

State of Illinois
Department of Transportation
Bureau of Local Roads and Streets

SPECIAL PROVISION
FOR
FULL-DEPTH RECLAMATION (FDR) WITH EMULSIFIED ASPHALT

Effective: April 1, 2012
Revised: January 4, 2019

All references to Divisions, Sections, and Articles in this Special Provision shall be construed to mean specific Divisions, Sections, and Articles in the Standard Specifications for Road and Bridge Construction adopted by the Department of Transportation.

Description. This work shall consist of cold milling and pulverizing all of the existing bituminous layers and/or portions of the aggregate base material to a specified depth and maximum size; mixing emulsified asphalt, water and additives with the recycled material; and spreading and compacting the mixture.

Materials. Materials shall be according to the following Articles of Division 1000 – Materials.

Item	Article/Section
(a) Portland Cement (Note 1)	1001
(b) Water.....	1002
(c) Fine Aggregate (Note 2)	1003
(d) Coarse Aggregate (Note 2).....	1004
(e) Fly Ash (Note 1)	1010.02
(f) Lime Slurry (Note 1)	1012.04
(g) Reclaimed Asphalt Pavement (Note 3)	1031
(h) Emulsified Asphalt (Note 4)	1032.06
(i) Cold Pulverized Material (Note 5)	
(j) Mix Design (Note 6)	

Note 1 If necessary, the mix design may require additional additives to increase fines in the mix. The type and allowable percentage will be described in the mix design.

Note 2. The mix design will specify gradation and quality of any additional aggregate. Any additional fine aggregate shall meet Class B quality as a minimum. Any additional coarse aggregate shall meet Class C quality as a minimum.

Note 3. The Engineer may allow reclaimed asphalt pavement (RAP) from Conglomerate “D” Quality or better RAP stockpiles as specified in Article 1031.02 or from millings of the existing highway. The RAP material shall not exceed the maximum size requirement of the cold pulverized material, and when blended with the cold pulverized material shall produce a product which meets the specifications of the mix design.

Note 4. The CIR-FDR emulsified asphalt shall be selected for the project by the emulsified asphalt supplier based on the Contractor's mixture design. The supplied emulsified asphalt residue penetration shall be within ± 25 percent of the design emulsified asphalt residue penetration. A representative from the emulsified asphalt supplier will be on the job site at the beginning of the project to monitor the characteristics and performance of the emulsified asphalt. Throughout the job, the representative will be available to check on the project and make adjustments to the emulsified asphalt formulation as required. The emulsified asphalt shall be received on the job site at a temperature no greater than 120 °F (49 °C).

The CIR-FDR emulsified asphalt shall meet the following requirements:

CIR-FDR EMULSIFIED ASPHALT MATERIAL SPECIFICATION			
Test	Procedure	Minimum	Maximum
Viscosity, Saybolt Furol, at 77 °F (25 °C), SFS	AASHTO T 59	20	100
Sieve Test, No. 20 (850 μ m), retained on sieve, %	AASHTO T 59		0.10
Storage Stability Test, 24 hr, %	AASHTO T 59		1.0
Distillation Test, Residue from distillation to 347 °F \pm 9 °F (175 °C \pm 5 °C), %	AASHTO T 59 ¹	64.0	
Oil distillate by volume, %	AASHTO T 59		1.0
Penetration, 77 °F (25°C), 100 g, 5 s, dmm	AASHTO T 49	75	200

Note: 1. Modified AASHTO T 59 procedure – distillation temperature of 347 °F \pm 9 °F (175 °C \pm 5 °C) with a 20 minute hold.

Note 5. Prior to the addition of the emulsified asphalt, the gradation of the cold pulverized material shall meet the following requirements.

COLD PULVERIZED MATERIAL GRADATIONS		
Grad No.	Sieve Size and Percent Passing	
	2 in. (50 mm)	1 1/2 in. (37.5 mm)
PM 3	100	100 - 97

Note 6. A mix design for each distinct section shall be submitted to the Department prior to construction using actual materials (in-situ sampled by the Contractor and new materials from the Contractor's material suppliers) proposed for the project. The job mix formula shall meet the following criteria and be approved by the Engineer.

FDR WITH EMULSIFIED ASPHALT MIX DESIGN REQUIREMENTS			
Test Method	FDR Type 1 ¹	FDR Type 2 ¹	Test Purpose
Gradation for Design Millings, AASHTO T 27	Report	Report	
Sand Equivalent, ASTM D2419, Method B	Report	Report	
Modified Proctor, ASTM D1557, Method C	Report	Report	Optimum Moisture Content for Density and Compaction
Design Moisture Content	Report	Report	Dispersion of Emulsion
Superpave Gyrotory Compaction, 1.25° angle, 87 psi (600 kPa)	30 gyrations at 6 in (150 mm)	30 gyrations at 6 in (150 mm)	Laboratory Density Indicator
Short Term Strength (STS), ASTM D 1560, Part 13, 175 g/25 mm of width	175 minimum	150 minimum	Stability Indicator
Bulk Specific Gravity (Density), ASTM D 6752 or ASTM D 2726	Report	Report	Laboratory Density Indicator
Rice (Maximum Theoretical) Specific Gravity, ASTM D 2041	Report	Report	Laboratory Density Indicator
Air Voids, Modified	Report	Report	Laboratory Density Indicator
Indirect Tensile Strength, ASTM D 4867, psi (kPa)	40 (276) minimum	35 (241) minimum	Strength Indicator
Conditioned Indirect Tensile Strength, ASTM D 4867, psi	25 (172) minimum	20 (138) minimum	
Additional Additive(s) ²			
Coarse Aggregate	Report	Report	
Fine Aggregate	Report	Report	
RAP	Report	Report	
Fly Ash	Report	Report	
Cement, %	1.0 maximum	1.0 maximum	
Emulsified Asphalt ²			
Distillation Residue, %	Report	Report	
Residue Penetration, dmm	Report	Report	
Optimum Emulsion Content, %	Report	Report	
Residual Asphalt to Cement Content Ratio	3:1 minimum	3:1 minimum	

Notes: 1. FDR Type 1 for mixtures containing < 8 percent passing No. 200. FDR Type 2 for mixtures containing ≥ 8 percent passing No. 200 or for all granular mixtures.
2. Report shall include type/gradation and producer/supplier.

Equipment. Equipment shall be according to the following Articles of Division 1100 – Equipment.

- (a) Self-Propelled Pneumatic-Tired Rollers (Note 1) 1101.01(c)
- (b) Vibratory Roller (Note 2) 1101.01(g)
- (c) Mechanical Sweeper 1101.03
- (d) Motor Grader 1101.05
- (e) Self-Propelled Milling Machine 1101.16(a)
- (f) Self-Propelled Vibratory Padfoot Roller (Note 3)
- (g) Self-Propelled Reclaimer (Note 4)
- (h) Water Truck (Note 5)

- Note 1. The self-propelled pneumatic-tired roller shall have a gross weight (mass) of not less than 25 tons (23 metric tons).
- Note 2. The double drum vibratory steel roller shall have a gross weight of not less than 10 tons (9 metric tons).
- Note 3. The self-propelled vibratory pad foot roller shall have 84 in. (2133 mm) wide drums and gross weight of not less than 10 tons (9 metric tons). A front mounted blade is recommended for back-dragging. A self-propelled vibratory pad foot roller shall be required for each self-propelled reclaimer.
- Note 4. The self-propelled reclaimer shall be capable of fully pulverizing the existing pavement to the depth required, incorporate the emulsified asphalt and water, and mix the materials to produce a homogeneous material. The minimum power of the self-propelled reclaimer shall be 500 hp (373 kW). The self-propelled reclaimer shall be capable of reclaiming not less than 8 ft (2.4 m) wide and up to 12 in. (305 mm) deep in each pass. The self-propelled reclaimer shall have a system for adding emulsified asphalt with a full-width spray bar consisting of a positive displacement pump interlocked to the self-propelled reclaimer's ground speed so that the amount of emulsion being added is automatically adjusted with changes to the self-propelled reclaimer's ground speed. The additive system shall be capable of incorporating up to 7 gal/sq yd (31.7 L/sq m) of emulsified asphalt. Individual valves on the spray bar shall be capable of being turned off as necessary to minimize emulsion overlap on subsequent passes.
- Note 5. Water trucks shall be set up for a controlled spray.

CONSTRUCTION REQUIREMENTS

Weather Limitations. This work shall be performed when the atmospheric temperature in the shade and away from artificial heat is 50 °F (10 °C) and rising. Also, the weather shall not be foggy or rainy. The weather forecast shall not call for freezing temperature within 7 days with after placement of any portion of the project and the annual average low temperature within 7 days of the end of the project shall be greater than 32 °F (0 °C). The Engineer may restrict work when the heat index is greater than 100 °F (38 °C).

Pre-pulverization and Initial Shaping. The existing pavement shall be pre-pulverized by the self-propelled reclaimer and/or shaped by the motor grader to correct for profile, crown, and contour, according to the plans, before the addition of the emulsified asphalt. Water, coarse aggregate, RAP Material, or other additives required may be added during this operation. The pre-pulverized and shaped material shall be compacted with a vibratory roller in static mode to support equipment and/or traffic and to provide depth control during processing. Depth of pre-pulverization and shaping shall be 1 in. (25 mm) to 2 in. (50 mm) less than the depth of final processing.

Processing. Moisture content shall be within ± 1.0 percent from the mix design. If the moisture content is too low, water shall be added directly to the mixing chamber of the reclaimer by a water truck connected to the reclaimer. The emulsified asphalt shall be applied at the percentage recommended in the mix design. The required depth of reclamation shall be monitored regularly. Prior to spreading and compacting, the processed material shall have a gradation meeting the mix design.

Compaction. The recycled material shall be compacted according to the following.

- (a) Growth Curve. Compaction shall be accomplished by performing a growth curve within the first one-half mile of production. If an adjustment is made to the emulsified asphalt application rate or recycled depth, the Engineer reserves the right to request an additional growth curve. The growth curve, consisting of a plot of lb/cu ft (kg/cu m) versus number of passes with the project breakdown roller, shall be developed. Roller speed during the growth curve testing shall be the same as the normal paving operation. This curve shall be established by use of a nuclear gauge. Tests shall be taken after each pass until the highest lb/cu ft (kg/cu m) is obtained. This value shall be the target density.

A new growth curve is required if the rollers used on the growth curve are replaced with a new roller during production. The target density shall apply only to the specific gauge used. If additional gauges are to be used to determine density specification compliance, the Contractor shall establish a unique minimum allowable target density from the growth curve location for each gauge.

- (b) Rollers. Immediately after processing and final shaping the recycled material shall be compacted with equipment meeting the following requirements.

MINIMUM ROLLER REQUIREMENTS FOR FDR			
Breakdown Roller (one of the following)	Intermediate Roller ¹	Final Roller (one or more of the following) ¹	Density Requirement
P ¹ , PF ²	P, V _D	P, V _s	95 - 102 percent of the target density obtained on the growth curve

Note(s): 1. Equipment definitions in Table 1 of Article 406.07.

2. PF - Self-propelled vibratory padfoot roller for breakdown rolling.

- (c) Rolling. The breakdown roller shall be 500 ft (150 m) or less behind all self-propelled reclaimer units. The recycled material shall be compacted by the padfoot roller, applying high amplitude and low frequency, or the pneumatic-tired roller. Breakdown rolling shall be performed until the breakdown roller walks out of the material. Walking out for the padfoot roller is defined as light being clearly evident between all of the pads at the material–padfoot drum interface and being no more than 3/16 in. (5 mm) deep. Walking out for the pneumatic-tired roller is defined as no significant wheel impressions being left on the surface.

After the completion of breakdown rolling, the motor grader shall be used to cut the recycled material no deeper than necessary to remove breakdown roller marks from the initial compaction and to achieve desired cross slope.

The bladed recycled material shall be compacted by the intermediate and final rollers. The number of passes and order of rollers may be altered to meet compaction requirements. Finish rolling shall not be done in vibratory mode. Water may be lightly sprayed by a water truck to aid in improving final density and appearance. A second water truck is required if water is also being added at the reclaimer. After the first day of the emulsion addition, the recycled base shall not be shaped as chunking may result.

Opening to Traffic. The compacted recycled pavement shall be proof rolled with the type of truck traffic expected on the road. If permanent deformation does not occur, moving truck traffic may be allowed on the recycled pavement. If permanent deformation greater than 0.25 in. (6 mm) occurs, truck traffic shall be kept off until the recycled pavement is firm enough to support expected traffic with minimal deformation.

Curing. Before placing any surfacing, the recycled pavement shall be allowed to cure until the moisture content of the recycled pavement is less than 2.5 percent, or less than 50 percent of the optimum moisture content as determined during the mix design process, or at the discretion of the Engineer. The recycled pavement shall be surfaced before November 1.

Surface Test. The completed recycled pavement will be tested for smoothness in the wheel paths with a 16 ft (5 m) straightedge.

For each variation in the recycled pavement that exceeds 3/8 in. (10 mm), the entire area affected shall be corrected by a self-propelled milling machine. The recycled pavement shall be swept by a mechanical broom to remove all loose material from the recycled pavement before opening to traffic.

The Contractor shall furnish a 16 ft (5 m) straightedge and shall provide for its jobsite transportation at no additional cost to the Department.

Quality Control/ Quality Assurance (QC/QA).

- (a) Quality Control by the Contractor. The Contractor shall perform or have performed the inspection and tests required to assure conformance to contract requirements. Control includes the recognition of obvious defects and their immediate correction. This may require increased testing, communication of test results to the job site, modification of operations, suspension of the work, or other actions as appropriate.

The Engineer shall be immediately notified of any failing tests and subsequent remedial action. Passing tests shall be reported to the Engineer no later than the start of the next work day.

- (b) Quality Assurance by the Engineer. The Engineer will conduct independent assurance tests on split samples taken by the Contractor for quality control testing. In addition, the Engineer will witness the sampling and splitting of these samples and will immediately retain witnessed split samples for quality assurance testing.

(c) Tests Methods and Frequency.

- (1) Depth of Pulverization (Milling). The nominal depth at the centerline shall be required. Anytime depth changes are made or equipment is idle, a depth check shall be taken.
- (2) Pulverized Material Sizing and Gradation. A sample shall be obtained before emulsified asphalt addition and screened using a 1.5 in. (37.5 mm) sieve (or smaller sieve if required) to determine if meeting the maximum particle size requirement. Gradations shall be performed each day on the moist millings using the following sieves: 1.5 in., 1.0 in., 3/4 in., 1/2 in., 3/8 in., No. 4, No. 8, No. 16, and No. 30. The resulting gradation shall be compared to the mix design gradations to determine any necessary changes to emulsion content.

Sampling procedures shall generally be in accordance with ASTM D 979 or AASHTO T 168. When the Engineer determines the location for a gradation sample, the contractor will be notified to turn off the emulsified asphalt and mark the location continuing to pulverize the existing pavement until the Engineer is satisfied with the length of material pulverized without the addition of the emulsified asphalt. The maximum length of pulverization without the addition of the emulsified asphalt shall not exceed 100 ft (30 m). After the Contractor collects the gradation sample, the machine will be backed up to the location where the emulsified asphalt was turned off, then re-pulverize this material, adding the required amount of emulsified asphalt to the pulverized material.

- (3) **Emulsified Asphalt Content.** The Engineer shall be notified any time emulsified asphalt content is changed. The emulsified asphalt content shall be checked and recorded for each segment in which the percentage is changed. Emulsified asphalt content changes shall be made based upon mix design recommendations, which are based upon different mix designs for road segments of varying construction. The emulsified asphalt content shall be checked from the belt scale totalizer or emulsified asphalt pump totalizer.
- (4) **Water Content.** The Engineer shall be notified any time the water content is changed. Water content at the milling head shall be checked and recorded for each segment in which the percentage is changed. This information shall be gathered from the water metering device, which can be checked from the belt scale totalizer to verify daily quantities used. Water content changes shall be made based on mixture consistency, coating, and dispersion of the recycled materials.
- (5) **Compacted Density.** A wet density shall be determined using a nuclear moisture-density gauge generally following the procedures for ASTM D 2950, backscatter measurement. This measurement shall be compared to the target density obtained by the growth curve.
- (6) **Frequency.** The following table provides the minimum frequency for tests; however, the Engineer may increase the testing frequency if the construction process is experiencing problems or unknown conditions are encountered.

QC/QA TESTING FREQUENCY		
Test	QC Frequency ¹	QA Frequency ¹
Depth of Pulverization	1 per 500 ft (150 m)	1 per 1000 feet (300 m)
Pulverized Material Gradation	1 per 0.5 day of production	1 per day of production
Emulsified Asphalt Content	1 per 500 ft (150 m)	1 per 1000 feet (300 m)
Water Content	1 per 500 ft (150 m)	1 per 1000 feet (300 m)
Compacted Density	1 per 0.25 mile (0.4 km)	1 per mile (1.6 km)

Note: 1. The Contractor shall perform all quality control tests within the first 500 ft (150 m) after startup or any change in the mix. The Department will also run the split samples at these locations.

Method of Measurement.

Bituminous materials will be measured for payment as specified in Section 1032.

Coarse aggregate will be measured in square yards (square meters).

Full-depth reclamation will be measured in square yards (square meters) of the recycled pavement.

Basis of Payment.

The bituminous material will be paid for at the contract unit price per ton (metric ton) for CIR-FDR EMULSIFIED ASPHALT.

The coarse aggregate will be paid for at the contract unit price per square yard (square meter) for ADD ROCK.

The full-depth reclamation will be paid for at the contract unit price per square yard (square meter) for FULL-DEPTH RECLAMATION, of the thickness specified.

If provided as a payment item, the additional cement, lime or fly ash required by the mix design will be measure and paid as specified in Section 302. If not provided as a payment item, the cost of additional cement, lime or fly ash required by the mix design will be paid for according to Article 109.04.