Optimizing Long-Term Reflectivity in Acrylic Cool Roof Coating Formulations

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Agenda

- Cool Roofing introduction
- Cool Roofing Benefits
- Solar Reflectivity Index
- Components of a roof coating and contribution to Solar Reflectivity
- Study on Additive Approach
- EPS Polymer Technology and Keeping White Roofs White Longer

Cool Roofs

Roofs with reflective surfaces, or cool roofs, contribute to mitigating the "urban heat island" phenomenon. They bounce back the sun's intense rays, taking in **80% less heat** than conventional dark-colored roofs **and reducing indoor temperatures by as much as 30% during hot weather conditions.**

A cool roof diminishes the transfer of heat to a building, enabling it to remain cooler and use less energy for air conditioning. In residential buildings with air conditioning, the solar reflectance from a cool roof can **potentially decrease the peak demand for cooling by 11–27%.**

Cool roofs **reduce overall temperature and stress on the power grid.**

The U.S Department of Energy (DOE) advocates for cool roof coatings as an economical and minimally disruptive approach to boost the **energy efficiency of pre-existing buildings.** These buildings currently represent over 20 billion square feet of commercial roofing space that is available for retrofit in the United States.

Sources: NYC °CoolRoofs, U.S. Department of Energy, Cool Roof Fact Sheet, U.S. Environmental Protection Agency, Reducing Urban Heat Islands: Compendium of Strategies, Cool Roofs, pp. 1, 8.

Typical Benefits of Cool Roof Coatings

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Extend the life of the roof

Protect the roof surface by providing a low-cost, sacrificial layer that absorbs the punishment of the elements

Reflective roof coatings **reduce surface temperatures**

Greater occupant comfort – in occupied buildings without A/C

Avoids building or occupant disruption and roof replacement

Save money

Repair and /or coat vs tear off and replace

Federal and local tax deductions

Less A/C required for cooling

Peak Energy Use Reduction

Understanding Reflectivity

Solar energy reaches Earth as electromagnetic (EM) radiation. When this energy strikes a surface, it is either absorbed — contributing to heat — or reflected. While the sun is the primary source of EM radiation, all objects above absolute zero emit some energy, which is why thermal imaging works.

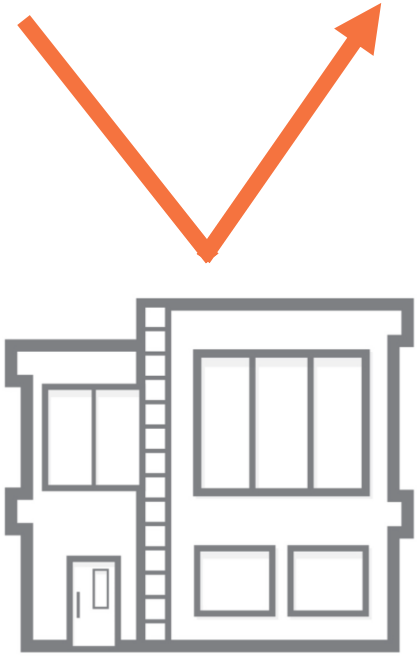
The solar performance of roof coatings is a combination of the ability of a material to both reflect and emit EM radiation. Three metrics are used to describe this, outlined below and in the following slide's figure.

Solar Reflectance (SR)
The fraction of solar energy reflected by the surface. Higher SR values mean less heat absorption and cooler roof temperatures.

Thermal Emittance (TE)
The ability of a surface to release absorbed heat. High TE values help the roof cool more efficiently.

Solar Reflectance Index (SRI):
A composite metric combining SR and TE to indicate a material's overall ability to reject solar heat.

Roof Coating Needs - SRI



SOLAR REFLECTANCE
The solar energy that is reflected by the roof

THERMAL EMITTANCE
The relative ability of the roof surface to radiate heat

Acrylic roof coatings = ~0.9

Solar Reflectance Index (SRI)

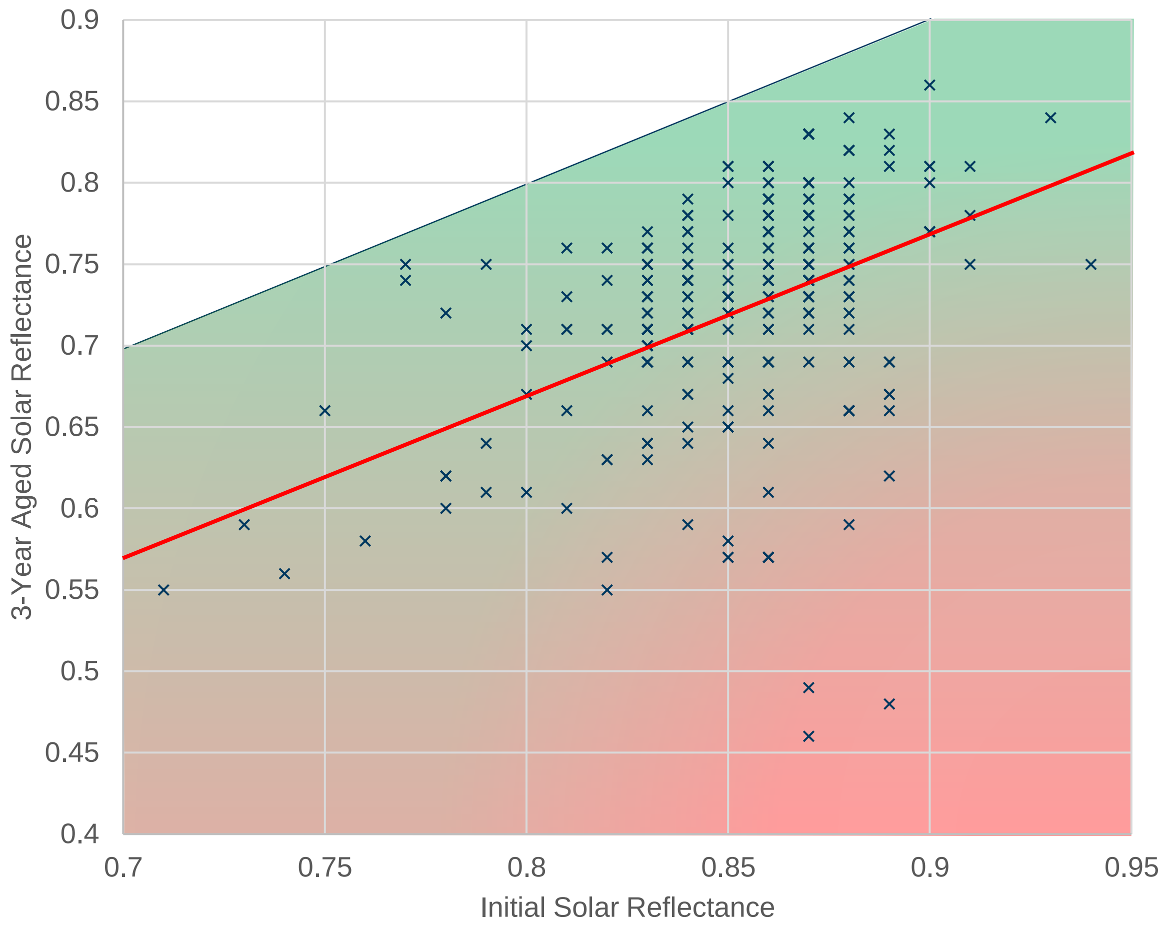
Calculated value indicating the ability of a roof surface to return solar energy to the atmosphere.

Combines reflectance and emittance.

Typically reported as a value between 0 and 100.

Influence of DPUR on Solar Reflectance

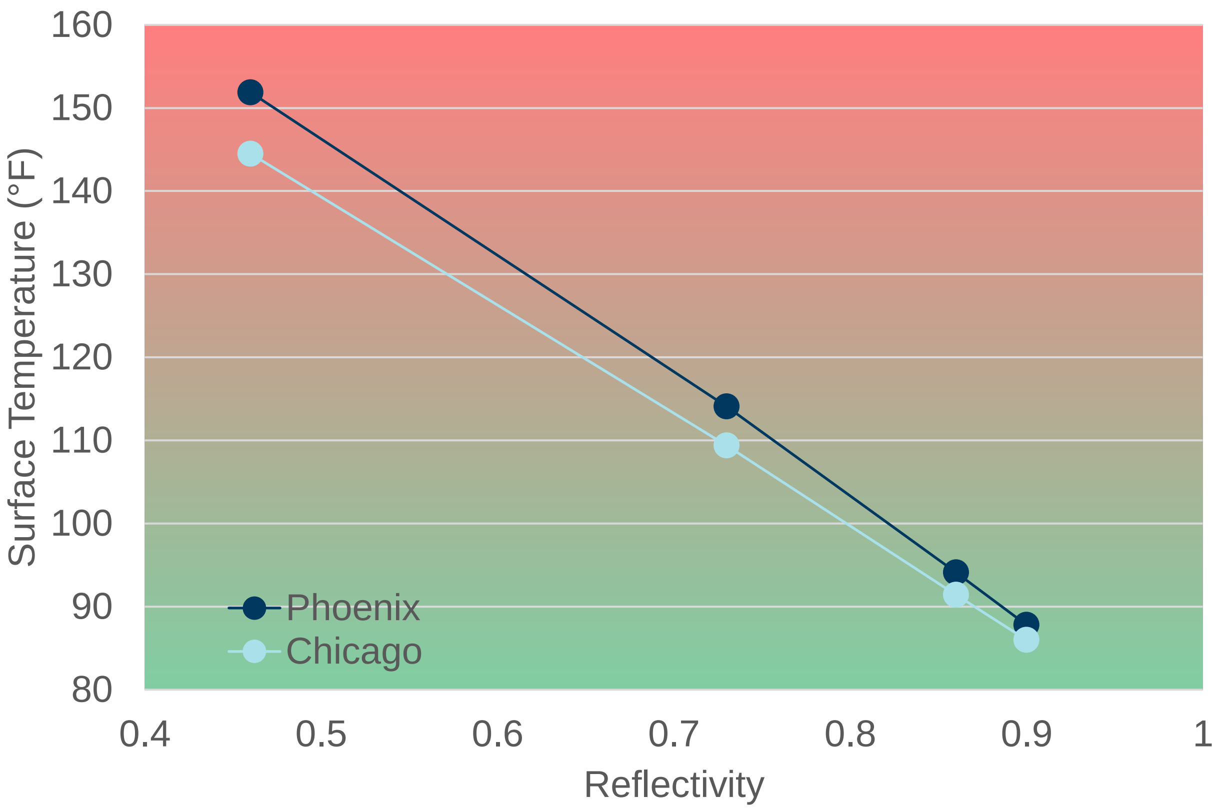
- Cool Roof Rating Council records initial and 3-year aged reflectance
- Decrease in reflectance ranges from 0.02 to 0.4
- Average decrease is 0.13 ± 0.05
- How does this translate to temperature?



Source: Cool Roof Rating Council

Influence of Reflectivity on Surface Temperature

- Calculate surface temperature from solar reflectance and thermal emissivity according to ASTM E1980
- Change in reflectance from 0.85 to 0.73 equates to an increase in roof temperature of ~20°F
- A decrease of 0.4 could result in an average temperature increase by as much as 60°F



Parameters for Calculations	
Ambient Air	80°F
Wind	Low (5 $W \cdot m^{-2} \cdot K^{-1}$)
Solar flux Phoenix	960 W/m^2
Solar flux Chicago	860 W/m^2

Source: https://coolcolors.lbl.gov/assets/docs/SRI%20Calculator/SRI-calc10.xls

EPS Test Fence Panels

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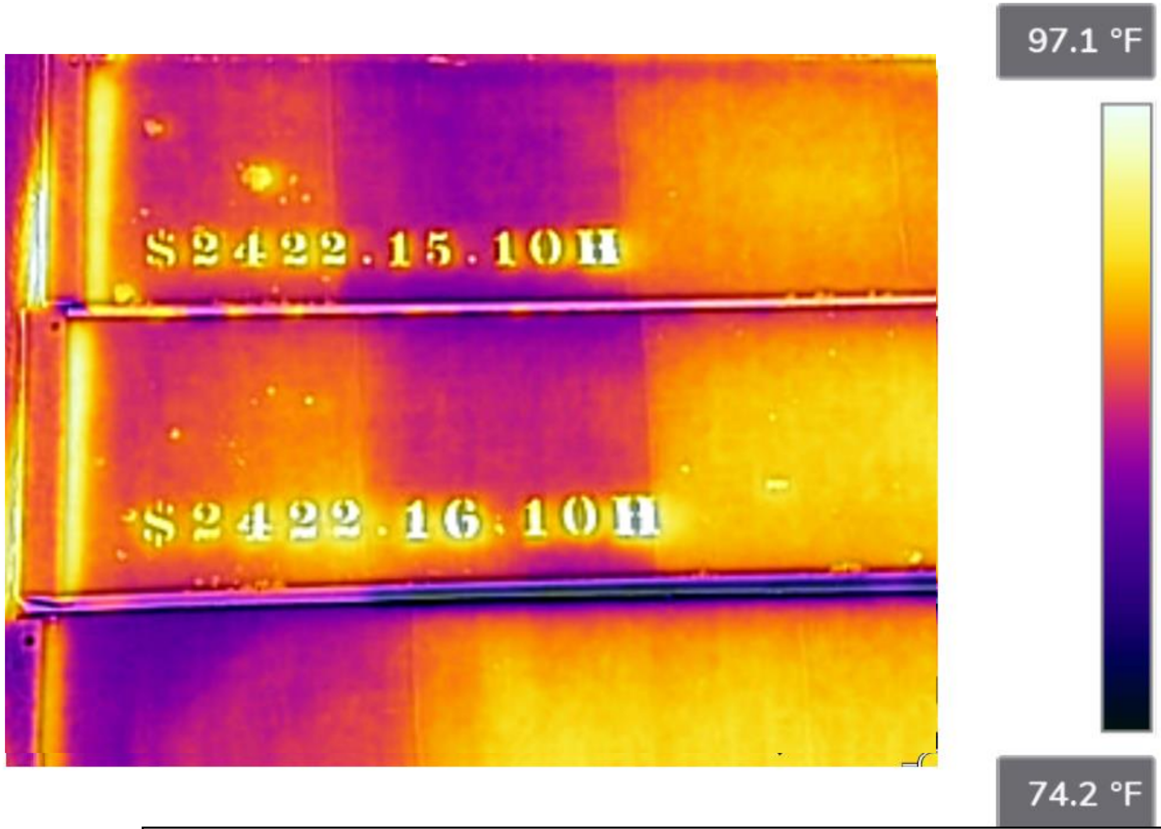
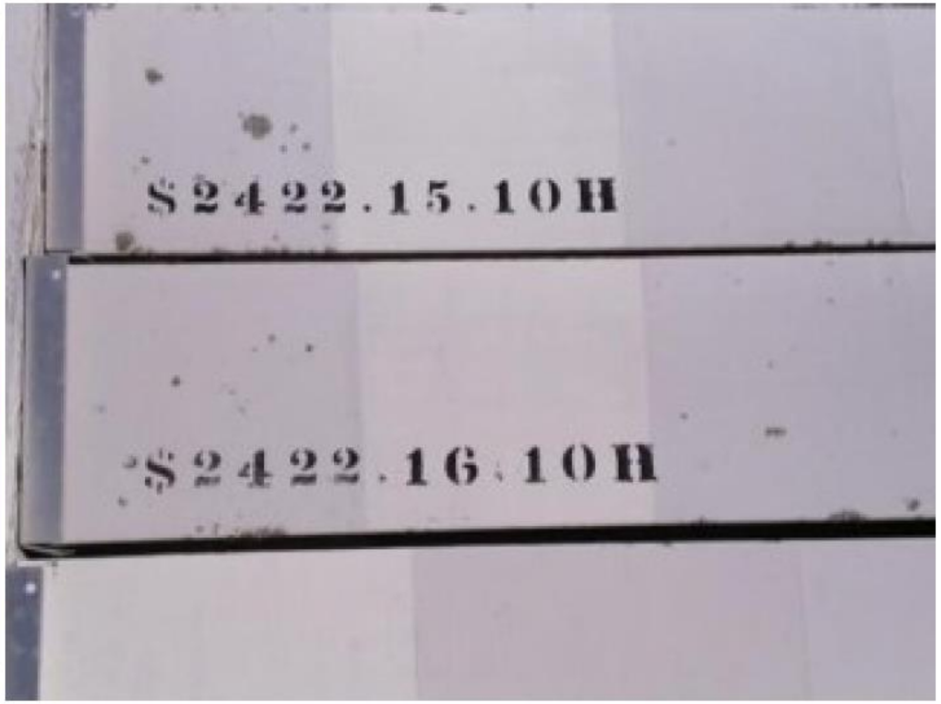
Thermogram:



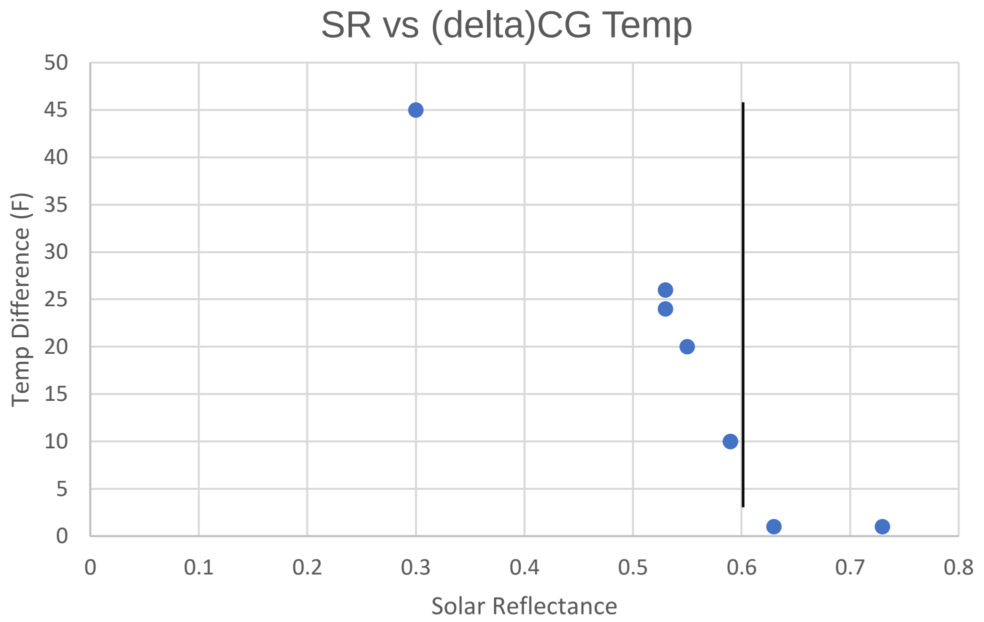
Photo

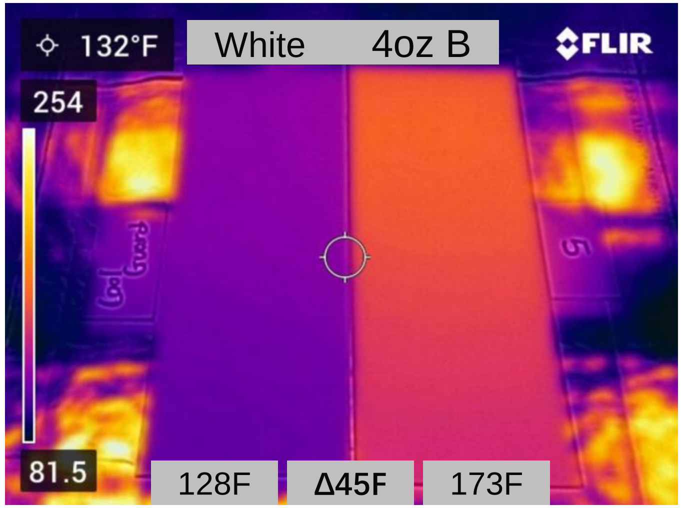


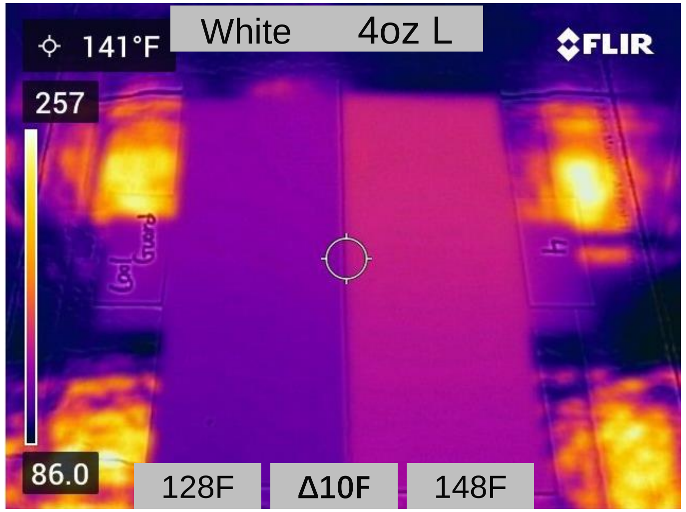
Here, the difference in temperature between section A and B for boards 15 & 16 is
8 °F (83 °F for the clean section B, and 91 °F for the dirty section A)
Picture taken at 10 am on a clear day, outdoor temperature was 83 °F.

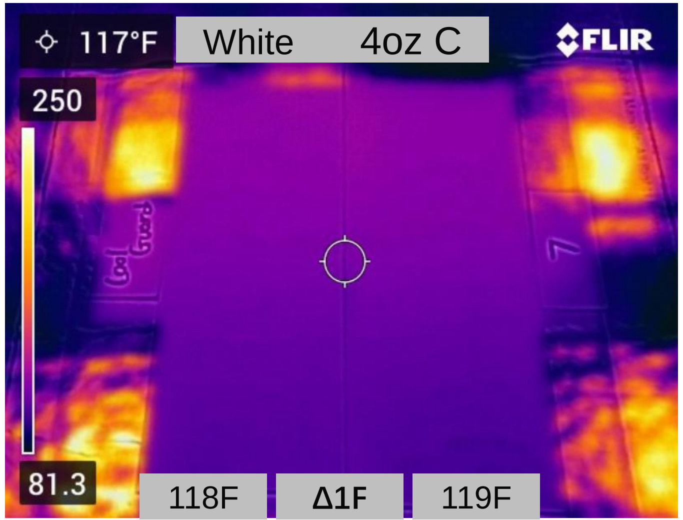
Tinted Samples
SR vs. Surface Temperature

Colorants	SR	Emissivity	SRI	Temp	Temp vs CG
B	0.30	0.91	32	173	45
B, E	0.53	0.91	63	153	26
B, E	0.53	0.90	62	151	24
C	0.73	0.91	90	119	1
C, F, L	0.59	0.91	71	139	10
C, F, L	0.59	0.90	71	135	10
EU	0.63	0.90	76	124	1
L	0.55	0.91	65	148	20





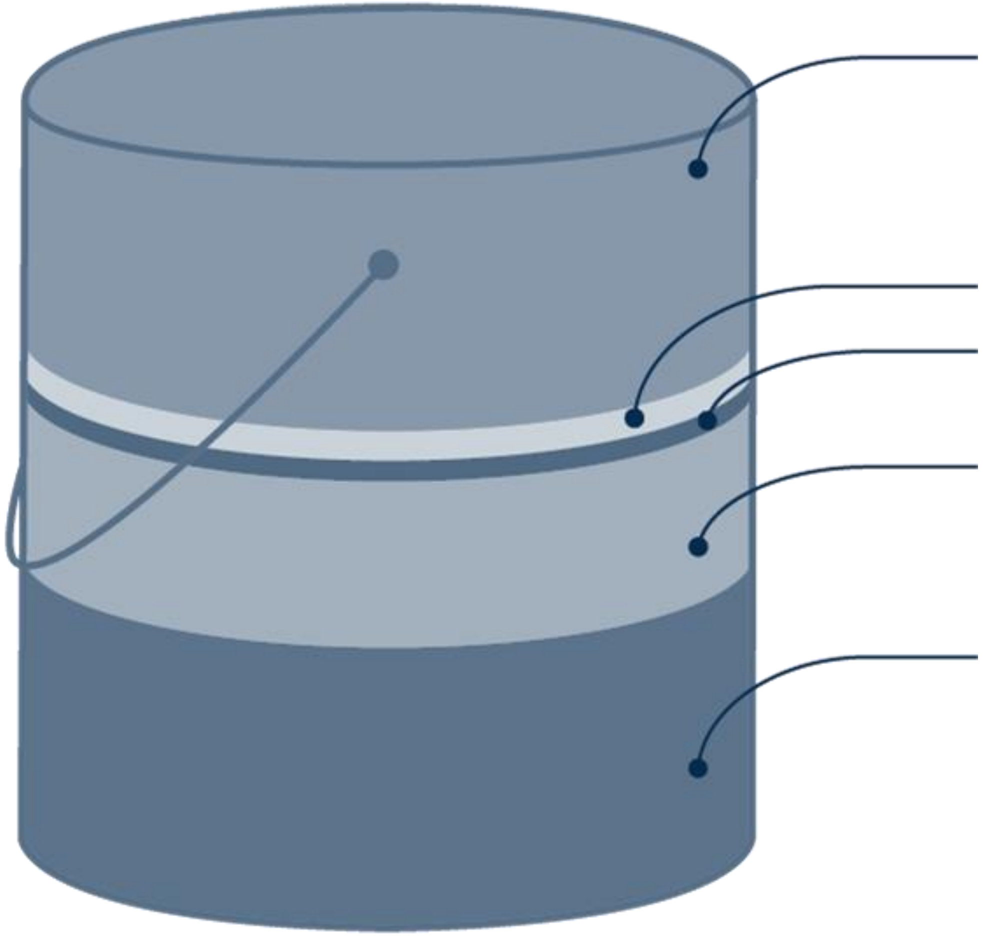




Components of Acrylic Roof Coatings

Raw Material	Pounds
Water	155
Dispersant	3
Ammonia	3
Defoamer	1
TiO2	90
Calcium Carbonate	370
Defoamer	2
Acrylic Latex (55% solids, 45% water)	450
Coalescent	7
Biocide/Fungicide	11
Glycol	11
Cellulose Thickener	3
Total	**1162**

Parameter	Value
Wt% solids	65
Vol% solids	51
PVC	40
VOC, g /liter	41
wpg	11.6



Paint Components Effect on Solar Reflectivity

Latex (Polymer Binder)	Pigments and Fillers	Additives
The backbone of the coating, holding pigments and fillers together. It influences film formation, flexibility and resistance to bleed-through. However, softer binders can attract dirt and allow migration of underlying materials. Surfactants used to stabilize latex can also feed microbial growth.	TiO_2 provides whiteness and reflectivity. Other fillers add bulk and modify physical properties, but excessive use can harm the film's durability and adhesion to a substrate.	**Biocides:** Prevent microbial growth and staining. **Dispersants and surfactants:** Improve stability and wetting but may increase susceptibility to dirt and biofouling. **Thickeners and rheology modifiers**: Affect application properties but can promote microbial growth. **Coalescents and plasticizers:** Aid in film formation but can also promote microbial growth and dirt pickup.

Solar Reflectivity Additive Testing

Paints

White base paints only

Fillers

Pigment A

Dosing: 4.5 / 9 lb/100gal

Pigment B

Dosing: 24 lb/100

Pigment C

Dosing: 24 lb/100

Pigment D

Dosing: 30 lb/100

Blended System

4.5 lb/100 Pigment A + 24 lb/100 Pigment C

Sample	Solar Refl.	Emissivity	SRI
Polymer A			
Control	**0.86**	**0.9**	**109**
Pigment A - 1x	0.86	0.9	109
Pigment A - 2x	0.87	0.9	110
Pigment B	0.85	0.9	107
Pigment C	0.85	0.9	107
Pigment C + Pigment A	0.86	0.9	109
Pigment D	0.86	0.9	109
Polymer B			
Control	**0.86**	**0.9**	**109**
Pigment A - 1x	0.87	0.9	110
Pigment A - 2x	0.87	0.9	110
Pigment B	0.86	0.9	109
Pigment C	0.85	0.9	107
Pigment C + Pigment A	0.86	0.9	109
Pigment D	0.86	0.9	109

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What Causes Reflectivity to Degrade?

Even though TiO_2 remains reflective, other components and environmental factors can interfere with its ability to reflect light. The three most common mechanisms of reflectivity degradation in roof coatings are:

Bleed-through

Migration of compounds from the substrate through the coating. These compounds can absorb light themselves, change the properties of the coating so it is more susceptible to other mechanisms of reflectivity degradation, or both.

Biofouling

Fungi and algae grow on the coating surface, blocking light from reaching the coating.

Dirt Pickup

Accumulation of organic and inorganic particles that block light from reaching the surface.

Each of these mechanisms reduces the amount of light that reaches and is reflected by the TiO_2, leading to a less reflective coating

Bleed-Through Resistance

The latex used is key to resisting bleed-through. Since the latex polymer forms the continuous phase surrounding the pigments and fillers, any migrating compounds must pass through it to affect the surface.

There are two substrates that are particularly problematic:

Bitumen Substrates

Contain oils that migrate upward and absorb solar energy.

PVC Membranes

Contain plasticizers that soften the coating, thus potentially increasing dirt and microbial susceptibility.

EPS® Bleed Blocking Polymer

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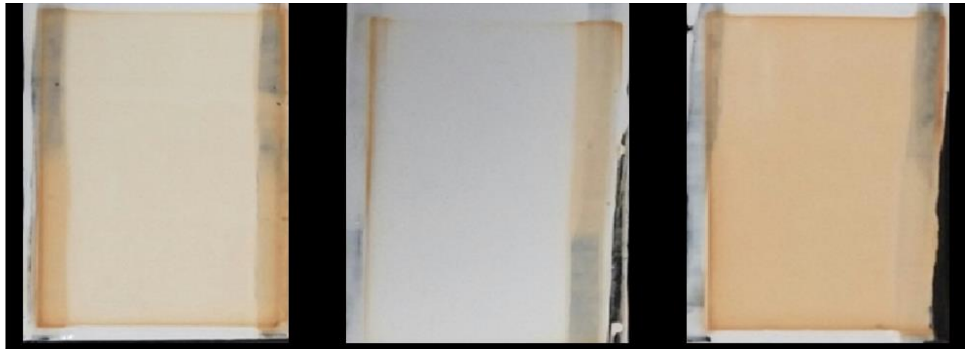
Asphalt Bleed Blocker

- All-acrylic emulsion designed to minimize asphalt bleed through in cool roof coatings while maintaining flexibility and toughness
- Base coat only or all-purpose base coat and topcoat

Commercial Basecoat | EPS® Polymer | Commercial Topcoat

Commercial Basecoat + Silicone Topcoat | EPS® Polymer Basecoat + Silicone Topcoat | No Bleed Block Technology + Silicone Topcoat



Roofing Membrane Coatings Exterior Exposure – Marengo, IL

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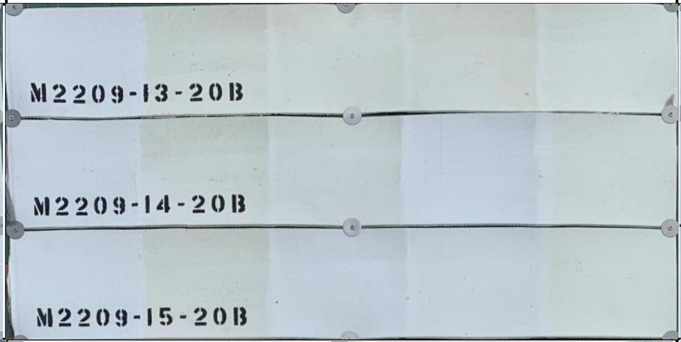
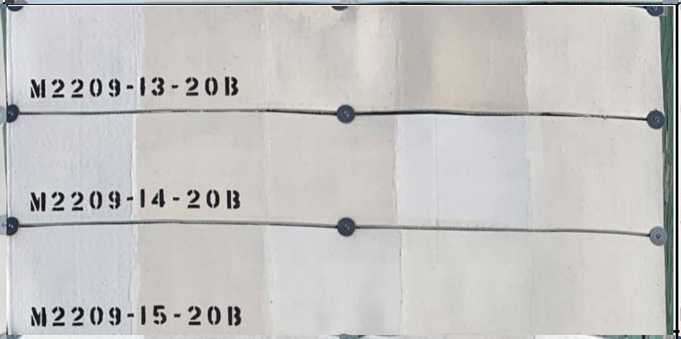
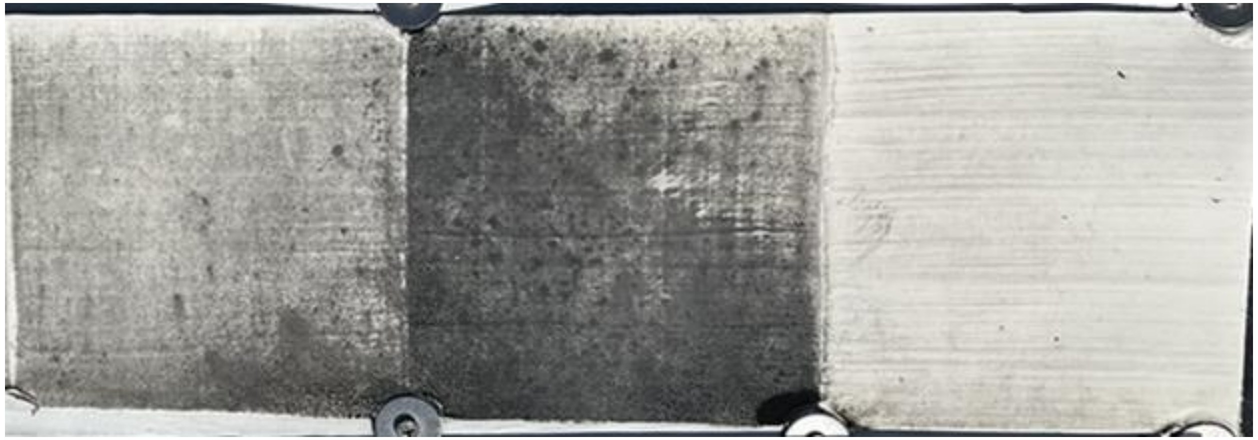
	TPO	APP Modified Bitumen	PVC
Initial			
15 Months			
38 Months			

Biofouling – 6 years Exposure - FL

- The figure below shows the results of a long-term outdoor exposure test in Florida.
- Three coatings with identical formulations and preservative packages—but different latexes—showed dramatically different results after 6 years.
- The coating in the center, made with a comparative resin, was almost completely overgrown. The left-hand experimental coating showed moderate growth, while the coating on the right, containing an EPS® roofing polymer remained substantially free of biological growth.



EPS® Polymer

Dirt Pickup Resistance

The keys to keeping white roofs white are bleed-blocking and **dirt pickup resistance**

- **Dirt pickup resistance** (DPUR) is a crucial requirement for roof coatings
- Accumulated dirt reduces reflectivity
- DPUR can significantly affect **building energy costs** in roof coating applications
- However, these do not significantly affect thermal emittance

Methods for Improving Dirt Pickup Resistance

CONCEPT

- Use of higher Tg resins
- Incorporation of specialty additives
- Utilize resins containing benzophenone
- **EPS Dirt Pickup Technology**

LA Exposure – 12 months

EPS employs a **novel DPUR technology** that is built directly into an acrylic latex. These resins offer improved DPUR without the added complexities of BP.

The figure below shows the results of a comparative test in which six coatings were applied to panels and exposed in Southern California for twelve months. The three sections on the left (A–C) all have a Tg of −26 °C, while the three sections on the right (D–F) have a Tg of −10 °C. The results are telling:

- **Coatings with no DPUR technology (A and F) show significant dirt accumulation.**
- **Coatings with Benzophenone (C and D) perform better.**
- **Coatings made with the novel EPS DPUR-integrated latexes (B and E) showed the best performance—demonstrating that the right latex can make a big difference.**

Conclusion

- Among all the components in an acrylic cool roof coating, the **choice of latex binder** stands out as the most critical factor influencing long-term reflectivity.
- As the continuous phase of the coating, latex not only determines the **coating's flexibility** but also plays a central role in **resisting common reflectivity degradation mechanisms such as bleed-through, biofouling and dirt pickup.**
- By choosing the right binder chemistry, manufacturers can significantly **extend the reflective performance and durability of cool roof coatings** — delivering coatings that not only start white, but stay white.

QUESTIONS

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