Spray on Rejuvenator
NRRA Topic Synthesis
October 2019

Prepared for: NRRA Preventive Maintenance Team
Prepared by: WSB
1. Background

1.1 What is a Spray on Rejuvenator?

HMA pavements age over time and due to oxidative age hardening and weathering from ultraviolet rays and water thereby trending towards becoming brittle. Spray on rejuvenators, designed to penetrate into the asphalt pavement to a certain depth, can be applied to HMA pavement surfaces (Figure 1.1-1) serving as a cost-effective method intended to reverse the effects of aging. Rejuvenators strengthen the HMA material at the surface to resist the detrimental effects of exposure to sun, water, and air. To achieve optimal performance, it is recommended that rejuvenators be applied to roadways in good condition as a preventive maintenance treatment. Spray on rejuvenators, when applied to good roadways enhance the durability of the pavement surface.

![Figure 1.1-1. Application of spray applied emulsions.](image)

**Petroleum-Based Rejuvenators**

Asphalt is essentially made up of two distinct components, maltenes and asphaltenes (Durante, n.d.). Asphaltenes are hard, brittle, and insoluble components in asphalt. They are not as highly reactive as maltenes thus furnishing asphalt binder its structure. Maltenes are volatile in nature and are susceptible to degradation by oxidation. They play the role of maintaining strength and flexibility.

Using adsorption chromatography in the presence of an acid reagent, maltenes can be further fractioned into four distinguishable sub fragments, which are polar compounds (PC) or nitrogen bases, first acidaffins ($A_1$), second acidaffins ($A_2$), and saturates ($S$) or paraffins (Durante, n.d.).
With exposure to sun and weather, asphaltene content increases over time while maltene content decreases. Volatilization during manufacturing and oxidation in the field are the main factors contributing to this volatilization and pavement failure. The flexibility and adhesion properties of the asphalt binder material could be restored if the maltene content could be replaced.

Petroleum-based rejuvenators can be applied to the surface of the roadways to reverse the effects of pavement aging by essentially re-balancing the ratio of maltenes to asphaltenes.

**Bio-Based Rejuvenators**

Bio-based rejuvenators have been gaining popularity in recent years due to the environmentally friendly aspects of the products. They are sourced from different natural ingredients such as soybeans, oranges, corn and other plant-based ingredients that do not contain maltenes. Bio-based rejuvenators are intended to provide similar rejuvenating benefits to the pavement as petroleum-based rejuvenators. However, bio-based rejuvenators employ an agricultural medium to deliver the polymers to the pavement surface (Barr, J., Cammarata, D., Rivera, R., Walck, C., & Waters, J., 2018).

Unlike petroleum-based rejuvenators, bio-based rejuvenators do not restore the maltene contents in the pavement, but they use agricultural medium to restore oxidized pavement. The chemical components and compositions of bio-based rejuvenators are often not known as industry producers considered them as a trade secret.

### 1.2 Why NRRA Members Wanted This

**1.2.1 NRRA Members Involved**

There are eight state agencies that are currently involved in the spray on rejuvenators synthesis, including the California DOT, Illinois DOT, Iowa DOT, Michigan DOT, Minnesota DOT, Missouri DOT, North Dakota DOT, and Wisconsin DOT.

**1.2.2 Why This Effort is Being Done**

The purpose of this project is to guide the research need statement for the upcoming research project on test sections investigating type of rejuvenating products, laboratory and performance testing, allowable or acceptable friction values, and pavement marking reflectivity.
2. Literature Review

An online survey was distributed across the eight state agencies to collect information on spray on rejuvenators. Additionally, a literature search was performed through the Transport Research International Documentation (TRID) database.

2.1 Petroleum-Based Rejuvenators

Durante M. (n.d.) states that the effectiveness of maltene replacement has been proven through already completed studies. These studies have shown that maltene-based rejuvenators “return molecularly exact, depleted chemicals into the asphalt matrix”. These rejuvenators, when applied to new pavements within their first two years of construction, helped to prolong pavement life. The first application serves to replenish maltene content lost during asphalt mixing. Ideally, these pavements only need to be resprayed with rejuvenators three to five years later or as needed depending on the conditions of the pavements. These reapplications serve to replenish maltene contents lost due to weathering and oxidation.

2.1.1 Type of Products

Descriptions of the products were obtained from the official webpages of the suppliers. The NRRA is not affiliated with any of the products listed. The advertised benefits are solely for reference and do not represent NRRA’s stance on the products. Specifications for each type of products, if available, can be found in the Appendix.

**CMS-1PF**
CMS-1PF is a hybrid emulsion containing polymer-modified asphalt base. It restores lost binder and assists in increasing tracking resistance and enhancing durability. It usually cures within 1.5 hours.

**CRF® Restorative Seal**
CRF® is a blend of petroleum oil and water using a cationic emulsion. This product is designed to fill the surface voids with emulsion and provide retention to the sand applied to it.

**GSB-88®**
GSB-88® is a gilsonite-based sealer and is an environmentally-friendly product certified by GreenCircle®. This product has been approved by the Federal Aviation Administration (FAA) to be applied on airfields to mitigate pavement raveling. Loose aggregate and debris released from the pavement as a result of raveling may cause damage to the jet engines. This product is also applied on roadways.

**Pass® QB**
Pass® QB is a rejuvenating seal applied to seal low severity distress cracks, introduce new asphalt to the surface course, and reverse the effect of oxidation to delay the degradation of the pavement. It contains a blend of asphalt, rejuvenator oil, and polychloroprene latex polymer.

**Ravel Check®**
Ravel Check® is an asphalt-based emulsion with penetrating chemistry and asphalt resins, designed to rejuvenate and restore pavements that have issues related to weathering and oxidation.
Reclamite®
Reclamite® is a maltene-based cationic petroleum emulsion developed by the Golden Bear Oil Company in 1960. It is designed to penetrate the pavement surface to assist in restoring maltene contents and enhance the durability of the pavement surface.

ReGenX®
ReGenX® is an age-regenerating surface treatment that reverses effects of asphalt oxidation and when applied as routine treatments helps to extend the life of the pavement. This product does not require re-striping after application. Technical and safety documents were at the stage of development.

RejuvaSeal®
RejuvaSeal® is made from coal tar, aromatic oils, and specialty solvents designed to revitalize, seal, and protect the asphalt pavements. This product penetrates the pavement surface and restores the binder in aged asphalt pavements. Agencies should check the legality in respective states prior to using this coal tar-based product.

2.2 Bio-Based Rejuvenators

2.2.1 Type of Products
Description of the products was obtained from the official webpage of the suppliers. The NRRA is not affiliated with any of the products listed. The advertised benefits were solely for reference and do not represent NRRA’s stance on the products.

Anova
Anova has been incorporated into recycled asphalt pavement (RAP) and recycled asphalt shingles (RAS) mixtures. It can also be used as rejuvenating asphalt emulsion for surface seals.

Biorestor®
Biorestor® is a restorative asphalt modifier developed with bio-based oils with synthetic polymer modification. It helps to reduce cracking and raveling and increase flexibility and penetration of the asphalt.

Delta Mist™
Delta Mist™ is a plant-based rejuvenator based on the original Delta S technology formulated by the Warner Babcock Institute for Green Chemistry (WBI). This product penetrates the surface up to 3/8-inch, which helps to restore oxidized binder and decrease the amount of lost fines and aggregates.

RePlay™
RePlay™ is 88 percent bio-based and contains soy and other agricultural oils, with nine polymers introduced. This product reverses the aging of the pavement binder from 3/4-inch up to 1 1/4-inch from the pavement surface. It cures in 30 minutes or less and it is non-toxic. There is no need to restripe the pavement after the application.
2.3 Research Studies

Evaluation of Rejuvenating Fog Seals (NCAT Test Track - Mississippi DOT and Tennessee DOT)

Seven different products as shown in Table 2.3-1 were applied on a pavement layer with an asphalt content of 6.8 percent over a gravel aggregate base. This section was built in 2012 for the Test Track. Tests performed were based on the modification of the Federal Aviation Administration’s procedure P-632 (Asphalt Pavement Rejuvenation). Rheological properties of the extracted binder were examined two and four weeks after the application of the rejuvenating products. A dynamic friction test was also conducted after 3, 24, and 96 hours of applications. Another friction test was also performed after traffic simulated with the NCAT Three Wheel Polishing Device.

<table>
<thead>
<tr>
<th>Product</th>
<th>Application Rate (gallon per square yard)</th>
<th>Dilution Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMS-1PF</td>
<td>0.08</td>
<td>30% residual</td>
</tr>
<tr>
<td>ReGenX®</td>
<td>0.07</td>
<td>2:1</td>
</tr>
<tr>
<td>RejuvaSeal®</td>
<td>0.06</td>
<td>100% residual</td>
</tr>
<tr>
<td>Delta Mist™</td>
<td>0.10</td>
<td>30% residual</td>
</tr>
<tr>
<td>Biorestor®</td>
<td>0.03</td>
<td>1:1</td>
</tr>
<tr>
<td>RePlay™</td>
<td>0.015</td>
<td>100% residual</td>
</tr>
<tr>
<td>Reclamite®</td>
<td>0.08</td>
<td>1:1</td>
</tr>
</tbody>
</table>

Products were ranked, where Grade A representing the best performing products, based on criteria as shown in Table 2.3-2 such as rheological properties and friction test results. However, the results may vary depending on the pavement binders, aggregates, and mix designs.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Biorestor®</td>
</tr>
<tr>
<td></td>
<td>RePlay™</td>
</tr>
<tr>
<td>B</td>
<td>ReGenX®</td>
</tr>
<tr>
<td></td>
<td>Delta Mist™</td>
</tr>
<tr>
<td></td>
<td>Reclamite®</td>
</tr>
<tr>
<td>C</td>
<td>CMS-1PF</td>
</tr>
<tr>
<td></td>
<td>RejuvaSeal®</td>
</tr>
</tbody>
</table>

FAA specifications could be used to provide guidance in evaluating the rheological and friction properties of the rejuvenators.

Evaluation of Rejuvenators and Surface Sealing Products to Extend Asphalt Pavement Life (Missouri DOT - TR201720)

The objective of the research was to extend the life of a pavement by improving the rheological properties of the mix or binder, decreasing the permeability of the pavement, and reducing the amount and severity of cracking or joint deterioration. Another goal of the research conducted by the Missouri DOT was to maintain the pavement integrity by maintaining friction and durability.
Test sections were located on Route N in St. Charles County. The site location is a two-lane roadway with an Average Daily Traffic (ADT) of 4,500. The surface layer is a 1.75-inch thick BP-1 mix laid in 2014, with an average pavement thickness of 9.25 inches. Existing distresses observed were minor block cracking and longitudinal cracking.

Products applied were Biorestor®, Ravel Check®, Reclamite®, and CRF®. Binder properties were tested prior to product application, and all sections had a MSCR grade of PG 64-22E. The tests conducted included field permeability tests in accordance with internal spec (Missouri DOT TM-83), mainline visual surveys, friction testing in accordance with ASTM standard E274 – FN 40R. All tests were conducted at pre-treatment, 30-day, 6-month, 1-year, and 2-year intervals.

<table>
<thead>
<tr>
<th>Table 2.3-3</th>
<th>Missouri DOT Rejuvenators Study – Rejuvenators Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product</td>
<td>Application Rate (gallon per square yard)</td>
</tr>
<tr>
<td>Biorestor®</td>
<td>0.01</td>
</tr>
<tr>
<td>Ravel Check®</td>
<td>0.04</td>
</tr>
<tr>
<td>Reclamite®</td>
<td>0.02</td>
</tr>
<tr>
<td>CRF®</td>
<td>0.08</td>
</tr>
</tbody>
</table>

Existing pavement was relatively impermeable with a permeability of less than 0.5 foot per day, thus the 1-month permeability result was inconclusive. Rejuvenator properties were tested in accordance with Table 2.3-4.

<table>
<thead>
<tr>
<th>Table 2.3-4</th>
<th>Missouri DOT Rejuvenators Study – Rejuvenators Chemical Component Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test on Residue from Distillation</td>
<td>Minimum</td>
</tr>
<tr>
<td>Viscosity $60^\circ$C (cST)</td>
<td>1000</td>
</tr>
<tr>
<td>Maltene Distribution Ratio, MDR:</td>
<td></td>
</tr>
<tr>
<td>(Polar Compounds)+(First Acidaffins)</td>
<td>0.7</td>
</tr>
<tr>
<td>(Saturates)+(Second Acidaffins)</td>
<td></td>
</tr>
<tr>
<td>(Polar Compounds)</td>
<td>0.5</td>
</tr>
<tr>
<td>(Saturates)</td>
<td></td>
</tr>
<tr>
<td>Percentage of Asphaltenes (%)</td>
<td>-</td>
</tr>
</tbody>
</table>

Ravel Check®, Reclamite®, and CRF® were observed to visually fill cracks, but not Biorestor®. Table 2.3-5 showed that Biorestor®, Reclamite®, and CRF® showed acceptable percentage of asphaltenes, and only the CRF® showed an acceptable maltene distribution ratio. Biorestor® and Reclamite® had friction numbers (2 months after application) close to the number prior to treatment, within 3 percent.
### Table 2.3-5

**Missouri DOT Rejuvenators Study – Test Results**

<table>
<thead>
<tr>
<th>Product</th>
<th>Percentage of Asphaltenes (%)</th>
<th>MDR</th>
<th>PC/S Ratio</th>
<th>2-month Percent Decrease in Friction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biorestor®</td>
<td>&lt; 0.1</td>
<td>N/A</td>
<td>N/A</td>
<td>-2.9</td>
</tr>
<tr>
<td>Ravel Check®</td>
<td>23.0</td>
<td>1.4</td>
<td>3.4</td>
<td>-27.5</td>
</tr>
<tr>
<td>Reclamite®</td>
<td>1.8</td>
<td>1.4</td>
<td>5.2</td>
<td>-2.0</td>
</tr>
<tr>
<td>CRF®</td>
<td>0.24</td>
<td>0.9</td>
<td>1.8</td>
<td>-23.6</td>
</tr>
</tbody>
</table>

Note: Highlighted cells showed acceptable test results.

The Biorestor® and Reclamite® fulfill the criteria acceptable percentage of asphaltenes and friction testing (2-month after application).

**Long Range Paving Plan – Appendix C Resurfacing and Pavement Preservation Treatments (Metropolitan Government of Nashville and Davidson County, Tennessee)**

Metro Nashville has conducted evaluations on products including Reclamite®, GSB-88®, RejuvaSeal®, PASS®, and RePlay™. Pass® produced satisfactory results thus the Metro has adopted this product into its preservation program. Both GSB-88® and RePlay™ are under the evaluation of Tennessee DOT. GSB-88® took a long time to cure, which would cause a larger impact on traffic. RejuvaSeal® had a strong coal tar smell, which could raise concerns if it is applied on residential streets. Reclamite® has been adopted by the Metro on 2- to 3-year old pavements with an overall condition index greater than 80.

**Nontraditional Fog Seals for Asphalt Pavement: Performance on Shoulder Sections in Minnesota (MnDOT)**

Two bio-based sealers, RePlay™ and Biorestor®, were applied on bituminous shoulder sections that were less than two years old. The shoulders were originally paved using a PG binder of 58-34.

Both products were evaluated using the Fourier Transform Infrared (FTIR) absorption spectroscopy methods. The profiles of RePlay™ and Biorestor® were found to share similarities. These products were not compared in terms of their binder properties as similar test results were expected.

Retro reflectivity testing for average post-treatment showed that under the same application rate of 0.02 gallon per square yard, RePlay™ had a higher reduction in retro reflectivity (62 percent reduction) than Biorestor® (41 percent reduction). However, both products had the same retro reflectivity recovery, which was approximately 1,600 truck passes.

Dynamic Friction Tester (DFT) runs were performed in accordance with ASTM E1911 at one and four hours after the applications. Friction numbers of sections treated with RePlay™ decreased by 14 percent and sections treated with Biorestor® decreased by 11 percent. Friction measurements obtained during year three on sections where RePlay™ and Biorestor® applied showed recovered friction performance similar to the control section.
Under the U.S. Federal Highway Administration (FHWA) Spray Applied Emulsion Preventive Maintenance Treatments research study, the rejuvenators applied were Pass® QB, CRF®, and Reclamite®. Test sections were spread out in locations across the states to determine the effects of climate, traffic volume, roadway surface, and the timeframe between the roadway being constructed and the application of a rejuvenator have on the performance.

Friction testing was performed using the Circular Texture Meter (CTM) in accordance with ASTM E-2157 and Dynamic Friction Tester (DFT) in accordance with ASTM E-1911 after the emulsions were cured. Sections applied with Reclamite® and Pass® QB had friction numbers lower than control sections, however, Pass® QB showed a higher decrease in friction after application as compared to Reclamite®. Permeability tests were run not just on the surface of the cores, but on the complete cores. The results of which showed that Pass® QB had a lower permeability than Reclamite®. In other words, Pass® QB sealed the pavement surface better than Reclamite®.

Dynamic Shear Rheometry (DSR) tests were conducted on binders extracted to determine the complex modulus, G*, which indicates the softening of the surface materials. Reclamite® had the highest impact on softening the surface, followed by CRF® and Pass® QB. The results correlated to the rejuvenator content in the products. Reclamite® is a rejuvenator oil thus contains the highest rejuvenator content as compared to CRF® and Pass® QB which contain blends of rejuvenator oil with asphalt.

Dynamic Creep Tests were carried out to determine the rheological properties of the thin specimens by measuring the mixture stiffness. CRF® showed the lowest stiffness, followed by Reclamite® and PASS® QB.

The Static Bending Test using the Bending Beam Rheometer (BBR) was performed to obtain the stiffness and m-value, which indicates the low-temperature phase angle. These parameters help to determine the hardening of asphalt pavements. Reclamite® and CRF® reduced the low temperature stiffness, but they also reduced the m-value. This result contradicted the expectations that softening the asphalt at low temperature would improve its relaxation properties. However, any conclusions made from the BBR test had insufficient statistical confirmation due to sparse data.

Findings showed that there was a significant softening of the surface layer when products that contain a higher rejuvenator content were applied. The softening of the in-place asphalt and alleviating the skid issues are dependent on the ability of the rejuvenator to penetrate the pavement surface.
3. Specifications

In the Asphalt Rejuvenators study (Boyer, 2000), it has been stated that agencies should implement a performance type specification, of which the outcomes would be to help to prevent unacceptable friction results and performance characteristics. It would not be recommended to specify application rate since each rejuvenator performs differently according to the study. However, it is ultimately the agency’s decision if a rate should be specified by the agency or by the manufacturer.

Three specifications covered in this synthesis include sources from the Federal Aviation Administration (FAA), Florida Pavement Preservation Council (FPPC), and the Maryland State Highway Administration (MDSHA).

<table>
<thead>
<tr>
<th>Agency</th>
<th>Federal Aviation Administration (FAA)</th>
<th>Florida Pavement Preservation Council (FPPC)</th>
<th>Maryland State Highway Administration (MDSHA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spec</td>
<td>P-632</td>
<td>335</td>
<td>2.08.03.03, 2.09.04, 9.01.01.02</td>
</tr>
</tbody>
</table>

Links to each specification are as follows.

- Federal Aviation Administration (FAA) - P-632 Asphalt Pavement Rejuvenation
- Florida Pavement Preservation Council (FPPC) - FPPC335 Asphalt Rejuvenation Specifications
- Maryland State Highway Administration (MDSHA) - 2018 Pavement & Geotechnical Design Guide

3.1 Material Type and Performance

3.1.1 Material Type

<table>
<thead>
<tr>
<th>Agency</th>
<th>FPPC</th>
<th>MDSHA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spec</td>
<td>335-2</td>
<td>9.01.01.02</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Material Description</th>
<th>Spray on Rejuvenator Material Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emulsion composed of petroleum resin oil base uniformly emulsified with water</td>
<td>FPPC</td>
</tr>
<tr>
<td>Type B-2 with specialized emulsion of maltenes (2 parts maltene + 1 part water)</td>
<td>MDSHA</td>
</tr>
</tbody>
</table>

3.1.2 Recovered Binder Properties

FAA specifies the rejuvenators must fulfill the following criteria for recovered binders as included in 632-2.1.
Table 3.1.2-1
FAA Material Requirements

<table>
<thead>
<tr>
<th>Property of Binder</th>
<th>Requirement for Asphalt Pavement Three Years or Less in Age</th>
<th>Requirement for Asphalt Pavement More Than Three Years in Age</th>
<th>Test Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absolute viscosity $60^\circ$C (P)</td>
<td>$\geq 25%$ Decrease</td>
<td>$\geq 40%$ Decrease</td>
<td>ASTM D2171</td>
</tr>
<tr>
<td>Complex Modulus $60^\circ$C, $G^*$ (kPa)</td>
<td></td>
<td></td>
<td>AASHTO T315</td>
</tr>
<tr>
<td>Viscosity $60^\circ$C, $\eta=G^*/\omega$ (Pa·s)</td>
<td></td>
<td></td>
<td>Report</td>
</tr>
</tbody>
</table>

The binder extracted per ASTM 2171, Method A and recovered per ASTM D1856 or D5404 from samples of the upper 3/8-inch of the surface of the treated pavement must exhibit the percent decrease in absolute viscosity or complex viscosity and corresponding phase angle increase listed in Table 3.1.2-1, when compared to the values from adjacent untreated samples from the same pavement in the prescribed timeframe. Binder extraction, recovering and testing must be performed within 48 hours of obtaining pavement cores or equivalent surface area samples.

The FPPC specifies that the “asphalt rejuvenating agent shall have the capability to penetrate the asphalt pavement surface, and shall be absorbed and incorporated into the asphalt binder.” Specification 335-3 is summarized in the table below.

Table 3.1.2-2
FPPC Material Performance Requirements

<table>
<thead>
<tr>
<th>Performance</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viscosity</td>
<td>Reduced by a minimum of 25% for a pavement two years or less in age, and reduced by a minimum of 40% for a pavement greater than two years in age</td>
</tr>
<tr>
<td>Test Method</td>
<td>AASHTO T315-05 Dynamic Shear Rheometer (DSR) method for asphalt testing</td>
</tr>
<tr>
<td>Core Requirement</td>
<td>Apply to extracted asphalt binder, taken from cores extracted fifteen to thirty days following application, in the upper 3/8 inch of pavement</td>
</tr>
<tr>
<td>Additional Performance Requirement</td>
<td>Treated areas shall be sealed in-depth to the intrusion of air and water</td>
</tr>
</tbody>
</table>

3.1.3 Friction Requirements
FAA P632-2.2 specifies that the results of the two tests between 24 and 96 hours after application shall indicate friction is increasing at a rate to obtain similar friction value of the pavement surface prior to application. The long-term test shall indicate no apparent adverse effect with time relative to friction values and existing pavement surface.
3.2 Roadway Candidate

FAA states that a typical asphalt pavement candidate must not have structural, load related distresses (or has provisions to correct these distresses) and with low to moderate environmental, temperature related distresses. The recommended corrected Pavement Condition Index in accordance with ASTM D5340 should be equal to or greater than 70 to qualify as a candidate.

MDSHA Specification 2.08.03.03 specifies the application of asphalt rejuvenator type B-2 is only allowed on roadways fulfilling the criteria as follows.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>International Roughness Index (IRI)</td>
<td>0 – 100</td>
</tr>
<tr>
<td>Average Daily Traffic (ADT)</td>
<td>0 – 25,000</td>
</tr>
<tr>
<td>Skid number</td>
<td>Greater than 40</td>
</tr>
<tr>
<td>Structural Cracking Index (SCI)</td>
<td>Greater than 75</td>
</tr>
</tbody>
</table>

3.3 General Construction Requirements

3.3.1 Weather and Seasonal Limitations
Rejuvenators must be applied only when the surface is dry. FAA Specification P632-4.2 states that the rejuvenation product must applied when the weather forecast is in accordance with the manufacturer’s recommendations for application and curing. FPPC Specification states that the surface treatment shall not be applied when the temperature is less than 40˚ in the shade. When applying emulsions, the temperature of the surface shall be a minimum of 59˚F, and no more than 140˚F.

3.3.2 Equipment
FAA (P632-4.3) and FPPC (355-4) specifications state that the Contractor must furnish equipment and hardware necessary for the performance of the work. The distributor must be designed and equipped in accordance with the manufacturer’s recommendations and capable of delivering the rejuvenators uniformly.

3.3.3 Preparation of Surface
FAA (P632-4.4) and FPPC (335-5) call for cleaning pavement surface immediately prior to placing the surface treatment.
3.4 Basis of Payments

FAA Specification P632-8.1 states that the payment for accepted rejuvenation product will be made at the contract unit price per square yard for asphalt rejuvenation adjusted according to Table 3.4-1.

<table>
<thead>
<tr>
<th>FAA Rejuvenation Pay Reduction</th>
<th>% Payment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Binder Rejuvenation at Acceptance Percent Reduction in Absolute Viscosity or Complex Modulus</strong></td>
<td></td>
</tr>
<tr>
<td>Pavement More Than 3 Years in Age</td>
<td>Pavement 3 Years or Less in Age</td>
</tr>
<tr>
<td>≥ 40</td>
<td>≥ 25</td>
</tr>
<tr>
<td>30.0 – 39.9</td>
<td>20.0 – 24.9</td>
</tr>
<tr>
<td>Less than 30.0</td>
<td>Less than 20.0</td>
</tr>
</tbody>
</table>

FPPC Specification 335-8 states that the payment will be made under:

- Asphalt rejuvenating emulsion Per square yard
- Test core removal Each
- Test core laboratory analysis – viscosity Each
References

Appendix

Product Technical Documents
CMS-1PF
1. Identification

Product identifier CMS-1PF
Other means of identification Not available.
Recommended use Not available.
Recommended restrictions None known.

Manufacturer/Importer/Supplier/Distributor information

Manufacturer: Ergon Asphalt & Emulsions, Inc.
Address: P. O. Box 1639
           Jackson, MS 39215-1639
Website: www.ergonasphalt.com
Telephone: 1-800-222-7122 (Customer Service)
E-mail: sds@ergon.com
24 hour Emergency (CHEMTREC): North America 1-800-424-9300; International 1-703-527-3887

2. Hazard(s) identification

Physical hazards Not classified.
Health hazards Carcinogenicity Category 1B
Environmental hazards Not classified.
OSHA defined hazards Not classified.

Label elements

Signal word Danger
Hazard statement May cause cancer by skin contact.
Prevention Obtain special instructions before use. Do not handle until all safety precautions have been read and understood. Wear protective gloves/protective clothing/eye protection/face protection.
Response If exposed or concerned: Get medical advice/attention.
Storage Store locked up.
Disposal Dispose of contents/container in accordance with local/regional/national/international regulations.

Hazard(s) not otherwise classified (HNOC) None known.
Supplemental information Vapors containing hydrogen sulfide may accumulate during storage or transport. HYDROGEN SULFIDE (H2S) can be harmful or fatal if inhaled.

3. Composition/information on ingredients

Mixtures

<table>
<thead>
<tr>
<th>Chemical name</th>
<th>Common name and synonyms</th>
<th>CAS number</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>WATER</td>
<td></td>
<td>7732-18-5</td>
<td>50 - 70</td>
</tr>
<tr>
<td>ASPHALT</td>
<td></td>
<td>8052-42-4</td>
<td>20 - 40</td>
</tr>
<tr>
<td>EXTRACTS (PETROLEUM), HEAVY</td>
<td>NAPHTHENIC DISTILLATE SOLVENT</td>
<td>64742-11-6</td>
<td>1 - 20</td>
</tr>
</tbody>
</table>

4. First-aid measures

Inhalation If breathing is difficult, remove to fresh air and keep at rest in a position comfortable for breathing. Call a physician if symptoms develop or persist.
Skin contact If clothing sticks to the skin, do not remove. Lotion or hand cream may aid in the removal of asphalt. Wash contact areas with soap and water. If needed, seek medical attention.
Eye contact
Immediately flush eyes with plenty of water for at least 15 minutes. Remove contact lenses, if present and easy to do. Continue rinsing. Get medical attention if irritation develops and persists.

Ingestion
Rinse mouth. DO NOT induce vomiting. Get medical attention immediately. If ingestion of a large amount does occur, call a poison control center immediately.

Most important symptoms/effects, acute and delayed
Direct contact with eyes may cause temporary irritation.

Indication of immediate medical attention and special treatment needed
Treat symptomatically.

General information
Ensure that medical personnel are aware of the material(s) involved, and take precautions to protect themselves.

5. Fire-fighting measures

Suitable extinguishing media
Foam. Dry chemical powder. Carbon dioxide (CO2).

Unsuitable extinguishing media
Water. Do not use water jet as an extinguisher, as this will spread the fire.

Specific hazards arising from the chemical
During fire, gases hazardous to health may be formed.

Special protective equipment and precautions for firefighters
Firefighters must use standard protective equipment including flame retardant coat, helmet with face shield, gloves, rubber boots, and in enclosed spaces, SCBA. Structural firefighters protective clothing will only provide limited protection.

Fire-fighting equipment/instructions
ALWAYS stay away from tanks engulfed in flame. Fight fire from maximum distance or use unmanned hose holders or monitor nozzles. Move containers from fire area if you can do so without risk. In the event of fire, cool tanks with water spray.

Specific methods
In the event of fire and/or explosion do not breathe fumes. In the event of fire, cool tanks with water spray.

General fire hazards
No unusual fire or explosion hazards noted.

6. Accidental release measures

Personal precautions, protective equipment and emergency procedures
Keep unnecessary personnel away. Keep people away from and upwind of spill/leak. Keep out of low areas. Do not touch damaged containers or spilled material unless wearing appropriate protective clothing. Ventilate closed spaces before entering them. For personal protection, see section 8 of the SDS.

Methods and materials for containment and cleaning up
This product is miscible in water.

Large Spills: Stop the flow of material, if this is without risk. Dike the spilled material, where this is possible. Cover with plastic sheet to prevent spreading. Absorb in vermiculite, dry sand or earth and place into containers. Prevent entry into waterways, sewer, basements or confined areas.

Small Spills: Wipe up with absorbent material (e.g. cloth, fleece). Clean surface thoroughly to remove residual contamination.

Never return spills to original containers for re-use. For waste disposal, see section 13 of the SDS. Absorb or cover with dry earth, sand or other non-combustible material and transfer to containers. Ventilate area and avoid breathing vapors or mist. For large spills, dike far ahead of liquid spill for later disposal. Do not release into sewers or waterways.

Environmental precautions
Avoid discharge into drains, water courses or onto the ground.

7. Handling and storage

Precautions for safe handling
Avoid prolonged exposure. Use only in well-ventilated areas. Hydrogen sulfide, a very highly toxic gas, may be present with this material. Keep face clear of tank and/or tank car openings. Good personal hygiene is necessary. Wash hands and contaminated areas with water and soap before leaving the work site.

Conditions for safe storage, including any incompatibilities
Prevent electrostatic charge build-up by using common bonding and grounding techniques. Store in original tightly closed container. Store in a well-ventilated place. Store away from incompatible materials (see Section 10 of the SDS). Do not allow material to freeze.
8. Exposure controls/personal protection

Occupational exposure limits

<table>
<thead>
<tr>
<th>Components</th>
<th>Type</th>
<th>Value</th>
<th>Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXTRACTS (PETROLEUM), HEAVY NAPHTHENIC DISTILLATE SOLVENT (CAS 64742-11-6)</td>
<td>PEL</td>
<td>5 mg/m³</td>
<td>Mist.</td>
</tr>
</tbody>
</table>

US. ACGIH Threshold Limit Values

<table>
<thead>
<tr>
<th>Components</th>
<th>Type</th>
<th>Value</th>
<th>Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASPHALT (CAS 8052-42-4)</td>
<td>TWA</td>
<td>0.5 mg/m³</td>
<td>Inhalable fraction.</td>
</tr>
</tbody>
</table>

US. NIOSH: Pocket Guide to Chemical Hazards

<table>
<thead>
<tr>
<th>Components</th>
<th>Type</th>
<th>Value</th>
<th>Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASPHALT (CAS 8052-42-4)</td>
<td>Ceiling</td>
<td>5 mg/m³</td>
<td>Fume.</td>
</tr>
<tr>
<td>EXTRACTS (PETROLEUM), HEAVY NAPHTHENIC DISTILLATE SOLVENT (CAS 64742-11-6)</td>
<td>STEL</td>
<td>10 mg/m³</td>
<td>Mist.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Components</th>
<th>Type</th>
<th>Value</th>
<th>Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>TWA</td>
<td></td>
<td>5 mg/m³</td>
<td>Mist.</td>
</tr>
</tbody>
</table>

Biological limit values

No biological exposure limits noted for the ingredient(s).

Appropriate engineering controls

Provide adequate ventilation, including appropriate local extraction, to ensure that the defined occupational exposure limit is not exceeded.

Individual protection measures, such as personal protective equipment

**Eye/face protection**
Safety glasses. If risk of splashing, wear safety goggles or face shield.

**Hand protection**
Chemical resistant gloves are recommended. If contact with forearms is likely wear gauntlet style gloves. Wash hands after handling.

**Other**
Chemical/solvent resistant gloves are recommended. If contact with forearms is likely, use gauntlet-style gloves. Wear suitable protective clothing as protection against splashing or contamination.

**Respiratory protection**
When workers are facing concentrations above the exposure limit they must use appropriate certified respirators.

**Thermal hazards**
Wear appropriate thermal protective clothing, when necessary.

**General hygiene considerations**
Always observe good personal hygiene measures, such as washing after handling the material and before eating, drinking, and/or smoking. Routinely wash work clothing and protective equipment to remove contaminants.

9. Physical and chemical properties

**Appearance**
Brown to black in color.

**Physical state**
Liquid.

**Form**
Liquid.

**Color**
Brown

**Odor**
Mild. Tar-like

**Odor threshold**
Not available.

**pH**
2.1 - 4

**Melting point/freezing point**
Not available.

**Initial boiling point and boiling range**
212 °F (100 °C)

**Flash point**
400.0 °F (204.4 °C)

**Evaporation rate**
< 1

**Flammability (solid, gas)**
Not available.

**Upper/lower flammability or explosive limits**

- **Flammability limit - lower (%)**
  Not available.

- **Flammability limit - upper (%)**
  Not available.

- **Explosive limit - lower (%)**
  Not available.
Explosive limit - upper (%)
Not available.

Vapor pressure
< 1 mm Hg @ 20 C

Vapor density
> 1

Relative density
Not available.

Solubility(ies)
Soluble

Partition coefficient (n-octanol/water)
Not available.

Auto-ignition temperature
> 700 °F (> 371.11 °C)

Decomposition temperature
Not available.

Viscosity
Not available.

Other information
Density
8.50 lb/gal

10. Stability and reactivity
Reactivity
The product is stable and non-reactive under normal conditions of use, storage and transport.

Chemical stability
Stable under normal temperature conditions.

Possibility of hazardous reactions
Hazardous polymerization does not occur.

Conditions to avoid
Avoid temperatures exceeding the flash point. Contact with incompatible materials. Do not overheat product.

Incompatible materials
Strong oxidizing agents.

Hazardous decomposition products
Upon decomposition, this product may yield sulfur dioxide, carbon monoxide, carbon dioxide and/or low molecular weight hydrocarbons. Hydrogen sulfide.

11. Toxicological information

Information on likely routes of exposure

Ingestion
Expected to be a low ingestion hazard.

Inhalation
Prolonged inhalation may be harmful.

Skin contact
Causes mild skin irritation. May cause cancer by skin contact.

Eye contact
Harmful in contact with eyes.

Symptoms related to the physical, chemical and toxicological characteristics
Direct contact with eyes may cause temporary irritation.

Information on toxicological effects

Acute toxicity
Not available.

Skin corrosion/irritation
Prolonged skin contact may cause temporary irritation.

Serious eye damage/eye irritation
Harmful in contact with eyes. None known.

Respiratory or skin sensitization
Respiratory sensitization
Not available.

Skin sensitization
May cause skin disorders if contact is repeated or prolonged.

Germ cell mutagenicity
No data available to indicate product or any components present at greater than 0.1% are mutagenic or genotoxic.

Carcinogenicity
Contains polycyclic aromatic compounds (PACs). Prolonged and/or repeated skin contact with certain PACs has been shown to cause skin cancer. Prolonged and/or repeated exposures by inhalation of certain PACs may also cause cancer of the lung and of other sites of the body. NTP Carcinogens (DHHS).

IARC Monographs. Overall Evaluation of Carcinogenicity
ASPHALT (CAS 8052-42-4) 2B Possibly carcinogenic to humans.

US. OSHA Specifically Regulated Substances (29 CFR 1910.1001-1050)
Not listed.

Reproductive toxicity
Not classified.

Specific target organ toxicity
- single exposure
Not classified.

Specific target organ toxicity
- repeated exposure
Not classified.
Aspiration hazard: Not available.

Chronic effects: Prolonged or repeated contact with skin may cause redness, itching, irritation, eczema/chapping and oil acne.

Further information: This product has no known adverse effect on human health.

12. Ecological information

Ecotoxicity: Not expected to be harmful to aquatic organisms.

<table>
<thead>
<tr>
<th>Product</th>
<th>Species</th>
<th>Test Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMS-1PF (CAS Mixture)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fish</td>
<td>LC50</td>
<td>56014.5313 mg/l, 96 hours estimated</td>
</tr>
</tbody>
</table>

* Estimates for product may be based on additional component data not shown.

Persistence and degradability: No data is available on the degradability of this product.

Bioaccumulative potential: No data available.

Mobility in soil: No data available.

Other adverse effects: No other adverse environmental effects (e.g. ozone depletion, photochemical ozone creation potential, endocrine disruption, global warming potential) are expected from this component.

13. Disposal considerations

Disposal instructions: Collect and reclaim or dispose in sealed containers at licensed waste disposal site. Dispose in accordance with all applicable regulations. No components are identified as hazardous wastes. Disposal recommendations are based on uncontaminated material.

Local disposal regulations: Dispose in accordance with all applicable regulations.

Hazardous waste code: The waste code should be assigned in discussion between the user, the producer and the waste disposal company. Not applicable.

Waste from residues / unused products: Dispose of in accordance with local regulations. Empty containers or liners may retain some product residues. This material and its container must be disposed of in a safe manner (see: Disposal instructions). Avoid discharge into water courses or onto the ground.

Contaminated packaging: Empty containers should be taken to an approved waste handling site for recycling or disposal. Since emptied containers may retain product residue, follow label warnings even after container is emptied.

14. Transport information

DOT: Not regulated as dangerous goods.

IATA: Not regulated as dangerous goods.

IMDG: Not regulated as dangerous goods.

Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code: Not available.

15. Regulatory information

US federal regulations: All components are on the U.S. EPA TSCA Inventory List.


Superfund Amendments and Reauthorization Act of 1986 (SARA): Immediate Hazard - No

Hazard categories: Delayed Hazard - Yes

Immediate Hazard: Fire Hazard - Yes

Pressure Hazard: Reactivity Hazard - No
### SARA 302 Extremely hazardous substance

<table>
<thead>
<tr>
<th>Chemical name</th>
<th>CAS number</th>
<th>Reportable quantity</th>
<th>Threshold planning quantity</th>
<th>Threshold planning quantity, lower value</th>
<th>Threshold planning quantity, upper value</th>
</tr>
</thead>
<tbody>
<tr>
<td>HYDROCHLORIC ACID</td>
<td>7647-01-0</td>
<td>5000</td>
<td>500 lbs</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**SARA 311/312 Hazardous chemical**

Not regulated.

**SARA 313 (TRI reporting)**

Not regulated.

### Other federal regulations

**Clean Air Act (CAA) Section 112 Hazardous Air Pollutants (HAPs) List**

Not regulated.

**Clean Air Act (CAA) Section 112(r) Accidental Release Prevention (40 CFR 68.130)**

Not regulated.

**Safe Drinking Water Act (SDWA)**

Not regulated.

### US state regulations

**US. Massachusetts RTK - Substance List**

- ASPHALT (CAS 8052-42-4)
- EXTRACTS (PETROLEUM), HEAVY NAPHTHENIC DISTILLATE SOLVENT (CAS 64742-11-6)

**US. New Jersey Worker and Community Right-to-Know Act**

Not regulated.

**US. Pennsylvania RTK - Hazardous Substances**

- ASPHALT (CAS 8052-42-4)
- EXTRACTS (PETROLEUM), HEAVY NAPHTHENIC DISTILLATE SOLVENT (CAS 64742-11-6)

**US. Rhode Island RTK**

Not regulated.

**US. California Proposition 65**

WARNING: This product contains a chemical known to the State of California to cause cancer.

**US - California Proposition 65 - CRT: Listed date/Carcinogenic substance**

- ASPHALT (CAS 8052-42-4) Listed: January 1, 1990

### International Inventories

<table>
<thead>
<tr>
<th>Country(s) or region</th>
<th>Inventory name</th>
<th>On inventory (yes/no)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>Australian Inventory of Chemical Substances (AICS)</td>
<td>Yes</td>
</tr>
<tr>
<td>Canada</td>
<td>Domestic Substances List (DSL)</td>
<td>Yes</td>
</tr>
<tr>
<td>Canada</td>
<td>Non-Domestic Substances List (NDSL)</td>
<td>No</td>
</tr>
<tr>
<td>China</td>
<td>Inventory of Existing Chemical Substances in China (IECSC)</td>
<td>Yes</td>
</tr>
<tr>
<td>Europe</td>
<td>European Inventory of Existing Commercial Chemical Substances (EINECS)</td>
<td>Yes</td>
</tr>
<tr>
<td>Europe</td>
<td>European List of Notified Chemical Substances (ELINCS)</td>
<td>No</td>
</tr>
<tr>
<td>Japan</td>
<td>Inventory of Existing and New Chemical Substances (ENCS)</td>
<td>No</td>
</tr>
<tr>
<td>Korea</td>
<td>Existing Chemicals List (ECL)</td>
<td>Yes</td>
</tr>
<tr>
<td>New Zealand</td>
<td>New Zealand Inventory</td>
<td>Yes</td>
</tr>
<tr>
<td>Philippines</td>
<td>Philippine Inventory of Chemicals and Chemical Substances (PICCS)</td>
<td>Yes</td>
</tr>
<tr>
<td>United States &amp; Puerto Rico</td>
<td>Toxic Substances Control Act (TSCA) Inventory</td>
<td>Yes</td>
</tr>
</tbody>
</table>

*A "Yes" indicates that all components of this product comply with the inventory requirements administered by the governing country(s).

A "No" indicates that one or more components of the product are not listed or exempt from listing on the inventory administered by the governing country(s).

### 16. Other information, including date of preparation or last revision

**Issue date** 06-23-2014

**Revision date** 03-11-2015

**Version #** 02

**Further information** HMIS® is a registered trade and service mark of the NPCA.
References
ACGIH
EPA: AQUIRE database
NLM: Hazardous Substances Data Base
US. IARC Monographs on Occupational Exposures to Chemical Agents
IARC Monographs. Overall Evaluation of Carcinogenicity
National Toxicology Program (NTP) Report on Carcinogens
ACGIH Documentation of the Threshold Limit Values and Biological Exposure Indices

Disclaimer
The information provided in this Safety Data Sheet is correct to the best of our knowledge, information and belief at the date of its publication. The information given is designed only as a guidance for safe handling, use, processing, storage, transportation, disposal and release and is not to be considered a warranty or quality specification. The information relates only to the specific material designated and may not be valid for such material used in combination with any other materials or in any process, unless specified in the text. The information in the sheet was written based on the best knowledge and experience currently available.

Revision Information
Hazard(s) identification: Supplemental information
Composition / Information on Ingredients: Ingredients
Accidental release measures: Personal precautions, protective equipment and emergency procedures
Handling and storage: Precautions for safe handling
Physical & Chemical Properties: Multiple Properties
GHS: Classification
CRF®
CRF® Crackfiller / Restorative Seal
Specification Sheet

PRODUCT SPECIFICATIONS:

<table>
<thead>
<tr>
<th>Test on Emulsion</th>
<th>Test Method</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viscosity @ 25°C, SFS</td>
<td>ASTM D-244</td>
<td>25-150</td>
</tr>
<tr>
<td>Sieve Test, % w</td>
<td>ASTM D-244 (Mod)</td>
<td>0.1 max.</td>
</tr>
<tr>
<td>Particle Charge Test</td>
<td>ASTM D-244</td>
<td>Positive</td>
</tr>
<tr>
<td>Cement Mixing Test, % w</td>
<td>ASTM D-244</td>
<td>2.0 max.</td>
</tr>
<tr>
<td>Pumping Stability</td>
<td>Pass</td>
<td></td>
</tr>
<tr>
<td>5-day Settlement Test, % w</td>
<td>ASTM D-244</td>
<td>5.0 max.</td>
</tr>
<tr>
<td>Residue, % w</td>
<td>ASTM D-244 (Mod)</td>
<td>64 min.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Test on Residue from Distillation</th>
<th>Test Method</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Viscosity @ 60°C, cSt</td>
<td>ASTM D-2170</td>
<td>1,000-4,000</td>
</tr>
<tr>
<td>Maltene Distribution Ratio PC + A₁</td>
<td>ASTM D-2006-70</td>
<td>0.7-1.1</td>
</tr>
<tr>
<td>S + A₂</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PC/S Ratio</td>
<td>ASTM D-2006-70</td>
<td>0.5 min.</td>
</tr>
<tr>
<td>Asphaltenes, %w</td>
<td>ASTM D-2006-70</td>
<td>11.0 max.</td>
</tr>
</tbody>
</table>

1Test procedure identical with ASTM D-244 except that distilled water shall be used in place of two percent sodium oleate solution.

2Pumping stability is determined by charging 450 ml of emulsion into one-liter beaker and circulating the emulsion through a gear pump (Roper 29.B22621) having ¼" inlet and outlet. The emulsion passes if there is no significant oil separation after circulating ten minutes.

3ASTM D-244 Evaporation Test for percent of residue is modified by heating 50 gram sample to 149°C (300°F) until foaming ceases, then cooling immediately and calculating results.

4In the Maltene Distribution Ration Test by ASTM Method D2006-70:

PC = Polar Compounds, A₁ = First Acidaffins,
A₂ = Second Acidaffins, S = Saturated Hydrocarbons.

Product shall be freeze stabilized and if freezing has occurred a homogeneous mixture shall be obtained when the material has thawed and been thoroughly mixed.
Ravel Check®
PRODUCT SPECIFICATIONS

RAVEL CHECK® Asphalt Pavement Preservation/Rejuvenation Liquid

With

LOCK the ROCK® Technology

Be Pro-Active, Not Re-Active

Stop Asphalt Raveling in its Tracks

✓ Preserve
✓ Extend
✓ Seal
Pavement Preservation remains at the top of inquiries from municipal, county and state agencies seeking more cost effective alternatives in preserving asphalt. Preservation refers to the process of maintaining or returning pavement condition to like new. Replacing Hot Mix Asphalt (HMA) components modified or lost during manufacturing and in-service are those containing the highest concentration of maltenes. RAVEL CHECK® Asphalt Pavement Preservation/Rejuvenation Liquid with Gilsonite provides the highest level of maltenes, which are considered the primary chemical component lost from oxidized HMA.

HMA is a combination of approximately 94% aggregate and 6%. Aggregate is selected based on multiple criteria ranging from size, shape, hardness, absorption and durability. Aggregate typically is not the failing component in pavement. It is the failing HMA releasing the aggregate resulting in material loss. The production process starts the binder oxidation process; a thin film of heated asphalt is applied to aggregate in the presence of excessive air. The HMA is profiled and compacted in place creating the road. In the first few years of life HMA loses a significant portion of maltenes, the liquefying components in the HMA. These losses are due primarily to oxidation. Continued oxidation increases binder hardness, shrinkage and cracking. As the binder-aggregate bond is severed, aggregate fines are first to leave the HMA matrix, followed by larger aggregate, leading to local pavement failure.

RAVEL CHECK pavement preservation liquid is a new product utilizing proven technology to restore asphalt back to near new condition by replacing components lost during production and use. Gilsonite is a naturally occurring asphaltite bitumen containing the highest concentrations of maltenes available in a bitumen-like material. Maltenes are accepted as the lower molecular weight (<3,000), more fluid components providing flexibility in HMA. Asphaltenes are the more solid components providing body to the asphalt. Typically, asphalt contains 10-30% asphaltenes and 70-90% maltenes.

Gilsonite has a low oxygen content relative to nitrogen, indicating the contained nitrogen has basic functionality and is believed one of the reasons Gilsonite provides superior aggregate coating. The basic characteristic is likely the reason Gilsonite is less prone to free radical oxidation, thus interfering with the asphalt oxidation process naturally occurring with untreated asphalt. The nitrogen also provides additional UV protection.

Gilsonite provides increased UV protection to surface asphalt. The high nitrogen content is believed to increase the aggregate wetting/coating characteristics to aggregate.

Gilsonite is naturally occurring and mined as an ore. It is a very low pen asphalt with low aromatic content. The superior durability, resistance to oxidation and relatively low polynuclear aromatic composition make Gilsonite the ideal component to improve rejuvenation performance and maintain the health (green) for the environment and personnel handling RAVEL CHECK® preservation liquid.

There are 4 mechanisms to rehabilitate (rejuvenate) the asphalt matrix:

1. Applying fluxing oil (e.g. WD-40) to the surface;
2. Add virgin asphalt (as Gilsonite);
3. Add refined asphalt (typical asphalt emulsion); or
4. Add maltenes (resins) to the asphalt to increase ductility.

UNIQUE Paving Materials elected to incorporate all mechanism of rejuvenation and rehabilitation into RAVEL CHECK® liquid.

RAVEL CHECK® liquid is one of the few products on the market that addresses every need of asphalt...restoring ALL the properties that have been lost during HMA production and rapid oxidation of the asphalt binder.
RAVEL CHECK preservation liquid will rejuvenate and extend pavement life 3-5 years. Applications within the first year of HMA life seal the cracks and slow the HMA oxidation process. Maintaining the like new HMA maltene-asphaltenes ratio will maintain flexibility and RAVEL CHECK liquid’s LOCK THE ROCK® technology glues aggregate back down in HMA and in chip seal applications.

RAVEL CHECK liquid is one of the only rejuvenators formulated for both large distributor truck and local brush/squeegee applications. RAVEL CHECK preservation liquid is available in bulk, drums, pails and bottles. The ready to apply formulation, bulk or packaged, makes RAVEL CHECK liquid easier and simpler to apply.

RAVEL CHECK preservation liquid dries to a black color contrasting with the surrounding area. The appearance is equivalent to new pavement and is perceived as a major improvement in pavement quality and appearance. Once striped, RAVEL CHECK preservation liquid provides the appearance of new pavement.

<table>
<thead>
<tr>
<th>RAVEL CHECK® PRESERVATION LIQUID PRODUCT SPECIFICATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tests on Emulsion Concentrate:</strong></td>
</tr>
<tr>
<td>Viscosity: Saybolt Furol Seconds (SFS) @ 77°F</td>
</tr>
<tr>
<td>D-244</td>
</tr>
<tr>
<td>Specific Gravity @ 60°F</td>
</tr>
<tr>
<td>Density @ 60°F, lb/gal</td>
</tr>
<tr>
<td>Sieve Test %</td>
</tr>
<tr>
<td>5 Day Settlement %</td>
</tr>
<tr>
<td>pH</td>
</tr>
<tr>
<td><strong>Tests on Residue From Distillation or Evaporation</strong></td>
</tr>
<tr>
<td>Viscosity @ 275°F, Cps.</td>
</tr>
<tr>
<td>Penetration @ 77°F Dmm</td>
</tr>
<tr>
<td>Solubility % in Trichloroethylene</td>
</tr>
<tr>
<td>Asphaltenes, %</td>
</tr>
<tr>
<td>Maltenes, % (calculated)</td>
</tr>
<tr>
<td><strong>Additional Compositional Information, Finished Ready for Application</strong></td>
</tr>
<tr>
<td>Component</td>
</tr>
<tr>
<td>Bitumen</td>
</tr>
<tr>
<td>Gilsonite</td>
</tr>
<tr>
<td>Penetrating Component</td>
</tr>
<tr>
<td>Water and Emulsifier</td>
</tr>
</tbody>
</table>
Penetrating surface asphalt, RAVEL CHECK preservation liquid increases penetration by approximately one penetration grade based on AASHTO M 20 and ASTM D 946. The increased penetration demonstrated RAVEL CHECK liquid will effectively penetrate the asphalt and transfer maltenes into surface pavement, replacing maltenes lost due to aging and oxidation returns the asphalt back to near original chemical composition. This increases asphalt flexibility and combined with the additional asphalt and Gilsonite delivered, provides the LOCK THE ROCK® technology performance to protect and extend pavement life.

<table>
<thead>
<tr>
<th>Penetration Grade</th>
<th>Comments</th>
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<tbody>
<tr>
<td>40-50</td>
<td>Hardest Grades</td>
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<tr>
<td>60-70</td>
<td>Typical grades used in the U.S.</td>
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<tr>
<td>85-100</td>
<td></td>
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<tr>
<td>120-150</td>
<td></td>
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<tr>
<td>200-300</td>
<td>Softest grade</td>
</tr>
</tbody>
</table>

Background Rejuvenators

- Rejuvenators are a higher performance pavement surface treatment relative to sealers. Sealer performance is limited to sealing the pavement, filling small cracks and sealing out water. Rejuvenators are more effective in blocking UV rays and reducing contact limiting binder oxidation.

- Rejuvenators extend the sealer performance by returning the pavement surface layer to near new chemical and physical condition. Starting during crude distillation and continuing through HMA production, asphalt temperatures exceed >600°F distillation/350°F HMA production, initiating the oxidation process. In pavement, oxidation is the process of oxygen chemically reacting with pavement components, resulting in different chemical structures. The greater the oxidation the greater the change in chemical and physical components. Generally accepted in the industry is the loss of maltenes from the asphalt. Maltenes are sometimes referred to as resins or heavy oils. Rejuvenating asphalt to a pre-oxidized condition requires returning lost components and supplying additional asphalt. In addition to maintaining the highest maltenes concentration, RAVEL CHECK preservation liquid includes environmentally-friendly solvents to effectively transport the maltenes to the oxidized pavement.

- Rejuvenators are surface treatments and must provide a durable wearing surface. Pavement flexing, vehicle maneuvering and unpredictable weather require adhesion, strength, flexibility, sealing, UV protection and environmental acceptability. RAVEL CHECK liquid is applied at varying application rates between 0.075 gallons/square yard to 0.15 gallons/square yard. The age, porosity and overall condition of the pavement will determine the specific rate of application.
The negative environmental impact from older pavement surface treatments based on coal tar is becoming an ever increasing liability. In several states and the District of Columbia they are already banned. Many major box stores no longer handle these products. The human health and environmental impact create too high a liability for those handling these products.

Rejuvenator applications include miles of road, walking/golf paths, parking lots and any paved area. Optimizing rejuvenator performance for all applications requires ease of application with automated sprayer trucks, small sprayer apparatus including mini spray bars and spraying wands. The preferred rejuvenator must be ready to apply in both bulk and as package form. Bulk is typically handled in approximately 5,000 gallon truck load quantities. Package applications for localized repairs require less than 10 gallons of rejuvenator typically in 5-gallon pails (1 gallon per 90-100 ft²). Localized application can be applied using a small spray apparatus, sealer brooms and squeegees.

UNIQUE developed RAVEL CHECK preservation liquid with Gilsonite as the optimum formulation delivering superior performance and environmental friendliness.

1.01 MATERIAL SPECIFICATIONS

The asphalt rejuvenating agent shall be an emulsion composed of a petroleum resin oil base uniformly emulsified with water. Each bidder must submit with his bid a certified statement from the asphalt rejuvenator manufacturer showing that the asphalt rejuvenating emulsion conforms to the required physical and chemical requirements.

2.01 SPECIFIED MATERIAL

The product RAVEL CHECK asphalt rejuvenating liquid is manufactured by UNIQUE Paving Materials Corp. and is the standard for these specifications and all bids for this project shall comply with this standard.

3.01 DILUTION

RAVEL CHECK liquid is not to be blended with water unless specified by the manufacturer. It shall be spread on the pavement in concentrated form at a rate of 0.075 to 0.15 gallons per square yard as approved by the manufacturer or a Manufacturer Approved Application Representative (MAAR).

4.01 MANUFACTURER APPROVED APPLICATION REPRESENTATIVE (MAAR)

The RAVEL CHECK rejuvenating liquid shall be applied by the MAAR experienced with such material. The MAAR shall have a minimum of three years of experience applying the product for the intended use and have successfully demonstrated their qualifications to the manufacturer.

5.01 SAND

The application or broadcasting of sand is an option. The manufacturer or MAAR shall determine if sand is required. If so required, the rate will generally be 1 to 2 pounds of sand per square yard.

Sand shall be broadcast evenly in a single pass over the surface with a mechanical spreader prior to applying RAVEL CHECK rejuvenating liquid.

Sand shall be consistent in gradation, dry and free of debris, dirt and aggregates.
6.01 APPLICATION EQUIPMENT

The mechanical equipment used for spreading the rejuvenating liquid shall be self-propelled, designed and equipped to apply the rejuvenating liquid uniformly on varying surface widths, at prescribed application rates, and with an allowable variation of specified application rate by the manufacturer.

7.01 SURFACE CONDITIONS

Prior to application, the MAAR shall determine whether the existing surface to be treated requires sweeping and cleaning. This surface preparation, if required, shall be accomplished by hand brooming, power blowing, mechanical or other approved cleaning methods.

Pavements previously coated with coal tar based sealers or surface treatments will limit RAVEL CHECK rejuvenating liquid penetration. Do not apply RAVEL CHECK liquid to pavements previously treated with coal tar. Discuss historical pavement treatments with MAAR prior to application. UNIQUE has a test procedure to determine if coal tar has been previously applied.

8.01 APPLICATION TEMPERATURES / WEATHER CONDITIONS

The ambient temperature when RAVEL CHECK preservation liquid is applied shall be as recommended by the manufacturer. The rejuvenating liquid shall not be applied to paved surfaces when the ambient temperature is below 50°F.

The RAVEL CHECK rejuvenating liquid shall be applied only when the existing surface is thoroughly dry and when it is not threatening to rain.

9.01 BIDDERS CERTIFIED SUBMISSIONS

All bidders must submit with their bid the manufacturer’s certification that the rejuvenating liquid is in complete conformity with the specified material in section 2.01.

RAVEL CHECK rejuvenating liquid is manufactured by UNIQUE Paving Materials Corp. and is a product of known quality and accepted performance.

RAVEL CHECK® is a registered trademark of UNIQUE Paving Materials Corp.
Reclamite®
### RECLAMITE® Asphalt Rejuvenating Agent

#### Specifications:

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<th>Tests</th>
<th>Test Method</th>
<th>Requirements</th>
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<td>ASTM</td>
<td>AASHTO</td>
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<td>Tests on Emulsion:</td>
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<td></td>
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<tr>
<td>Viscosity @ 25°C, SFS</td>
<td>D-244</td>
<td>T-59</td>
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<tr>
<td>Residue, % w&lt;sup&gt;(1)&lt;/sup&gt;</td>
<td>D-244 (mod)</td>
<td>T-59 (mod)</td>
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<tr>
<td>Miscibility Test&lt;sup&gt;(2)&lt;/sup&gt;</td>
<td>D-244 (mod)</td>
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<tr>
<td>Sieve Test, % w&lt;sup&gt;(3)&lt;/sup&gt;</td>
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<td>Particle Charge Test</td>
<td>D-244</td>
<td>T-59</td>
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<tr>
<td>Percent Light Transmittance&lt;sup&gt;(4)&lt;/sup&gt;</td>
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<td>GB</td>
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<td>Flash Point, COC, °C</td>
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<tr>
<td>Viscosity @ 60°C, cSt</td>
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<tr>
<td>Asphaltenes, %w</td>
<td>D-2006-70</td>
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<tr>
<td>Maltene Distribution Ratio</td>
<td>D-2006-70</td>
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</tr>
<tr>
<td>PC + A&lt;sub&gt;1&lt;/sub&gt;&lt;sup&gt;(5)&lt;/sup&gt;</td>
<td></td>
<td></td>
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<tr>
<td>S + A&lt;sub&gt;2&lt;/sub&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PC/S Ratio&lt;sup&gt;(5)&lt;/sup&gt;</td>
<td>D-2006-70</td>
<td>---</td>
</tr>
<tr>
<td>Saturate hydrocarbons, S&lt;sup&gt;(5)&lt;/sup&gt;</td>
<td>D-2006-70</td>
<td>---</td>
</tr>
</tbody>
</table>

1. ASTM D-244 Evaporation Test for percent of residue is made by heating 50 gram sample to 149°C (300°F) until foaming ceases, then cool immediately and calculate results.
2. Test procedure identical with ASTM D-244 60 except that .02 Normal Calcium Chloride solution shall be used in place of distilled water.
3. Test procedure identical with ASTM D-244 60 except that distilled water shall be used in place of two percent sodium oleate solution.
4. Test procedure is attached.
5. Chemical composition by ASTM Method D-2006-70:
   - PC = Polar Compounds
   - A<sub>1</sub> = First Acidaffins
   - A<sub>2</sub> = Second Acidaffins
   - S = Saturated Hydrocarbons

Note: For gal/ton conversion use 242 gal/ton.

Note: Data presented are typical. Slight variation may occur from lot to lot.
RejuvaSeal®
1. **PRODUCT NAME**
   RejuvaSeal®

2. **MANUFACTURER**
   Pavement Rejuvenation International, LP.
   5327 Industrial Way Drive
   Buda, TX 78610
   Phone: (512) 295-1166
   Fax: (512) 295-1196

   Manufactured in various locations throughout USA & Canada.

3. **PRODUCT DESCRIPTION**
   RejuvaSeal® is a revolutionary three-in-one treatment for asphalt pavements. RejuvaSeal is designed to penetrate the asphalt surface and revitalize the asphalt binder while sealing the surface against contaminants such as fuel, water, and de-icing chemicals.

   When applied correctly, it restores ductility (flexibility) while reducing viscosity (brittleness). It makes asphalt pavement fuel resistant and seals the surface against fuel, oil, salt and other contaminants while replenishing oils essential to the longevity of asphalt pavement. It can reverse the aging process with an even wearing, black finish.

   RejuvaSeal will not peel, chip, or delaminate. It seals the pavement and improves the appearance and image of the asphalt surface.

4. **PRODUCT USE**
   RejuvaSeal should be used to rejuvenate, seal and provide a fuel resistant surface. It is also recommended for use on a surface where a coal-tar emulsion would be too slippery. The penetration allows RejuvaSeal to seal and rejuvenate without changing the surface structure of asphalt.

   Grooved runways and roads do not have to be re-grooved, nor is PFC asphalt degraded.

   RejuvaSeal is a preventative maintenance product that will pay off in long term dividends by significantly reducing the major, capital expenditures associated with reconstruction.

5. **TECHNICAL DATA**
   RejuvaSeal meets or exceeds the FAA’s Engineering Brief 44 A & B, FAA Spec P-629 and the TXDOT specification for sealer/rejuvenators.

   The product is composed of the following materials:
   - ASTM D490 RT 12 Coal Tar (35%-50%)
   - Petroleum Distillate (32%-42%)
   - Rejuvenator (15%-40%)

   RejuvaSeal has the following Bituminous Material property requirements:
   - Specific Gravity ASTM D70 1.04 min
   - Engler Viscosity ASTM D1665 8.0 max %
   - Water by Vol. ASTM D95 2.0 max
   - Softening Point ASTM D36 50°-55° max
   - Distillation % by wt ASTM D20
     - 170 C <20
     - 270 C 20-50
     - 300 C 40-60

6. **ADDITIONAL FEATURES**
   RejuvaSeal requires one coat application and usually cures within 24 hours.

7. **SURFACE PREPARATION**
   Prior to application of RejuvaSeal, the surface should be free of all dirt and contaminants. Vegetation should be destroyed with herbicide. RejuvaSeal should only be applied when the pavement is dry and the surface temperature is 50° F or higher.

8. **EQUIPMENT**
   RejuvaSeal is applied with state-of-the-art high volume equipment, utilizing computer -controlled flow rates nozzles to assure uniform application rate.

9. **APPLICATION**
   RejuvaSeal should be uniformly applied with a pressure distributor at a specified rate. It is recommended that a pre-test application be conducted 4-24 hours prior to application to determine the appropriate rate at which the material should be applied.

   Applied correctly, it is a one-step application process in which treated surfaces can usually be reopened within 24 hours.

10. **AVAILABILITY & COST**
    RejuvaSeal is available through distributors and applicators world wide.

    RejuvaSeal is a cost-effective method of pavement rejuvenation. Actual costs are dependent on field surface conditions, systems used, and size of project.

11. **WARRANTY**
    RejuvaSeal is shipped from the manufacturing site and is warranted to meet all composition and performance criteria as stated herein.

12. **TECHNICAL SERVICES**
    Independent laboratory test results and further technical data are available upon request.