DESIGN

The mix design establishes the optimum rate of rejuvenating agent.

ASPHALT REJUVENATING AGENT (ARA)

A minimum 10 gallon sample is needed from the proposed approved source to prepare the replicates for the range of application rates. ARA shall meet the requirements of the specification and Materials I.M. 437.

EXISTING PAVEMENT

Submit a schedule, sampling plan, and traffic control plan to the Engineer for approval 7 days prior to sampling. Obtain 6 inch cores cut to a depth that represents the entire thickness of the HIR layer. Trim cores to remove aggregate and other material that will not be utilized in the HIR layer.

DEVELOPING THE MIX DESIGN

The contractor performs the mix design in accordance with Appendix B. A series of tests are used to measure the properties of the mixture and determine an optimum ARA rate.

FIELD CONTROL OF ASPHALT REJUVENATING AGENT (ARA)

CALIBRATE AND MONITOR ARA RATE OF FLOW

The contactor shall provide a positive means of accurately metering the rate of flow and total delivery of the ARA. The Engineer should verify the rate of application with production yield checks during construction.

The contractor may use the delivery pump as one of the options to determine total gallons of ARA 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 with in ± 1.5% of the required gallons. If the contractor elects to use delivery ticket quantities and production yield, calibration of the pump would not be necessary.

The production yield is determined by comparing the quantity of ARA used to the quantity required for the square yards per inch (square meters per centimeter) of compacted thickness as measured. Production yield shall be within the specified tolerance of the target application rate. The application rate specifies the quantity of ARA added to the RAP volume. Check to verify the rate of application by yield check.

ADJUSTMENT OF ARA CONTENT

The Engineer must approve any revision in the ARA content. Changes in the content, particularly a reduction, may have a significant impact on the long term performance of the HIR layer. The Engineer and Contractor should consider adjustments to the HIR operations before reducing the asphalt stabilizing agent content.

ARA SAMPLING

A one-quart sample of ARA shall be obtained each day. The sample from the first day and one each week shall be forwarded to the District Materials Engineer for testing. The other samples shall be retained for submission in the event of a failing test. The District Materials Laboratory will determine the percent residual binder of the emulsion sample or perform DSR tests on binder samples. The Central Materials Laboratory may conduct further qualifying tests as required in Appendix C.

The sample should be taken from the last point prior to incorporation. Do not sample from the asphalt supplier's tanker. Sample from the tanker that is part of the HIR train. A plastic bottle must be used to sample emulsions and a metal tin must be used for hot asphalt binder.

Samples of loose HIR mixture and ARA must be taken by someone with a minimum of a HMA Sampler Certification.

FIELD CONTROL OF HIR MIXTURE

MIXTURE SAMPLING

Sample loose HIR mixture from the roadway using sampling methods described in Materials I.M. 322. One 40 pound sample placed in an airtight bag or container will be required per day. Each sample must be taken from the roadway after the RAP and ARA have been mixed and placed by the screed and before rolling.

The sample shall be promptly delivered to the District Materials Laboratory for density determination. Additional samples should be taken when a significant change in the RAP or HIR mixture occurs.

LABORATORY TESTING PROCEDURE

1. Remove a representative 1000 g sample to determine the moisture content of the mixture. Dry the entire sample to a constant dry mass in an oven at a temperature not to exceed 275°F. Record all weight measurements to the nearest 0.5 g.

Moisture content will be calculated using the following formula:

$$\%\,\text{Moisture} = \frac{(\text{Wet Sample Mass - Dry Sample Mass})}{\text{Dry Sample Mass}} \times 100$$

Example: Given: Wet Sample Mass = 1017.0 g
Given: Dry Sample Mass = 985.5 g

$$\%\ \text{Moisture} = \frac{(1017.0 - 985.5)}{985.5} \times 100 = 3.2\%$$

2. Split the remainder of the bulk sample and prepare two 4000 g gyratory specimen for 6 inch diameter gyratory molds from each split sample. Molds shall be at room temperature. Do not use paper disks. Use plastic disks, wax-paper disks, or coat the base and head plate with a thin layer of light oil. Compact each sample to 30 gyrations. Determine the bulk wet density of the compacted specimen as follows.

3. Pre-weigh the gyratory mold with the base plate. Determine the mass of each mold to the nearest 0.5 g. Charge the mold with the HIR mixture and record the total mass to the nearest 0.5 g. Determine the mass of the specimen by subtracting the mass of the mold and base plate. The height of the specimen may be recorded from the gyratory compactor at the completion of the compaction process.

The required height, of the compacted specimen, is 115 $\pm$ 5 mm. If the height needs to be adjusted, the amount of HIR needed is determined by the following formula:

$$\text{Adjusted weight of the mixture} = \frac{115\ (\text{weight of mixture used})}{\text{Specimen height obtained}}$$

4. Compute the laboratory wet density using the following equation.

$$\text{Gyratory Laboratory Wet Density (kg/m}^3) = \frac{\text{Specimen Mass (g)}}{\text{Specimen Height (mm)}} \times 56.588$$

$$\text{Gyratory Laboratory Wet Density (lb/ft}^3) = \text{metric wet density (kg/m}^3) \times 0.062436$$

5. Compute the laboratory dry density using the following equation.

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

NOTE: A difference in the character of the HIR (Coarser or finer) or wet weather conditions can affect the laboratory density. Variations in laboratory dry density of more than 3 pounds per cubic foot between successive samples shall be investigated promptly.

If the investigation determines the character of the HIR has changed, the corresponding dry density result representing the lot shall be used. An identifiable difference in pavement may be the cause of the change.

Unexplained variations or variations caused by rain, affecting the dry density by more than 3 pounds per cubic foot for successive Lots, shall be averaged with the previous days dry density result. The average of both days will be reported as the dry density result representing the current day's lot.

FIELD DENSITY TESTING PROCEDURE

The project inspection personnel shall select and mark the field density test locations. Each day of HIR production shall be divided into approximately equal sublots per Appendix C. A random location in each sublot shall be selected for moisture and density testing.

The Contractor will determine the in-place density and moisture using a nuclear gauge in direct transmission mode at the maximum allowable probe depth in accordance with Materials I.M.

334. The nuclear gauge moisture measurements shall be adjusted by the correction factor below to account for the asphalt binder in the mixture. The dry density and percent of lab density of each test location is determined using the following equations. Report both values to one decimal place. Sublots that do not achieve the specified minimum percent density should be re-rolled immediately and re-tested. The optimum condition for re-rolling is when the HIR layer is warm (typically in the afternoon). The Engineer may require adjustments to moisture application rates.

Field Compacted Dry Density = Gauge Wet Density – Gauge Moisture

$$\text{Percent Laboratory Density} = \frac{\text{Field Compacted Dry Density}}{\text{Laboratory Gyratory Dry Density}} \times 100$$

Example:			
Field Compacted Gauge Wet Density	2090.6	=	130.5
Gauge Moisture	-168.2	=	-10.5
Correction Factor	+120.2	=	7.5
Field Compacted Dry Density	2042.6 kg/m³	=	127.5 lb./ft.³

APPENDIX B - MIX DESIGN METHOD FOR HIR WITH ASPHALT REJUVENATING AGENT

GENERAL

The mix design for HIR is performed by the Contractor. The primary steps in the mix design process are:

- Process, dry, sieve, and blend the roadway samples.
- Prepare, compact, cure, and test HIR mixtures over a range of ARA contents.
- Determine the optimum ARA content for the HIR mixture.
- Report results to the Engineer.

1. PREPARE THE ROADWAY SAMPLES

Crush the cores and combine into a bulk RAP sample. Freezing the cores overnight may aid in crushing efficiency. Dry the bulk sample in open pans at room temperature. Sieve the bulk sample into a minimum of 3 size fractions (+3/8 inch, +1/8 inch, pan) and re-blend to achieve uniformity.

Perform sieve analysis according to Materials I.M. 302 and I.M. 306. Weigh the retained and passing portions of the aggregate, and calculate the percent retained on each sieve split by the following equation:

$$Z = \frac{X}{X + Y} \text{ x } 100$$

Where: "X" = weight of the retained portion, g
"Y" = weight of the passing portion, g
"Z" = percent of the total sample retained

Ensure the following gradation band is met:

Sieve Size	% Passing
1.5 inch	100
1.0 inch	100
3/4 inch	85-95
No. 4	40-55
No. 30	5-15
No. 200	0.5-3

2. MIXTURE BATCHING

Prepare a blending chart with a minimum of 3 ARA contents (use 0.5% by weight of RAP as the first point).

A. Determine the amount of ARA needed for each trial mix batch as follows:

$$ARA\ Weight = \frac{(RAP\ batch\ weight) \times (Target\ ARA\%)}{100 - Target\ ARA\%}$$

B. Separately heat the combined RAP batch and ARA to 245° ± 5°F (118° ± 3°C) as checked by a thermometer in the pan of aggregate. The mixing bowl and utensils shall also be heated before mixing operations begin. Always keep the mixing bowl buttered.

C. Weigh the required amount of RAP into the mixing bowl; Add the required amount of ARA and mix for 20 seconds on speed 1.

D. Lower the mixing bowl and clean the dough hook and the bottom and side of the bowl by scraping with a spatula. Incorporate any adhering mixture or binder back into the sample within 2 minutes from the start of the cleaning operation.

E. Raise the bowl and continue mixing for 15 seconds on speed 2. Then repeat Step D and again stir any adhering mix or ARA back into the sample with the spatula.

F. Break the samples down according to IM 357.

G. Take 2 samples of approximately 5000 gram each for gyratory compaction.

H. Take a sample of a minimum of 2000 gram for G_{mm} determination.

I. Spread the material into a pan such that the material is 1 to 2 inches thick.

J. Test loose mix at each ARA content for maximum specific gravity per IM 350.

3. COMPACT AND CURE MIXTURES

A. Compact specimens immediately after mixing. Do not use paper disks. Use a gyratory compactor with a 4 inch mold at 1.25 degree angle, 87 psi (600 kPa) ram, and 30 gyrations.

B. Place approximately 4700 grams of material into the mold and compact specimens per IM 325G.

C. If necessary, adjust the weight of the sample to achieve the required test specimen height.

$$\text{Adjusted sample weight} = \frac{(\text{trial sample weight})(\text{intended height})}{\text{trial sample height}}$$

D. Adjust the weight of the sample 0.75% for every 1% change in ARA content.

E. Extrude specimens from the molds immediately after compaction. Place each specimen in a small container to account for material loss from the specimens during curing.

F. Cure compacted specimens for 2 hours at 245°F (118°C).

4. PERFORMANCE TESTING

A. Determine bulk specific gravity of each compacted (cured and cooled) specimen according to ASTM D 2726 or equivalent; however, the mass of the specimen in water (measurement C) should be recorded after 1 minute of submersion.

B. Determine specimen heights according to ASTM D 3549 or equivalent. Alternatively, the height can be obtained from the gyratory compactor readout.

C. Sort the specimens into equal sublots based on height and density for further testing.

D. Run AASHTO T322 at the lowest ARA content with the following exceptions:

- Specimens shall be 6 inches in diameter and at least 4 1/2 inches in height and compacted to the design density. Trial specimens are needed to establish the number of gyrations for compacting the 6 inch specimens. Test specimens shall be cured at 245ºF (118°C) for 2 hours. After curing, two specimens shall be cut from each compacted specimen to 2 inches in height.
- Measure the bulk specific gravity of each cut specimen.
- Test two specimens at each of three test temperatures (-22ºC, -10ºC, 0ºC).
- The tensile strength test shall be carried out on each specimen directly after the tensile creep test at the same temperature as the creep test.
- The critical cracking temperature is defined as the intersection of the calculated pavement thermal stress curve (derived from the creep data) and the tensile strength line (the line connecting the results of the average tensile strength at the three temperatures).

E. Run AASHTO T324 at the highest ARA content. Test temperature shall be 40°C. No more than 8 mm of rutting in the first 8000 passes. Follow IM 319 for testing procedure.

F. Run AASHTO T283 at all ARA contents.

5. SELECT OPTIMUM ARA CONTENT

A. Select an ARA content that satisfies the following criteria:

Surface Recycle Mix Design Requirements		
Property	****Test Method**	**Limits**
Air Voids at 30 gyrations, (%)	IM 350, IM 321	Report
Tensile Strength, (psi min)	AASHTO T283	75
Retained Strength based on cured stability, (% min)	AASHTO T283	80
Rut Resistance at 8000 passes, (mm max)	AASHTO T324	8
Thermal Cracking, (°C)	AASHTO T322	-22

6. A copy of the Contractor mix design shall be submitted to the IDOT District Materials Office for approval 21 days prior to construction. Normal review times are within 5 working days.

APPENDIX C – Sampling & Testing Guide Minimum Frequency

HOT-IN-PLACE RECYCLED ASPHALT PAVEMENT

MATERIAL OR CONSTRUCTION ITEM	TESTS	METHOD OF ACCEPTANCE & RELATED IMs	QUALITY CONTROL					INDEPENDENT ASSURANCE & VERIFICATION S&T						REMARKS
			SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	S&T TYPE	SAMPLE BY	FREQ.	SAMPLE SIZE	TEST BY	REPORT	
SOURCE INSPECTION														
Asphalt Rejuvenating Agent	Quality	AS 437												
GRADE INSPECTION														
RAP (2318.02)	Max Size							V	RCE	1st day + 1/week	10 lb	RCE		
Rejuvenating Agent	Quality Residue	Cert 360						V	RCE/CONTR RCE/CONTR	1/project 1/day (1)	1 qt 1 qt	CTRL DME		Must use plastic bottle for emulsion
Uncompacted Mixture	Density	Appendix A						V	RCE	1/lot	40 lb	DME		Sealed Container
Compacted Mixture	Density	Appendix A	CONTR	10/lot		CONTR								Witnessed by RCE
Smoothness		SP												

AS-Approved Source
ASD-Approved Shop Drawing
S&T-Sampling & Testing

Cert- Certification Statement

RCE-Resident Construction Engineer/Project Engineer
DME-District Materials Engineer
CTRL-Central Materials Office
CONTR-Contractor

IA-Independent Assurance
V-Verification

(1) The sample from the first day and 1/week shall be forwarded to the District Laboratory for testing. The other samples shall be retained for submission in the event of a failing test result.