Transportation Research Division

Technical Report 15-15

Use of Hot In-place Recycling Pavement and/or 1” Thin HMA Overlay on US Route 202, Lebanon to Sanford, Eastbound

Construction and 1st Interim Report, September 2015
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Introduction

The Strategic Highway Research Program 2 (SHRP 2) is a federally funded initiative to develop and implement processes and products to improve our nation’s transportation system. SHRP 2 has four focus areas: Renewal, Safety, and Capacity & Reliability. Two main objectives were pursued by the research performed under the second Strategic Highway Research Program, SHRP 2 Renewal Project R26. Firstly, develop guidelines on pavement preservation strategies for high-traffic-volume roadways that can be implemented and used by public agencies. A secondary objective was to identify promising pavement preservation strategies for application on high-traffic-volume roadways that might not commonly be used and to make recommendations for further research opportunities. In 2014, MaineDOT received SHRP2 Implementation Assistance Program funding to demonstrate the use of the R26 product. It is in this context that two treatments were performed on Route 202 from NH/Maine State line to Sanford.

In May & June 2014, MaineDOT conducted two different treatments on 11.86 miles of Route 202 in southern Maine. Hot In place recycling (HIR) was applied on 8.68 miles followed by 1” thick, 9.5 mm nominal aggregate size HMA Overlay over the HIR and continued another 3.18 miles. These treatments were principally used because they keep the geometrical, grade and cross-slope, characteristics of the road while using and enhancing the existing materials.

HIR and Overlay Technology

Hot In-place Recycling
Hot In-place recycling (HIR) has been described as an on-site, in-place method that rehabilitates deteriorated asphalt pavements and thereby minimizes the use of new materials. Basically, this process consists of four steps: (1) softening of the asphalt pavement surface with heat; (2) scarification and/or mechanical removal of the surface material; (3) mixing of the material with recycling agent, asphalt binder, or new mix; and (4) laydown and paving of the recycled mix on the pavement surface. The primary purpose of hot in-place recycling is to correct surface distresses not caused by structural inadequacy, such as raveling, cracks, ruts and holes, and shoves and bumps. It may be performed as a single-pass operation or a multiple-pass operation. In a single-pass operation the virgin materials are mixed with the restored reclaimed asphalt pavement (RAP) material in a single-pass, whereas in the multi-step process, a new wearing course is added after recompacting the RAP materials.

HMA Overlay
As one of the most popular treatment for pavement (AASHTO Survey, 1999), an asphalt overlay is a method in which an existing asphalt surface is paved over with a new asphalt cross section. Sometimes the first process in overlay application involves milling. A machine known as an asphaltic mill will “shave” the top of an asphalt surface down to enable the new asphalt to match existing asphalt, curb and gutter, sidewalks, or concrete pads. The mill most always shaves the existing asphalt down to the thickness that the overlaid surface receives. Areas that cannot be accessed by the mill will be removed.

After that, most asphalt overlays require removal and replacement of the very poor areas in a process known as base patching.

Next, a street sweeper prepares the surface and a tack coat adhesive is applied. After the area is prepared, the first layer of asphalt, known as the “leveling course” or shim is applied. This layer helps re-grade areas of the existing asphalt that may have rutting or drainage issues. Thickness of this layer may vary because of the inconsistencies of the existing surface. Finally, the surface layer of asphalt is applied.

### Benefits of Hot In place Recycling and Overlay

**Hot In-place Recycling**
The advantages of hot in-place recycling are that elevations and overhead clearances are preserved, it is comparatively economical, and needs less traffic control than the other rehabilitation techniques. This process can also be used to recoat stripped aggregates, re-establish crown and drainage, modify aggregate gradation and asphalt content, and improve surface frictional resistance. Hot In-place recycling is usually performed to a depth of 20 mm to 50 mm (3/4 to 2 in), with 25 mm (1 in) being a typical depth.

**Overlay**
Thin asphalt overlays provide many benefits over competing pavement preservation products, and they enjoy a high public acceptance. Their primary advantages are:

- Improve Ride Quality
- Reduce Distresses
- Maintain Road Geometrics
- Reduce Noise
- Low Life Cycle Costs
- Provide Long Lasting Service. Etc.

During the life cycle of a roadway, an HMA overlay is typically placed once or more before extensive rehabilitation is required.

### Cost Considerations

Hot In place Recycling is comparatively economical and needs less traffic control than the other rehabilitation techniques. The cost of a Hot In-place Recycling (HIR) project was roughly 33% less than a mill and fill because with a mill and fill there are trucks carrying away the milled pavement and bringing back new HMA to replace the milled pavement. Whereas on a HIR project the existing materials is recycled thereby eliminating all the trucks need for removal and replacement.

According to Chou and Al. (2008), thin overlays on asphalt are almost always most cost effective. Overall both projects cost were around $2.7 million, which yields a total of $230,274 per mile.

### Project Location

In 2014 a preservation project along US Route 202 utilized Hot In-place Recycling (HIR) and/or 1” Overlay. The project, from Lebanon to Sanford (PIN 20272.00 and PIN 20272.10), begin more precisely...
at the New Hampshire / Maine state line (station 10+00) and extend easterly for 11.86 miles to the intersection of Ridgeway Ave (station 637+10) for project PIN 20272.00 and for 8.68 miles to a point 0.36 miles easterly of the Sanford/Lebanon town line (station 468+50) for project PIN 20272.10.

The projects location is shown on the maps below.

![Figure 1: 20272.00 Location Map](image1.png)  ![Figure 2: 20272.10 Location Map](image2.png)

### Project Scope

Two pavement preservation techniques were implemented for this SHRP 2 Renewal Project R26. The project PIN 20272.10 involved recycling the existing pavement (Hot In-place recycling) at a depth of 1 ½” to the mainline only started at the Maine / New Hampshire border on Route 202 Lebanon and extended 8.68 miles in Sanford as described previously.

The project PIN 20272.00 Treatment was 1” Surface 9.5 mm on the mainline and shoulders in the same location. Then a shim with a 1” 9.5 mm overlay mainline and shoulders continued another 3.18 miles.

The overlay section built on 3.18 miles without the Hot in place recycling will be considered as a control section. This section begins at Station 468+50 and extends to Station 637+10. The remainder of the project beginning at Station10+00 was treated with Hot in place recycling and 1” Overlay. This last section will be the test section. Pavement data from the ARAN will be used to compare performance of the control and test section. Data will be used from network collection on a two year cycle in the right lane only. The following table shows the data collected before the treatments. As we can notice, the control section had a worse IRI but a better rutting than the test section.
NOTES

1. BACKUP PAVEMENT USING EXISTING MATERIAL OR REMOVE EXCESS INSLOPE MATERIAL AND REGRADE. PAYMENT WILL BE MADE UNDER THE APPROPRIATE HOURLY ITEM

2. CROSS SLOPE SHALL BE CONTINUOUS FROM CENTER LINE TO FOG LINE

Figure 3: Typical section 1

Figure 4: Typical section 2

EXCAVATION SECTIONS

Figure 5: Typical excavation sections
Table 1- Ride, Rut and PCR Ratings

<table>
<thead>
<tr>
<th>Pre-Paving (2013)</th>
<th>IRI (in/mile)</th>
<th>Rut Depth Left Wheel Path (inches)</th>
<th>Rut Depth Right Wheel Path (inches)</th>
<th>Pavement Condition Rating (PCR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>116.9</td>
<td>0.23</td>
<td>0.25</td>
<td>3.5</td>
<td></td>
</tr>
<tr>
<td>102.4</td>
<td>0.28</td>
<td>0.28</td>
<td>3.6</td>
<td></td>
</tr>
<tr>
<td>157.4</td>
<td>0.10</td>
<td>0.15</td>
<td>3.3</td>
<td></td>
</tr>
</tbody>
</table>

Table 1- Ride, Rut and PCR Ratings

**Project 20272.00 - 1" Overlay**

<table>
<thead>
<tr>
<th>Section</th>
<th>Item ID</th>
<th>Item Description</th>
<th>Quantity</th>
<th>Unit</th>
<th>Unit Price</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>0010</td>
<td>202.202</td>
<td>Removing Pavement Surface</td>
<td>420.000</td>
<td>SY</td>
<td>3.000</td>
<td>1,260.000</td>
</tr>
<tr>
<td>0020</td>
<td>202.203</td>
<td>Pavement Butt Joints</td>
<td>2,970.000</td>
<td>SY</td>
<td>3.000</td>
<td>8,910.000</td>
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<tr>
<td>0060</td>
<td>304.10</td>
<td>Aggregate Subbase Course - Gravel</td>
<td>4,017.000</td>
<td>CY</td>
<td>27.000</td>
<td>108,459.000</td>
</tr>
<tr>
<td>0070</td>
<td>403.21</td>
<td>HMA 9.5 MM</td>
<td>350.000</td>
<td>T</td>
<td>110.000</td>
<td>38,500.000</td>
</tr>
<tr>
<td>0080</td>
<td>403.211</td>
<td>HMA (Shimming)</td>
<td>4,420.000</td>
<td>T</td>
<td>83.250</td>
<td>367,965.000</td>
</tr>
<tr>
<td>0090</td>
<td>403.21</td>
<td>HMA 12.5 MM Base</td>
<td>810.000</td>
<td>T</td>
<td>79.500</td>
<td>64,395.000</td>
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<tr>
<td>0100</td>
<td>409.15</td>
<td>Bituminous Tack Coat</td>
<td>11,400.000</td>
<td>G</td>
<td>3.000</td>
<td>34,200.000</td>
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<td>0110</td>
<td>410.152</td>
<td>Emulsified Asphalt Sealcoat</td>
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<td>SY</td>
<td>2.210</td>
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### Project 20272.10 - Hot In Place Recycling

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<tr>
<th>Section</th>
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<th>Quantity</th>
<th>Unit</th>
<th>Unit Price</th>
<th>Amount</th>
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<tbody>
<tr>
<td>0010</td>
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<td>Hot In-place Recycling</td>
<td>130,030.000</td>
<td>SY</td>
<td>4.870</td>
<td>633,246.100</td>
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</table>

Total Cost of 8.68 Miles HIR: 633,246.100

**HIR Cost per Mile**: 72,954.620

### Both Projects - Costs Synthesis

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
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<tbody>
<tr>
<td>Total Cost for both projects HIR + Overlay (11.86 Miles)</td>
<td>2,731,050.100</td>
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<tr>
<td>Both projects cost per Mile</td>
<td>2,731,050.100</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Cost for both projects (HIR Section - 8.68 Miles)</td>
<td>2,042,856.410</td>
</tr>
<tr>
<td>Both projects cost per Mile HIR section</td>
<td>2,042,856.410</td>
</tr>
</tbody>
</table>

### Photos

The following photos were taken with the Department’s Automatic Road Analyzer (ARAN) from network collection in 2013, the year before placement (left column). Additional photos were taken by the
Transportation Research Division, the year following placement at approximately the same locations (right column).

Figure 6 One year Pre-Paving

Figure 7 One year Post-Placement

Figure 8 One year Pre-Paving

Figure 9 One year Post-Placement

Figure 10 One year Pre-Paving

Figure 11 One year Post-Placement
Conclusions

The project is a field demonstration for Hot In-place Recycling treatment and/or 1” Thin HMA Overlay. This implementation was considered a success. A field visit, one year post-paving, showed that the cracks are coming back even though the road is still in a good shape especially if we take into account the condition of the road before the treatment (many cracks).

The sections of US Route treated will be monitored for pavement performance over a five year period. Work shall include field visits and observations of distresses, analysis of rut and ride data from the ARAN and if needed, subsurface investigations such as coring, and falling weight deflectometer (FWD) will be utilized in the event of premature failure. An interim report will be prepared after two years service and final report after five years.
SPECIAL PROVISION SECTION
401 HOT MIX ASPHALT
(Thin Lift Surface Treatment – ¾ inch and 1 inch)

Description The Contractor shall furnish a uniformly blended, homogeneous mixture placed as one or more courses of Hot Mix Asphalt Pavement (HMA) on an approved base in accordance with the contract documents and in reasonably close conformity with the lines, grades, thickness, and typical cross sections shown on the plans or established by the Resident. The Department shall accept this work under Quality Assurance provisions as specified in Special Provision Section 400; Subsection 401 - Hot Mix Asphalt Pavement, and Standard Specifications Section 106 - Quality.

The Thin Lift Surface Treatment shall meet all of the Materials, Seasonal Limitations, Equipment, and Construction requirements of Section 401, with the following additions and changes.

Materials The combined aggregate gradation required for this item shall be classified as a 9.5mm Thin Lift Mixture (TLM) mixture, using the Aggregate Gradation Control Points as defined in 703.09.

Compaction As a minimum, compaction of the Thin Lift Surface Treatment will be obtained using a minimal roller train consisting of a 10 ton vibratory roller, 16 ton pneumatic roller, and a 10 ton finish roller. Once the methods are established, rolling patterns, equipment, and methods will become part of the QCP. Failure to conform to these requirements will be treated as a second incident under 106.4.6 QCP Non-compliance.

Acceptance Method A, B & C - Test Strip Requirements If the proposed JMF has been used and approved under Method A or B testing requirements for mix volumetric and density on a current MaineDOT project, including carryover mix designs used the previous year, a test strip will not be required. A test strip at a nominal depth of 1¼ inch, full lane width, shall be required with any new JMF’s. The test strip is intended to allow the Contractor to establish a method of compaction for the Thin Lift Surface Treatment areas. The Contractor may elect to forgo the test strip in favor of the Control Strip Option as detailed in this specification.

All test strips (onsite or offsite) shall be evaluated using Method B testing protocol. Mix samples and cores will be obtained from the test strip. A minimum of three mix samples shall be randomly selected from the test strip. Three cores shall be randomly sampled from the mat and tested for density. If the pay factor for Density falls below 0.86 for Method B, all of the cores will be randomly re-cut. A new pay factor will be calculated that combines all initial and retest results. If the resulting pay factor is below 0.86 for Method B, the Department will reject the test strip. The Contractor will remove and replace rejected test strips at their expense. After completion of the test strip, the Contractor shall make any final adjustments to the job mix formula in accordance to Standard Specifications, Section 401, subsection 401.03 – Composition of Mixtures, or compaction method. Paving operations shall not resume until the Contractor and the Department determines that material meeting the Contract requirements can be produced, and any changes to the Job Mix Formula have been approved by the Department. The
Department shall pay for an accepted test strip as determined Section 401.222 – Pay Factor A and B, for this item.

The Contractor shall notify the Department at least 48 hours in advance of placing the test strip. Onsite test strips will not be excluded from the Project QA analysis, but will be evaluated in accordance with Section 401.03. On roads open to two way traffic, the test strip shall be placed over the full width of the travel way section, not to exceed 2000 ft in length, or 400 ton production. Prior to the placement of the test strip a passing verification test is required. A fog coat of bituminous tack coat shall be applied to the level course prior to surfacing. Payment will be made under the 409.15 – Bituminous Tack Coat pay item.

The Department may allow the Contractor to establish offsite test strips. If the Contractor proposes an offsite test strip the Department will require it to meet the onsite test strip requirements outlined in this specification with the exception that the offsite test strip will be excluded from the Project QA analysis.

Once the methods are established, the rolling patterns, equipment, and methods will become part of the QCP. The test strip will allow for any necessary adjustments to the mix design and or plant mixing procedures, as well as for the Department to evaluate the quality of the pavement. Changes to the compaction effort, number, or type of rollers may be permitted by the Department if damage to the HMA course becomes evident on the Thin Lift Surface Treatment areas. The use of a 10 ton vibratory roller, 16 ton pneumatic roller, and a 10 ton finish roller is required on all mixtures placed under this specification, unless otherwise authorized by the Department.

Control Strip Option The Contractor may elect to forgo the test strip for the Thin Lift Surface Treatment. If this option is selected, the Contractor will be required to provide a QCT onsite for the placement of the Thin Lift Surface Treatment to monitor placement activities and maximize the density of the material for each day of placement. The QCT will be required to perform density testing of the mixture using a density meter (according to ASTM D 2950). A control section will be established at the beginning of the first day of production to establish roller patterns. The control section mixture will be rolled until the density readings show less than 1 pcf change for the final roller passes. This density will be used as the target TMD for the mixture. The remainder of the areas to be paved shall be compacted to a minimum density of 98% of the target density as determined in the control section.

The Contractor shall record and provide reports of each day’s results, including a daily paving report listing the mixture type, mixture temperatures, equipment used, environmental conditions, and number of roller passes used to obtain the target TMD. Reports shall be signed by the QCT and presented to the Department’s representative by the end of the working day. If this option is selected, the QCT will be required to monitor the densities for the entire production run. The QCT shall be required to be onsite during all mainline paving operations.

The Department may halt the production and placement of the Thin Lift Surface Treatment and require the construction of a new test strip if the Department finds that material being produced, hauled, or placed does not meet the requirements of Sections 401.08 through 401.18

Method of Measurement The Department will measure Hot Mix Asphalt pavement by the ton in accordance with Section 109 - Measurement and Payment.
**Basis of Payment** The Department will pay for the Work, in place and accepted, in accordance with the applicable sections of this Special Provision; at the contract unit price per ton for the Pay Item listed in Special Provision Section 403 – Hot Mix Asphalt.

Payment will be made under:

<table>
<thead>
<tr>
<th>Pay Item</th>
<th>Pay Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>403.2104 9.5mm HMA - Thin Lift Surface Treatment</td>
<td>Ton</td>
</tr>
</tbody>
</table>

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SPECIAL PROVISION
SECTION 312
HOT IN-PLACE RECYCLING

312.01 Description This work shall consist of hot in-place recycling (HIR) existing hot mix asphalt (HMA) surface in a continuous multi-step process of heating, scarifying, and adding rejuvenator, then remixing, reshaping, and compacting the recycled mixture to the lines, grades, and dimensions shown on the plans or established by the Resident.

MATERIALS

312.020 Recycling Agent A recycling agent meeting the requirements of ASTM D 4552 grades RA25 or ERA25 (an emulsified RA25) petroleum-based recycling agents specifically designed as a rejuvenator meeting the requirements outlined in Table 1. At the start of production and during, the Contractor shall provide certified test results and documented quantities to the Resident for each shipment of recycling agent. Acceptance of this material is based on a signed Manufacturer’s Certification stating conformance with this specification. The use of any other grade of recycling agent requires prior approval from the Resident.

<table>
<thead>
<tr>
<th>Test Requirements</th>
<th>Test Method</th>
<th>Minimum</th>
<th>Maximum</th>
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<tbody>
<tr>
<td>Tests of Residue from Distillation:</td>
<td>T 201</td>
<td>901</td>
<td>4500</td>
</tr>
<tr>
<td>Viscosity, 140°F, cSt</td>
<td>T 48</td>
<td>215</td>
<td>-</td>
</tr>
<tr>
<td>Flash Point, CSC, °F</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tests on Residue from RTFO, 325°F:</td>
<td>T 240</td>
<td>-</td>
<td>3</td>
</tr>
<tr>
<td>Viscosity Ratio</td>
<td></td>
<td>-</td>
<td>4</td>
</tr>
<tr>
<td>Weight Change, ±, %</td>
<td></td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>T 228</td>
<td>Report</td>
<td></td>
</tr>
<tr>
<td>Saybolt Furol Viscosity @ 77°F, s</td>
<td>T 59(1)</td>
<td>15</td>
<td>85</td>
</tr>
<tr>
<td>Storage Stability, 24 hrs, %</td>
<td></td>
<td>-</td>
<td>1.0</td>
</tr>
<tr>
<td>Sieve, %</td>
<td></td>
<td>-</td>
<td>0.1</td>
</tr>
<tr>
<td>Cement Mixing, %</td>
<td></td>
<td>-</td>
<td>2.0</td>
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<tr>
<td>Asphalt Content by Evaporation, %</td>
<td></td>
<td>65.0</td>
<td></td>
</tr>
</tbody>
</table>

1. This testing requirement is only for ERA25

EQUIPMENT

312.030 The HIR train consists of a preheater unit, main recycling unit, and a conventional paver. The Contractor shall utilize equipment having the capability to process the existing pavement to a depth of up to 2 inches. The burner assembly shall be adjustable to heat between 8 and 14 feet in width. The entire heating unit shall be enclosed and vented to contain the heat and prevent damage to adjacent properties and landscape.
312.031 Preheater Unit The self-contained unit shall generate sufficient heat to soften the asphalt pavement to the depth required. Precautions must be taken not to overheat the existing pavement thereby softening the underlying asphalt pavement not to be scarified. The preheating machine shall be a self-propelled and completely self-contained unit capable of operating at speeds from ten feet to twenty-five feet per minute while uniformly heating the existing surface of the asphalt. The burner assembly shall be adjustable to heat between 8 and 14 feet in width. The entire heating unit shall be enclosed and vented to contain the heat and prevent damage to adjacent properties and landscape.

The heating unit shall consist of multi-rows of burners of a type specifically designed for and capable of producing 48 million BTUH; LPG will be used for the heating fuel in compliance with the State of Maine’s standard Air Pollution Control Laws. The BTUH production rate is based upon heating twelve (12') feet wide. Burners shall be located on the front of the heater boxes spaced no more than ten (10") inches apart to achieve proper heat penetration at the required temperature while causing no injury due to overheating the asphaltic surface.

The entire burner assembly shall be so designed so that it may be raised or lowered by a single control and capable of articulation. The burner assembly shall be adjustable in width from eight (8') feet to fourteen (14') feet. The entire heating unit shall be enclosed and vented to contain the heat and prevent damage to plant material or any structures along the roadway. Each unit shall be equipped with an on board 500 gallon water system to be used to adequately reduce the temperature of the exhaust in the venting system thereby preventing desiccation of trees and shrubs by evapotranspiration due to high heat. Hand hoses with adjustable nozzles will be placed on each unit to allow for pre-wetting of specific plants or objects.

312.032 Heater-Scarifier The heater-scarifier machine shall be one self-contained machine specifically designed to reprocess upper layers of existing asphalt pavements. The heater-scarifier machine shall be a self-propelled and completely self-contained unit capable of operating at speeds of ten (10) feet per minute to 25 feet per minute while uniformly heating, scarifying, applying rejuvenator, mixing, and screeding the existing pavement to a minimum depth of 1 inch at a minimum temperature of 250°F.

The heating unit shall consist of multi-rows of burners of a type specifically designed for and capable of producing 48 million BTUH; LPG will be used for the heating fuel in compliance with the State of Maine’s standard Air Pollution Control Laws. The BTUH production rate is based upon heating twelve (12') feet wide. Burners shall be located on the front of the heater boxes spaced no more than ten (10") inches apart to achieve proper heat penetration at the required temperature while causing no injury due to overheating the asphaltic surface. The entire burner assembly shall be so designed so that it may be raised or lowered by a single control and capable of articulation. The burner assembly shall be adjustable in width from eight (8') feet to fourteen (14') feet. The entire heating unit shall be enclosed and vented to contain the heat and prevent damage to plant material or any structures along the roadway. All equipment shall conform to Federal, State and local DOT and Fire Marshall regulations, and laws relative to the transportation of LPG.

312.033 Scarifying Unit The scarifying unit consists of no less than two rows of spring loaded, carbide tip teeth adjustable in width from 8 feet to 14 feet in increments to 1 inch and construction in 1 foot sections to conform to the pavement contour to insure penetration of the teeth and prevent damage to utility structures.
Spraying Unit Immediately behind the teeth of the scarifying unit, an application of a polymer modified rejuvenator shall be applied to the newly remixed area. The size of the nozzles located on the spray bar and pump shall be selected based upon the rate of application and the forward speed of the heater scarification unit. The tank on the machine shall be heated, and the heating unit on the storage tank for rejuvenator shall be thermostatically controlled to maintain an even specified temperature. This unit shall be equipped with an electronic digital measuring system, which shall be capable of maintaining the required application rate of the recycling agent with a tolerance of ± 5% for the mix design. The electronic digital measuring system shall continuously verify and display the application rate of recycling agent and cumulative total with respect to the volume of scarified material for the road surface. This device will be calibrated to show gallons used to the nearest tenth. The Contractor shall calibrate the electronic digital measuring system in the presence of the Resident or designee. Approved calibrations shall be done for each project. Work shall not progress until the calibration has been completed and verified.

Mill/Remixer Unit Immediately following the application of the recycling agent, a dual-drum enclosed mill shall mill the heated asphalt to the depth of the heat thoroughly mixing the rejuvenating agent with the scarified and milled material. This mill/remixer system shall be an integral part of the scarifying machine and shall be located between the spraying system, which applies the rejuvenator, and the screed. This unit shall be operated hydraulically, able to work at variable speeds from 0 rpm to 120 rpm, and shall be retractable from 8.6 feet to 14.6 feet wide. In addition, this unit shall be able to break in the center to allow for quarter point and crown control.

Screed The hot Scarified material shall be uniformly distributed to the desired longitudinal and transverse section by the use of a heated, augered vibratory screed. Temperature of the hot scarified material shall be maintained at 275°F minimum to 330°F maximum. The screed shall be equipped with an adjustable crown control and each end of the screed shall have hand wheel adjusting screws for providing the desired longitudinal grade and transverse slope.

Rollers All rollers shall conform to the requirements of Section 401.10 - Rollers.

MIX DESIGN

The Contractor will take a minimum of three cores per lane mile or a maximum of 20 cores per project from the existing HMA pavement to be analyzed. These cores will be taken from locations that will represent the entire project condition. For each of these cores, the Contractor shall provide descriptive notes of the core locations along with the associated test results showing percent of recovered asphalt content, aggregate gradation, and original penetration value for each sample.

The Contractor shall determine the application rate of the recycling agent such that the penetration value of the recovered binder from the loose mix samples taken during the heater scarification process is at least 30% or more of the average penetration value of the recovered asphalt binder from existing pavement cores. Testing of all samples for the penetration values required during production shall be performed in accordance with AASHTO T 49.

The Contractor may request to take additional cores from the existing HMA pavement to determine the mixture design. A 2-week notice shall be given to the Resident requesting permission for coring. Based on the information provided above, the Contractor shall determine the application rate of the recycling agent such that the minimum average penetration value of the asphalt binder in the recycled mixture is
30% higher than the average of the original penetration values as tested in accordance with AASHTO T 49, Penetration of Bituminous Materials. The final penetration value shall not exceed 100. After a test strip has been completed or as the work progresses, it may be necessary for the Resident to make necessary adjustments to the mix design.

CONSTRUCTION REQUIREMENTS

312.04 Weather Limitations Any HIR work shall be performed when;

a. HIR operations will be allowed between May 15th and September 15th inclusive in Zone 1 - Areas north of US Route 2 from Gilead to Bangor and north of Route 9 from Bangor to Calais.

b. The atmospheric temperature, as determined by an approved thermometer placed in the shade at the recycling location, is 50º F and rising.

c. When there is no standing water on the surface.

d. During generally dry conditions, or when weather conditions are such that proper heating, scarifying, adding, mixing, and placement can be obtained using proper procedures, and when compaction can be accomplished as determined by the Resident.

e. When the surface is not frozen and when overnight temperatures are expected to be above 32°F.

312.05 Surface Tolerance The complete surface of the HIR course shall be shaped and maintained to a tolerance, above or below the required profile or cross sectional shape, of \(\frac{3}{8}\) inch in 12 feet. Areas found to be in excess of \(\frac{3}{8}\) inch will require corrective action by means of milling, or placement of HMA shim. Any areas requiring corrective action will not be paid for directly, but will be considered incidental in the 312.20 unit price.

312.06 HIR Recycling Procedure The Contractor shall blend the milled asphalt pavement and rejuvenating agent to produce a homogenous HMA recycled mix. The Contractor shall use the application rates of the rejuvenator as determined by the mix design. The Contractor shall be responsible for cleaning the existing pavement and shoulder to be hot in-placed recycled by using mechanical sweepers, hand brooms, or other effective means until the surface is free of all material which might interfere with the milling process. The existing pavement shall be heated, scarified and mixed to a minimum depth of 1 inch. The heating system shall be regulated so that excessive heating and burning of the existing HMA does not occur. The existing surface shall be radiantly heated and no open flame will be permitted. The Contractor shall be responsible to repair any heat-damaged areas immediately at no additional cost to the Department. Under no circumstances shall the scarifying teeth penetrate into the existing base. The heated polymer modified rejuvenator shall be applied immediately following the scarifying teeth. The polymer modified rejuvenator is specifically formulated for use with the hot in-place recycling, and therefore, shall not be substituted unless approved by the Resident. The hot scarified material shall then be mill/remixed immediately following the application of the recycling agent to eliminate premature compaction of the hot recycled asphalt resulting in final differential compaction and to the desired longitudinal and transverse section by the use of an attached, heated, augured screed.

The Contractor shall control the speed of the equipment to ensure that the recycled pavement is properly milled, mixed, and uniformly distributed to the proper thickness, slope, and crown shown in the Contract Documents. Extra care shall be taken in controlling heater scarification equipment to prevent segregation of the recycled mix at the start and end of paving production as well as at any points where the heater scarification train needs to stop and restart. The Contractor shall control the width of each pass to provide proper placement of longitudinal joints including a 3 inch overlap onto adjacent lane passes. At all
manholes, valve boxes, etc., the finished grade of the heater-scarifying process shall be transitioned to blend into the existing grade.

312.07 Compaction The Contractor shall compact the mixture using a minimum roller train consisting of 10 ton vibratory roller. Compaction of the mixture shall be in accordance with Section 401.16. The processed material shall be compacted to a minimum density of 98% of the target density as determined in the test strip. The temperature of the scarified mixture shall be maintained between 275ºF and 330ºF prior to initial compaction.

TESTING REQUIREMENTS

312.08 Quality Control The Contractor shall operate in accordance with the approved Quality Control Plan (QCP) to assure a product meeting the contract requirements. The QCP shall meet the requirements of Section 106.4 - Quality Control and this Section. The Contractor shall not begin recycling operations until the Department approves the QCP in writing.

Prior to performing any recycling process, the Department and the Contractor shall hold a Pre-recycle conference to discuss the recycling schedule, type and amount of equipment to be used, sequence of operations, and traffic control. A copy of the QC random numbers to be used on the project shall be provided to the Resident. All field supervisors including the responsible onsite recycling process supervisor shall attend this meeting.

The QCP shall address any items that affect the quality of the Recycling Process including, but not limited to, the following:

- Make and type of all HIR equipment to be utilized by the Contractor.
- Project-specific HIR mix design.
- Method for eliminating / reducing damage to adjacent property and landscape form HIR process (prewetting, etc.)
- Make and type of rollers including weight, weight per inch of steel wheels, and average contact pressure for pneumatic tired rollers.
- Testing Plan.
- Recycling operations including recycling speed, methods to ensure that segregation is minimized, grading and compacting operations.
- Methods for protecting the finished product from damage and procedures for any necessary corrective action.
- Method of grade checks.
- Examples of Quality Control forms.
- Name, responsibilities, and qualifications of the Responsible onsite Recycling Supervisor experienced and knowledgeable with the process.
- A note that all testing will be done in accordance with AASHTO and MDOT/ACM procedures.

The Project Superintendent shall be named in the QCP, and the responsibilities for successful implementation of the QCP shall be outlined. The Contractor shall sample, test, and evaluate the HIR process in accordance with the following minimum frequencies:

<table>
<thead>
<tr>
<th>MINIMUM QUALITY CONTROL FREQUENCIES</th>
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<tbody>
<tr>
<td>Test or Action</td>
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<table>
<thead>
<tr>
<th>Density</th>
<th>1 per 1000 feet / lane</th>
<th>ASTM D 2950</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Temperature</td>
<td>4 per day at even intervals</td>
<td></td>
</tr>
<tr>
<td>Surface Temperature</td>
<td>At the beginning and end of each day’s operation</td>
<td></td>
</tr>
<tr>
<td>Yield of recycling agent used</td>
<td>1 per 1000 ft/lane</td>
<td></td>
</tr>
<tr>
<td>Penetration of recovered PG binder of recycled mixture</td>
<td>1 per 10000 ft/lane</td>
<td>AASHTO T 49</td>
</tr>
</tbody>
</table>

The Contractor will be required to determine the penetration of the PG binder recovered from the recycled mixture in accordance with AASHTO T 49 at the frequency established above. The mix design for the HIR process may be adjusted if the penetration value is not more than 30% greater than the average original penetration value used in mix design.

The Department may view any QC test and request a QC test at any time. The Contractor shall submit all QC test reports and summaries in writing, signed by the appropriate technician, to the Department’s on-site representative by 1:00 P.M. on the next working day, except when otherwise noted in the QCP due to local restrictions. The Contractor shall make all test results, including randomly sampled densities, available to the Department onsite.

The Contractor shall cease recycling operations whenever one of the following occurs:

a. The Contractor fails to follow the approved QCP.
b. The Contractor fails to achieve 98 percent density after corrective action has been taken. c. The finished product is visually defective, as determined by the Resident.
d. The computed yield differs from the mix design by 10 percent or more.
e. The QC penetration values are not at least 30% or more than the average original penetration values specified in the mix design.
f. The QC penetration values exceed 100.

Recycling operations shall not resume until the Department approves the corrective action to be taken.

312.10 Test Strip The Contractor shall assemble all items of equipment for the HIR operation on the first day of the recycling work. The Contractor shall construct a test strip for the project at a location approved by the Resident. The Responsible onsite Recycling Supervisor will work with Department personnel to determine the suitability of the mixed material, moisture control within the mixed material, and compaction and surface finish. The test strip section is required to:

a. Demonstrate that the equipment and processes can produce recycled layers to meet the requirements specified in these special provisions.
b. Verify the percent recycling agent is sufficient to compact the HIR material.
c. Determine the sequence and manner of rolling necessary to obtain the compaction requirements and establish a target density.

The test strip shall be at least 300 feet in length of a full lane-width (or a half-road width). HIR production will not start until a passing test strip has been accomplished. If a test strip fails to meet the requirements
of this specification, the Contractor will be required to repair or replace the test strip to the satisfaction of the Resident. Any repairs, replacement, or duplication of the test strip will be at the Contractor’s expense.

The test strip shall then be rolled using the specified compaction equipment as directed until the density readings show an increase in dry density of less than 1 pcf for the final four roller passes of each roller. The Contractor and Department will each determine a target density using their respective gauges by performing several additional density tests and averaging them. The average of these tests will be used as the target density of the recycled material for QC.

Following completion of the test strip, compaction of the material shall continue until a density of not less than 98 percent of the test strip target density has been achieved for the full width and depth of the layer. During the construction and compaction of the HIR base, should three consecutive Quality Control test results for density fail to meet a minimum of 95 percent of the target density, or exceed 102 percent of target density, a new test strip shall be constructed.

312.11 Method of Measurement HIR material will be measured by the square yard.

312.12 Basis of Payment The accepted quantity of HIR material shall be paid for at the contract unit price per square yard, complete in-place to the specified limits, which price shall be full compensation for furnishing all equipment and labor for heating, scarifying, blending, milling, placing, grading, compacting and for all incidentals necessary to complete the work.

Payments will be made under:

<table>
<thead>
<tr>
<th>Pay Item</th>
<th>Pay Unit</th>
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<tbody>
<tr>
<td>312.20 Hot In-Place Recycling</td>
<td>Square Yard</td>
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