

Spray-Applied Rejuvenators and Sealers for Effective Pavement Preservation

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Outline



- Pavement Aging and Tools
- Rejuvenators
 - What, why, and how are they used?
 - Research and Projects
- Spray-Applied Asphalt-Based Treatments
 - Fog Seals
 - Rapid Penetrating Emulsion





Why Do Pavements Age?

- Asphalt binder **oxidizes** with time
 - Becomes stiffer, brittle, prone to cracking
 - Referred to as **aging** in pavement industry
- 2 approaches to address aging
 - **Physical:** Limit exposures by covering/sealing pavement, reducing permeability
 - Ex. Fog seal, chip seal
 - **Physiological:** Directly affect asphalt binder
 - Ex. Rejuvenators



Graphic: Illinois Center for Transportation



When Should A Pavement Be Treated?



Early is better!

"Most of oxidative aging in the upper stratum of an asphalt concrete pavement occurs during the first 4 years after construction. After this period, the asphalt aging rate decreases significantly... <u>(a surface seal)</u> <u>must be placed during the first 2 years</u> (approximately) of the pavement's life."

- Permeability of Asphalt Surface Seals and Their Effect on Aging of the Underlying Asphalt Concrete – Joe Button, Transportation Research Record Journal, 1996





Proactive Approach





- Early treatments extend life, save money, safer for workers and motorists
- Surface treatments are most effective early in life



Asphalt Materials, In

Pavement Condition Index

History Of Rejuvenators

- First applications recorded around 1970
 - Reclamite and Koppers BPR most notably
- Asphalt-derived products to balance maltene to asphaltenes ratio
- Proposed specifications involved extracting and recovering asphalt binder in top 3/8"
 - Viscosity decrease by minimum 40%
 - Penetration increase by minimum 20%
- Currently no universal specifications (AASHTO)
 - Local specs, FAA, etc. can vary
- Push towards bio-oil and plant-based materials in recent years
 - Same function as asphalt-based maltene materials
- Increase in usage in past decade, but not new concepts





Source: Boyer, "Asphalt Rejuvenators – Fact or Fable"

What Is A Rejuvenator?

- Materials or additives that offset, maintain, or restore properties of asphalt that degrade with aging
- Low-to-medium viscosity oils at ambient temperature soluble in asphalt binder
- Three broad categories
 - **Petroleum-based:** derived from petroleum products
 - Bio-based: derived from plants
 - **Hybrid:** blended with asphalt binder or residue
- Aging is not "reversable", but can be offset or mitigated with these products







How Can Rejuvenators Be Used?

- Spray-applied to pavement surface
 - Post-construction for preventative maintenance
- Added into asphalt binder or RAP/RAS during HMA production
 - Increase amount of RAP/RAS
- Cold Recycling Additive
 - Added to RAP/RAS at ambient/nearambient temperatures
- *Rejuvenator chemistry is often designed for a specific application (Not all created equal)*









Why Use A Rejuvenating Emulsion?



- Offset aging gradient near surface of the pavement
 - Where most of oxidative aging occurs
- Improve Performance Grade of binder
 = better crack resistance
- Reduces pavement permeability
- Extends preservation timeline when applied **EARLY**
 - Less effective later in pavement life





Rejuvenator Performance: Industry Opinion



Appendix D-1:

Approved Preventive Maintenance Treatments

- Historical applications show improvement in cracking resistance, life extension
- Michigan 3R guideline good resource for different treatments
- Effective rejuvenator applications can expect to give **2-4 years** of life extension (RoadResource.org)

Fix Type	Life Extension (in years) *	Life Extension (in years)	Life Extension (in years)	PASER Rating	ADA Required (Yes/No)
	Flexible	Composite	Rigid		
HMA Crack Treatment	1-3	1-3	N/A	6-7	N
Overband Crack Filling	1-2	1-2	N/A	6-7	N
One Course Non-Structural HMA Overlay	5-7	4-7	N/A	4-5****	Y
Mill and One Course Non- Structural HMA Overlay	5-7	4-7	N/A	3-5	Y
Single Course Chip Seal	3-6	N/A	N/A	5-7 ¹	N
Double Chip Seal	4-7	3-6	N/A	5-7 ¹	Y
Single Course Micro-Surface	3-5	**	N/A	5-6	Y
Multiple Course Micro-Surface	4-6	**	N/A	4-6****	Y
Ultra-Thin HMA Overlay	3-6	3-6	N/A	4-6****	Y
Paver Placed Surface Seal	4-6	**	N/A	5-7	Y
Full Depth Concrete Repair	N/A	N/A	3-10	4-5 ***	N ²
Concrete Joint Resealing	N/A	N/A	1-3	5-8	N
Concrete Spall Repair	N/A	N/A	1-3	5-7	N
Concrete Crack Sealing	N/A	N/A	1-3	4-7	N
Diamond Grinding	N/A	N/A	3-5	4-6	N
Dowel Bar Retrofit	N/A	N/A	2-3	3-5 ***	N
Longitudinal HMA Wedge/Scratch Coat with Surface Treatment	3-7	N/A	N/A	3-5****	Y
Flexible Patching	**	**	N/A	N/A	N
Mastic Joint Repair	1-3	1-3	N/A	4-7	N
Cape Seal	4-7	4-7	N/A	4-7	Y
Flexible Interlayer "A"	4-7	4-7	N/A	4-7	Y
Flexible Interlayer "B" (SAMI)	4-7	4-7	N/A	3-7	Y
Flexible Interlayer "C"	4-7	4-7	N/A	3-7	Y
Fiber Reinforced Flexible Membrane	4-7	4-7	N/A	3-7	N
Fog Seal	**	**	N/A	7-10	N
GSB 88	**	**	N/A	7-10	N
Mastic Surface Treatment	**	**	N/A	7-10	N
Scrub Seal	**	**	N/A	4-8	N

MDOT Local Agencies 3R Guidelines







Rejuvenator Performance: Residue Penetration



Penetration of Residue, 25 °C





Rejuvenator Performance: Residue Delta Tc



∆Tc of Residue, °C Oil A Oil B Top 1/2" Top 1/2" Next 1/2" Next 1/2" 0 Q -0.5 -1 -1 -1 -1.5 -2 -2.5 -1.7 -1.9 -2.1 -2.5 -2.5 -2.6 -3 -3.5 -3.2 -4 -3.9 -4.5

■Treated ■Control



Other Performance Tests



- Extraction and binder recovery tests:
 - DSR (G*, phase angle)
 - High temp Critical PG
 - Low Temp Critical PG
 - Viscosity
- Ideal CT ASTM D8225
 - Known to be sensitive to aging, additives







National Research Initiatives



- MNDOT National Road Research Alliance (NRRA) Spray on Rejuvenator Test Section
 - 12 rejuvenator products applied on sections of MnROAD and 15th St NE in St. Michael, MN
 - Research funded through 2023
- NCAT Test Track study on rejuvenators
 - 7 different surface treatments applied in 2012
 - Reports available on NCAT site
- NCHRP 10-114: "Developing Performance and Safety Specifications for Rejuvenating Seals"
 - Currently in RFP
 - Determine performance impact, life extension, optimization of rates, and suggested practices



Project Selection

Ideal: surface films intact, no raveling



Satisfactory surface films >50% intact, minimal raveling; may require sanding



Exercise Caution: Films ~50%, minor raveling, consider hybrid treatment







Project Selection: Permeability And Texture

- Permeability: measuring rate of water flow through pavement
 - Higher permeability = better penetration into pavement
 - Adjust application rate
- Mean Texture Depth Use Circular Track Meter (CTM) or Sand Patch
 - Texture loss = residue did not penetrate (more typical for asphalt-based materials)
- Testing before and after application
- Test patches are common
 - Sample material on squares at pre-weighed rates







Application Of Rejuvenating Emulsions



- Easy to apply using conventional spray equipment and/or distributors
 - Storage stable, minor mixing only
 - Generally, no heating required
 - Rates 0.035 gal/sy to 0.10 gal/sy
 - Full-width or longitudinal
- Dosage easily adjusted with application rates



Full Width Application



Application Of Rejuvenating Emulsions



- Formulation can be adjusted to be project-specific
 - Addition of asphalt-based emulsions (50/50)
 - Designed with penetrating capabilities
- Dry time dependent on ambient conditions
 - Good conditions = traffic release <1hr
- "Sanding" requirement project and material specific
 - Penetrating emulsions may not require or require less
 - Depend on existing permeability, friction, texture



Longitudinal Joint Application



Typical Application

Sanding Process

- Usually ~0.25-0.5 lb/sy for fat areas and to provide early frictional resistance
 - Projects with film loss or areas of concern
 - Sand is swept or allowed to wear away



River sand on county highway









Application Of Penetrating Rejuvenators



Full Width Treatment



8:49am

9:01am

9:28am

- New pavement, for effective penetrating capability
- Reduce or omit the need for sanding



Hybrid Rejuvenators And Sealers



- Asphalt-based hybrid
 - Asphalt emulsion blende with rejuvenating emulsion
- Gilsonite-based
 - Additive to seal pavement and give longer-lasting dark color
 - Existing guideline in MI
- Better contrast with new striping
- Lower permeability
- Better aesthetics
- Existing pavement markings will need replaced











Asphalt-Based Sealers

- Physical means to seal surface with asphalt residue
 - Reduce permeability
- Fog seals
 - Inexpensive, large permeability reduction
 - Can cause texture/friction loss, may be worn away easier
- Rapid Penetrating Emulsions (RPE)
 - Penetrate surface to fill voids, materials remains below surface even after surface residue worn away
 - Minimal effect on texture and friction







Rejuvenator vs RPE

-Penetrate

pavement

to $\frac{1}{2}$ "

voids and

texture

-Reduce

but not

impermeable/



-Oil-based slow-setting emulsion (25-30% solids) -Rate ≤ 0.1 gal/yd2 (0.03) gal/SY res.) surface ~ $\frac{1}{4}$ " -Restore properties of the depending on asphalt binder and reduce permeability -Recommend PCR > 70permeability

-2 to 4 years added life claimed

-\$1/yd2 to \$3/yd2 applied cost with sanding

-Low viscosity asphalt emulsion (35-40% solids) Rate ~ 0.15 gal/yd2 (0.06

- gal/SY res.)
- -Reduce permeability and maintain texture
- -Best if applied within the first 2 years
 - -Not enough data on added life yet
- \sim \$0.75/yd2 applied cost, usually not sanded

TUMINOUS PROTACKO OMEIGS



What Is A Rapid Penetrating Emulsion?

Designated As RPE

- Asphalt emulsion ~30 40% AC
- Designed to <u>penetrate</u> voids of bituminous pavement
- Reduces air and water intrusion while maintaining pavement texture
- "In" the pavement instead of "on" the pavement
- Quick resistance to water
- Most effective when applied in first year of pavement life





RPE Penetrating Capability



Laboratory Compacted Slab



ONERPE Application vsONEDiluted SS-1H Application0.15 gal/sy0.15gal/sy





RPE Effect On Permeability And Texture



Hendricks County, IN 2016



Where Is RPE Used?



Project Selection

- New Hot Mix Asphalt Pavement
 - Centerline
 - Full Width
- Recycled Pavements
 - Full Width
- Low density areas
 - Spot Repair



At Application



5 Minutes After Application



RPE Centerline Treatment Effect





Reduced permeability allows the treated centerline to dry faster than other parts of the pavement





Recycled Pavement Application



Cold Central Plant Recycling



1st Application 0.20 gsy

2nd Application 0.15 gsy

30 Minutes After Final Application

6-month Review After One Winter

- RPE allows placement of more asphalt residue into mix after construction
- Typical treatment would be a double chip seal or 2" HMA overlay
- Creates uniformity in permeability: better tack for HMA or only single chip seal necessary
- Chip seal or overlay delayed past 1st season of construction





Complimentary Treatments



- Surface treatments are complementary with other preventative and reactive maintenance products/methods
- Combining with a product such as VRAM can protect top and bottom = bulletproof joint



Conclusion



- Are rejuvenators effective?
 - Area of ongoing research nationally
 - Appear to be, but success needs to be defined by user expectations
- What is the expected life/cost in terms of EAC/ROI?
- What steps can I take to have success and what should I look for?
 - Do the research and testing up front Not all pavements are ideal
- What other product options are available?
 - Hybrid rejuvenators
 - Rapid Penetrating Emulsions



Questions?



Thank You!

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