Advanced Elastomeric Cool Roof coatings for highly weatherable stay-clean roof coatings

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Outline of talk

- Basics of cool-roof coatings
- “System” options for cool-roof coatings
- High adhesion acrylic resin with excellent dirt resistance
- PVDF technology for coatings with highly durable stay clean properties
Green Movement

Core Values

- Conservation
- Sustainable
- Environmentally Friendly
- Reducing Carbon Foot Print

Roofing?

- 90% of Roofs in the US are dark colors
- Absorb Heat (150-190°F)
- Contribute to “Urban Heat Island Effect”
- Result in higher utility bills
- Accelerate deterioration of roofing materials which are sent to landfills
- Higher electricity demand leading to blackouts
Solar Reflectance ($\rho$) is a ratio indicating the amount of solar energy reflected by a surface.
Reflective Cool White Roofing

- Add R-value of roofs
  - EPA estimates up to R19 value

- Reduce building heat-gain

- 15-30% HVAC savings

- Increase HVAC and roof membrane longevity

- Resulting in lower greenhouse gas emissions
System approaches to cool roofing—example of after-market roof coating

- Elastomeric topcoat-10-20 mils dft
- Elastomeric primer-10-20 mils dft
- Substrate
- High performance topcoat* ~ 3 mils dft
- Elastomeric primer-10-20 mils dft
- Substrate

- Choice of primer binder will depend on numerous factors such as substrate (asphalt? TPO? etc.), location (do I need low temperature flexibility?), etc.
Degraded membranes can be replaced or repaired

- Crazing
- UV deterioration
- Seam splitting
- Hail damage
- Dirt pick up and mildew growth
High Adhesion Acrylic
Elastomeric Latex for Superior Adhesion and Durability
High Adhesion binder can be employed to repair various membrane types

- Lowers the cost to building owners and improves the profitability of roofing contractors
  - Refurbishing existing membranes cheaper than replacing
  - Eliminating the primer lowers the cost of materials and labor

Features
- Meets ASTM D6083-05 specification
- Excellent adhesion to various membrane types
- Excellent dirt pickup resistance
- Resistant to water ponding
- Ambient cross-linking functionality for increased toughness
- High solids for greater formulating latitude
Surface Wetting vs. Gel Fraction

High gel content; poor flow

Low to moderate gel; good flow
High Adhesion Polymer Basecoat

Passes ASTM D6083 wet peel adhesion requirement, even over difficult to adhere to membranes such as aged TPO, without requiring a solvent based primer.
High Adhesion Polymer Basecoat provides superior elastomeric properties

- **Elongation**: ASTM minimums
- **Tensile**: psi
- **Tear**: lbf/inch

**Basecoat** provides superior elastomeric properties.
High Adhesion Polymer helps keep a cool roof “white”

Dirt added as a slurry and allowed to dry overnight

% Whiteness Reduction

Iron Oxide
Coal Ash

High Adhesion Polymer
Standard Acrylic

Photo of cleaned coating
Iron Oxide Coal Ash

Photo of cleaned coating
Iron Oxide Coal Ash
High Adhesion Polymer demonstrates excellent exterior durability

Sprayed Polyurethane Foam Substrate

<table>
<thead>
<tr>
<th>Commercial 1</th>
<th>Commercial 2</th>
<th>High Adhesion Polymer</th>
<th>Commercial 3</th>
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Thermoplastic Polyolefin Substrate

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4 years at South 5° Exposure
High Adhesion Acrylic has very good dirt pick-up resistance

At two years South 5° exposure in Cary, NC
Waterborne Polyvinylidene Fluoride Resin
The Basis for Weathering Properties

PVDF
Polyvinylidene Fluoride

C-F Bond

Retention of Color and Gloss

Resistance to Dirt Pick-up

Resistance to Mildew & Fungi

Resistance to Rain and Chemicals

Resistance to Film Erosion
Waterborne PVDF coatings for “stay-clean” surfaces

At least three mechanisms contribute to the “stay-clean” advantages of PVDF-based coatings:

- PVDF crystallinity and barrier properties
- Fluoropolymer surface properties
- Inhospitality to fungal growth
Key properties of coatings based on Waterborne PVDF resins

- **Highly resistant to UV degradation**
  - Long term color retention
  - Long term gloss retention
  - Highly chalk resistant

- **Resistant to chemicals & corrosive environments**

- **Very abrasion resistant**

- **Highly flexible**

- **Low dirt pickup**
Benefits of Waterborne PVDF based Coatings

Coatings formulated with Waterborne PVDF latex exhibit the following benefits for building and structure owners:

- Reduced Maintenance
  - Fewer recoats
  - Better dirt pick up performance
  - Improved mold and mildew resistance
- Environmentally friendly
  - Aqueous
  - Low VOC’s

Waterborne PVDF resins are designed for high performance exterior applications
**Waterborne Latex Technology - Polymerization & Film Formation**

**Polymerization:**
- **Stage 1:** PVDF Polymerization to produce “seed” (>60% fluorine by weight)
- **Stage 2:** Acrylic Emulsion Polymerization:

**Film Formation:**
- **CONSOLIDATION**
- **COMPACATION DEFORMATION**
- **INTERDIFFUSION**
Why high PVDF resin based coatings don’t chalk

How high PVDF resin levels lead to reduced chalking and improved color retention

For high PVDF resin levels, the pigment stays covered by PVDF resin even after all the surface acrylic is gone

Pigment stays encapsulated: minimal chalk and color fade!!
Waterborne PVDF Emulsions vs. Acrylics

Waterborne coatings on Al Appearance after 7.5 years South 45° Florida exposure

- Cobalt blue pigment allows penetration of UV inside the coating: a very severe test
- Color fade comes only from resin (polymer) degradation and chalking effects
- No chalking or cracking for Waterborne PVDF coatings; no progression of color fade
- Acrylics have completely faded in 5-10 years
Paints on primed fiber cement, 50 months South Florida 45 South exposure, January 2014
Paints on primed fiber cement
58 months South Florida 45 South exposure, January 2014

Under flap
Unwashed
Washed

Commercial paint 1  Commercial paint 2  Commercial paint 3  Waterborne PVDF
Acrylic and PVDF Roof System Exposure

Commercial

Standard Acrylics

Acrylic Basecoat
PVDF Topcoat

2 years exposure South 5°
Acrylic and PVDF Roof System Exposure

EPDM
Galvanized Steel
Aluminum

Commercial
Standard Acrylics
Acrylic Basecoat PVDF Topcoat

2 years exposure South 5°
Excellent Dirt Pick-Up Resistance

Acrylic Resin Based Coating

Waterborne PVDF Based Coating

PVDF resin based coatings have excellent dirt pick up resistance.
Stain blocking of asphalt species

*Paints applied on SBS asphalt substrate; air-dried then baked at 60 C for one week*

Acrylic basecoat – 10 mils dry-film thickness and Fluoropolymer topcoat - 2 mils dry-film thickness

Commercial elastomeric acrylic paint- 10 mils dry-film thickness

Single coat, paint based on Fluoropolymer 2 mils dry-film thickness

*Original paint colors*
Inherent Mold, Mildew and Fungal Resistance

Coating Water Pick Up Performance Comparison

Resistance to Mildew & Fungi

Acrylic Resin Based Coating

Waterborne PVDF Based Coating

18 months, South Florida
Neither paint contains biocide.
PVDF Resin Outdoor Exposure History

- Panels put out for exposure in January, 2000
- Florida, south facing, 45°
- TSR > 75% after 13 years
- Formulations based on Kynar Aquatec® ARC
- Photo taken January, 2014
Waterborne PVDF coating on PVC Membrane 1.5 Years of Exposure in Southern Georgia
System Approach for Metal Restoration

High Performance topcoat* based on Waterborne PVDF latex ~2-6 mils dft*

Waterborne acrylic primer ~2-10 mils dft*

Metal

*
Field Application of Waterborne PVDF based Coatings

Surface Preparation
• metal must be in sound, clean, and dry condition, free of contamination (mildew, dirt, grease, oils, etc.)

Priming
• apply appropriate primer
• application equipment
  • conventional airless spray
  • medium nap roller
  • high quality nylon/polyester bristle brush

Top Coat Application
• same application equipment as primer

Dry/Cure Time for each Coating
• touch: ~ 2 hours
• hardness: ~ 24 hours
Waterborne PVDF vs. commercial coatings

**Waterborne PVDF vs. waterborne acrylic urethane hybrid**

- Superior weatherability: color retention and chalk resistance
- Higher falling sand erosion resistance
- Meets AAMA 2605 requirements

![Comparison of coatings](image)
Commercial Applications of Waterborne PVDF Coatings
Summary

- **Water-based chemistry; allows formulators to meet stringent VOC requirements**

- **Manufactured without fluorosurfactants and alkylphenol ethoxylate (APEO) surfactants**

- **Roofing systems based on acrylic basecoat and PVDF topcoat have performance benefits**
  - High adhesion to difficult substrates
  - Excellent dirt pick-up resistance for stay clean properties
  - Excellent color fade resistance in tinted coatings