S T A T E O F T E N N E S S E E

(Rev. 2-8-21) January 1, 2021

SPECIAL PROVISION

REGARDING

HOT IN PLACE RECYCLED ASPHALT- REMIX PROCESS

Description

This work shall consist of Hot In Place Recycling of the existing bituminous pavement in a continuous multi-step process of heating, scarifying or milling, remixing, blending of the dislodged material with an asphalt rejuvenating agent, spreading, reshaping, leveling, and compacting the asphalt pavement. All work shall be performed in accordance with the Standard and Supplemental Specifications 407 except as modified herein and in reasonably close conformity to the lines and grades shown on the plans or as directed by the engineer.

Materials

An asphalt rejuvenating agent with 3% polymer (ARA-3P) shall be uniformly dispersed and blended into the hot recycled material at a rate between 0.10 to 0.30 gallons per square yard per inch of depth. The exact rate shall be determined by TDOT based on the in situ volumetrics and/or stiffness of the asphalt pavement. The Contractor shall provide and deliver samples of the proposed ARA-3P to the Regional Lab at least 21 days prior to beginning the work in order for tests to be performed and completed. Submitted samples will also be used to perform verification test on the properties of the material.

The ARA-3P shall be capable of increasing the ductility and lowering the viscosity of the asphalt binder in the existing pavement to be recycled. The ARA-3P shall be composed of a polymer modified asphalt emulsion containing a minimum of 3.0% SBS polymer blended to an asphalt base stock. The polymer modified base stock shall be further blended with process oils and other additives before emulsification to achieve the desired finished product properties.

The Producer/Supplier shall manufacture the ARA-3P in compliance with TDOT Standard Operating Procedure (SOP) 3-2, Certified Supplier Requirements. The manufacture shall issue with each load a manufactures certification and certified weight using TDOT form DT-0293 Emulsion. A unit weight (pounds per gallon) shall be included with each certification.

Material unused in storage tanks shall be transferred into tankers for re-weighing. Certificated weights less reweights shall be comparable to the accumulated gallons used that are provided by the Contractor.

The ARA-3P material shall meet the following requirements:

Property	**Method**	**Minimum**	**Maximum**
Viscosity @ 25°C, Sec	AASHTO T 59	15	100
Sieve Test, %	AASHTO T 59	--	0.10
24-Hour Storage Stability, % (Note 1)	AASHTO T 59	--	1.0
Residue by Distillation, % (Note 2)	AASHTO T 59	60	--
Oil Distillate, % by Volume	AASHTO T 59	--	2.0
Particle Charge	AASHTO T 59	Positive	
Pump Stability Test @ 140°F (Note 3)	TM 101	3 passes	
Test on Emulsion from Pump Stability Test			
Sieve Test, %	ASTM D244	--	0.10
Test on Residue from Distillation			
Solubility in TCE, % (Note 4)	ASTM D2042	97.5	--
Elastic Recovery @ 4°C, % (Note 5)	AASHTO T-301	58	--
Penetration @ 4°C, 100 g, 5 sec, dmm	ASTM D5	60	150
Asphaltenes, % (Note 6)	KT-MR20	--	25

Note 1: After standing undisturbed for 24 hours, the surface shall show no white, milky colored substance, but shall be a smooth homogeneous color throughout.
Note 2: 1 Use distillation temperature of 350°F with a 20 minute hold.
Note 3: TM 101 is identified within these specifications or plan notes.
Note 4: ASTM D5546, "Test Method for Solubility of Polymer-Modified Asphalt Materials in 1,1,1-Trichloroethane" may be substituted where polymers block the filter in Method D2042.
Note 5: The elongation is 20 cm, the test temperature is 4°C and the relaxation time is 5 minutes.
Note 6: KT-MR20 is identified within these specifications or plan notes.

All tests must be completed for certification of material by supplier and test results must accompany delivered material.

Construction Requirements

A. Equipment

All equipment necessary for the satisfactory performance of this work shall be on hand and approved prior to the beginning of construction. Processing equipment shall be capable of uniformly heating the existing pavement, homogenously mixing ARA-3P to the scarified or milled

recycle material, distributing the mixture uniformly over the width and depth being processed, and finishing and compacting the recycled pavement so as to produce a uniform cross section and surface of the required evenness and texture without tearing, shoving or gouging.

Heating units shall be self-propelled rigid sections of indirect radiant or infrared heaters that will uniformly heat the existing pavement to a temperature sufficient to allow milling, scarifying, or dislodging the material to the specified depth without fracturing the aggregate, burning petroleum distillates in the asphalt binder, subjecting the existing surface to an open flame, or producing undesirable pollutants. An adequate number of self-propelled pre-heating units of sufficient length shall be utilized to comply with these requirements. Pavement sections shall be heated approximately 4 inches beyond the width of scarifying or milling. The heating units shall have enclosed or shielded hoods.

The Contractor may utilize individual multiple pass heating-milling units employing the windrowing process. Tunnel heaters shall be utilized that are capable of heating the underlying pavement while shielding the previously milled material from direct flame.

Milling/Scarifying units shall be capable of uniformly dislodging and removing the heated pavement to the desired depth for a full lane width of 12 feet without fracturing the aggregate. The units shall be height adjustable to clear obstructions in the existing pavement. Acceptable means of measurement shall be provided to verify that the desired recycling depth is obtained.

Distribution and blending units shall be a controlled system that is capable of uniformly adding, dispersing, blending, and mixing the ARA-3P at the established rate with the dislodged material either prior to or during remixing. The unit shall be so equipped to enable the contractor to provide documentation of the application rate of the added material(s). The system shall be calibrated and synchronized to the speed of the operation. The quantity of ARA-3P shall be controlled within –0.02 to +0.05 gallons per square yard of surface treated within the given application rate. The process shall include a mixing system after or during blending of the ARA-3P with the in-place asphalt mix. The mixing system shall consist of a twin shaft pugmill or an on board heated mixing drum capable of providing a uniform mix free of temperature and/or aggregate segregation whose binder content does not vary by more than 0.2% by total weight of the mix transversely across the recycled lane at any given section. The equipment shall include a devise that will measure and record the accumulated gallons of rejuvenating agent within an accuracy of 2%.

The spreading, leveling and paving unit shall meet the provisions of Standard Specification Subsection 407.06

Compaction of the recycled mat shall be accomplished with rollers that conform to Standard Specification Subsection 407.07.

B. Preparation

Prior to heating, identified break-out repair shall be completed and the existing surface cleaned of all loose and objectionable material including thermoplastic and markers by blading, brooming, or other methods approved by the Engineer. Extraneous material shall be removed from all potholes and cracks in the existing surface. Any and all unsuitable, unwanted, or clean-out material shall be properly disposed of.

C. Weather Limitations

The minimum surface temperature of the pavement prior to heating shall be 45ºF and the minimum ambient air temperature shall be 50ºF. Work is not permitted during foggy or raining conditions. Unless otherwise permitted in writing, hot in place recycling shall be limited to the period from April 1
to November 30. If a surface treatment is to be applied, the period limitations for the treatment as identified in the Standard Specifications shall apply.

D. Heating and Temperature Requirements

The entire lane width of the pavement surface being processed shall be uniformly heated with a series of heating units meeting the equipment requirements herein. The heating process shall be conducted utilizing indirect heat in such a manner that the mix is not subject to damage by temperature exposure of excessive intensity or prolonged heat durations. The maximum mix temperature shall not exceed 330ºF. The minimum temperature directly behind the screed shall not be less than 190ºF and/or at a temperature that will assure that the time available for compaction is achievable. Deductions for failure to meet densities will be applied. An adequate number of self-propelled pre-heating units of sufficient length shall be utilized to comply with these requirements. Pavement sections shall be heated approximately 4 inches beyond the width of scarifying or milling. Traverse temperature differentials behind the screed shall not exceed 25ºF.

If requested by the Contractor, the Department may consider the use of Warm Mix Technology and reestablish the mixing and compaction temperatures. The WMA additive shall be compatible with the ARA-3P and shall be on the Departments Qualified Products List.

Roadside vegetation protection utilizing a water spray system attached to the heating units shall be provided if deemed necessary by the Engineer.

E. Blending and Remixing

The ARA-3P shall be applied uniformly to the dislodged, milled or scarified existing pavement at a rate of 0.10 to 0.30 gallons per square yard per inch of depth prior to remixing in a pugmill or mixing drum. The exact rate shall be determined by TDOT based on the in situ volumetrics and/or stiffness of the asphalt pavement. The Contractor shall provide and deliver samples of the proposed ARA-3P to the Regional Lab at least 21 days prior to beginning the work in order for tests to be performed and completed. The milled, scarified, or uniformly dislodged existing pavement treated with ARA-3P shall be conveyed into a mixing unit and thoroughly mixed to produce a consistent recycled mix. The ARA-3P shall be added with equipment meeting the requirements identified herein and shall be controlled through metering devices capable of adjusting for the variation of material fed into the mixing unit, the variation time of the mixing cycle, and/or the variation speed of the operation. The Contractor shall provide to the Engineer the accumulated gallons and application rates in gallons per square yard of the applied ARA-3P daily and at any time requested. The metering device(s) shall be calibrated in the presence of a TDOT representative. The Contractor shall provide written certification of the amounts used prior to payment.

Material unused in storage tanks shall be transferred into tankers for re-weighing. Certificated weights less reweights shall be comparable to the accumulated gallons used that are provided by the Contractor.

F. Spreading and finishing

Unless otherwise specified or permitted, the process shall be limited to daylight hours. The mixture shall be spread and struck off to the established line, grade and elevation by means of approved asphalt paving machine(s). The Contractor shall be required to pave in the direction of traffic. The hot side of any constructed longitudinal joint shall overlap the previously paved lane 4 inches.

Unevenness of texture, segregation, tearing or shoving of the bituminous mixture that occurs during the paving operation, shall be reason to stop the paving until the condition is corrected. Unacceptable mix shall be immediately removed and replaced at the Contractor's expense. Automatic screed controls utilizing either the ski type grade reference system or a non-contact averaging system will be required on all work. Where the ski type system is used, the ski shall have the maximum practical length and in no case shall it be less than 40 ft. (12 m) in length.

G. Compaction and Density Requirements

Compaction, density requirements, and test strips shall comply with Standard Specification Subsection 407.15. The Contractor shall use a sufficient number and type of rollers to obtain proper compaction and obtain the specified densities. Density shall be measured with a calibrated nuclear gauge.

The Contractor shall obtain 4 inch diameter cores at locations determined by the Engineer to calibrate the nuclear gauge and determine if the density of the test strip is acceptable. TDOT shall take possession of the samples and deliver them to the Regional Laboratory for testing. Holes formed by extracting samples shall be filled with an approved material and properly compacted. Cutting samples and repairing sample holes shall be at the Contractor's expense.

H. Surface Requirements

The surface shall be tested with a 12 foot straightedge applied parallel to the centerline of the pavement. The deviation of the surface from the testing edge of the straightedge shall not exceed 1/4 inch. The crown in crowned pavements shall be tested with a string-line applied at right angles to the centerline of the pavement and the crown shall not deviate more than 1/2 in. (13 mm) from that specified on the Plans. Deviations greater than the specified tolerances shall be corrected by methods best suited for the purpose. Pavement that cannot be corrected to comply with the specified tolerances shall be removed and replaced at the Contractor's expense.

The plans will indicate if the surface of the recycled pavement is subject to a Smoothness Special Provision.

I. Surface Treatments

The rejuvenated pavement surface shall be maintained if and until the surface treatment shown in the Plans is completed. The recycled pavement shall be allowed to cure at least 1 week or until the moisture content of the pavement is less than 2.0% before applying the treatment unless otherwise directed by the Engineer. The surface treatment shall be applied within 21 days of completion of the Hot in Place Recycled Asphalt.

Method of Measurement:

The Department will measure Hot in Place Recycled Asphalt by the square yard complete in place. The length used in computing the area will be measured along the centerline of the work. The width will be that shown on the plans or as designated by the Engineer.

The Department will measure Asphalt Rejuvenating Agent by the gallon based on the amount of material applied, complete in-place, at the rate of application determined by the Department

Basis of Payment:

The Department will pay for accepted quantities, complete in place, at the contract prices as follows:

Item No.	Description	Unit
311-03.xx	Hot in Place Recycling of Asphalt Pavement	Square Yard
311-03.10	Asphalt Rejuvenating Agent	Gallon

Such payment shall be full compensation for any additional materials, labor, equipment and incidentals necessary for the proper performance of the work and to meet the provisions of this specification.

A deduction in payment, not as a penalty but as liquidated damages, shall be made for failure to meet the density requirements. As soon as practical after the final rolling is completed on each lot, 5 density tests shall be performed by the Department at locations determined by the Engineer, and an average of all such tests shall be computed. Any deduction for failure to meet density requirements shall be computed to the nearest 0.1% as a percentage of the total payment otherwise due for each lot. The percent of total payment to be deducted shall be 5 times the percent the average in-place density for each lot that fails to meet the requirements of Standard Specification Subsection 407.15. Any deduction in monies due the Contractor for failure to meet the Density Requirements shall be made under the item for Density Deduction.

Resistance of Emulsions to Shear Induced Degradation, TM 101

A. Scope

This test procedure measures the propensity for an asphalt emulsion to incur shear induced degradation as a result of being pumped or circulated by means of a positive displacement gear pump. A representative sample of emulsion, after being pre-sieved [#20 mesh, according to ASTM D-244] and conditioned to 60° C, is subjected to three pumping cycles. Afterward, the emulsion is tested according to ASTM D-244 for Sieve. Any emulsion which, after being subjected to the

required number of pumping cycles, exhibits degradation in the form of sieve exceeding 0.050%, shall be considered suspect and will be rejected.

B. Apparatus

Viking Model F-432 Gear Pump, driven at 500 +/- 10 rpm by Dayton 1/3 h.p. electric motor; metal inlet and outlet lines to and from the pump; numerous plastic containers [either 1/2 gal. or 1 gal.] for transfer/collection of material being pumped.

C. Procedure

[1] Condition approximately 1500g of previously sieved [per ASTM D-244] asphalt emulsion to 60 ±1° C. in a sealed container inside a laboratory oven or water bath [held at less than 100° C].

[2] Flush the pump assembly with approximately 2 liters of heated [50-60° C] water or, preferably, compatible emulsifier solution.

[3] Place the inlet line of the pump assembly into the 60° C emulsion. The first 400 ml. [approximately] of material out of the outlet line of the pump shall be discarded [on the first cycle only], with the remaining emulsion caught in a clean plastic container. The container of pumped emulsion shall be immediately transferred to the pump inlet line and the procedure repeated using clean 'catch containers' until the requisite number of cycles has been completed.

[4] The emulsified asphalt sample shall then be tested for sieve in accordance with ASTM D-244. If conditions warrant, Saybolt Furol viscosity can also be evaluated before and after pumping.

KTMR-20 CHEMICAL ANALYSIS OF ASPHALT REJUVENATING AGENTS (Kansas Central Lab Test KT-MR-20)

A. Scope

This method is used to determine the composition of petroleum oils and asphalts in terms of: Asphaltenes Content, Polar Compounds Content, First Acidaffins Content, and Saturated Compounds Content. In addition, Second Acidaffins Content and the Maltene Ratio are calculated.

B. Definitions

1. Asphaltenes Content: That portion of the material not soluble in pentane.
2. Polar Compounds Content: That portion of the material soluble in pentane and that reacts with cold 85% (of concentrated) sulfuric acid.
3. First Acidiffins Content: That portion of the material that is soluble in pentane and that reacts with cold concentrated sulfuric acid.
4. Second Acidiffins Content: That portion of the material that is soluble in pentane and reacts with cold fuming sulfuric acid. (This is a calculated quantity)
5. Saturated Compounds Content: That portion of the material that is soluble in pentane and does not react with cold fuming sulfuric acid.
6. Maltene Ratio: Strictly a calculated quantity.

C. Referenced Documents

AASHTO M 231: Weighing Devices Used in the Testing of Materials

D. Procedure 1 - Asphalt Content

1. Apparatus

a. (2) 125 Erlenmeyer flask with ground glass stopper fitting and stopper
b. Pentane, technical grade
c. Toluene, analytical reagent grade
d. 50 mL graduated cylinder
e. (2) 15 mL Gooch crucible with filter
f. (2) Walter crucible holder
g. (2) 250 mL side arm vacuum flask
h. Regulated vacuum source with gauge and hoses
i. (2) Wash bottles for solvents
j. (2) Crystallizing dish
k. 60 mL separatory funnel
l. Lab stand with ring
m. Hot plate with adjustable temperature control
n. Laboratory vent hood
o. Weighing device in accordance with AASHTO M 231 Class A
p. Oven capable of maintaining 221 +/- 9 ºF.

2. Sample Preparation

This determination is made on as received material from the asphalt subsection, where the material is reduced.

3. Procedure

a. Duplicate determinations of this procedure are required.
b. Place a clean and dry 125 mL Erlenmeyer flask with ground glass stopper fitting onto a tared analytical balance. Record the mass of the flask to the nearest 0.1 mg. Dispense into the flask 1.0 +/- 0.1 g of the as received ARA material. Record the mass of the flask plus sample to the nearest 0.1 mg.
c. Calculate the mass of the sample by subtracting the mass of the flask from the mass of the flask plus sample.
d. Using a 50 mL graduated cylinder add 50 +/- 5 mL of tech grade pentane. Stopper the flask and swirl until the sample appears to be completely dissolved.
e. Allow the flask to stand undisturbed for a minimum of 15 hours.
f. Place a 21 mm fiber glass filter into the bottom of a 15 mL Gooch crucible.
g. Take a 30 mm fiberglass filter and evenly tuck it into the same crucible to form a bowl shaped reservoir in the bottom of the crucible.

h. Place the crucible into a Walter crucible holder that is set into a 250 mL vacuum flask connected to a regulated vacuum source with a gauge. Turn the vacuum on, and run 20 +/- 5 mL of pentane through the crucible filter.

i. Turn off the vacuum and place crucible into a drying oven set at 105 +/- 5ºC for 30 +/- 5 minutes. Remove crucible from oven and allow to cool to room temperature in a desiccator. When cooled weigh and record the mass of the crucible to the nearest 0.1 mg.
Transfer the contents of one of the flasks into a 60 mL separatory funnel. Rinse the sample flask into the funnel using pentane dispensed from a wash bottle.
Save the sample flask for use in step **c.12** of this procedure.

j. Set up the apparatus as shown in Figure 1. Adjust the vacuum source so it will deliver a maximum vacuum of 10 inches of mercury.

k. Place the Gooch crucible in the holder , turn on the vacuum and slightly open the valve on the separatory funnel allowing the solution to drip onto the filter in the crucible. Adjust the flow rate so that the solution level does not exceed the top edge of the filter in the crucible. Adjust flow as needed as asphaltene builds up on the filter.

l. Once the separatory funnel is empty, rinse it into the crucible twice using 10 +/- 2 mL of pentane. Rinse the inside of the crucible with 15 +/- 2 mL of pentane, being sure not to disturb the asphaltene residue held up on the filter. a + b

> ***Note a:*** *Save the separatory funnel to be used later in section* ***c.12.*** *of the method.*
> ***Note b:*** *Save the filtrate in the vacuum flask for use in another section of KTMR-20. One of the duplicates will be used in Polar Compounds Content and the other in Saturates Content.*

m. Shut the vacuum off and remove the crucible from the holder and place it in a 105ºC drying oven for 15 +/- 2 minutes. Remove the crucible from the oven and allow it to cool to room temperature in a desiccator.

n. When the crucible has cooled to room temperature, weigh back and record the mass of the crucible and its contents to 0.1 mg.

o. Tare, weigh and record the mass of a clean, dry 60 mL crystallizing dish to 0.1 mg.

p. Retrieve the separatory funnel, the sample flask, and any other items such as stir rods, that may have come into contact with the sample solution before filtering. Rinse each item twice using 10 +/- 2 mL of toluene capturing the rinse solvent in the crystallizing dish.

q. Place the dish on a hot plate inside a vent hood and allow the solvent to evaporate without ever coming to a boil. When it is apparent that the solvent has been driven off, place the dish into a drying oven at 105ºC for 15+/- 2 minutes. Remove and allow to cool in a desiccator.

r. Once cooled to room temperature, weigh back and record the mass of the dish and its contained residue to 0.1 mg.

4. Calculations

Asphaltene Content, $wt/wt\% = ((C+D)/M)100\%$

Where: C = (crucible + residue) - (tare mass of crucible), in grams
D = (dish + residue) - (tare mass of dish), in grams
M = sample mass, in gram