TEST & EVALUATION REPORT

Screening Evaluation of Shingle Rejuvenator

August 15, 2018

Report For: Bio-Based Spray Systems, LLC, Greener Shingle Solutions

Attn: Mike Freisthler, Bruce Robinson

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	Bio-restore Roof Shingle Treatment	06/07/18	Bio-based Spray Systems

Client: Bio-Based Spray Systems, Greener Shingle Solutions **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 Bio-Based's Biorestore Roof Shingle Treatment System.

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 the Biorestore Roof Shingle Treatment 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:
    - o Shingle Color Change
    - o Overspray effects on vegetation, structures, vehicles, and wildlife.

NEXT STEP:

Review by Bio-based Spray Systems, Greener Shingle Solutions.

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

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

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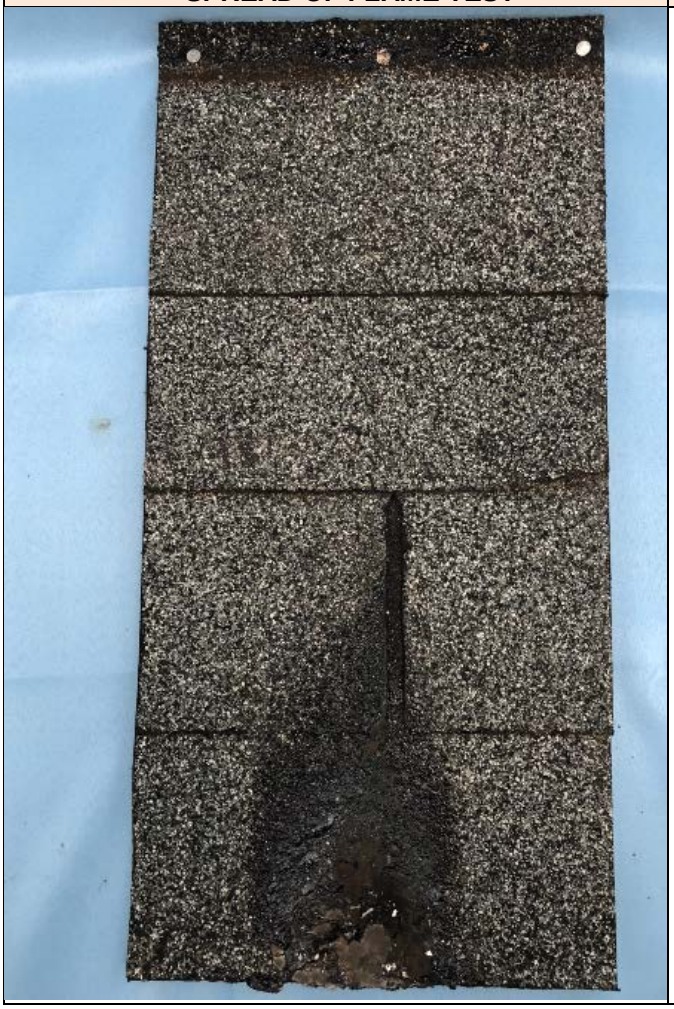
APPENDIX

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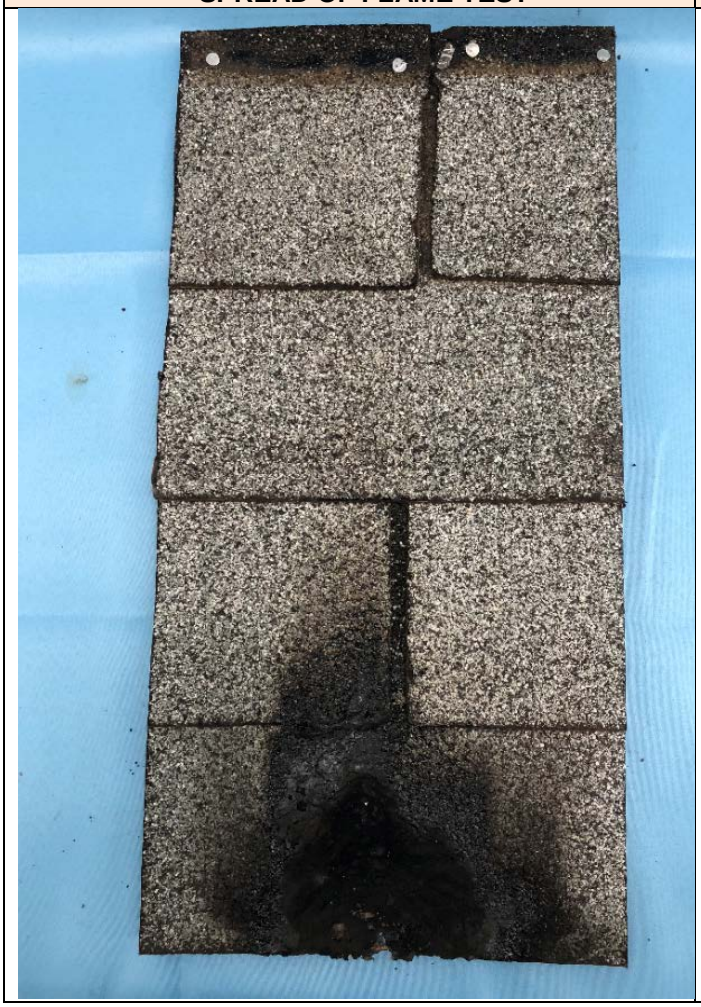
A2. Spread of Flame Test per ASTM E108M – Untreated Samples

- UNTREATED SAMPLE #3 AFTER SPREAD OF FLAME TEST	-
	X

DISCUSSION:

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

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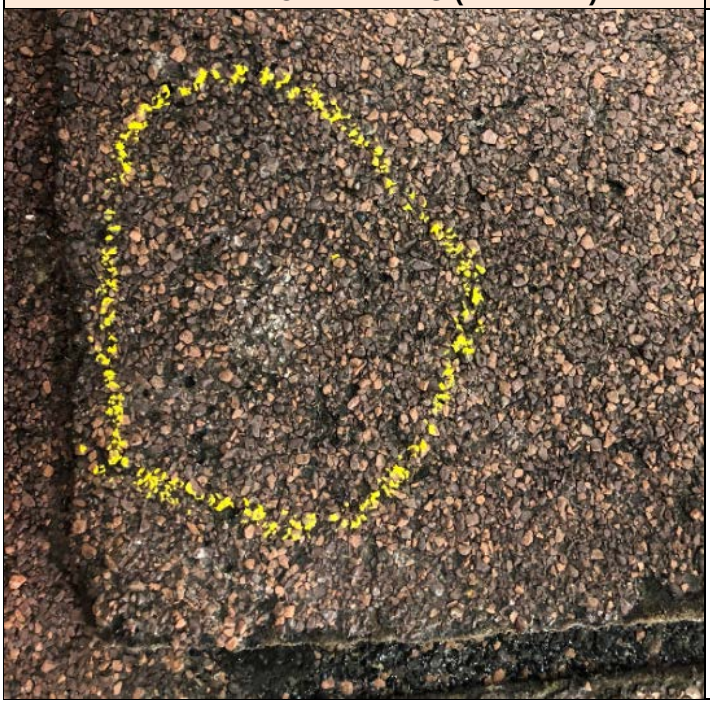
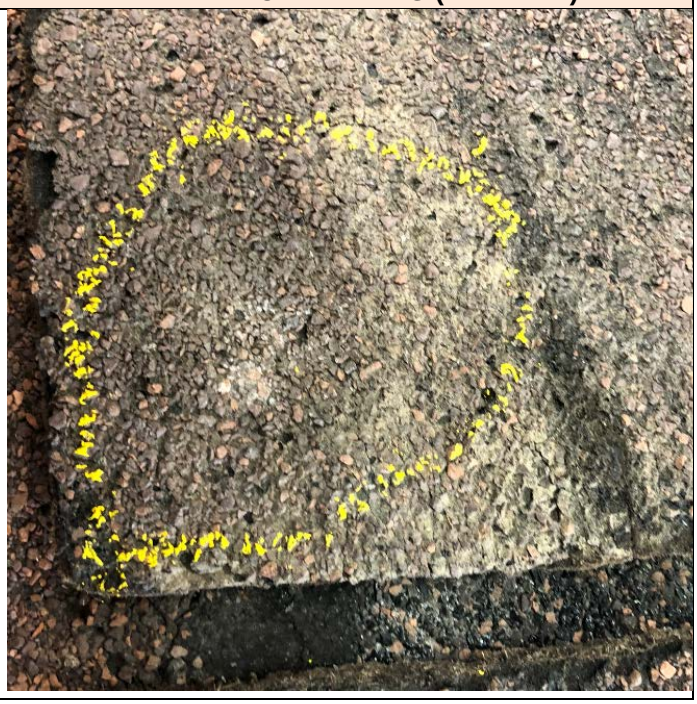
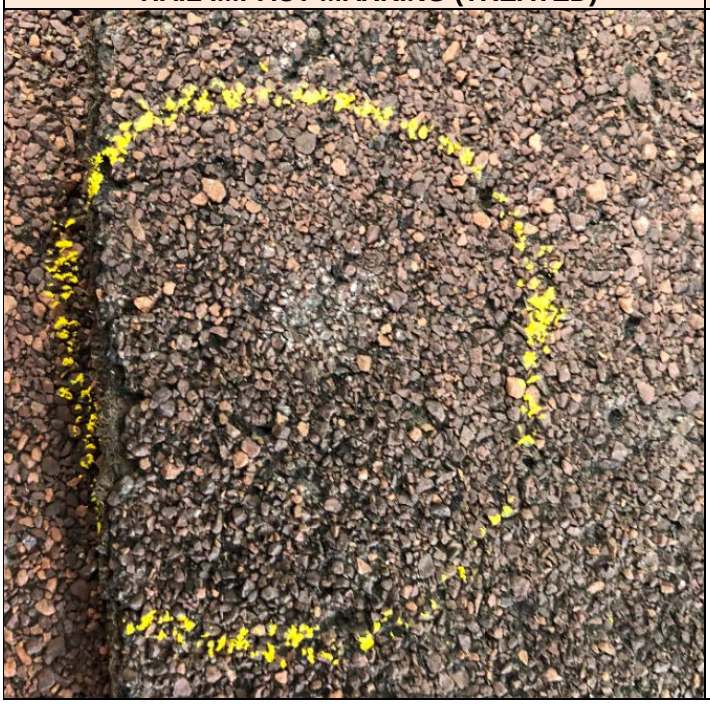
A3. Hail Impact Steel Ball Test per UL 2218 on Treated Material

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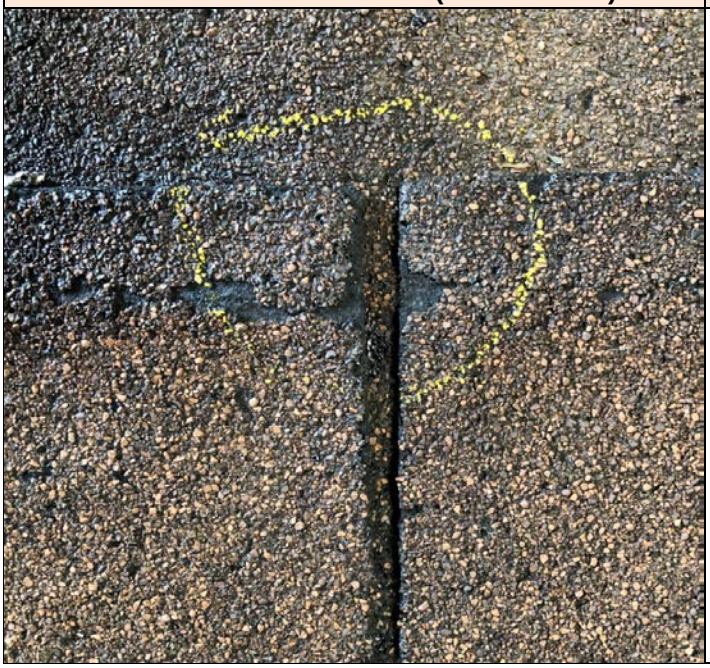
A9. Hail Impact Steel Ball Test per UL 2218 on Untreated Material

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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