Cool Roofs Standards & the ECRC Product Rating Program

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GRBES- NKUA
Outline

- Introduction
- Cool Roof Standards
- Towards a European Standard for cool roofs
- The ECRC roof product rating program
- Future developments
Cool roofs:

- contribute to mitigating climate change
- reduce the urban heat island effect
- increase the sustainability of buildings
Cool roofs technology has long been applied and promoted in the U.S. and other countries around the world like Japan, Australia, Brazil, India etc.
The European Cool Roofs Council

- Formulation of cool roof product rating programme in Europe.
- Inclusion of cool materials in European Standards, Energy Assessment Methods.
- Promote the benefits of cool materials to engineers, stakeholders, etc.

- ✔ ECRC product rating program launched
- ✔ An Interlaboratory comparison (ILC) conducted
- ✔ Bridging with CEN for measurement standards development
- ✔ Actions of promotion & dissemination
Cool Roof Standards
Definition

Cool roofs

- high solar reflectance
  - less solar radiation absorbed
  - lower surface T
  - less heat penetrates into the building

- high infrared emittance
  - faster release of heat (IR radiation)
  - less heat transferred to ambient air
Measurement of SR

1. Spectrophotometer with an integrating sphere

- EN 410: Glass in building. Determination of luminous and solar characteristics of glazing
- CIE 130-1998 Practical Methods for the Measurement of Reflectance and Transmittance

Total spectral hemispherical reflectance for a small area (≥0.1 cm²) of a flat and uniform sample (250 to 2500 nm).
2. Portable solar reflectometer


CRRC-1 Method #1: Standard Practice for Measuring Solar Reflectance of a Flat, Opaque, and Heterogeneous Surface Using a Portable Solar Reflectometer
Measurement of SR

3. Pyranometer (in situ measurements)

ASTM E1918: Standard Test Method for Measuring Solar Reflectance of Horizontal and Low-Sloped Surfaces in the Field

clear-sky global solar reflectance of a horizontal or near-horizontal surface ($\approx 10$ m$^2$) when the sun angle to the normal from the surface ($\theta$) is $< 45^\circ$. 
Measurement of e

1. D&S Emissometer

Infrared emittance in the range of \( \approx 5-80\mu m \),

2. TIR-100 Emissometer

Infrared emittance in the range of \( \approx 2.5 - 40 \, \mu\text{m} \),

EN 15976 Flexible sheets for waterproofing. Determination of emissivity
Measurement of e

3. FTIR – Spectrometer with golden sphere

EN 12898 Glass in building. Determination of the emissivity

Spectral Infrared emittance in the range of $\approx 2,5 - 100 \, \mu m$
Solar Reflectance Index (SRI)

SRI: Radiative properties (solar reflectance and infrared emittance) and convective cooling effects are combined into one scheme. It quantifies how hot a flat surface would get relative to a standard black (reflectivity 5%, emittance 90%) and a standard white surface (reflectivity 80%, emittance 90%).

SRI = 123.97 - 141.35x + 9.655x^2

Where:

x = ((a - 0.029e) . (8.797 + hc)) / (9.5205e + hc)

a = Solar absorbance (1 - TSR)
e = Thermal emittance
hc = Convective coefficient, W.m^2.K^-1

5 = low convective coefficient
12 = medium convetional coefficient
30 = high convective coefficient

ASTM E1980: Standard Practice for Calculating Solar Reflectance Index of Horizontal and Low-Sloped Opaque Surfaces
Towards a European standard
An interlaboratory comparison (ILC) was organised and conducted between 12 EU labs to provide the ECRC with information regarding its product rating programme under development, aiming to:

- compare different measurement methodologies (mainly ASTM and European (EN) standards,) for
  - measuring and calculating (SR) and
  - infrared emittance (e),
- provide information on their suitability to be used for cool roof products assessment.
- Share results with CEN/TC 254: “Flexible sheets for waterproofing” (WG16: Roofing sheet reflectivity) to proceed with the development of an EU standard for SR and emissivity
**Towards a European standard**

<table>
<thead>
<tr>
<th>Product type</th>
<th>Sample description</th>
<th>Sample code</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coating</td>
<td>Waterborne elastomeric acrylic coating</td>
<td>S1</td>
<td>White, smooth</td>
</tr>
<tr>
<td></td>
<td>Elastomeric waterproof coating</td>
<td>S2</td>
<td>NIR reflecting black, smooth</td>
</tr>
<tr>
<td></td>
<td>Elastomeric waterproof coating</td>
<td>S3</td>
<td>Black, smooth</td>
</tr>
<tr>
<td></td>
<td>Elastomeric waterproof coating</td>
<td>S4</td>
<td>NIR reflecting brown, smooth</td>
</tr>
<tr>
<td></td>
<td>Aluminium-thermoplastic hydrocarbon based roof coating</td>
<td>S5</td>
<td>Aluminium, smooth</td>
</tr>
<tr>
<td>Asphalt membrane (modified bitumen)</td>
<td>Granulated bituminous membrane</td>
<td>S6</td>
<td>White, rough</td>
</tr>
<tr>
<td></td>
<td>Granulated bituminous membrane</td>
<td>S7</td>
<td>Black, rough</td>
</tr>
<tr>
<td></td>
<td>Granulated bituminous membrane</td>
<td>S8</td>
<td>Green, rough</td>
</tr>
<tr>
<td>Shingle</td>
<td>Multicoloured asphalt shingle</td>
<td>S9</td>
<td>Red, rough</td>
</tr>
<tr>
<td>Single ply membrane</td>
<td>FPO membrane</td>
<td>S10</td>
<td>White, smooth</td>
</tr>
<tr>
<td>Concrete tile</td>
<td>High profile multi-colour coated tile</td>
<td>S11</td>
<td>Multicoloured, profiled, Rough</td>
</tr>
<tr>
<td></td>
<td>Curved profile tile, monocolour</td>
<td>S12</td>
<td>Profiled, smooth, smooth</td>
</tr>
<tr>
<td></td>
<td>Flat monocolour tile</td>
<td>S13</td>
<td></td>
</tr>
<tr>
<td>Metal roof</td>
<td>Prepainted metal</td>
<td>S14</td>
<td>Silver, smooth</td>
</tr>
<tr>
<td></td>
<td>Prepainted metal</td>
<td>S15</td>
<td>Dark brown, slight textured finish</td>
</tr>
<tr>
<td></td>
<td>Bare pretreated metal</td>
<td>S16</td>
<td>Off white, Smooth</td>
</tr>
<tr>
<td></td>
<td>Bare pretreated metal</td>
<td>S17</td>
<td>Silver, Smooth</td>
</tr>
</tbody>
</table>

✓ All product samples have been prepared following specific guidelines

The 17 samples represent the range of commercially available roofing materials covering the full range of reflectance and emittance values.
Towards a European standard

<table>
<thead>
<tr>
<th>Spectrophotometer</th>
<th>Reflectometer</th>
<th>ASTM C1371 Emissometer</th>
<th>EN 15976 Emissometer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lab 1</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Lab 2</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Lab 3</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Lab 4</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lab 5</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Lab 6</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Lab 8</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lab 9</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Lab 10</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Lab 11</td>
<td>x</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Lab 12</td>
<td></td>
<td></td>
<td>x</td>
</tr>
</tbody>
</table>

✓ spectrophotometers equipped with integrating spheres of 150mm diameter and one large sphere of 75cm diameter
Spectrophotometer measurements: Comparison of ASTM E903 (using ASTM E891 & G173) & EN410 standards

<table>
<thead>
<tr>
<th>Samples</th>
<th>ΔSR E891 – G173</th>
<th>ΔSR E891 – EN410</th>
</tr>
</thead>
<tbody>
<tr>
<td>S1 white coating</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>S2 NIR refl. black coating</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>S3 black coating</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>S4 NIR refl. Brown coating</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>S5 Aluminium coating</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>S6 White Granulated bituminous membrane</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>S7 Black Gran. bituminous membrane</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>S8 Green Gran. bituminous membrane</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>S9 Multicoloured asphalt shingle</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>S10 White FPO membrane</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>S12* Curved profile tile, monocolour</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>S13* Flat monocolour tile</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>S14 Prepainted metal silver</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>S15 Dark brown Prepainted metal</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>S16 Off white Prepainted metal</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>S17 bare metal</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

The highest differences were observed between the ASTM E891 and the EN 410 solar spectra.
Towards a European standard

Spectrophotometer measurements: Comparison of ASTM E903 (using ASTM E891 & G173) & EN410 standards

Spectrally selective black coating

Non selective black coating
Towards a European standard

Spectrophotometer measurements: Comparison of ASTM E903 (using ASTM E891 & G173) & EN410 standards

- The differences in the SR values from using different solar spectral irradiances (ASTM E891, ASTM G173 and EN 410) are in the range of 0-4%SR and they are more important for spectrally selective materials.
- They contribute to the total uncertainty of the measurement method indicating that the use of single solar spectrum would provide comparable and “fair” results in the framework of a product rating programme.

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
<th>NIR (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASTM E891-87 (1992)</td>
<td>Hazy sky AM1.5 beam-normal irradiance</td>
<td>58.1</td>
</tr>
<tr>
<td>ASTM G173-03 (2003)</td>
<td>Clear sky AM1.5 beam-normal irradiance</td>
<td>54.3</td>
</tr>
<tr>
<td>CIE 85 (1989)</td>
<td>Global radiation, AM1</td>
<td>49.5</td>
</tr>
</tbody>
</table>

The NIR_{E891} (700-2500nm) is by 8.6%NIR higher than that of the CIE standard.
Towards a European standard

- A strong correlation between the SR determined by a spectrophotometer (ASTM E903) and a reflectometer (ASTM C1549) was found.

![Graph showing correlation between SR determined by different methods](image)
Absolute differences as high as 0.08 between the two methods, however overall trends are quite similar.

A strong correlation between the two test methods for flat roof products.
Towards a European standard

- ECRC participates in CEN TC254 “Flexible sheets for waterproofing” (WG16: Roofing sheet reflectivity) that will develop a standard for solar reflectance and emissivity
- A recommendation based on the ILC carried out by the ECRC was sent to CENTC254WG16
- CENTC254WG16 has approved this recommendation
- Agreement between CEN and ASTM in order to convert their document in an European standard (in progress)
The ECRC Product Rating program
ECRC Product rating program overview

- A uniform and credible system for rating and reporting the radiative properties of roofing materials launched in 2015.
- Roofing product manufacturers & sellers will label various roof products with radiative property values.
- Code bodies, architects, building owners, specifiers etc. can have credible radiative properties data.
- The radiative properties that will be reported are the solar reflectance (SR) and the infrared emittance (e) and calculated SRI.
- Radiative properties are determined and verified through testing by ECRC approved test laboratories and a process of random testing of rated products.
- The ECRC product rating program does not specify minimum or target values for any radiative property.
ECRC adopted standards

**Solar reflectance:**

1. ASTM E903 in conjunction with G173-03.
2. ASTM C1549.
3. CRRC-1 Test Method #1

- Variegated Roofing Products: CRRC-1 Test Method #1.
- Tile Products: CRRC-1 Test Method 1 or the Template method

**SRI:** ASTM E1980

**Infrared Emittance:**

1. ASTM C1371
2. EN 15976

- Low conductivity materials: Any product not on an uninsulated metal substrate shall be tested using the Slide Method.
- Profiled products: Measurement of products having cylindrical surfaces shall be done according to the method described in the Devices & Services Technical Note TN 11-2
The ECRC Product rating program

- ECRC
- Accredited/approved labs
- Rated roof products
ECRC accredited/approved test labs

- Independent or manufacturer test labs
- ISO 17025 accredited for ECRC approved measurement methods
- Participate in QA procedures

- Independent test labs that have initiated process for ISO 17025 accreditation for ECRC approved measurement methods
- Pass the ILC test
- Participate in QA procedures
- Valid only for the 1st year of operation of the ECRC PRP and only if in a country there are no ISO 17025 accredited labs for the specific method
Participating Accredited / Approved Testing Laboratories (ATLs)

Below is a listing of the Test Laboratories.

Tests offered by participating Accredited/ Approved Testing Laboratories (ATLs)

<table>
<thead>
<tr>
<th>Laboratory name</th>
<th>Solar reflectance</th>
<th>Infrared emittance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ASTM E903-12</td>
<td>ASTM C1549-09</td>
</tr>
<tr>
<td>NKUA</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>EELab</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

Laboratories Contact information

NKUA

Contact person: Prof. Mat Santamouris
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Product rating process

- ECRC Accredited/approved Test Labs
- Manufacturer or seller
- ECRC
- ECRC rated products database
- ECRC rated product label
### Product rating process

<table>
<thead>
<tr>
<th>Rated Product ID Number</th>
<th>Initial</th>
<th>Aged</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RATED PRODUCT</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solar Reflectance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infrared Emittance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solar Reflectance Index</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Climate type</td>
<td>Date of measurement</td>
<td>Manufacturers name</td>
</tr>
</tbody>
</table>

European Cool Roofs Council Ratings are determined for a fixed set of conditions which may not be appropriate for determining differing seasonal performance. The actual effect of solar reflectance and thermal emittance on building performance may vary with differing conditions. The manufacturer of this product stipulates that these ratings were determined in accordance with the applicable European Cool Roofs Council procedures.
## Product Rating Database

**Nanophos - Greece**

<table>
<thead>
<tr>
<th>Pr. id</th>
<th>Brand</th>
<th>Product Type</th>
<th>Initial Solar</th>
<th>Initial Thermal</th>
<th>Initial SRI</th>
<th>Aged Solar</th>
<th>Aged Thermal</th>
<th>Aged (SRI)</th>
<th>Slope</th>
<th>Color</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>FA00000003</td>
<td>SurfaPaint Aqua X</td>
<td>Field-Applied Coating</td>
<td>0.83</td>
<td>0.88</td>
<td>104</td>
<td>-</td>
<td>-</td>
<td>Steep</td>
<td>White</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FA00000006</td>
<td>SurfaPaint Kirei</td>
<td>Field-Applied Coating</td>
<td>0.83</td>
<td>0.88</td>
<td>104</td>
<td>-</td>
<td>-</td>
<td>Steep</td>
<td>White</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FA00000008</td>
<td>SurfaPaint ThermoDry Elastomeric Roof Paint</td>
<td>Field-Applied Coating</td>
<td>0.84</td>
<td>0.89</td>
<td>106</td>
<td>-</td>
<td>-</td>
<td>Low</td>
<td>White</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FA00000004</td>
<td>SurfaPaint ThermoDry Exterior</td>
<td>Field-Applied Coating</td>
<td>0.86</td>
<td>0.90</td>
<td>108</td>
<td>-</td>
<td>-</td>
<td>Steep</td>
<td>White</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FA00000005</td>
<td>SurfaPaint ThermoDry Interior</td>
<td>Field-Applied Coating</td>
<td>0.85</td>
<td>0.89</td>
<td>107</td>
<td>-</td>
<td>-</td>
<td>Steep</td>
<td>White</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FA00000007</td>
<td>SurfaPaint ThermoDry Metals</td>
<td>Field-Applied Coating</td>
<td>0.83</td>
<td>0.89</td>
<td>105</td>
<td>-</td>
<td>-</td>
<td>Steep</td>
<td>White</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Rated Products database**

Rated Products will remain in the database for 3 years.
ECRC Product Rating Manual

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Product Rating Programme

About program Rating Programme

The European Cool Roof Council (ECRC) operates a rating program for the radiative properties (i.e. the solar reflectance and the infrared emittance) of roofing products. The purpose of the ECRC product rating program is to provide a uniform and credible system for rating and reporting the radiative properties of roofing materials. In the framework of this program, manufacturers and sellers have the opportunity to label roofing products with the measured values of their Initial Radiative Properties. These properties are determined and verified through testing by accredited/approved testing laboratories and a process of random testing of rated products. Any roofing product can be tested as long as it is in compliance with the specifications and requirements defined in the ECRC Product Rating Program Manual.

Rated products are granted the ECRC label and are published in the ECRC Rated Products Database on the ECRC website.

The ECRC believes that it is necessary to publish unbiased ratings for products to ensure consumers that the performance of the chosen technology has been verified. This is a key point particularly in cases where green building standards need to be satisfied (e.g. standards where the Solar Reflectance Index (SRI) value of the chosen roofing material may give additional points).
Future developments
Deterioration of cool roofs

WEATHERING

• UV (mostly) and visible radiation
• Thermal cycling
• Moisture
• Degradation

SOILING

• Dry and wet deposition of atmospheric aerosols and suspended dust
• Microbiological growth
Deterioration of cool roofs

Aging and weathering affects the performance of cool materials and has to be taken into account.
Ageing assessment

Natural weathering: exposing samples to outdoor ambient conditions (direct sunlight and other elements of weather) at exposure sites (weathering farms) with different climatic conditions

- ASTM G7: Standard Practice for Atmospheric Environmental Exposure Testing of Nonmetallic Materials
- ISO 877: Plastics -- Methods of exposure to solar radiation
- ISO 2810: Paints and varnishes - Natural weathering of coatings - Exposure and assessment

3 year exposure
Ageing assessment

**Artificial weathering**: accelerated degradation and studying the material’s behavior under controlled environmental conditions in the lab and in a reasonably fast time. They consist of light sources e.g. Xenon arc lamp to simulate the effect of sunlight. Temperature is controlled. The effects of outdoor moisture are simulated by direct, pure water spray and by relative humidity control.

- ISO11341: Paints and varnishes — Artificial weathering and exposure to artificial radiation — Exposure to filtered xenon-arc radiation

Soiling not taken into account
**LBNL Laboratory Aging Protocol**: an accelerated aging method that incorporates features of soiling and weathering. The method sprays a calibrated aqueous soiling mixture onto preconditioned coupons of roofing materials, and then exposes the soiled coupons to ultraviolet radiation, heat and water in a commercial weatherometer. It reproduces in three days the three-year aged values of solar reflectance.

Future developments

Taking into account that in order to assess a cool roof product’s long-term performance it is necessary to measure the aged product’s radiative values, the ECRC is currently actively working towards adopting a system for the rating of aged products.

- Integration of natural weathering in the ECRC product rating program

- Collaboration with LBNL in adapting an accelerated aging protocol to European conditions
Thank you!
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