TEST & EVALUATION REPORT

Shingle Rejuvenator Benchmark Life-Cycle Study

September 3, 2024

Report For: RoofRestor Rejuvenator
Saskatchewan, Canada

Email: info@greenershinglesrejuvenator.com

Sample Data/Information:

SAMPLE ID	GRADE/TYPE	DATE SAMPLED	DATE RECEIVED	SOURCE
Aged Asphalt Shingles	Architectural – Post Consumer	*Note 1	9/15/22	Roofing Contractor
Shingle Rejuvenator	RoofRestor	9/2022		

***Shingles removed from a home in Crystal River, FL approximately 14 years after installation**

OBJECTIVES:

Conduct a Benchmark Life-Cycle Study of RoofRestor Rejuvenator utilizing aged asphalt shingles that were removed from a home after approximately 14 years of exposure in Crystal River, Florida. Determine the estimated contribution to the shingles life-cycle made by the rejuvenator and quantify the differences to that of an untreated set of shingles.

The study used a miniature steep sloped roof, constructed at PRI made with commonly used stock material (2X4's, plywood, peel-n-stick underlayment, and stainless-steel roofing nails). Both slopes were roofed with the aged shingles, with one side being treated with RoofRestor rejuvenator and the other side being an un-treated roof deck. The rejuvenator was applied according the manufacturer's recommendations. See appendix for photos and details of construction

The miniature roof was weathered according to ASTM D4798 – "Standard Practice for Accelerated Weathering Test Conditions and Procedures for Bituminous Materials" using a modified exposure cycle consisting of, 51 minutes of light only and 9 minutes of light with rain. Studies have shown that 3000 Hours of APWS aging can be correlated to 10 years of normal outdoor exposure.

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CONCLUSIONS: Primary Property Assessment

- **Mass Loss**: Mass loss in asphalt shingles is due to both the oxidative aging of the binder and granular loss during the accelerated weathering process.
  - After 1,500 hours of exposure the mass loss of the un-treated shingles was 5.4% compared to 0.5% for the RoofRestor' rejuvenator.
    - ***RoofRestor Rejuvenator performs 10.8 times better than un-treated shingles***
  - After 3,000 hours of exposure the mass loss of the un-treated shingles was 9.1% compared to 1.0% for the RoofRestor' rejuvenator.
    - ***RoofRestor Rejuvenator performs 9.1 times better than un-treated shingles***

- **Wash off Material**: The exposure cycles consistently contained particulate material and shingle granules that were washed off by the accelerated weathering process.
  - After 1,500 hours of exposure the mass of the collected particulate from the un-treated shingles was 4.08g compared to 0.70g for the RoofRestor' rejuvenator.
    - ***RoofRestor Rejuvenator performs 5.8 times better than un-treated shingles***
  - After 3,000 hours of exposure the mass of the collected particulate from the un-treated shingles was 12.41g compared to 3.94g for the RoofRestor' rejuvenator.
    - ***RoofRestor Rejuvenator performs 3.1 times better than un-treated shingles***

- **Oxidative Aging** **(Measured by Carbonyl Indices)**: Oxidative aging in asphalt-based products can be quantified by a peak in a specific position on an FT-IR spectrum.
  - After 1,500 hours of exposure the un-treated shingles exhibited a 30.7% increase in carbonyl index, compared to Greener Shingle's 7.8% increase.
    - ***RoofRestor Rejuvenator performs 3.9 times better than un-treated shingles***
  - After 3,000 hours of exposure the un-treated shingles exhibited a 77.9% increase in carbonyl index, compared to Greener Shingle's 9.6% increase.
    - ***RoofRestor Rejuvenator performs 8.1 times better than un-treated shingles***

- **Shingle Flexibility**: After 1,500 and 3,000 hours of exposure, RoofRestor Rejuvenator improved low temperature flexibility from -22°F to -31°F.

- **Shingle Color and Appearance:** After 1,500 and 3,000 hours of exposure, the shingles treated with RoofRestor Rejuvenator exhibit a significantly different appearance than those left un-treated.
  - Un-treated shingles show a clear increase in the roofing granules lost. (Appendix A-4/5)

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DATA / RESULTS:

PROPERTIES	TEST METHODS	RESULTS, EXPOSURE HOURS			
		Before Treatment	Treated, 0 Hours	Treated, 1,500	Treated, 3,000
Properties of Shingles Not Treated with a Rejuvenator					
Visual Inspection of shingles (Photos)	PRI	See Appendix			
Weight of 5"x10" Sample, g	D751	147.8	147.8	139.8	134.6
Mass Change, % (Note 2)		---	---	-5.4	-9.1
Low Temperature Flexibility, °C (Note 3)	D5147-12	-22	-22	-22	-22
Carbonyl Index	E7214	0.95	0.95	1.37	1.69
Increase in Carbonyl Index from 0 Hours, %	Calculation			30.66	77.89
Material Lost during Exposure Cycles, g (Note 4)	PRI			4.08	12.41
Properties of Shingles Treated with RoofRestor Rejuvenator					
Visual Inspection of shingles (Photos)	PRI	See Appendix			
Weight of 5"x10" Sample, g	D751	147.8	146.4	145.7	145.0
Mass Change, % (Note 2)		---	---	-0.5	-1.0
Low Temperature Flexibility, °C (Note 3)	D5147-12	-22	-31	-31	-31
Carbonyl Index	E7214	0.95	1.67	1.80	1.83
Increase in Carbonyl Index from 0 Hours, %	Calculation			7.78	9.58
Material Lost during Exposure Cycles, g (Note 4)	PRI			0.70	3.94

Note 2 – Mass Change is calculated from the mass loss of a representative 5"x10" representative sample of shingle taken at each inspection interval, mass loss is expected with aging, lower mass loss is desirable.

Note 3 – Low temperature flexibility is the lowest temperature at which the shingle remains flexible – lower temperatures are more desirable.

Note 4 – Loss during exposure was measured by collecting granules and particulate matter from the collection system attached to the APWS weatherometer (See Appendix A-1 to A-9 for collection apparatus & sample photos).

Note 5 – Untreated samples were not exposed to additional aging in the APWS.

DISCUSSION:

The RoofRestor Rejuvenator exhibited efficacy via improving granule adhesion and shingle flexibility, indicating better overall comparative life-cycle properties. Based on the primary data Greener Shingle's product reduced oxidative aging (Carbonyl Index), and mass loss suggest the life-cycle of Greener Shingle's rejuvenation would be significantly greater than an un-treated product.

- *Carbonyl Index Note: when initially treated an increase in Carbonyl Index results this is due to the addition of bio-based oils (rejuvenators) that give an FT-IR response in the same peak area as the oxidative aging.*

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NEXT STEPS:

- Review with RoofRestor.

Tested by: _____ Date: September 3, 2024
Greg Lavin, Quality Assurance Manager

Reported by: _____ Date: September 3, 2024
Steven Loeffler, Client Services Manager

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APPENDIX

APPENDIX A-1 (Roof Deck Construction):

Ridge Cap Installation:

DISCUSSION:

A type of common, commercially used ridge-cap shingles were then cut and applies to the cap of the roof deck. The cap was selected for the closest visual match to the shingles used.

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APPENDIX

APPENDIX A-2 (Roof Deck Construction):

Application of Rejuvenators:

REJUVENATOR APPLICATION DATA:

PROPERTY	TEST METHODS	RESULTS, SAMPLE ID RoofRestor
Rejuvenator Application Data		
Dilution Rate, (%Water: %Product)	PRI Measurements	70:30
Volume Applied, mL		266
Weight Applied, g		257.1
Specific Gravity of Diluted Product	ASTM D70	0.9674
Calculated Application Rate, gal/ft^2	Calculation	0.0099

DISCUSSION:

The RoofRestor Rejuvenator was prepared and applied according to manufacturer guidelines using common garden spray bottles and allowed to cure for 24 hours:

- Manufacturer recommendations – A mixture of 70% water and 30% Rejuvenator concentrate stirred by hand to homogeneity.
- The product was applied were to one side of the roof deck at a target rate of 1 gallon per 100ft^2 using simple spray bottles.
- The other side was left un-treated.

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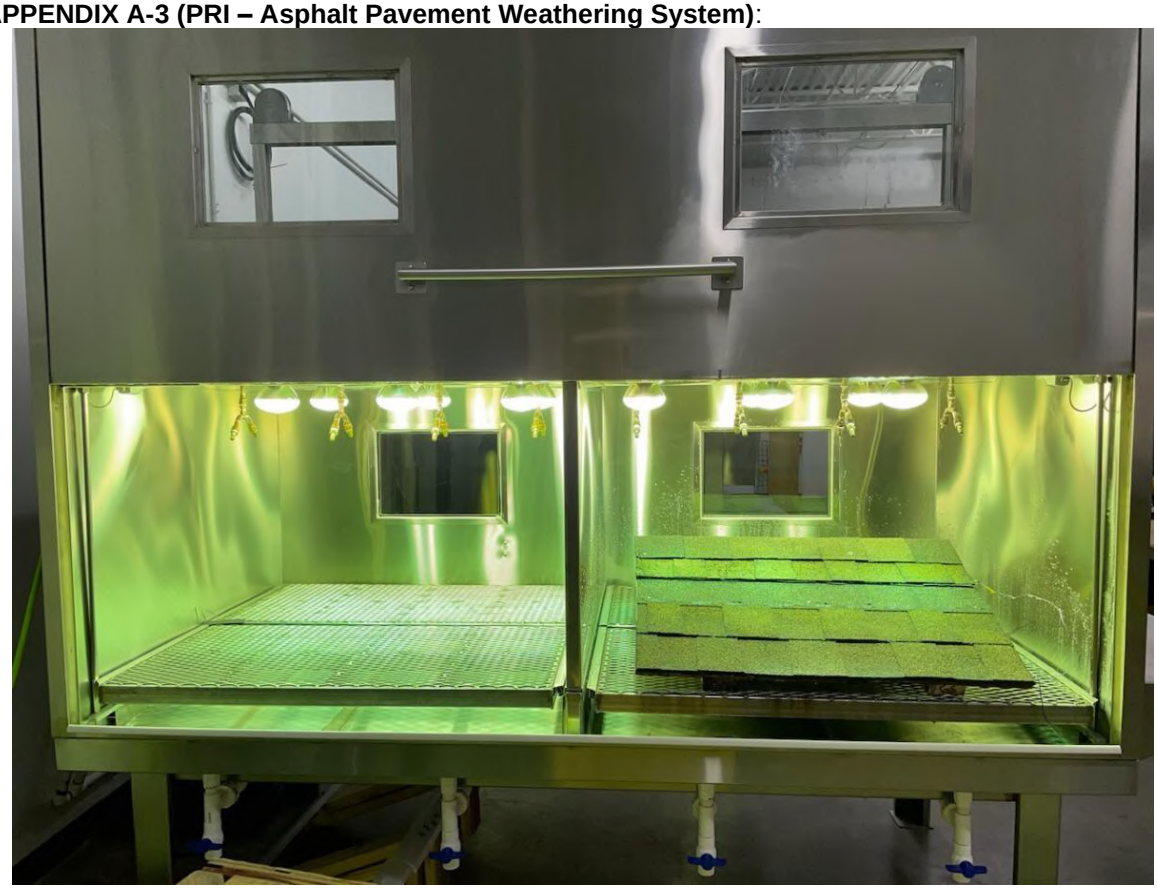
APPENDIX

APPENDIX A-3 (PRI – Asphalt Pavement Weathering System):



DISCUSSION:

An open view of PRI's Asphalt Pavement Weathering System with the roof deck positioned in the front chamber (right).

PRI's APWS was used for accelerated weathering of the roof deck after the application and curing of the rejuvenators. The weatherometer is monitored daily for even light distribution and water spray coverage, while temperature of the chamber, roof surface, water, ambient temperature and relative humidity are all tracked continuously.

ACCELERATED AGING PARAMETERS:

PARAMETER	SETTING
APWS Cycle and Climate Information	
Cycle Reference Method	ASTM D4798, Cycle A
Time of UV Light Exposure, mins	51
Time of UV Exposure with Rain Cycle, mins	9
Average Maximum Shingle Temperature, °F (Note 1)	149.5
Average "Rain Rate", gal/hr	12.6

Note 1 – Average Maximum Shingle Temperature is measured by taking the average of the temperature readings immediately before the beginning of the "rain cycle" when the temperature is at its highest level.

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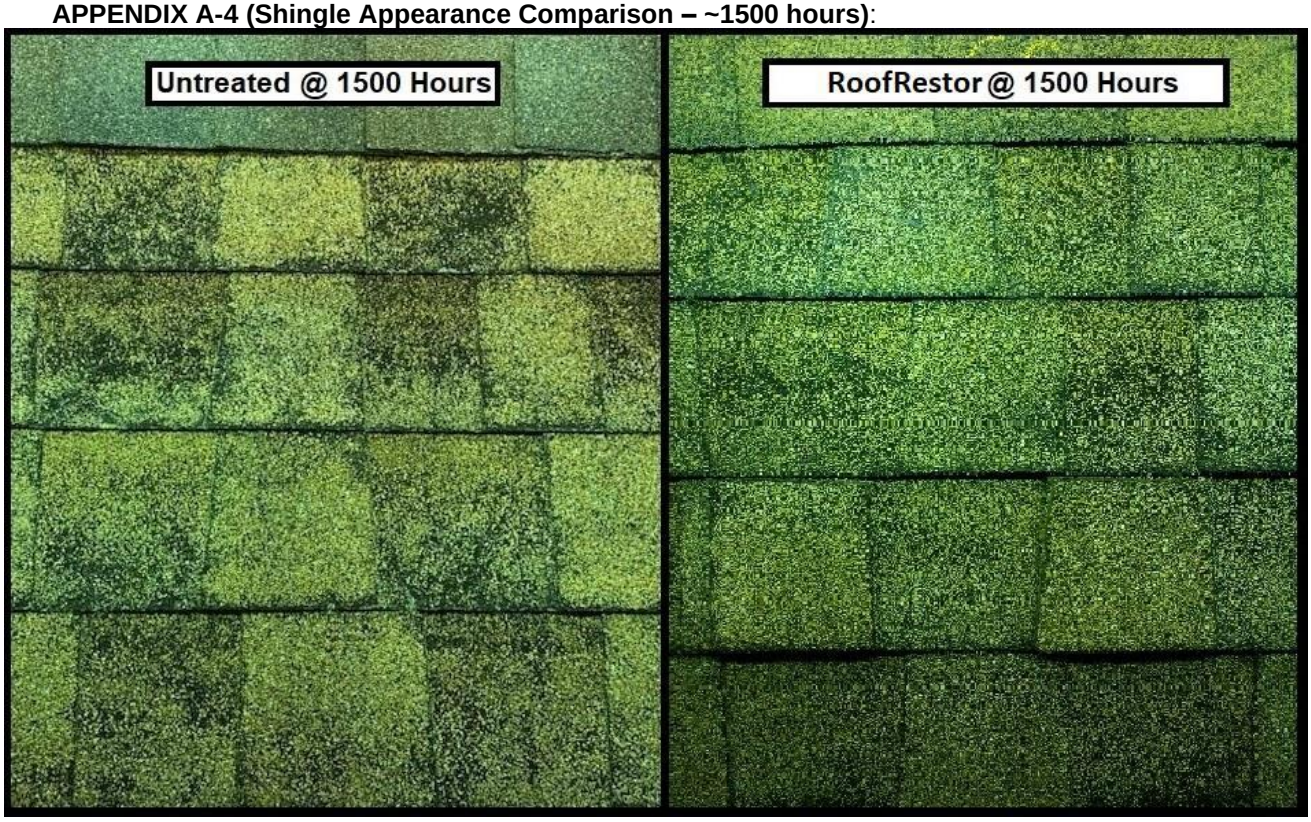
APPENDIX

APPENDIX A-4 (Shingle Appearance Comparison – ~1500 hours):



DISCUSSION:

There is a notable difference in appearance between the untreated and treated shingles after 1500 Hours.

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APPENDIX

APPENDIX A-5 (Shingle Appearance Comparison – ~3000 hours):

DISCUSSION:

There is a notable difference in appearance between the untreated and treated shingles after 3000 Hours.

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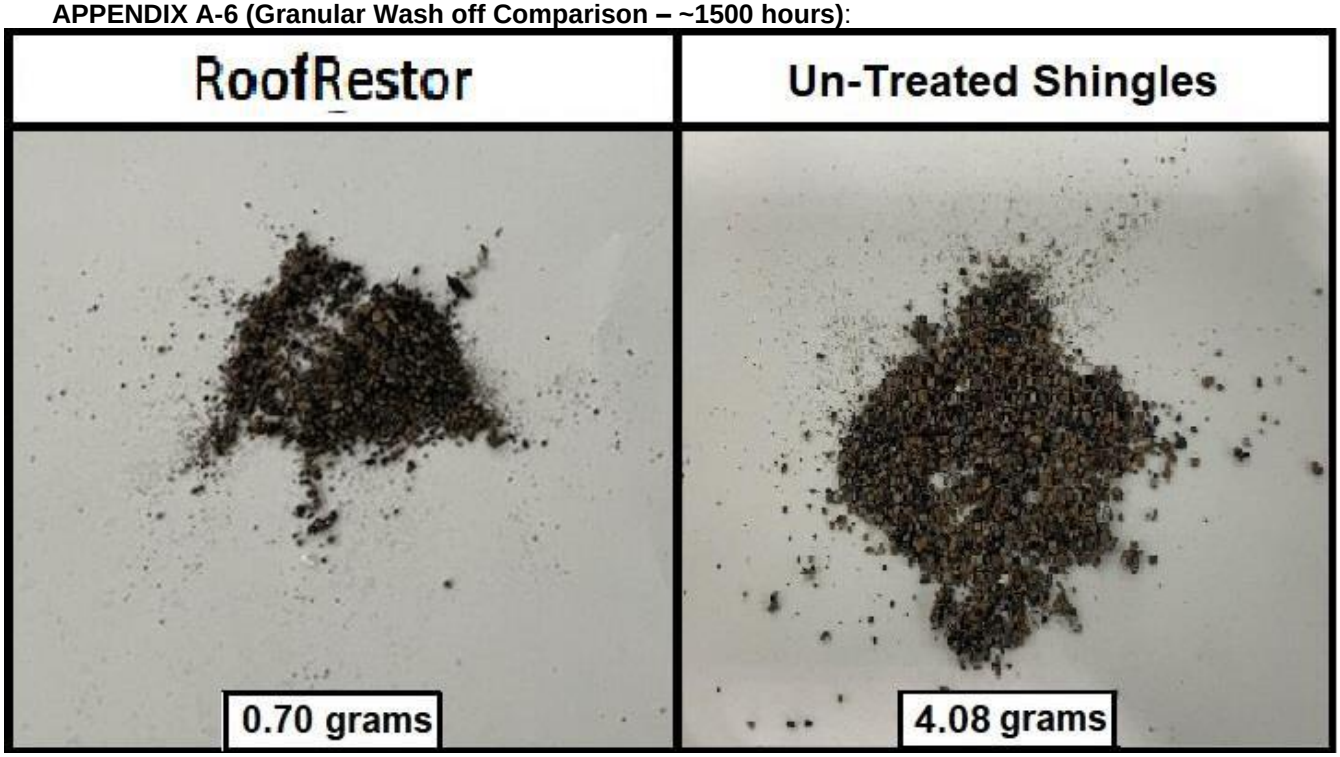
APPENDIX

APPENDIX A-6 (Granular Wash off Comparison – ~1500 hours):



DISCUSSION:

Granules and particulate washed from the roof decks after 1500 hours of exposure. Particles have been filtered from the accompanying runoff water and dried for quantification.

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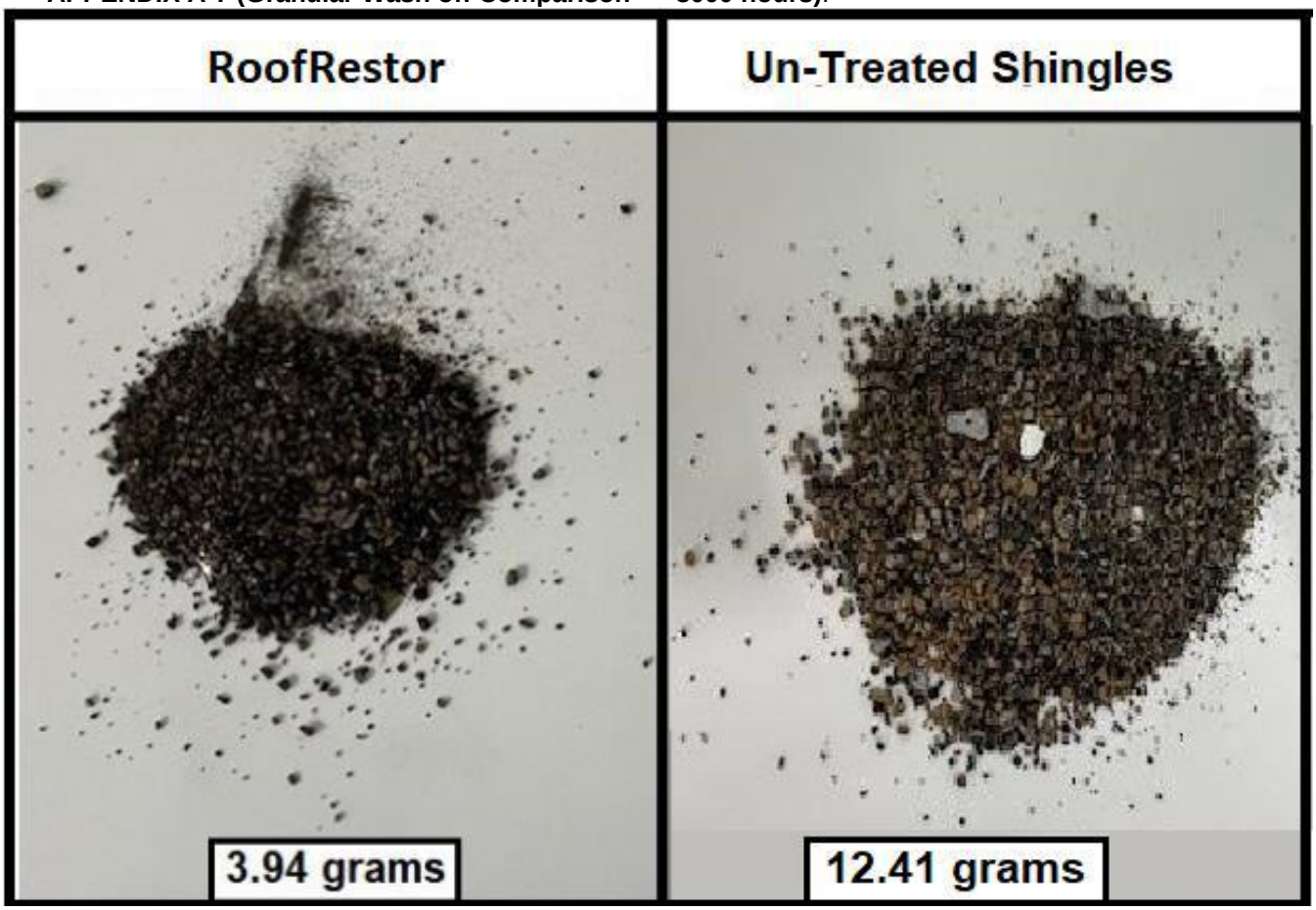
APPENDIX

APPENDIX A-7 (Granular Wash off Comparison – ~3000 hours):



DISCUSSION:

Granules and particulate washed from the roof decks after 3000 hours of exposure. Particles have been filtered from the accompanying runoff water and dried for quantification.

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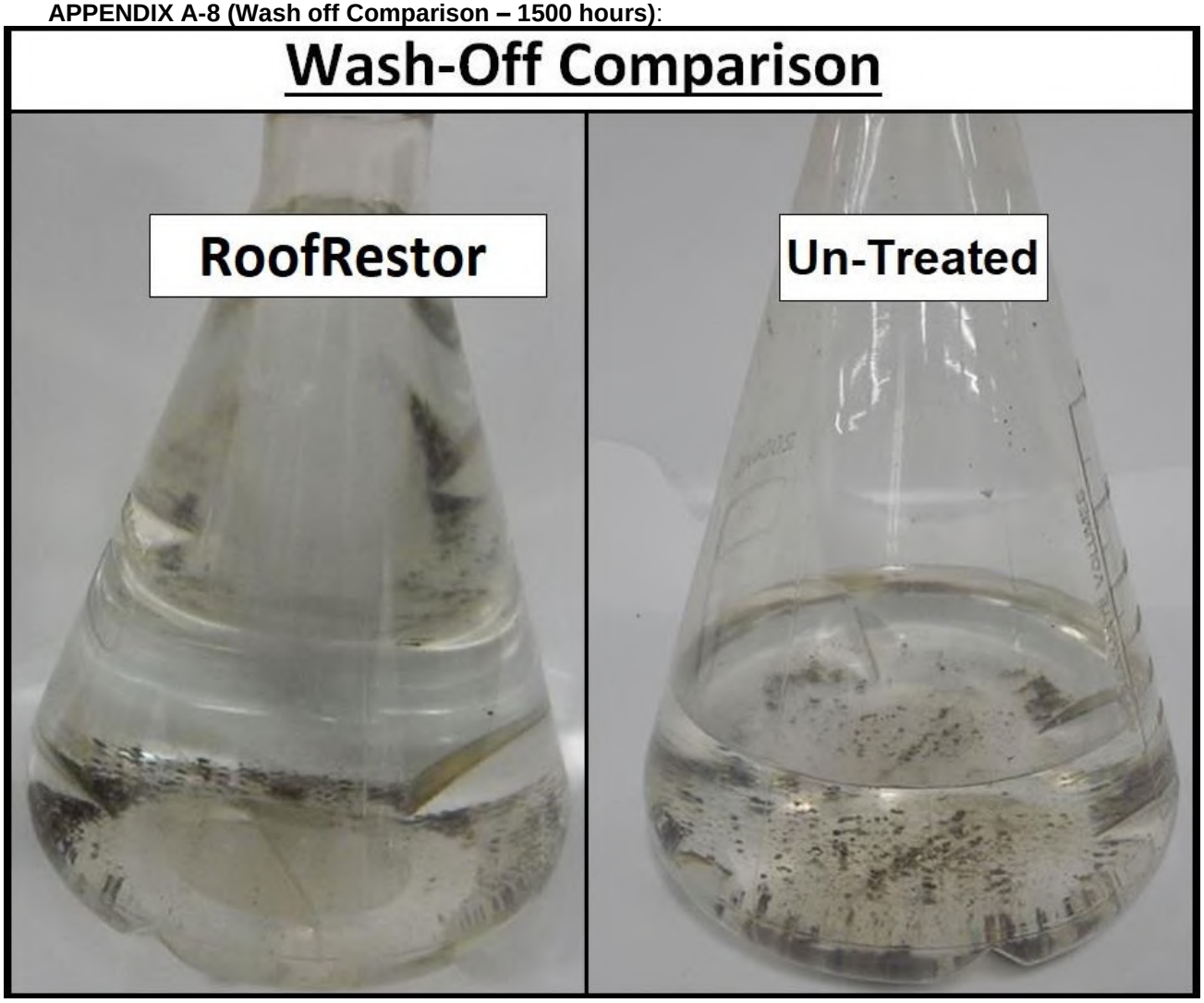
APPENDIX

APPENDIX A-8 (Wash off Comparison – 1500 hours):



DISCUSSION:

Granules and particulate washed from the roof decks after 1500 hours of exposure. Particles collected from sediment traps on the weatherometer.

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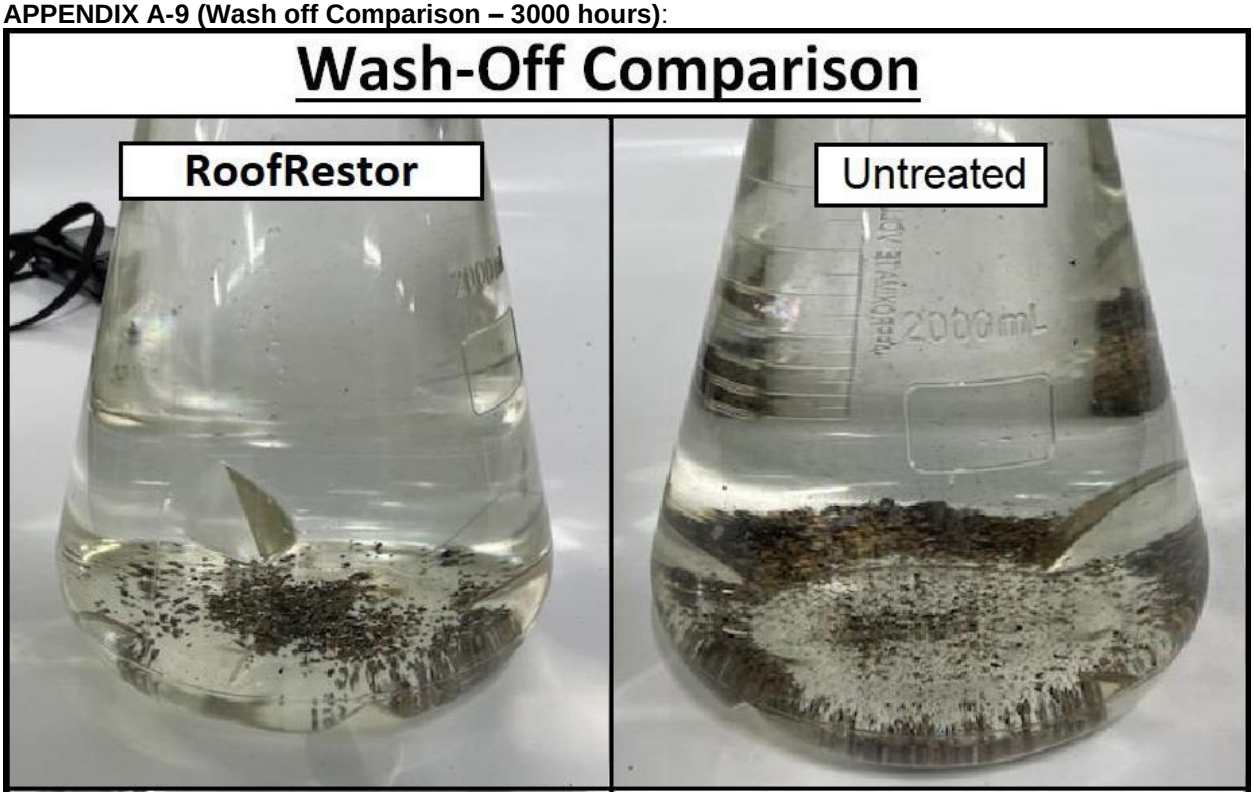
APPENDIX A-9 (Wash off Comparison – 3000 hours):



DISCUSSION:

Granules and particulate washed from the roof decks after 3000 hours of exposure. Particles collected from sediment traps on the weatherometer.

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TEST & EVALUATION REPORT

Shingle Rejuvenator Benchmark Life-Cycle Study

May 22, 2024

Report For: BioBased Spray Systems
2506 Fair Road
Sidney, OH 45365

Attn: Mike Freisthler

Sample Data/Information:

SAMPLE ID	GRADE/TYPE	DATE SAMPLED	DATE RECEIVED	SOURCE
Aged Asphalt Shingles	Architectural – Post Consumer	*Note 1	9/15/22	Roofing Contractor
Shingle Rejuvenator	BioBased Spray Systems	9/2022		
Shingle Rejuvenator	Competition	9/2022		

***Shingles removed from a home in Crystal River, FL approximately 14 years after installation**

OBJECTIVES:

Conduct a Benchmark Life-Cycle Study of two rejuvenators utilizing aged asphalt shingles that were removed from a home after approximately 14 years of exposure in Crystal River, Florida. Determine the estimated contribution to the shingles life-cycle made by both rejuvenators and quantify the differences.

The study used a miniature steep sloped roof, constructed at PRI made with commonly used stock material (2X4's, plywood, peel-n-stick underlayment, and stainless-steel roofing nails). Both slopes were roofed with the aged shingles, with one side being treated with RoofRestor™ Shingle Rejuvenator and the other side being treated with a competitive rejuvenator. Both were applied according their manufacturer's recommendations. See appendix for photos and details of construction

The miniature roof was weathered according to ASTM D4798 – "Standard Practice for Accelerated Weathering Test Conditions and Procedures for Bituminous Materials" using a modified exposure cycle consisting of, 51 minutes of light only and 9 minutes of light with rain. Studies have shown that 3000 Hours of APWS aging can be correlated to 10 years of normal outdoor exposure.

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CONCLUSIONS: Primary Property Assessment

- **Mass Loss**: Mass loss in asphalt shingles is due to both the oxidative aging of the binder and granular loss during the accelerated weathering process.
  - After 1,500 hours of exposure the mass loss of the competitive rejuvenator was 2.8% compared to 0.5% for the RoofRestor™ Shingle Rejuvenator.
    - ***RoofRestor™ Shingle Rejuvenator performs 5.6 times better than the competition.***
  - After 3,000 hours of exposure the competitive rejuvenator was 3.8% compared to 1.0% for the RoofRestor™ Shingle Rejuvenator.
    - ***RoofRestor™ Shingle Rejuvenator performs 3.8 times better than the competition.***

- **Wash off Material**: The exposure cycles consistently contained particulate material and shingle granules that were washed off by the accelerated weathering process.
  - After 1,500 hours of exposure the mass of the collected particulate from the competitive rejuvenator was 1.78g compared to 0.70g for the RoofRestor™ Shingle Rejuvenator.
    - ***RoofRestor™ Shingle Rejuvenator performs 2.5 times better than the competition.***
  - After 3,000 hours of exposure the mass of the collected particulate from the competitive rejuvenator was 9.86g compared to 3.94g for the RoofRestor™ Shingle Rejuvenator.
    - ***RoofRestor™ Shingle Rejuvenator performs 2.5 times better than the competition.***

- **Granular Loss** ($_{Dry}$): The granular loss test measures the amount of granules lost when a shingle surface is exposed to friction (the “rub” test).
  - After 1,500 hours of exposure, the granular loss of the shingles increased by 88% with the competitive rejuvenator, compared to a 23% increase with the RoofRestor™ Shingle Rejuvenator.
    - ***RoofRestor™ Shingle Rejuvenator performs 3.8 times better than the competition.***
  - After 3,000 hours of exposure, the granular loss of the shingles increased by 147% with the competitive rejuvenator, compared to a 50% increase with the RoofRestor™ Shingle Rejuvenator.
    - ***RoofRestor™ Shingle Rejuvenator performs 2.9 times better than the competition.***

- **Oxidative Aging** **(Measured by Carbonyl Indices)**: Oxidative aging in asphalt-based products can be quantified by a peak in a specific position on an FT-IR spectrum.
  - After 1,500 hours of exposure the competitive rejuvenator exhibited a 22.8% increase in carbonyl index, compared to RoofRestor™ rejuvenator’s 7.8% increase.
    - ***RoofRestor™ Shingle Rejuvenator performs 2.9 times better than the competition.***
  - After 3,000 hours of exposure the competitive rejuvenator exhibited a 49.5% increase in carbonyl index, compared to RoofRestor™ rejuvenator’s 9.6% increase.
    - ***RoofRestor™ Shingle Rejuvenator performs 5.2 times better than the competition.***

- **Shingle Flexibility**: After 1,500 and 3,000 hours of exposure, both rejuvenators improved low temperature flexibility from -22°F (pre-treatment) to -31°F post rejuvenator applications

- **Shingle Color and Appearance:** After 3,000 hours of exposure, both rejuvenators resulted in shingles that have similar appearances and colors.

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DATA / RESULTS:

PROPERTIES		TEST METHODS	RESULTS, EXPOSURE HOURS			
			Untreated, 0 Hours	Treated, 0 Hours	Treated, 1,500	Treated, 3,000
Properties of Shingles Treated with Competitive Rejuvenator						
Visual Inspection of shingles (Photos)		PRI	See Appendix			
Weight of 5"x10" Sample, g		D751	147.8	137.7	133.8	132.41
Mass Change, % (Note 2)			---	---	-2.8	-3.8
Low Temperature Flexibility, °F (Note 3)		D5147-12	-22	-31	-31	-31
Granular Adhesion (Loss), %	Wet	D4977	3.5	2.8	2.8	2.3
	Dry		3.4	1.7	3.2	4.2
Carbonyl Index		E7214	0.95	1.01	1.24	1.51
Increase in Carbonyl Index from 0 Hours, %		Calculation	N/A	N/A	22.77	49.50
Material Lost during Exposure Cycles, g (Note 4)		PRI	N/A	N/A	1.78	9.86
Properties of Shingles Treated with RoofRestor™ Shingle Rejuvenator						
Visual Inspection of shingles (Photos)		PRI	See Appendix			
Weight of 5"x10" Sample, g		D751	147.8	146.4	145.7	145.0
Mass Change, % (Note 2)			---	---	-0.5	-1.0
Low Temperature Flexibility, °F (Note 3)		D5147-12	-22	-31	-31	-31
Granular Adhesion (Loss), %	Wet	D4977	3.5	3.2	5.4	0.9
	Dry		3.4	2.2	2.7	3.3
Carbonyl Index		E7214	0.95	1.67	1.80	1.83
Increase in Carbonyl Index from 0 Hours, %		Calculation	N/A	N/A	7.78	9.58
Material Lost during Exposure Cycles, g (Note 4)		PRI	N/A	N/A	0.70	3.94

Note 2 – Mass Change is calculated from the mass loss of a representative 5"x10" representative sample of shingle taken at each inspection interval, mass loss is expected with aging, lower mass loss is desirable.

Note 3 – Low temperature flexibility is the lowest temperature at which the shingle remains flexible – lower temperatures are more desirable.

Note 4 – Loss during exposure was measured by collecting granules and particulate matter from the collection system attached to the APWS weatherometer (See Appendix A-3 for collection apparatus & sample photos).

Note 5 – Untreated samples were not exposed to additional aging in the APWS.

DISCUSSION:

Although both rejuvenators exhibited efficacy via improving granule adhesion and shingle flexibility, RoofRestor™ Shingle Rejuvenator exhibited better overall comparative life-cycle properties. Based on the primary data ROOFRESTOR™' reduced oxidative aging (Carbonyl Index), less dry granule loss and mass loss suggest the life-cycle of ROOFRESTOR™' rejuvenation would be greater than the competitors.

- *Carbonyl Index Note: when initially treated an increase in Carbonyl Index results this is due to the addition of bio-based oils (rejuvenators) that give an FT-IR response in the same peak area as the oxidative aging.*

Tested by: _____ Date: May 22, 2024
Greg Lavin, Laboratory Technician

Reported by: _____ Date: May 22, 2024
Steven Loeffler, Client Services Manager

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APPENDIX

APPENDIX A-1 (Roof Deck Construction):

Completed Roof Deck Before Rejuvenator Application

DISCUSSION:

A type of common, commercially used ridge-cap shingles were then cut and applies to the cap of the roof deck. The cap was selected for the closest visual match to the shingles used.

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APPENDIX

APPENDIX A-2 (Roof Deck Construction):

REJUVENATOR APPLICATION DATA:

PROPERTY	TEST METHODS	RESULTS, SAMPLE ID	
		Competitive	RoofRestor™
Rejuvenator Application Data			
Dilution Rate, (%Water : %Product)	PRI Measurements	50:50	70:30
Volume Applied, mL		266	266
Weight Applied, g		263.6	257.1
Specific Gravity of Diluted Product	ASTM D70	0.9920	0.9674
Calculated Application Rate, gal/ft^2	Calculation	0.0099	0.0099

DISCUSSION:

Both rejuvenators were prepared and applied according to manufacturer guidelines using common garden spray bottles and allowed to cure for 24 hours:

- Competitive rejuvenator – A mixture of 50% water and 50% Rejuvenator concentrate stirred by hand to homogeneity
- RoofRestor™ Shingle Rejuvenator – A mixture of 70% water and 30% Rejuvenator concentrate stirred by hand to homogeneity
- Both diluted products were applied to their respective side of the roof deck at a target rate of 1 gallon per 100ft^2 using simple spray bottles.

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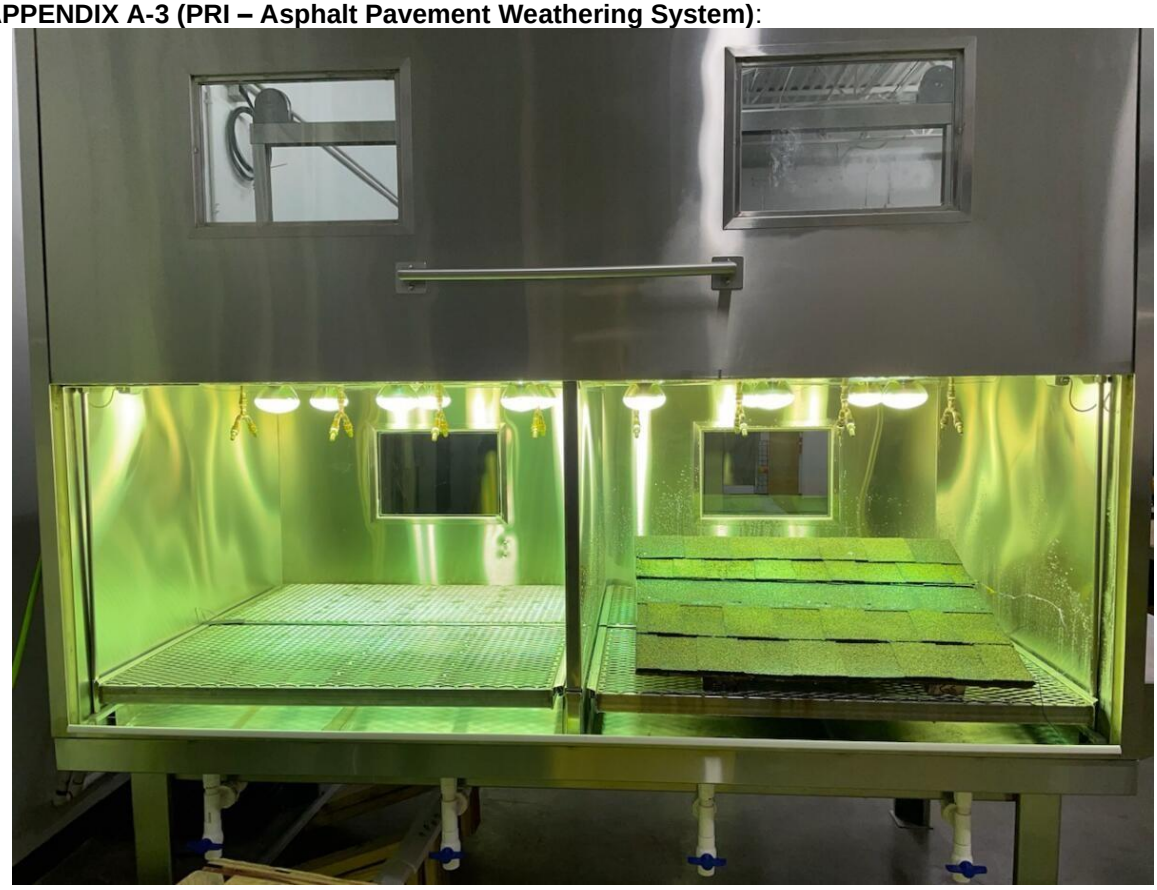
APPENDIX

APPENDIX A-3 (PRI – Asphalt Pavement Weathering System):



DISCUSSION:

An open view of PRI's Asphalt Pavement Weathering System with the roof deck positioned in the front chamber (right).

PRI's APWS was used for accelerated weathering of the roof deck after the application and curing of the rejuvenators. The weatherometer is monitored daily for even light distribution and water spray coverage, while temperature of the chamber, roof surface, water, ambient temperature and relative humidity are all tracked continuously.

ACCELERATED AGING PARAMETERS:

PARAMETER	SETTING
APWS Cycle and Climate Information	
Cycle Reference Method	ASTM D4798, Cycle A
Time of UV Light Exposure, mins	51
Time of UV Exposure with Rain Cycle, mins	9
Average Maximum Shingle Temperature, °F (Note 1)	149.5
Average "Rain Rate", gal/hr	12.6

Note 1 – Average Maximum Shingle Temperature is measured by taking the average of the temperature readings immediately before the beginning of the "rain cycle" when the temperature is at its highest level.

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APPENDIX

APPENDIX A-4 (Granular Wash off Comparison – ~1500 hours):

DISCUSSION:

Granules and particulate washed from the roof decks after 1500 hours of exposure. Particles have been filtered from the accompanying runoff water and dried for quantification.

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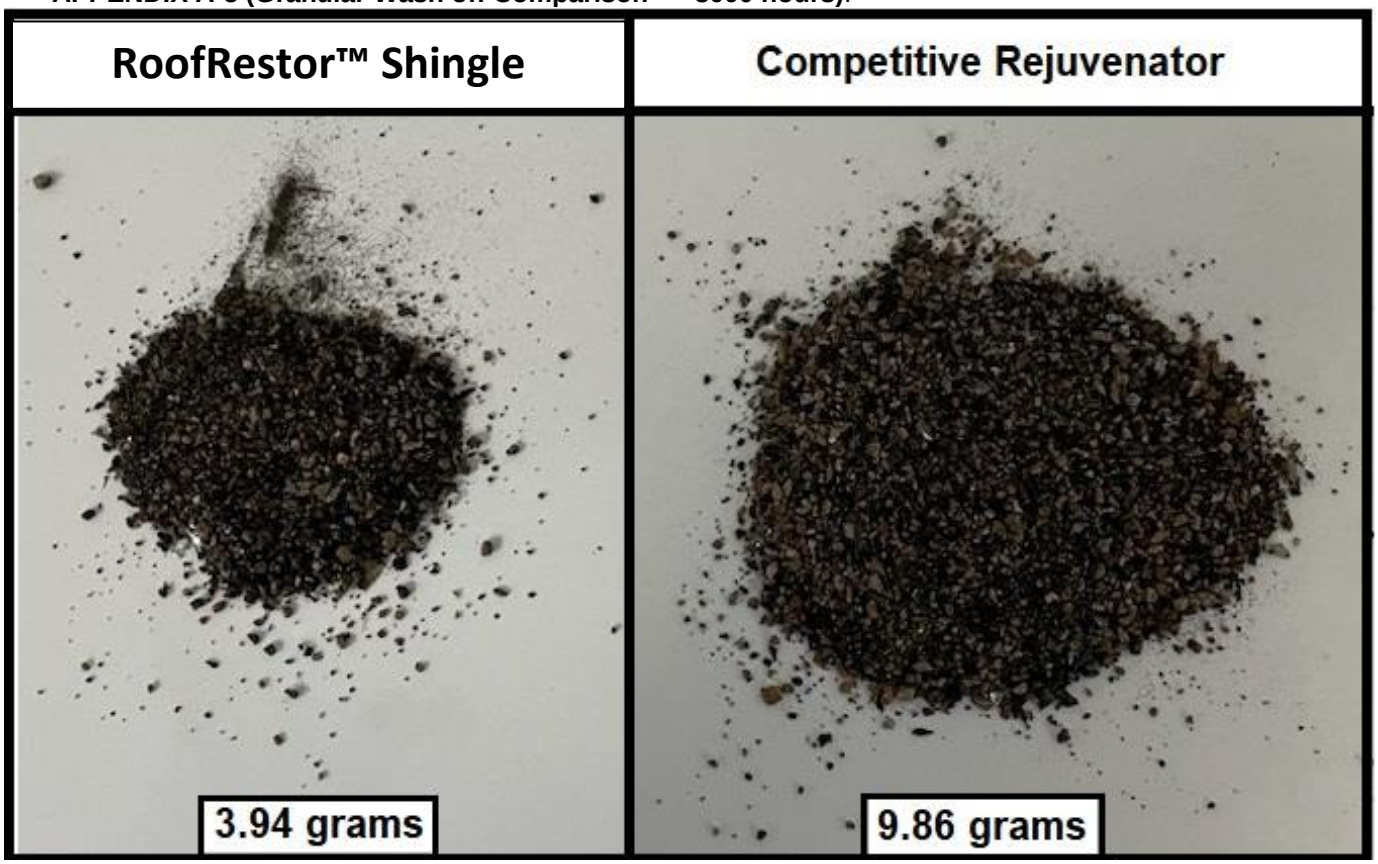
APPENDIX

APPENDIX A-5 (Granular Wash off Comparison – ~3000 hours):



DISCUSSION:

Granules and particulate washed from the roof decks after 3000 hours of exposure. Particles have been filtered from the accompanying runoff water and dried for quantification.

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TEST & EVALUATION REPORT

Screening Evaluation of Shingle Rejuvenator

May 22, 2024

Report For: BioBased Spray Systems
2506 Fair Road
Sidney, OH 45365

Attn: Mike Freisthler

Sample Data/Information:

SAMPLE ID	GRADE / TYPE	RECEIVED DATE	SOURCE
Aged Asphalt Shingles	3-Tab Organic Felt Based	06/14/18	B. Robinson, Regina Canada
Rejuvenator	RoofRestor™ Shingle Rejuvenator	06/07/18	BioBased Spray Systems

Client: BioBased Spray Systems **Project No.:** BBSS 01-02-01

BACKGROUND:

Rejuvenator has a long history of limited use in the asphalt roofing industry. Initial use was limited to conventional hot-mopped built-up-roofs. Over the years, there have been attempts to restore/maintain rejuvenated asphalt shingle roofs.

In the most recent times, asphalt rejuvenation has gained national focus in the paving industry. In response to the enhanced focus, a number of new technologies have been introduced. Some of these products are advancing the rejuvenation/restoration technologies and are hypothesized to exhibit efficacy in the asphalt roofing industry.

OBJECTIVE:

Perform and assess selected screening evaluation to provide insight on BioBased Spray Systems' RoofRestor™ Shingle Rejuvenator

CONCLUSIONS:

Based on a Spray Application Rate of 1 gal/125 ft.^{2}, followed by a five (5) day 'cure' period on aged shingles provided.

1. Flexibility$_{23°C}$ was improved (Failure to pass).
2. Granular Adhesion was improved significantly from a granular loss of 1.11 g to a loss after treatment of 0.15 g, an 86% improvement.
3. Hail Impact was slightly improved after treatment. The improvement, 6.6%, was minimized by the type of shingle evaluated – organic felt based. The data suggests Hail Impact would have a greater improvement on FG mat-based shingles.
4. Fire Resistance 'UL Speed of Flame:' The treated shingles exhibited a flame spread of 86 in^2 vs. the untreated shingles exhibiting a 144 in^2 spread. This was unexpected.

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DATA / RESULTS:

PROPERTIES			TEST METHODS	RESULTS	
				TREATED	NON-TREATED
Select Properties					
Flexibility; 1"x8" Specimens; Wt., 0.1 g.	Dir.	Replicate	D228-11 @ 23 ± 2°C		
	MD	#1		20.2, Pass	16.6, Pass
		#2		22.0, Pass	18.8, Fail
		#3		20.0, Pass	19.4, Fail
		#4		19.9, Pass	20.4, Fail
		#5		20.4, Pass	20.4, Fail
		Avg.		20.5	19.1
	CD	#6		20.1, Pass	19.4, Fail
		#7		24.5, Pass	20.6, Fail
		#8		21.9, Pass	19.4, Fail
		#9		22.6, Pass	20.4, Fail
		#10		23.5, Pass	21.8, Fail
		Avg.		22.5	20.3
Granule Adhesion; 2"x9" specimens, g loss	Dry	#1	D4977	0.11	0.98
		#2		0.18	1.25
		Avg.		0.15	1.12
	Wet, 2 hr. soak	#3		0.62	1.34
		#4		1.04	1.42
		Avg.		1.01	1.38
Hail Impact (Steel Ball Test), in.		#1	UL 2218	0.103	0.129
		#2		0.103	0.095
		#3		0.135	0.138
		Avg.		0.113	0.121
Spread of Flame, Width cm. x Length cm.		#1	E108M	10x10	-
		#2		8x9	-
		#3		-	12x12

DISCUSSION:

These screening evaluations strongly suggest that RoofRestor™ Shingle Rejuvenator provides benefits to key performance properties of asphalt shingles associated with durability and possible extended life cycles.

A number of factors remain, a brief list is noted below:

1. Efficacy with FG Mat Based shingles.
2. Effects of treatment design.
3. Durability and weatherability, duration of treatment.
4. Water sensitivity of treatment.
5. Quantification of possible improvements in fire resistance.
6. Impacts of treated shingles on Wind Uplift with Penetration, Resistance, and Tab Sealant Adhesion.
7. Impacts on Hail Impact Resistance of FG Mat based shingles.

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RECOMMENDATIONS:

- Expand screening evaluation to FG mat-based shingles, the dominant shingle type used in the US.
- Determine optimum application rate(s) by product type and condition.
- Determine the durability/weatherability of the treatment (how long does it last).
- Expand and quantify the possible improvements in fire resistance.
- Determine if treatment improves the performance of shingle tab sealants via penetration.
- Explore options to include algae and mildew resistance and/or fire-resistant technologies in with Biorestore product.
- Evaluate the possible negative effects including:
    - Shingle Color Change
    - Overspray effects on vegetation, structures, vehicles, and wildlife.

NEXT STEP:

Review by BioBased Spray Systems

Tested by: _____ Date: August 15, 2018
John D'Angelo, Technologist

Reviewed by: _____ Date: August 15, 2018
Ken Grzybowski, President

Revised by: _____ Date: May 22, 2024
Steven Loeffler, Client Services Manager

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APPENDIX

A1. Spread of Flame Test per ASTM E108M – Treated Samples

TREATED SAMPLE #1 AFTER SPREAD OF FLAME TEST	TREATED SAMPLE #2 AFTER SPREAD OF FLAME TEST

DISCUSSION:

Spread of flame covered less surface area (a distinct benefit). This is worthy of further investigation.

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A2. Spread of Flame Test per ASTM E108M – Untreated Samples

- UNTREATED SAMPLE #3 AFTER SPREAD OF FLAME TEST

DISCUSSION:

The control exhibited significantly more spread and damage than the treated shingles.

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A3. Hail Impact Steel Ball Test per UL 2218 on Treated Material

HAIL IMPACT MARKING (TREATED)	HAIL IMPACT MARKING (TREATED)

A4. Hail Impact Steel Ball Test per UL 2218 on Treated Material

HAIL IMPACT MARKING (TREATED)	HAIL IMPACT MARKING (TREATED)

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A5. Hail Impact Steel Ball Test per UL 2218 on Treated Material

HAIL IMPACT MARKING (TREATED)	HAIL IMPACT MARKING (TREATED)

A6 Hail Impact Steel Ball Test per UL 2218 on Treated Material

HAIL IMPACT MARKING (TREATED)	HAIL IMPACT MARKING (TREATED)

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A7. Hail Impact Steel Ball Test per UL 2218 on Untreated Material

HAIL IMPACT MARKING (UNTREATED)	HAIL IMPACT MARKING (UNTREATED)

A8 Hail Impact Steel Ball Test per UL 2218 on Untreated Material

HAIL IMPACT MARKING (UNTREATED)	HAIL IMPACT MARKING (UNTREATED)

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A9. Hail Impact Steel Ball Test per UL 2218 on Untreated Material

HAIL IMPACT MARKING (UNTREATED)	HAIL IMPACT MARKING (UNTREATED)

A10 Hail Impact Steel Ball Test per UL 2218 on Untreated Material

HAIL IMPACT MARKING (UNTREATED)	HAIL IMPACT MARKING (UNTREATED)

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DISCUSSION:

Because the test shingles were organic felt based, the criteria for Hail Impact Resistance; cracking, and damage to the shingle surface was not observed.

Consequently, we included photos exhibiting the results on the granular surface. The results were mixed primarily due to the severely aged conditions of the test shingles. However, the treatment appeared to re-adhere the granules, which reduced the surface damage some.

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