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:

Roof → / Building	Low-Slope	Steep-Slope
Residential	2008	2008
Non-Residential	2005	2008

DRAFT

May 17, 2006

CODE CHANGE PROPOSAL

2008 Title 24 Building Energy Efficiency Standards Update

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

(Revised May 17, 2006)

Roof → / Building	Low-Slope	Steep-Slope
Residential	2008	2008
Non-Residential	2005	2008

May 18, 2006

CODE CHANGE PROPOSAL

2008 Title 24 Building Energy Efficiency Standards Update

Inclusion of Solar Reflectance and Thermal Emittance Prescriptive Requirements for Steep-Sloped Nonresidential Roofs in Title 24

(Revised May 18, 2006)

CODE CHANGE PROPOSAL

2005 Title 24 Building Energy Efficiency Standards

Inclusion of Cool Roofs in Nonresidential Title 24 Prescriptive Requirements

Points in Agreement

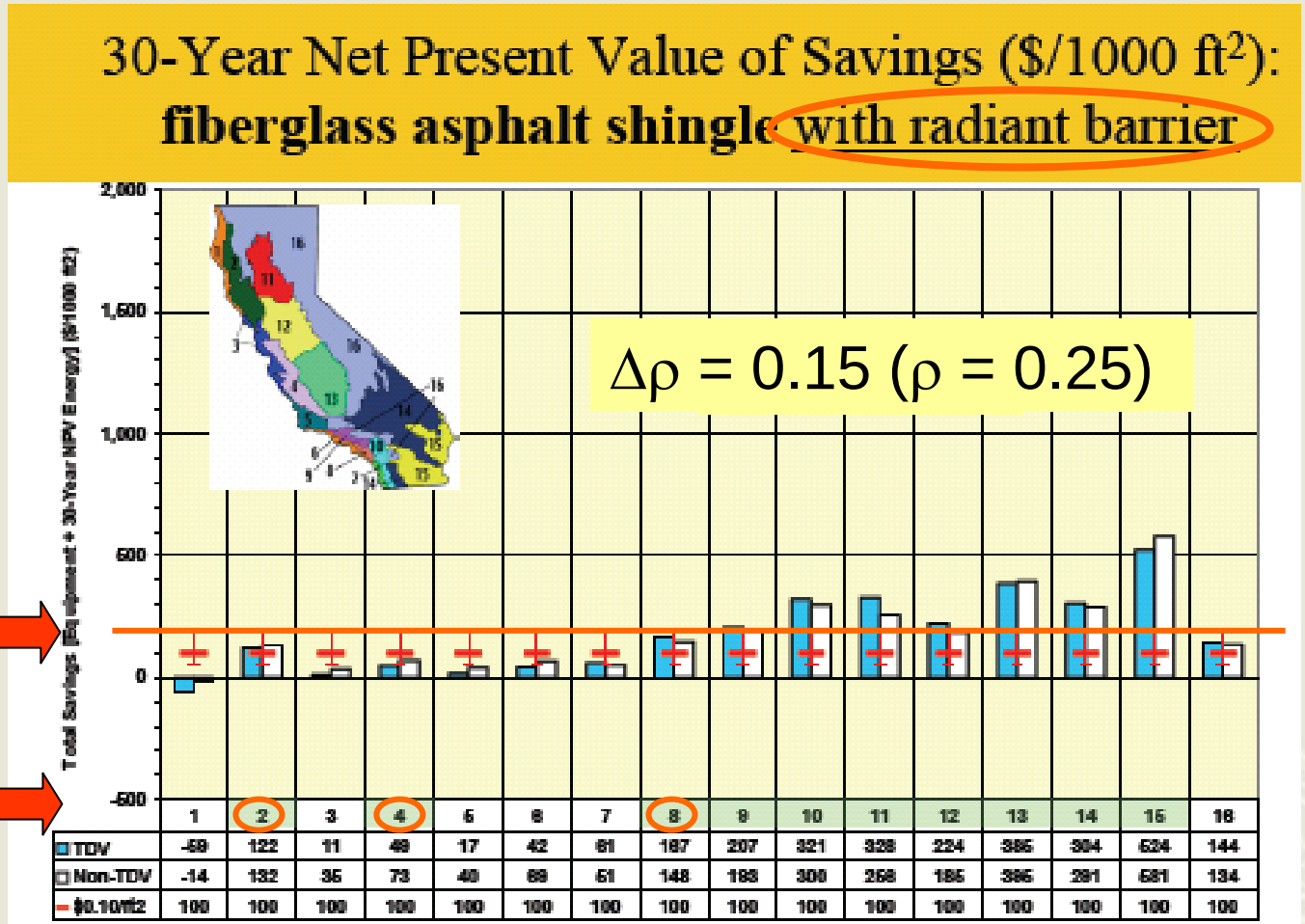
- Prescriptive requirements should be based on cost effective study
- Zones should be excluded from prescriptive requirements where cost effectiveness is not shown for all common roofing products
- 3-year aged properties should be used (CRRC) with appropriate default values

3-Year Aged Properties

- May Workshop Proposal (PIER):

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

Steep-Slope Residential

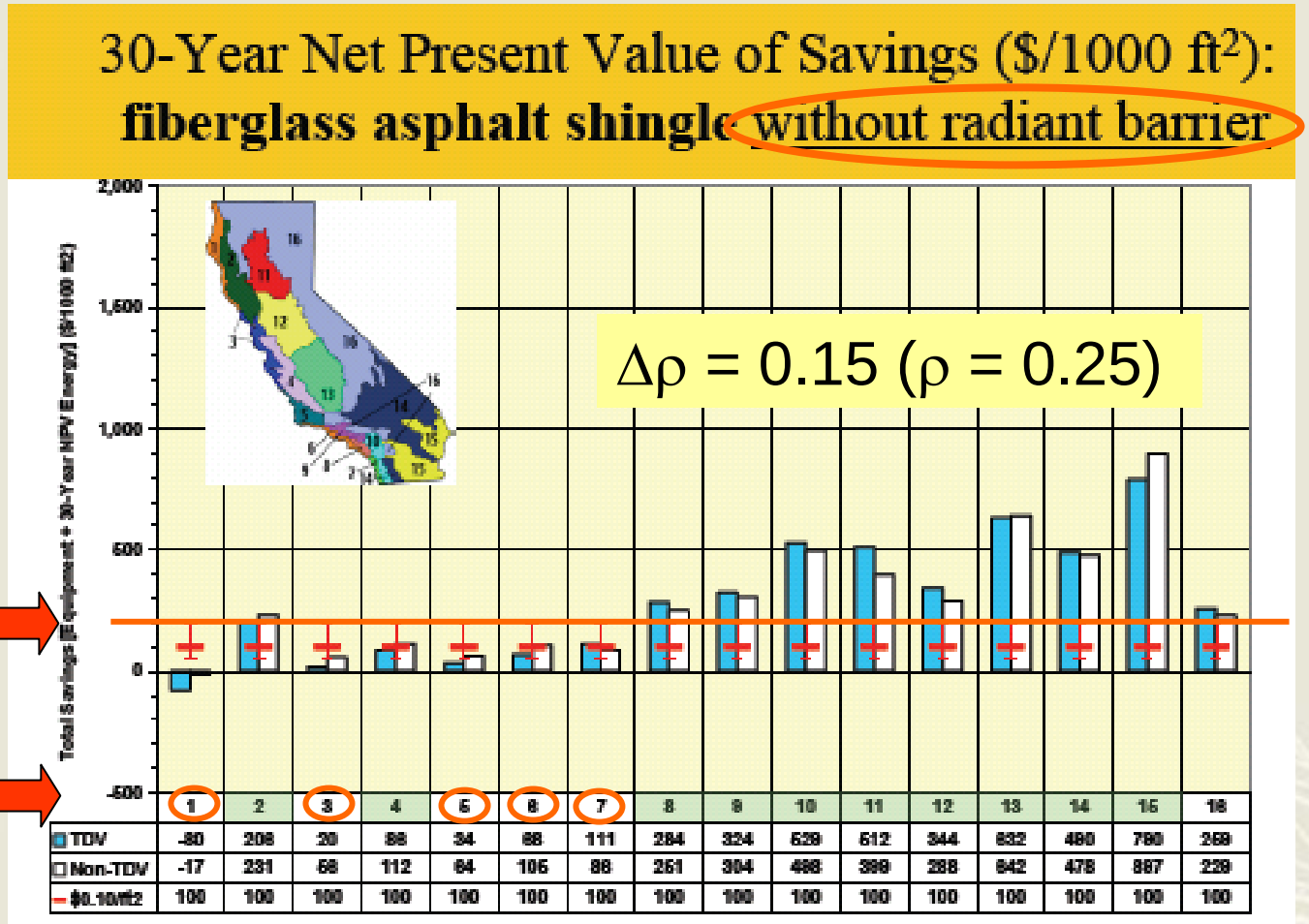


$0.20/ft²

Excluded Zones

Zones that require radiant barrier shaded green

Steep-Slope Residential



$0.20/ft²

Excluded Zones

Zones that require radiant barrier shaded green

Steep-Slope Residential

- Steep-Slope Residential (PIER)

All products

- ~~Fiberglass asphalt shingle~~ with $\varepsilon_{aged} \geq 0.75$:

  $\rho_{aged} \geq 0.25$

- ~~All other products with $\varepsilon_{aged} \geq 0.75$:~~

  ~~$\rho_{aged} \geq 0.40$~~

- All products with $\varepsilon_{aged} < 0.75$:

  $\rho_{aged} \geq$ ~~$0.40 + 0.31$~~ $* (0.75 - \varepsilon_{aged})$

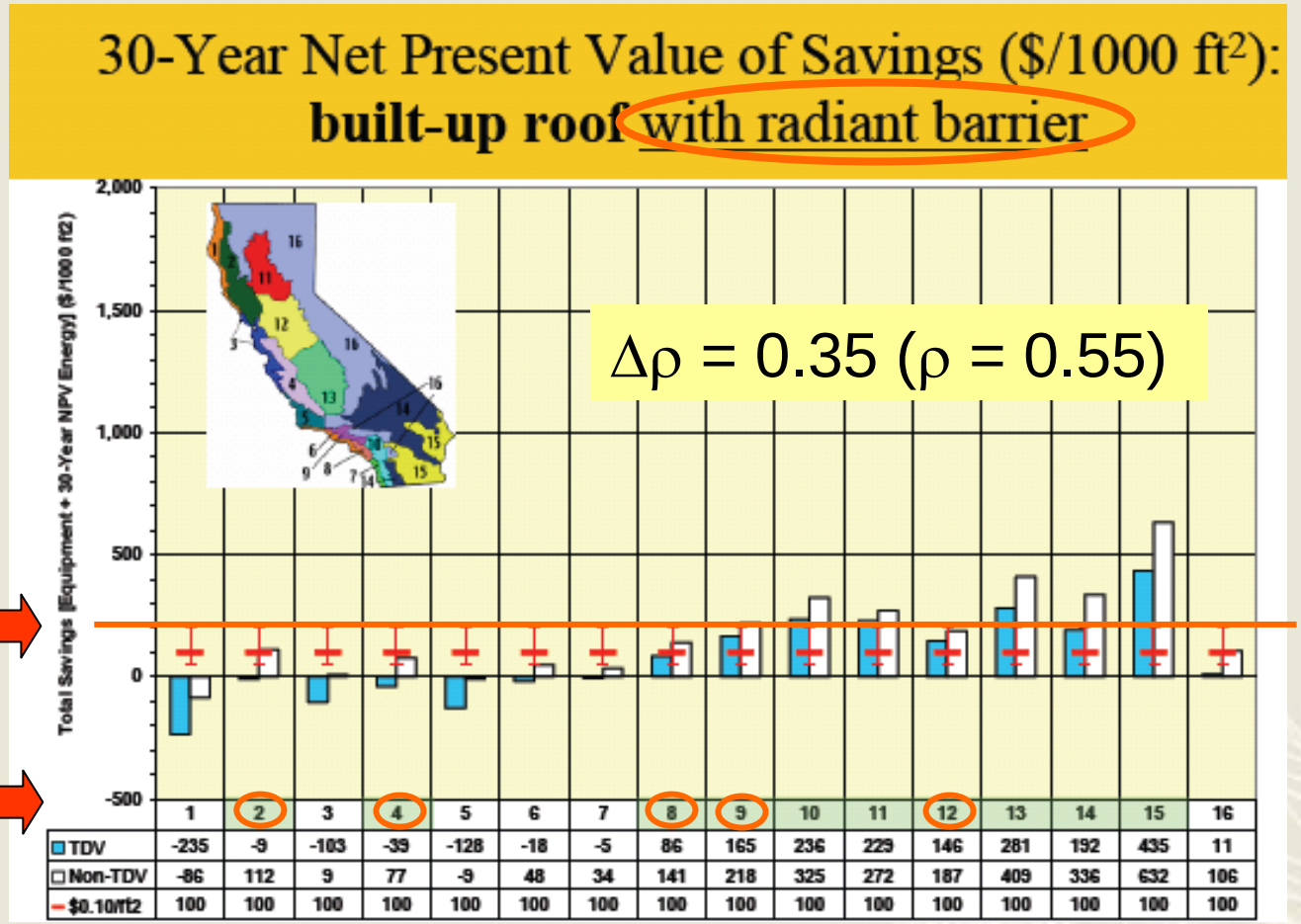
0.25 + 0.38

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

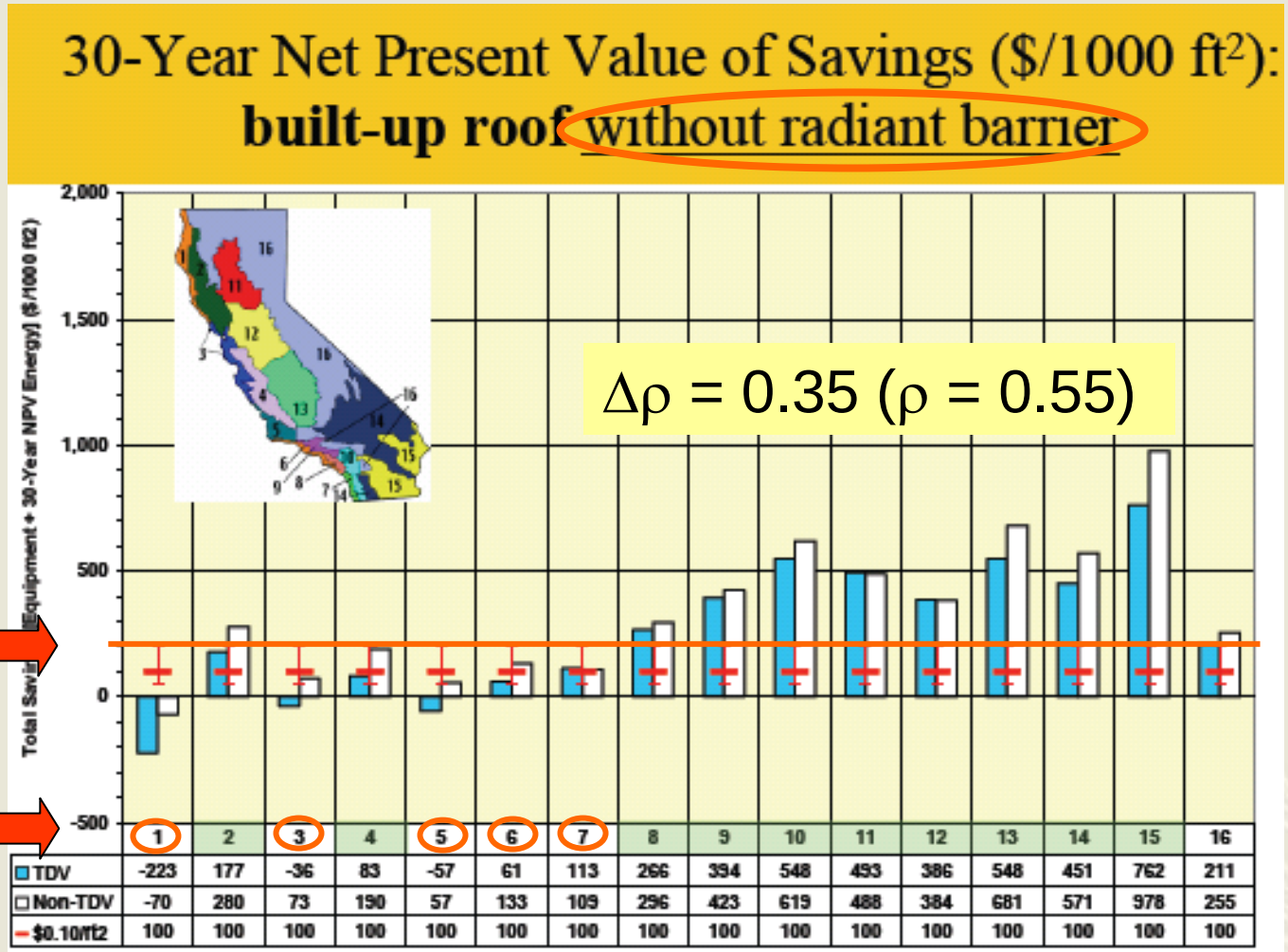


$0.20/ft²

Excluded Zones

Zones that require radiant barrier shaded green

Low-Slope Residential



$0.20/ft²

Excluded Zones

Zones that require radiant barrier shaded green

Low-Slope Residential

- Low-Slope Residential (PIER)

- All products with $\varepsilon_{aged} \geq 0.75$:

  $\rho_{aged} \geq 0.55$

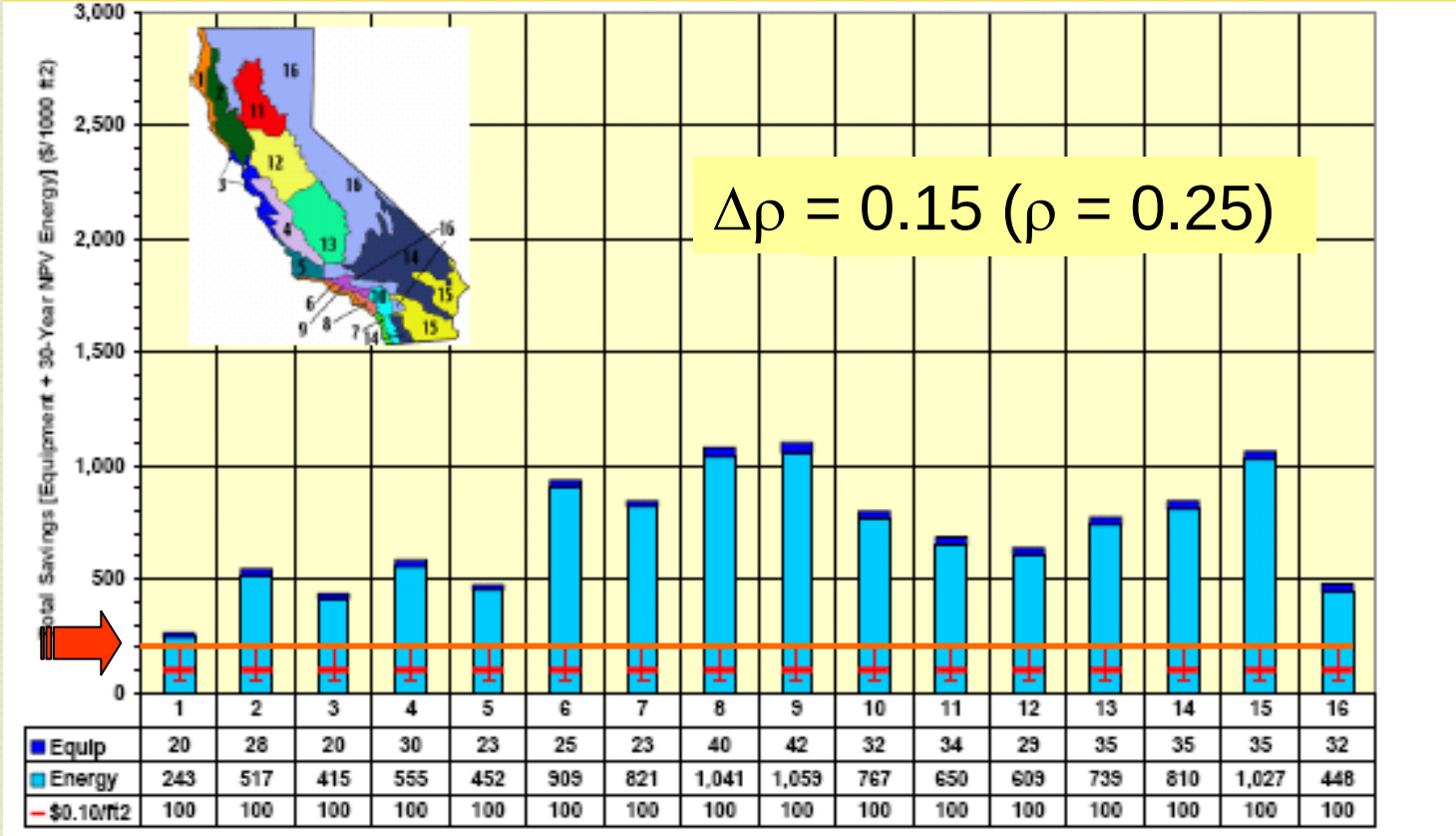
- All products with $\varepsilon_{aged} < 0.75$:

  $\rho_{aged} \geq 0.55 + 0.24 * (0.75 - \varepsilon_{aged})$

Zones Excluded = 1 through 9 and 12

Steep-Slope Nonresidential

30-year net present value of savings ($/1000 ft²): **shingle roofs**



	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Equip	20	28	20	30	23	25	23	40	42	32	34	29	35	35	35	32
Energy	243	517	415	555	452	909	821	1,041	1,059	767	650	609	739	810	1,027	448
$0.10/ft2	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

$0.20/ft^2

Steep-Slope Nonresidential

- Steep-Slope Nonresidential (PIER)

All products

- ~~Fiberglass asphalt shingle~~ with $\varepsilon_{aged} \geq 0.75$:

  $\rho_{aged} \geq 0.25$

- ~~All other products with $\varepsilon_{aged} \geq 0.75$:~~

  ~~$\rho_{aged} \geq 0.40$~~

- All products with $\varepsilon_{aged} < 0.75$:

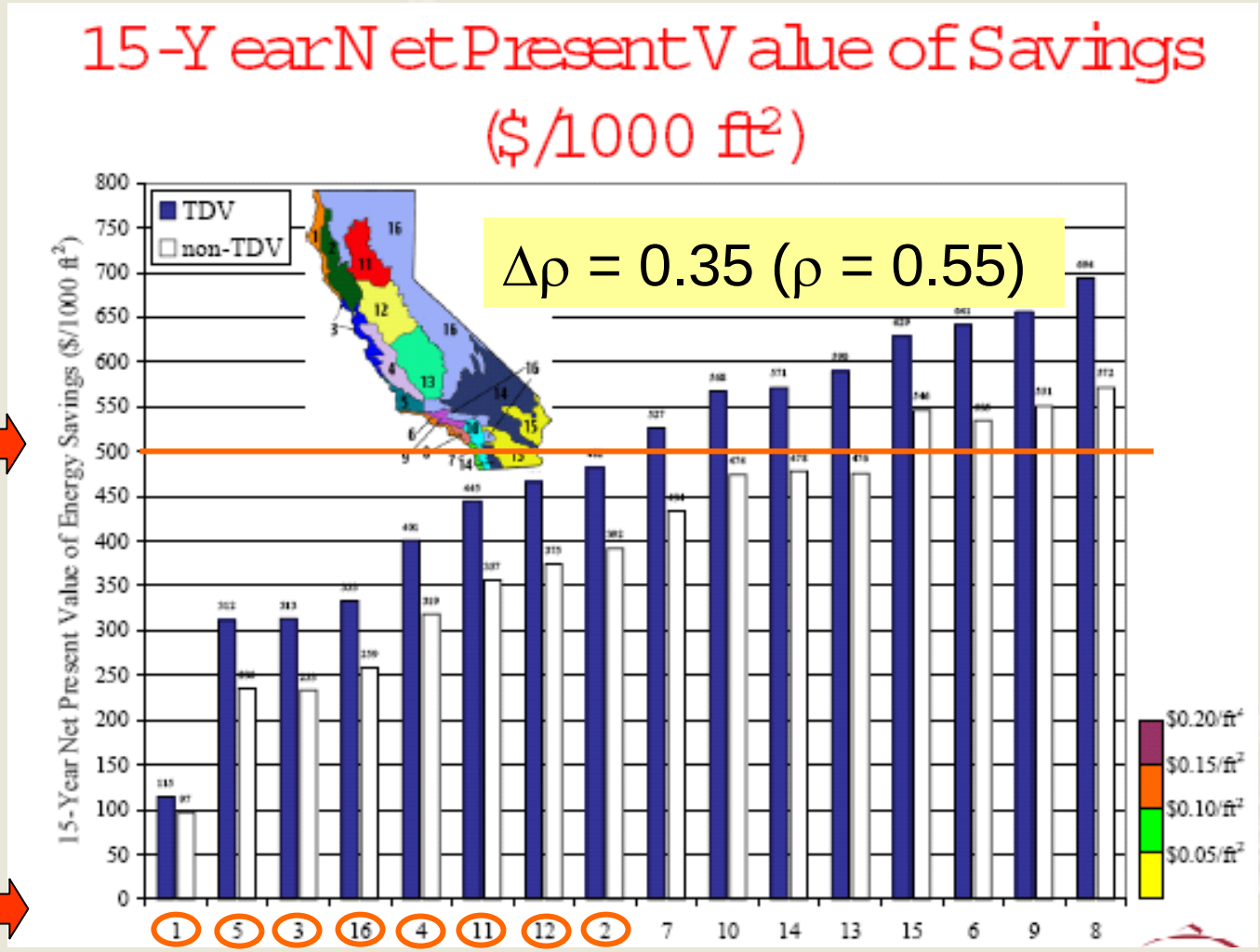
  $\rho_{aged} \geq$ ~~0.40 + 0.31~~ $* (0.75 - \varepsilon_{aged})$

  0.25 + 0.38

No Zones Excluded

Low-Slope Nonresidential

2005 Analysis



$0.50/ft²

Excluded Zones

Low-Slope Nonresidential

- Low-Slope Nonresidential

- All products with $\varepsilon_{aged} \geq 0.75$:

  $\rho_{aged} \geq 0.55$

- All products with $\varepsilon_{aged} < 0.75$:

  $\rho_{aged} \geq 0.55 + 0.24 * (0.75 - \varepsilon_{aged})$

Zones Excluded = 1 through 5, 11, 12, and 16

Impact of 0.40 Reflectance Criteria on Roof Color Selection

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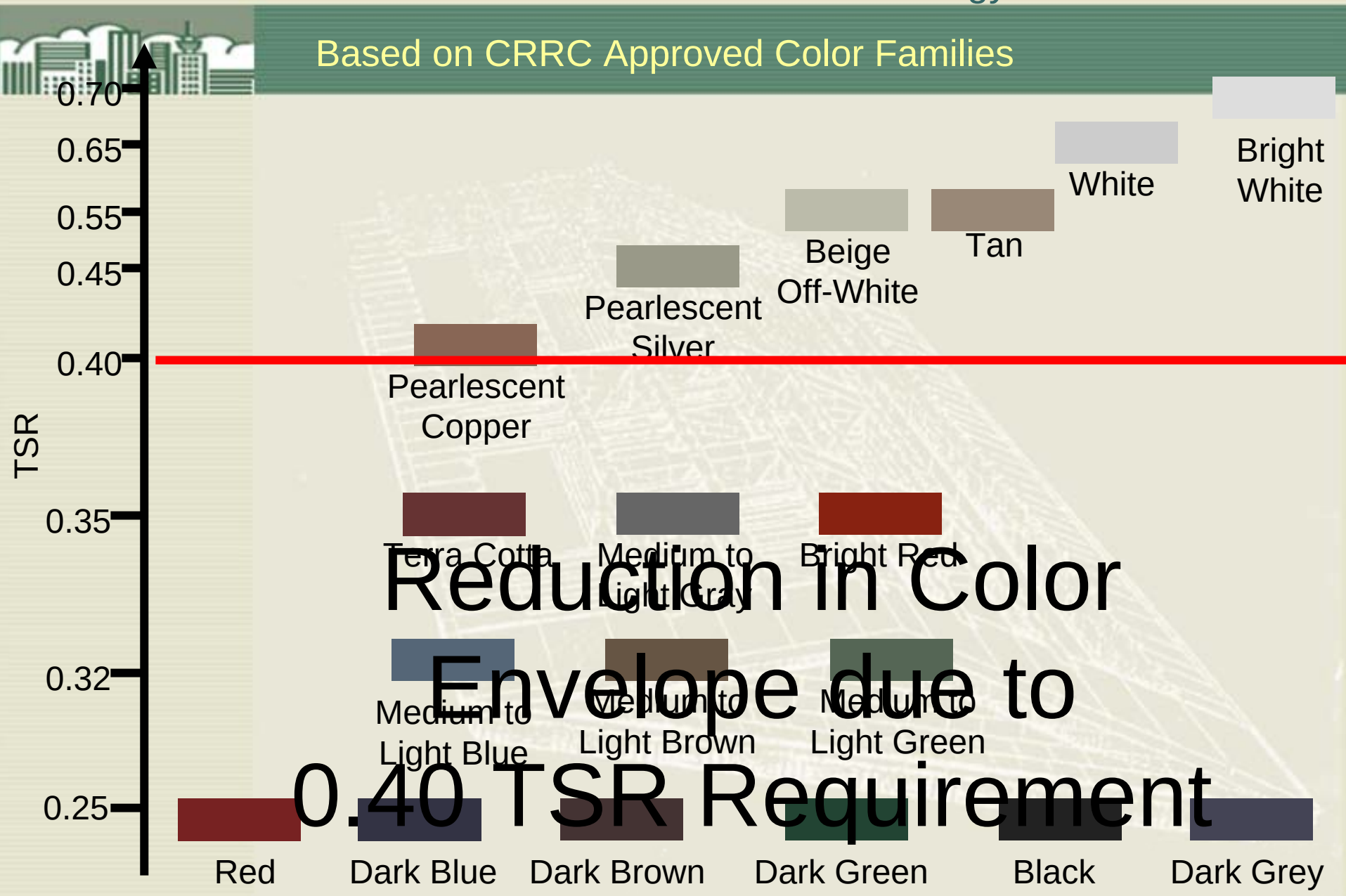
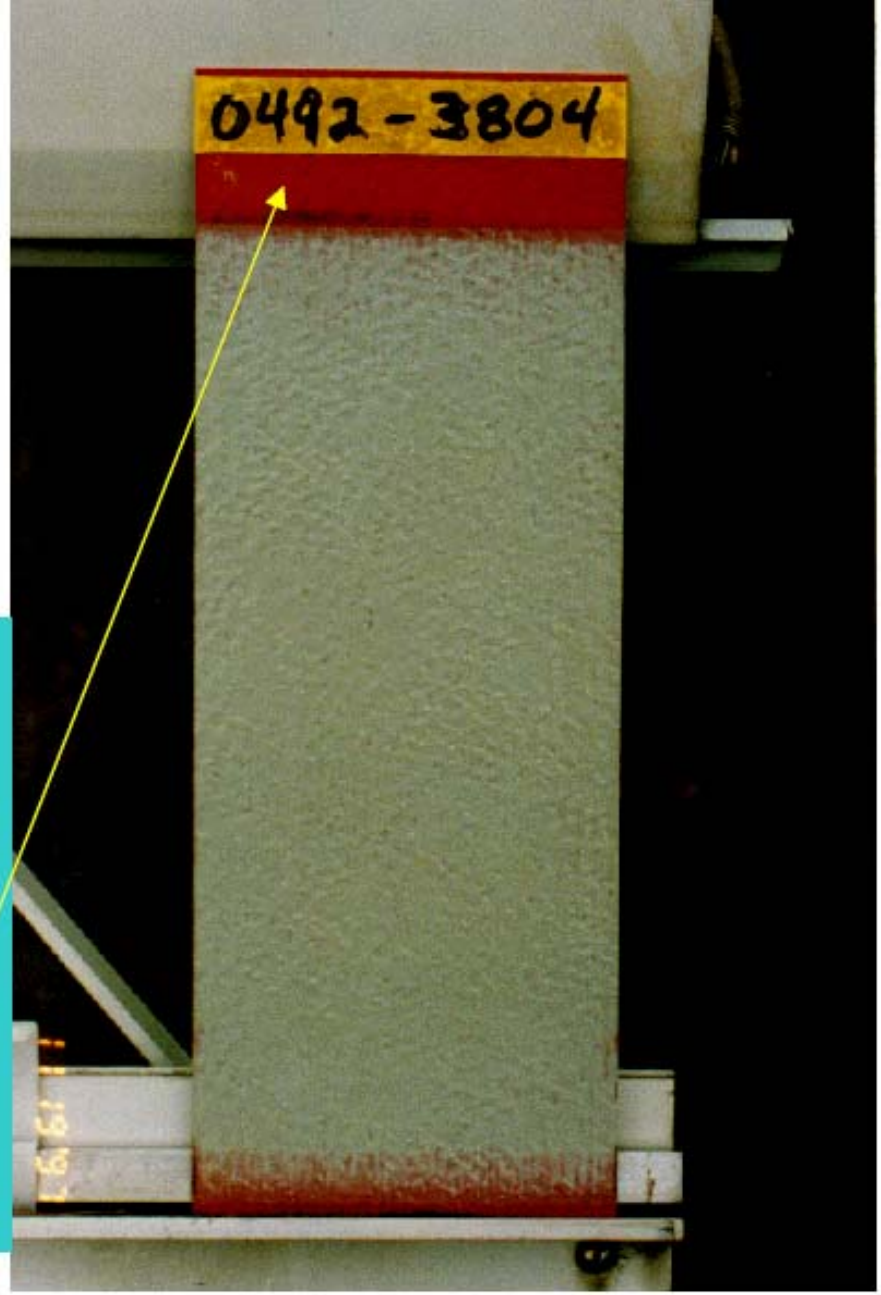
Mark Ryan
The Shepard Color Company

Effect of TSR Requirements on Color Envelope Based on State-of-the-Art Technology



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.



Courtesy of Arkema Inc.

Organic and Inorganic Blue Pigments

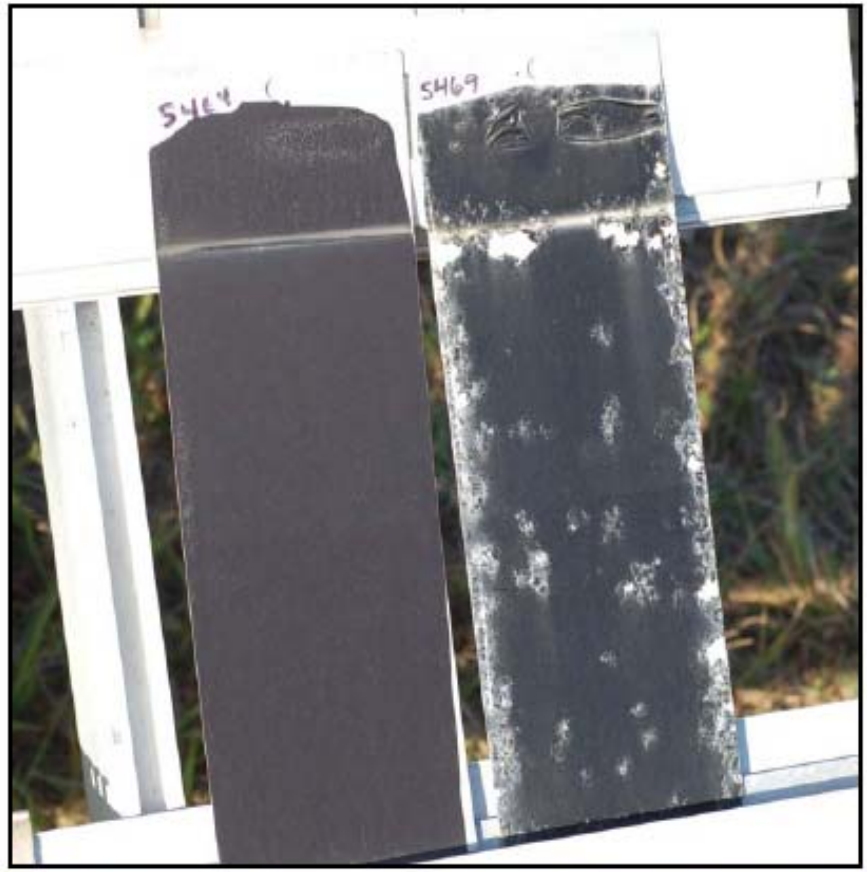
Blue/titanium dioxide (tint) KYNAR 500® PVDF based coatings after 31 years in Florida.
Right: Phthalocyanine blue tint (color had completely faded within ten years- underside of coating, where it is peeling, has original color)
Bottom: KYNAR 500 PVDF coatings made using various metal oxide pigments,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

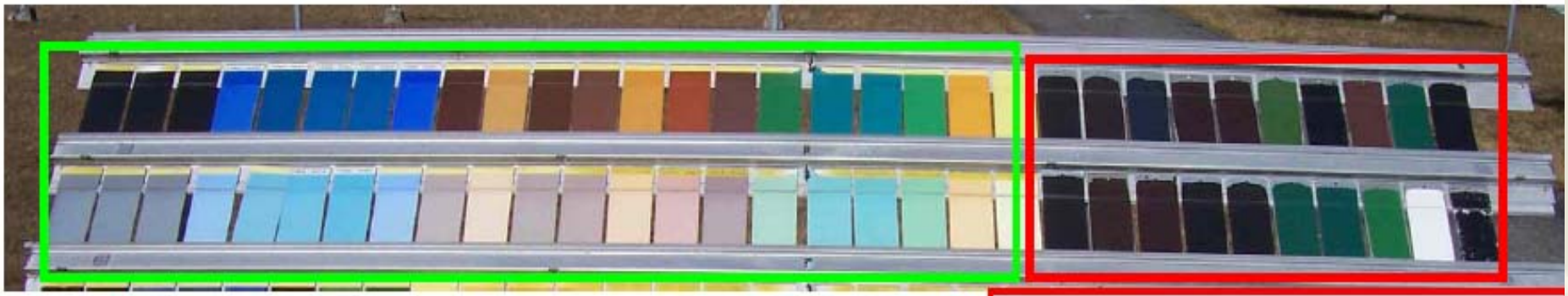
Original color (under flap)

Courtesy of Arkema Inc.

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):





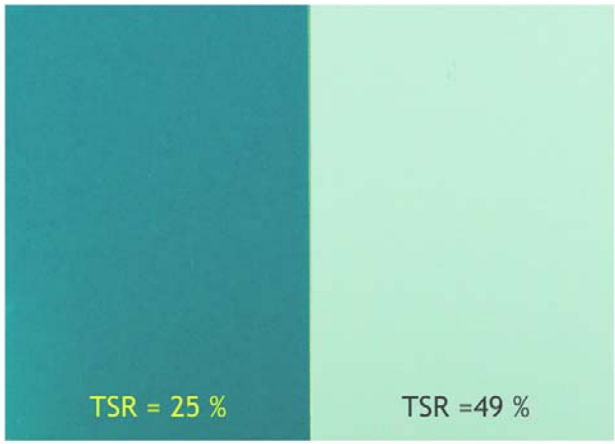
12 year old metal oxide pigment study

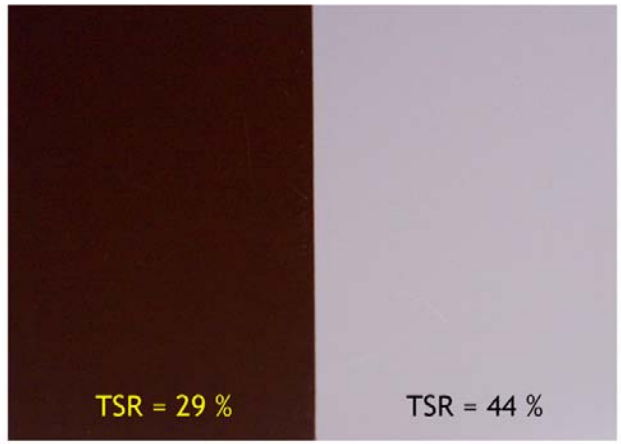
5 year old cool roof study

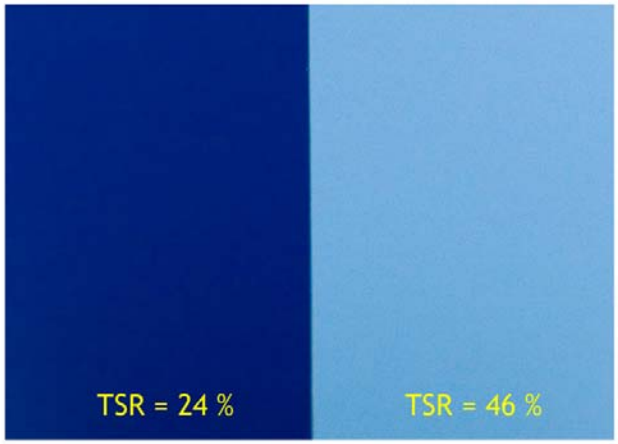
Courtesy of Arkema Inc.

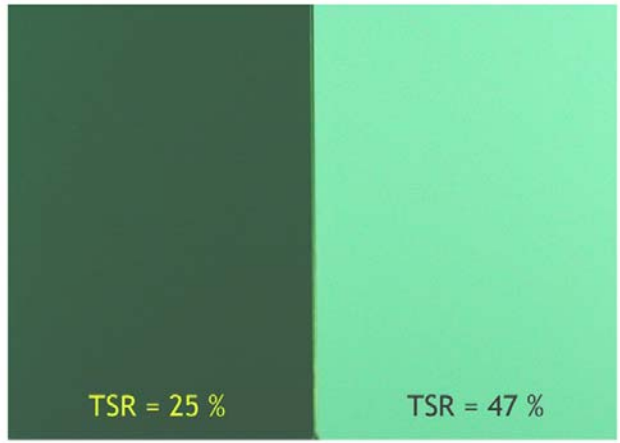
Organic pigment tint series using more durable organic pigment grades- Florida S45 weathering

Courtesy of Arkema Inc.


TSR = 25 %
TSR =49 %


TSR = 29 %
TSR = 44 %


TSR = 24 %
TSR = 46 %


TSR = 25 %
TSR = 47 %