Minimum Requirements of Cool Reflective Surfaces

COOL REFLECTIVE SURFACES

This is a brief explanation of Cool Surfaces technology, particularly in the context of roofing and its relevance in energy efficiency of the built environment. This serves as the basis for further research, study and discussion with the aim being the formal inclusion of cool surface technology in the relevant South African National Standards regulations and codes.

Background on Cool Surfaces

Cool surfaces are those building materials that remain cooler in relation to other surfaces exposed to the same environmental conditions with specific reference to solar radiation.

Solar radiation refers to the full spectrum of electromagnetic radiation emitted by the sun, starting from extremely high frequency and short wavelength gamma radiation through x-ray radiation, ultra-violet radiation, visible light, near-infrared radiation, infrared radiation, microwave radiation, radio-waves to long wavelength radio waves. The highest level of energy is carried by the shorter, higher frequency radiation (such as gamma radiation) and the lowest energy by the longer, lower frequency radiation (such as radio waves).

Earth's atmosphere reflects, scatters (a form of reflection) and absorbs much of the sun's radiation. It only allows some wavelengths to be transmitted through the atmosphere to the surface of the planet – what we then experience as sunlight. Fortunately for us the high energy gamma, x-ray and most of the ultraviolet radiation does not reach us. For example, ozone in the atmosphere absorbs ultraviolet radiation. Much of the infrared band is also absorbed or reflected by the atmosphere. The wavelengths beyond the infrared band do not carry much energy and therefor do not have much impact on heating surfaces on the planet. For example, radio waves are continually passing through our bodies but do not raise our body temperature.

We are concerned with the wavelengths of solar radiation that do cause significant heat gain when absorbed by materials on the planet's surface. This heat gain manifests from the absorption of a small portion of ultra-violet radiation (5% contribution to heat gain) the entire spectrum of visible light (roughly 51% contribution to heat gain) and mainly the near -infrared wavelengths of the infrared radiation spectrum (mainly the remaining 44% contribution to heat gain).

The ideal reflectance of a cool surface would be one which reflects ultraviolet radiation, visible light and the near-infrared spectrum radiation and would thus not absorb the heat -causing wavelengths of solar radiation reaching the planet's surface.

Here, the reference to reflectance deals primarily with a surface property of the materials. Due to its relatively high frequency and short wavelength, ultraviolet radiation is readily reflected by most solid, opaque surfaces. (Think of it as a car trying to pass through a set of road cones, swerving rapidly back and forth in tight turns – high frequency and high wavelengths. The likelihood of hitting the first few cones (being reflected off the outer surface of an object) is fairly high. As long as the surface is fairly solid and opaque – like a roof tile or an umbrella – ultraviolet radiation will be reflected without causing significant heat gain.

The visible light spectrum ranges from short wavelength, high frequency, high photon energy (violet) through to longer wavelength, lower frequency, lower photon energy (red).

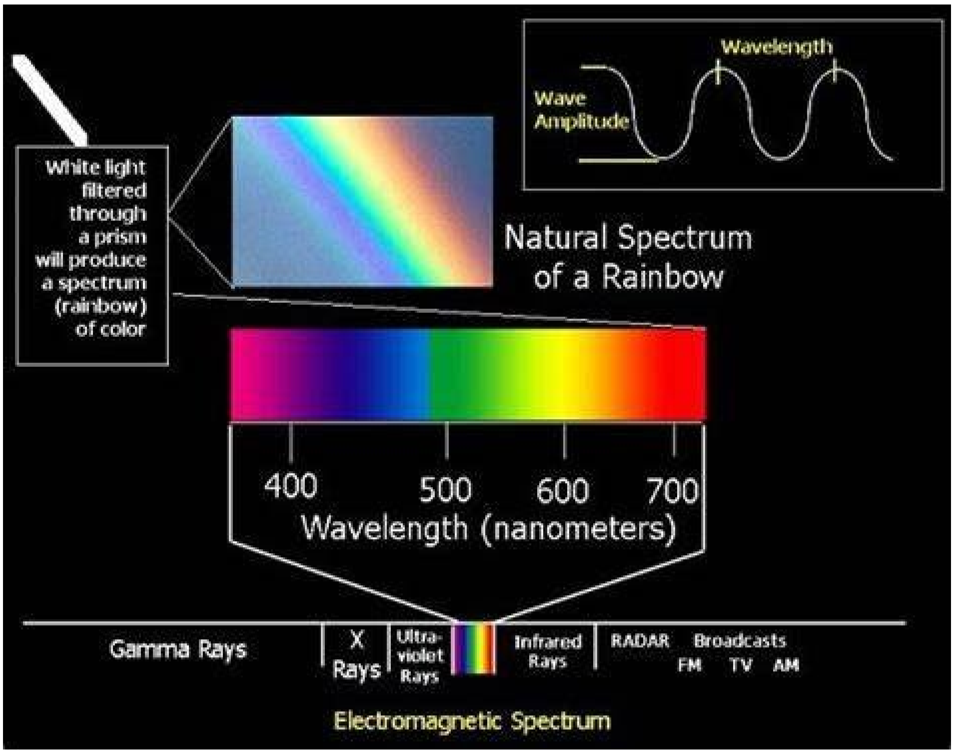

Fig 1: Electromagnetic Spectrum

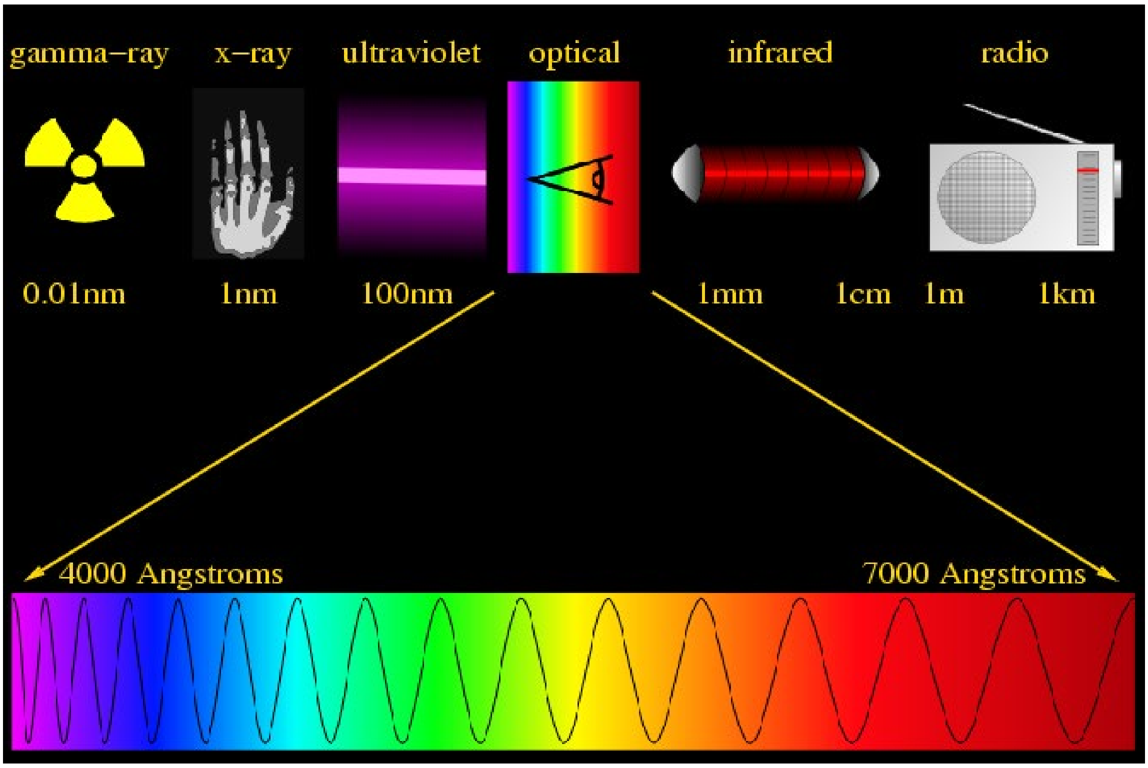

Fig 2: The Visible Light Spectrum is a small part of the Electromagnetic Spectrum

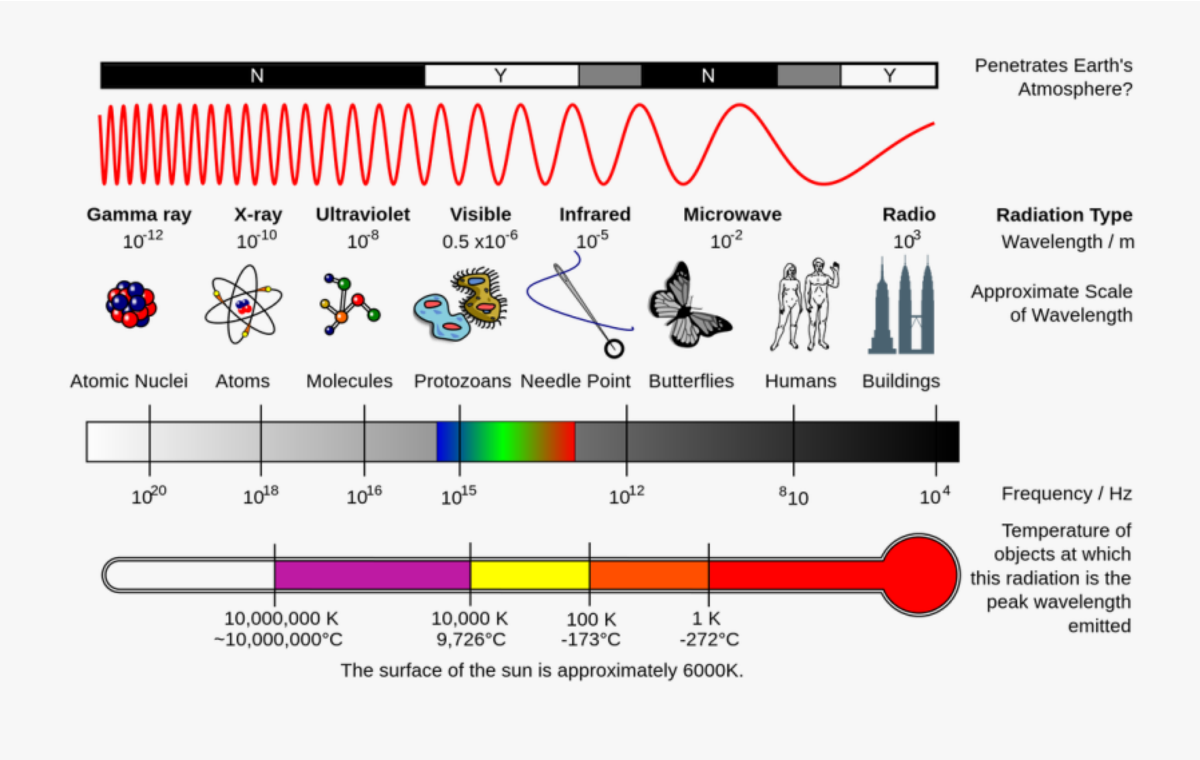

Fig 3: Comparative scale and impact of radiation types.

We see an object as being a certain colour because this frequency and wavelength is being reflected by the object, while all radiation of the other colours we are not seeing, are being absorbed by the object and are heating that object up. If an object is red (lowest energy radiation in the visible light spectrum) it is absorbing all the higher energy wavelengths.

Fig 4: Low heat and energy is reflected away from roof while higher heat and energy is absorbed and convert to high heat. This roof is likely to be hot.

A blue object would be cooler than a red object as it would be reflecting the higher energy wavelengths while the lower energy wavelengths are absorbed and convert to heat. The hottest object would be one that is black, as all the radiation of the visible light spectrum is being absorbed.

Fig 5. The coolest would be white since it is a combination of all the radiation in the visible light spectrum, indicating that all wavelengths are being reflected and not absorbed.

Fig 6: All heat and energy is absorbed by a black/ dark roof, almost no heat and energy is reflected away. This dark roof (and therefor the interior of the house) is likely **very hot**.

Colour therefore plays a significant role in cool surface technology, and it is a direct indicator of the range of visible light radiation that is either being absorbed or reflected. Thus, the surface is dealing with roughly 51% of the significant solar radiation.

The final requirement of a cool surface in terms of reflectivity is that it reflects as much near infrared radiation as possible. Fortunately, surfaces that reflect the lower frequencies of the lower frequencies of the visible light spectrum also tend to reflect near-infrared.

Minimum Requirements of the cool reflective coating products

Cool reflective coating product is to be applied by brush, roller or spray application.

Product to be approved by Cool Roof Rating Council (CRRC) laboratories or international equivalent with accredited labelling and laboratory certificate. If the product does not have a recognized laboratory tested certificate, it will not be considered for SANEDI projects or SACSA membership.

The below is an extract from the SANS Building Code 10400 XA prescribing the minimum requirements by law. Note these are lower than required by the SACSA and the SANEDI projects.

	INITIAL SOLAR REFLECTANCE ρ	(1) WEATHERED SOLAR REFLECTANCE ρ_{aged}	INITIAL THERMAL EMITTANCE ε	(2) SOLAR REFLECTANCE INDEX SRI
Roof	≥ 0.65	≥ 0.49	≥ 0.75	≥ 75

Notes:
(1) If an aged solar reflectance is not available for any roofing products, the aged value shall be derived from the initial tested value. See Annex D
(2) SRI shall be calculated and be based on medium wind speed of 2-6 meters per second. The Aged SRI aged shall be calculated based on the aged reflectance value of the roofing products.
See Annex D for Solar Reflectance Index, Reflectance and Emissivity for Typical Roofing Materials

Minimum Product Performance (R Values for Reflectivity and Emissivity)

*White Coating: Minimum solar reflectance - 0.75 and above.
Minimum emissivity - 0.75 and above.
*Pastel Coating: Minimum solar reflectance - 0.65 and above.
Minimum emissivity – 0.65 and above.

Aging – minimum warrantee of 7 years or more

The discrepancy between the lesser legal minimum requirements and SACSA's higher minimum requirements is to ensure a greater reflectivity and longevity of coatings used in the SANEDI projects. There is an initial weathering that decreases the efficacy of the SRI especially over the first three years after application. The lower the starting point, the lower the efficacy for the lifetime of the roof.

The preferred standardized laboratory testing methods accepted for product performance certificates must cover the minimum values for the following tabled tests. While there are other testing methods that can give verifiable results, they are non-standard and are not preferred. They are acceptable under certain conditions that will be entertained in conjunction with the participating laboratory. To avoid complications, it is advised that vendors seek labs that use the tests below.

USA Standard	SA Standard	Description	Efficacy
ASTM C1549,	SANS 1982	Standard Test Method for determination of Solar Reflectance (SR) near ambient temperature using a portable solar reflectometer	SR > 0,75
ASTM C 1371	SANS 1789	Standard Test Method for determination of Emittance of materials near room temperature using portable emissometer	TE > 0,75
ASTM E 1980.	SANS 1980	Solar Reflectance Index (SRI) calculates SR and TE in a single value expressed between and 100, with particularly cool materials exceeding 100.	SRI > 75%