Solar Reflectance and Thermal Emittance for Residential and Nonresidential Roofs

CEC Workshop - July 13, 2006
W. Lee Shoemaker
Cool Metal Roofing Coalition
Cool Metal Roofing Coalition

Members
- Metal Building Mfrs Association
- Metal Construction Association
- Natl. Coil Coaters Association
- N. Amer. Zinc-Aluminum Coaters
- American Iron & Steel Institute

Affiliates
- Oak Ridge National Laboratory
- American Zinc Association
Cool Metal Roofing Coalition

**Mission:** Educate architects, building owners, specifiers, codes & standards officials and other stakeholders about the sustainable, energy-related benefits of metal roofing.
- May Workshop Presentation:

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Inclusion of Solar Reflectance and Thermal Emittance Prescriptive Requirements for Residential Roofs in Title 24

(Revised May 17, 2006)

Inclusion of Cool Roofs in Nonresidential Title 24 Prescriptive Requirements

(Revised May 18, 2006)
Points in Agreement

- Prescriptive requirements should be based on cost effective study
- Zones should be excluded from prescriptive requirements where cost effectiveness is not shown for all common roofing products
- 3-year aged properties should be used (CRRC) with appropriate default values
3-Year Aged Properties

• May Workshop Proposal (PIER):

  - Use CRRC aged values $\rho_{\text{aged}}, \varepsilon_{\text{aged}}$ if labeled.
  - If CRRC labels only initial values $\rho_{\text{initial}}, \varepsilon_{\text{initial}}$, we estimate $\rho_{\text{aged}}$ and $\varepsilon_{\text{aged}}$:
    - $\rho_{\text{aged}} = 0.20 + 0.70 \times (\rho_{\text{initial}} - 0.20)$
    - $\varepsilon_{\text{aged}} = \varepsilon_{\text{initial}}$ ❌ Too lenient?
  - If the product does not have a CRRC label, default values are
    - $\rho_{\text{aged}} = 0.10$
    - $\varepsilon_{\text{aged}} = 0.75$
Steep-Slope Residential

30-Year Net Present Value of Savings ($/1000 ft$^2$):

*fiberglass asphalt shingle with radiant barrier*

\[ \Delta \rho = 0.15 \]  
\[ \rho = 0.25 \]

$0.20/ft^2$

Excluded Zones

Zones that require radiant barrier shaded green
$0.20/ft^2$

**Excluded Zones**

$\Delta \rho = 0.15 (\rho = 0.25)$

Zones that require radiant barrier shaded green
Steep-Slope Residential (PIER)

- **All products**
  - Fiberglass asphalt shingle with $\varepsilon_{\text{aged}} \geq 0.75$:
    $$\rho_{\text{aged}} \geq 0.25$$
  - All other products with $\varepsilon_{\text{aged}} \geq 0.75$:
    $$\rho_{\text{aged}} \geq 0.40$$
  - All products with $\varepsilon_{\text{aged}} < 0.75$:
    $$\rho_{\text{aged}} \geq 0.40 + 0.31 \times (0.75 - \varepsilon_{\text{aged}})$$

Zones Excluded = 1 through 8
Steep-Slope Residential and Nonresidential

- 0.40 vs. 0.25
  - Color availability
  - 0.40 Eliminates 13 of 18 CRRC Color Families
Low-Slope Residential

$0.20/ft^2$

Excluded Zones

Zones that require radiant barrier shaded green

$\Delta \rho = 0.35 \ (\rho = 0.55)$
Low-Slope Residential

$0.20/ft^2$

Excluded Zones

Zones that require radiant barrier shaded green

$\Delta \rho = 0.35 (\rho = 0.55)$
Low-Slope Residential

- Low-Slope Residential (PIER)

Zones Excluded = 1 through 9 and 12
Steep-Slope Nonresidential

$0.20/ft^2$

$\Delta \rho = 0.15 \ (\rho = 0.25)$
Steep-Slope Nonresidential (PIER)

- **All products**
  - Fiberglass asphalt shingle with $\epsilon_{aged} \geq 0.75$:
    - $\rho_{aged} \geq 0.25$
  - All other products with $\epsilon_{aged} \geq 0.75$:
    - $\rho_{aged} \geq 0.40$
  - All products with $\epsilon_{aged} < 0.75$:
    - $\rho_{aged} \geq 0.40 + 0.31 \times (0.75 - \epsilon_{aged})$

No Zones Excluded
Low-Slope Nonresidential

2005 Analysis

$0.50/ft^2

$\Delta \rho = 0.35 \ (\rho = 0.55)$

Excluded Zones
• Low-Slope Nonresidential

Zones Excluded = 1 through 5, 11, 12, and 16
Impact of 0.40 Reflectance Criteria on Roof Color Selection

CEC Workshop - July 13, 2006
Mark Ryan
The Shepard Color Company
Effect of TSR Requirements on Color Envelope
Based on State-of-the-Art Technology

Based on CRRC Approved Color Families

Red
Dark Blue
Dark Brown
Dark Green
Black
Dark Grey

Medium to Light Blue
Medium to Light Brown
Medium to Light Green

Pearlescent Copper
Pearlescent Silver
Off-White
Beige
Tan
White
Bright White

Reduction in Color Envelope due to 0.40 TSR Requirement
Color fade of organic pigments after long term Florida exposure - reds (I)

Commercial KYNAR 500® PVDF based coating with organic red pigment and UV absorbing clear coat after 5½ years in Florida, south 45 exposure. Original red color can be seen at the top underflap portion.
Organic and Inorganic Blue Pigments

Blue/titanium dioxide (tint) KYNAR 500® PVDF based coatings after 31 years in Florida.
Right: Phthalocyanine blue tint (color had completely faded within ten years- underside of coating, where it is peeling, has original color)
Bottom: KYNAR 500 PVDF coatings made using various metal oxide pigments, 33-39 years old

Original color (under flap)
Color fade of organic pigments after long term Florida exposure - blacks

Arkema laboratory KYNAR 500 PVDF based coatings with high TSR black pigment (left) and carbon black pigment (right), after 5 years in Florida, south 45 exposure. From a 2001 exposure series comparing new pigment grades, most of them "cool roof" metal oxide pigments (entire series can be seen below):

12 year old metal oxide pigment study

5 year old cool roof study

Courtesy of Arkema Inc.
Organic pigment tint series using more durable organic pigment grades - Florida S45 weathering

Courtesy of Arkema Inc.
TSR = 25 %
TSR = 49 %
TSR = 29 %
TSR = 44 %

TSR = 24 %
TSR = 46 %
TSR = 25 %
TSR = 47 %