



September 22, 2023

TEST & EVALUATION REPORT
Shingle Regenerator Benchmark Life-Cycle Study

ReGen Roof ReGenerator Study
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Report For: ReGen Roof

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Sample Data/Information:

Table with 5 columns: SAMPLE ID, GRADE/TYPE, DATE SAMPLED, DATE RECEIVED, SOURCE. Rows include Aged Asphalt Shingles, Shingle Rejuvenator (ReGen Roof), and Shingle Rejuvenator (Competitor).

\*Note 1: Shingles removed from a home in Crystal River, FL approximately 14 years after installation

OBJECTIVES:

Conduct a Benchmark Life-Cycle Study of two Roof Regenerating technologies 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 regenerators 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 Regen Roof Regenerator Technology and the other side being treated with the leading competitors product found to be much less concentrated. 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 for 3000 hours.

Studies have shown that 3000 Hours of APWS aging can be correlated to 10 years of normal outdoor exposure.



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**SUMMARY: Primary Property Assessment**

**Mass Loss:** In asphalt shingles, mass loss 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 untreated shingles was 5.4%, those treated with the competitive Regenerator were 2.8%, and those treated with Regen Roof's Regenerator were 0.5%. Regen Roof's Regenerator performs 10.8 times better than untreated shingles and 5.6 times better than the competition. After 3,000 hours of exposure, the mass loss of the untreated shingles was 9.1%, those treated with the competitive Regenerator were 3.8%, and those treated with Regen Roof's Regenerator were 1.0%. Regen Roof's Regenerator performs 9.1 times better than untreated shingles and 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 untreated shingles was 4.08g, those treated with the competitive Regenerator were 1.78g, and those treated with Regen Roof's Regenerator were 0.70g. Regen Roof's Regenerator performs 5.8 times better than untreated shingles and 2.5 times better than the competition. After 3,000 hours of exposure, the mass of the collected particulate from the untreated shingles was 12.41g, those treated with the competitive Regenerator were 9.86g, and those treated with Regen Roof's Regenerator were 3.94g. Regen Roof's Regenerator performs 3.1 times better than untreated shingles and 2.5 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 (See Appendix B-1 through B-7). After 1,500 hours of exposure, the untreated shingles exhibited a 30.7% increase in carbonyl index, compared to those treated with the competitive Regenerator (22.8%) and those treated with Regen Roof's Regenerator (7.8%). Regen Roof's Regenerator performs 3.9 times better than untreated shingles and 2.9 times better than the competition. After 3,000 hours of exposure, the untreated shingles exhibited a 77.9% increase in carbonyl index, compared to those treated with the competitive Regenerator (49.5%) and those treated with Regen Roof's Regenerator (9.6%). Regen Roof's Regenerator performs 8.1 times better than untreated shingles and 5.2 times better than the competition.

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

**Shingle Color and Appearance:** After 3,000 hours of exposure, both Regenerators resulted in shingles that have similar appearances and colors, while the untreated shingles exhibit a notable decline in appearance due to granular loss and fading.



**DATA / RESULTS:**

**Table 1: Shingles Before Aging**

PROPERTIES	TEST METHODS	RESULTS, BEFORE EXPOSURE		
		Treated with Untreated	Treated with Competitor	Treated with ReGen Roof
<i>Properties of Shingles Before APWS Aging</i>				
Visual Inspection of shingles (Photos)	PRI	See Appendix		
Weight of 5"x10" Sample, g	D751	147.8	137.7	146.4
Mass Change, % (Note 2)		---	---	---
Low Temperature Flexibility, °F (Note 3)	D5147-12	-22	-31	-31
3) Carbonyl Index	E7214	0.95	1.01	1.67

**Table 2: Shingles After 1500 Hours of Aging**

TEST PROPERTIES	METHODS	RESULTS, AFTER 1500 EXPOSURE HOURS		
		Treated with Untreated	Treated with Competitor	Treated with ReGen Roof
<i>Properties of Shingles After 1500 Hours of APWS Aging</i>				
Visual Inspection of shingles (Photos)	PRI	See Appendix		
Weight of 5"x10" Sample, g	D751	139.8	133.8	145.7
Mass Change, % (Note 2)		-5.4	-2.8	-0.5
Low Temperature Flexibility, °F (Note 3)	D5147-12	-22	-31	-31
Carbonyl Index	E7214	1.37	1.24	1.80
Increase in Carbonyl Index from 0 Hours, %	Calculation	30.66	22.77	7.78
Material Lost during Exposure Cycles, g (Note 4)	PRI	4.08	1.78	0.70

**Table 3: Shingles After 3000 Hours of Aging**

TEST PROPERTIES	METHODS	RESULTS, AFTER 3000 EXPOSURE HOURS		
		Treated with Untreated	Treated with Competitor	Treated with ReGen Roof
<i>Properties of Shingles After 3000 Hours of APWS Aging</i>				
Visual Inspection of shingles (Photos)	PRI	See Appendix		
Weight of 5"x10" Sample, g	D751	134.6	132.41	145.0
Mass Change, % (Note 2)		-9.1	-3.8	-1.0
Low Temperature Flexibility, °F (Note 3)	D5147-12	-22	-31	-31
Carbonyl Index	E7214	1.69	1.51	1.83
Increase in Carbonyl Index from 0 Hours, %	Calculation	77.89	49.50	9.58
Material Lost during Exposure Cycles, g (Note 4)	PRI	12.41	9.86	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 X-1 for collection apparatus & sample photos).**



**Discussion:**

Both Regenerators exhibited efficacy by improving granule adhesion and shingle flexibility. Regen Roof's Regenerator demonstrated superior overall comparative life-cycle properties. Based on the primary data, the reduced oxidative aging (Carbonyl Index) and mass loss observed with Regen Roof's Regenerator suggest that its life-cycle effectiveness is far greater than that of the competitive product and untreated shingles.

**Mass Change Note:** Mass change was calculated by taking representative samples measuring 5" x 10" and recording their mass at each interval. The sample taken at each interval was then used for subsequent testing to conserve sample area. The masses shown are not from the same sample but are cut from the same area and are of the same size.

**Carbonyl Index Note:** Initially, when treated, an increase in the Carbonyl Index is observed. This is attributed to the addition of bio-based oils (Regenerator), which give an FT-IR response in the same peak area as oxidative aging.

Tested by: 

Date: September 22, 2023

Greg Lavin, Quality Assurance Manager

Reported by: 

Date: September 22, 2023

Steven Loeffler, Client Services Manager



## APPENDIX

### APPENDIX A-1 (Roof Deck Construction)

#### Completed Roof Deck Before ReGen Roof's Nano Application



#### DISCUSSION:

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

## APPENDIX

### APPENDIX A-2 (Roof Deck Construction)

# Roof Deck After Regenerator Application



#### REGENERATOR APPLICATION DATA:

PROPERTY	TEST METHODS	RESULTS, SAMPLE ID	
		Competitor	ReGen Roof
<i>Regenerator Application Data</i>			
Dilution Rate, (%Water : %Product)	PRI Measurements	50:50	70:30
Volume Applied, mL		266	266
Weight Applied, Grams		263.6	257.1
Specific Gravity of Diluted Product	ASTMD70	0.9920	0.9674
Calculated Application Rate, gal/ft <sup>2</sup>	Calculation	0.0099	0.0099

#### DISCUSSION:

Both Regenerators were prepared and applied according to manufacturer guidelines using common garden spray bottles then allowed to penetrate for 24 hours:

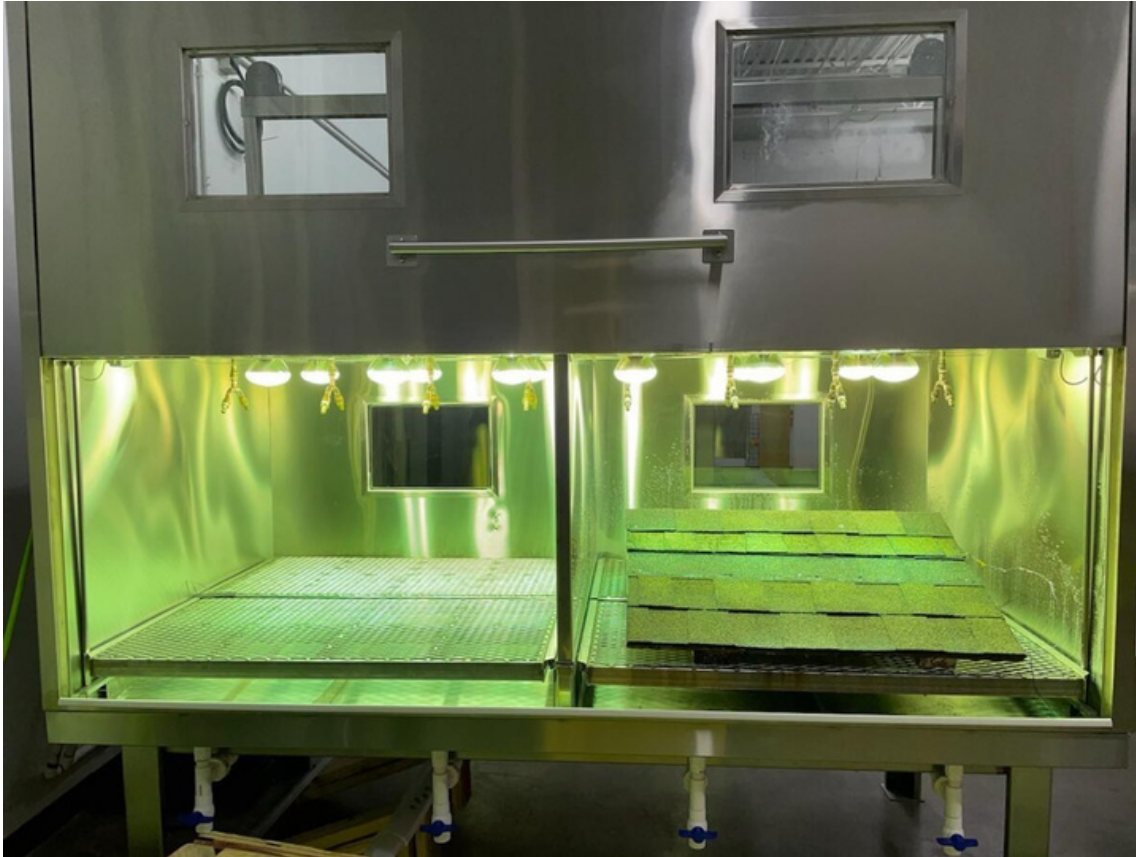
Competitive Regenerator – A mixture of 50% water and 50% Regenerator concentrate stirred by hand to homogeneity.

\*Regen Roof Regenerator – Was a noticeably much more dense concentrate, with the mixture requiring only 30% Regenerator concentrate and 70% water, it was also stirred by hand to homogeneity.

Both products were applied to their respective side of the roof deck at a target rate of 1 gallon per 100ft<sup>2</sup> using spray bottles.

## APPENDIX

### APPENDIX A-9 (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 regenerators. 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
<i>APWS Cycle and Climate Information</i>	
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 <sup>(Note 1)</sup>	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.



## APPENDIX

### APPENDIX A-11 (Granular Wash off Comparison ~1500 hours or 5 years)

Un-Treated Shingles	ReGen Roof	Competitor
 <p>4.08 grams</p>	 <p>0.70 grams</p>	 <p>1.78 grams</p>




**DISCUSSION:** Granules and particulate washed from the roof decks after 1500 hours or 5 years of exposure. Particles have been filtered from the accompanying runoff water and dried for quantification.





## APPENDIX

### APPENDIX A-11 (Granular Wash off Comparison ~3000 hours or 10 years)

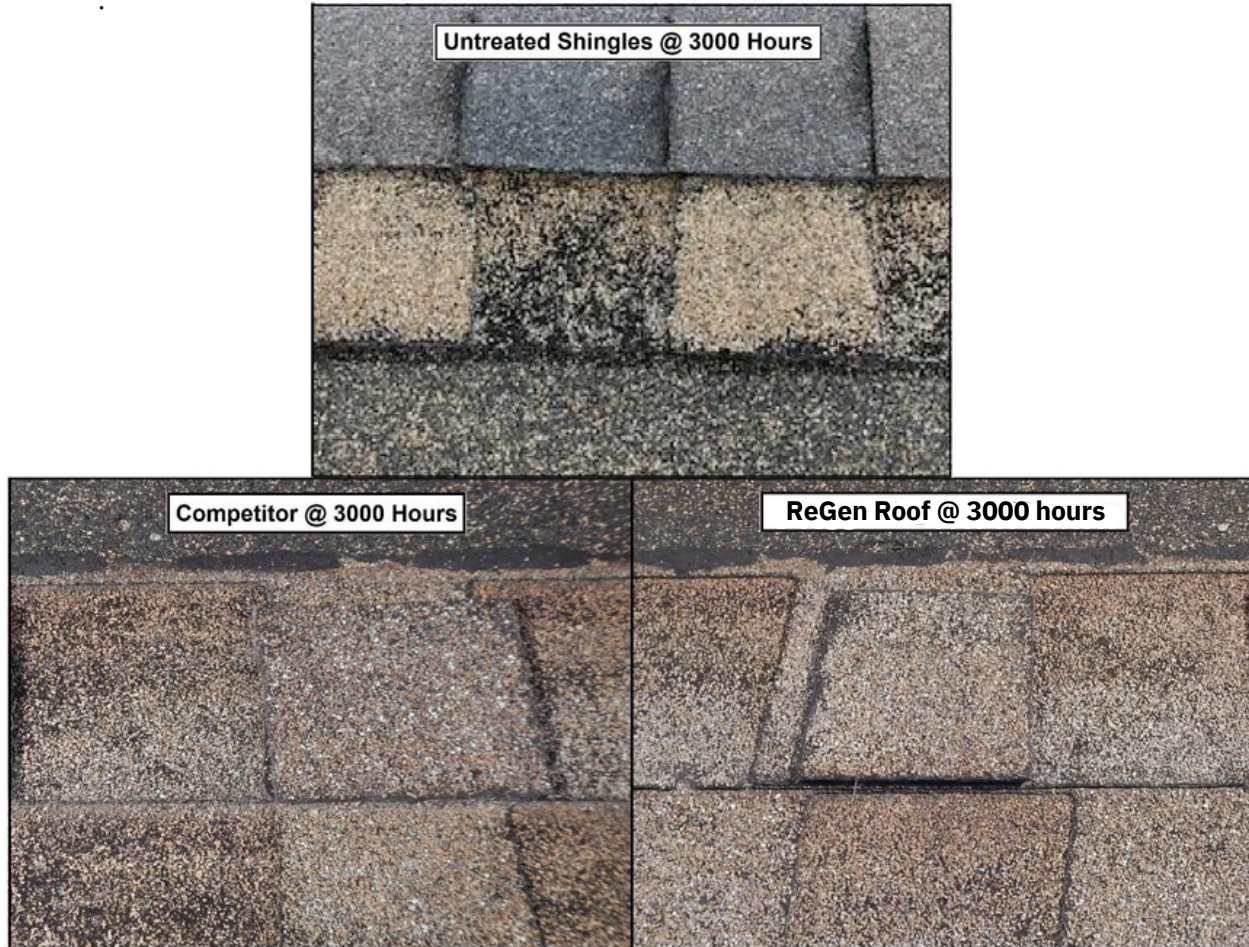
Un-Treated Shingles	ReGen Roof	Competitor
 <p data-bbox="240 957 435 991">12.41 grams</p>	 <p data-bbox="699 957 857 991">3.94 grams</p>	 <p data-bbox="1154 957 1312 991">9.86 grams</p>

**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 accurate quantification.



## APPENDIX

(APPENDIX A-11 (Granular Wash off Comparison – ~3000 hours))



**Close up view of all three sets of shingles after 3000 hours of APWS weathering.**