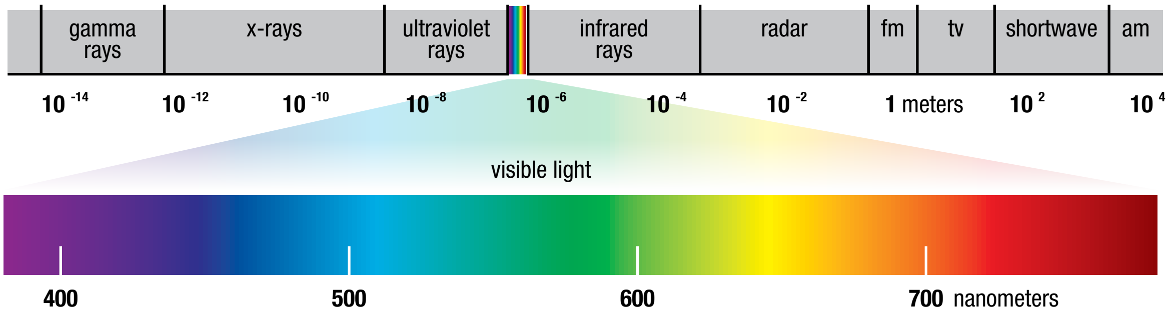
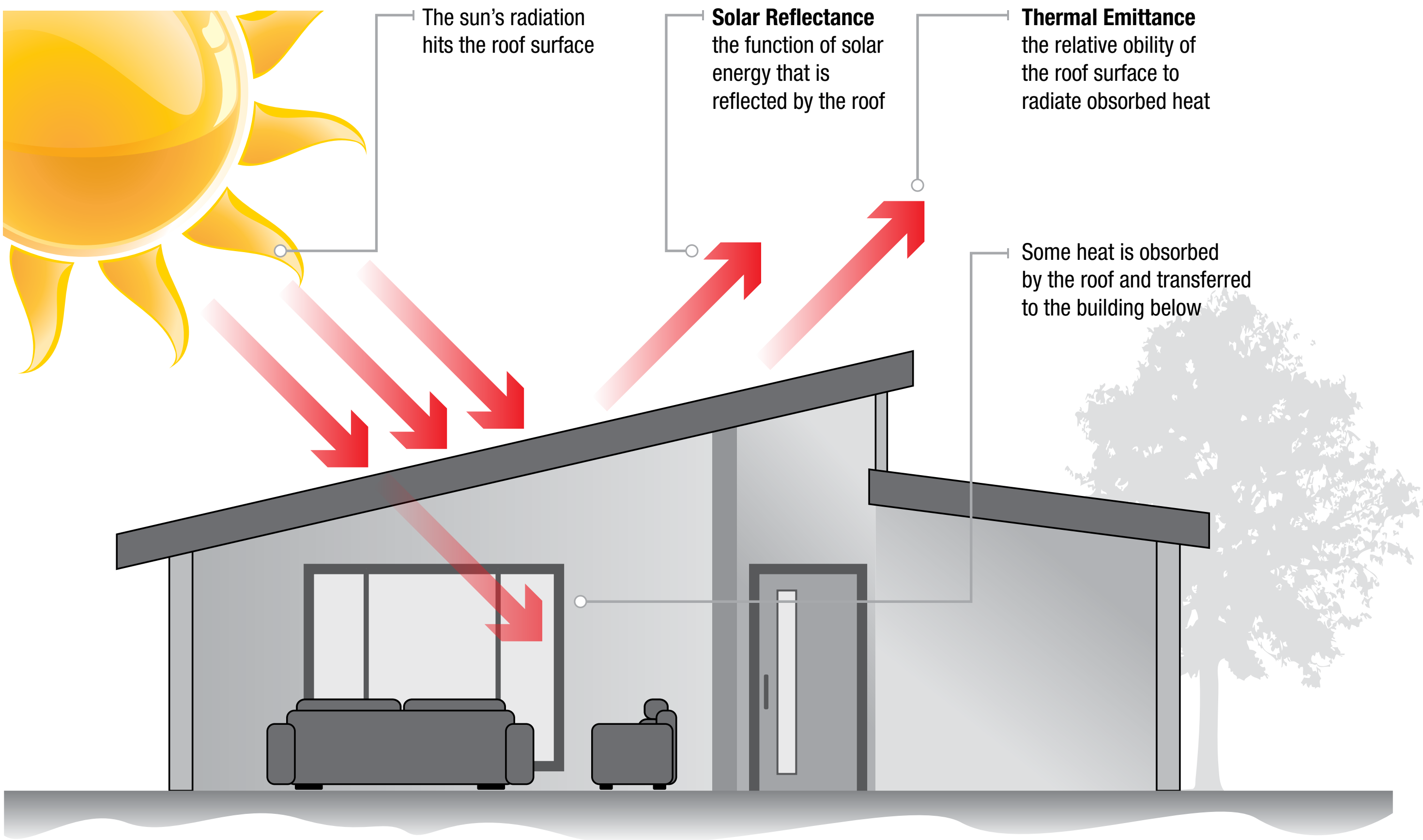
Solar Energy

A cool roof is characterised as one that reflects the sun's energy and emits radiation back into the atmosphere at a higher rate than standard materials. Cool roof performance may be achieved with additives to the base material, or by applying a CRP to an existing roof. These types of roofs literally stay cooler, thus reducing the amount of heat held and transferred to the building below, keeping the building a cooler and at a more constant temperature.

It is important to note that with modern technology, Cool Roof Paint's need not be white. There are many Cool Roof Paint products which use darker-coloured pigments that have increased reflectivity in the near infrared (non-visible) portion of the solar spectrum. With these technologies there are roofs that come in a wide variety of colours and still maintain a high solar reflectance. However a darker roof will never be as reflective as a light coloured roof.



Cool roofs reflect solar radiation within and outside the visible light spectrum. Cool Roof Paint's that reflect more in the infrared spectrum, can reflect less in the visible spectrum, and hence appear darker.



Method of action of a cool roof

Solar Energy continued

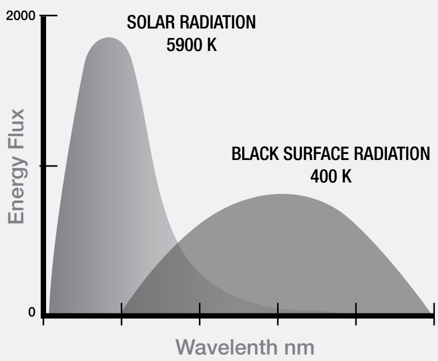
Solar energy or known as radiant energy* is transmitted via or in the form of electromagnetic waves.

Wave length is measured microns (1,000 microns = 1mm)

1 mil - 24.5 microns (mil thickness)

Energy is measured as $\mathbf{E} = \frac{hc}{L}$

- **E** = Energy
- **h** = Planks constant - 6.626 x 10-34 $(W \times S^2)$
- **c** = Speed of light - 3 x 10^8 (m/s)
- **L** = Wavelength (m)

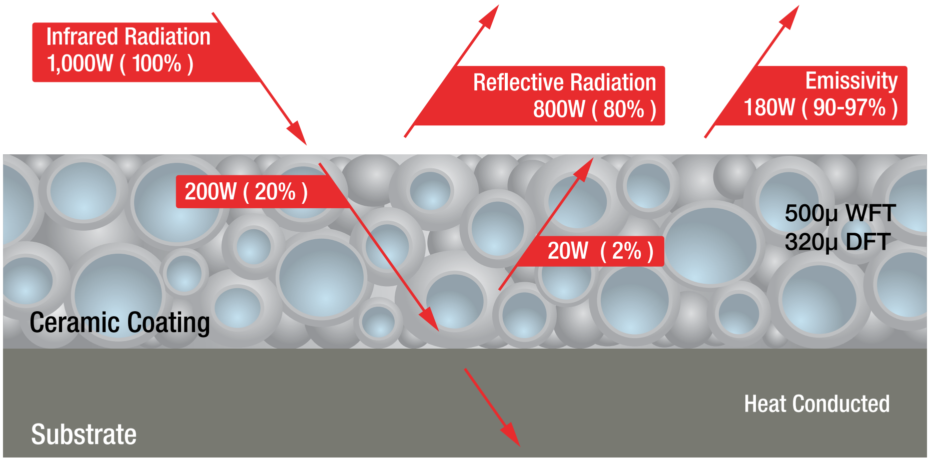


Solar radiation at different wavelength of light.

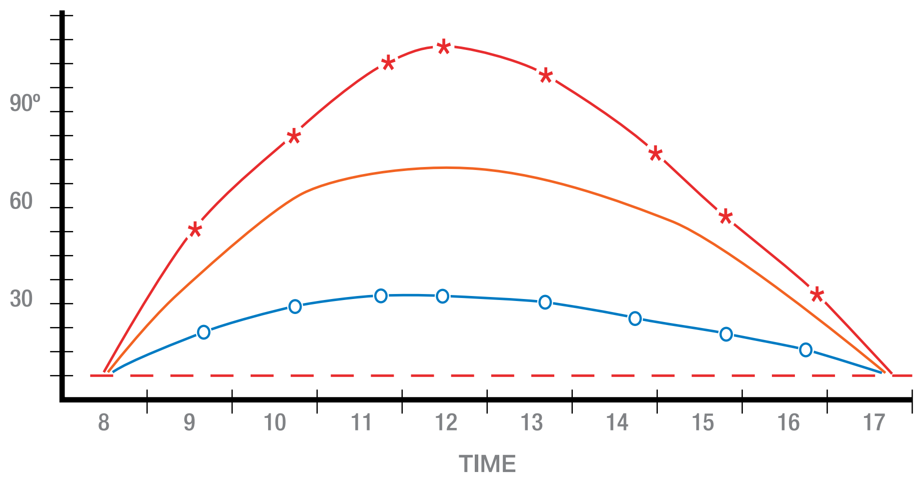
Curve A illustrates solar radiation outside the atmosphere at source temperature of 5900K.

Curve B solar radiation on earth surface.

Solar Radiation example



The above illustration is using a 1000W incident radiation as an example of reflectivity, absorbency, emissivity and conductivity.



The above illustration displays the degree/displacement as an example relating to temperature change over time. As you will notice amount of displacement marked * is much more than that marked o. The higher temperature compared over the same interval, the higher the degree of thermal shock.

Emissivity is the ability of a product to emit any heat energy that has been absorbed, i.e. any solar energy across the entire solar spectrum that is not reflected is absorbed. Emissivity is the ability of a product to release absorbed heat energy (from the full spectrum) via infrared radiation.

Reflectivity is the ability of a product to reflect solar energy across the entire solar spectrum – visible, UV and infrared.

R-value in terms of heat gain and heat loss is reflected as watts per m^2/(w/mo).

Heat Gain A building gains heat in three ways: Conduction, Convection and Radiation.

Heat loss is the ability of the product to restrict the amount of heat from conducting out of the structure.

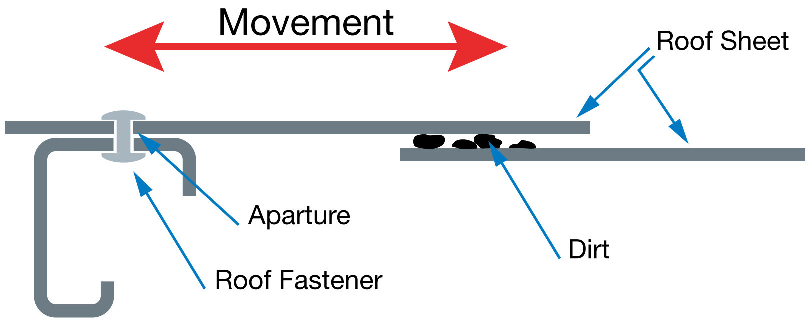
Thermal shock is the reaction of the substrate (over time) to the amount of heat directed onto it.

DFT Dry Film Thickness

The Effects of Thermal Shock

Thermal shock which is the major cause of roof degradation and water leakage can be reduced by up to 80% to avoid its adverse effects.

Thermal shock is the process of degradation of the integrity of the substrate or surface as a result of continued expansion and contraction due to temperature change in the substrate or surface. The higher the temperature change the more severe the effect of thermal shock will be.



With movement of the sheet (expansion and contraction) created by temperature change various undesirable conditions exist. The dirt will become a grinding medium and as a result will remove paint and or galvanising to expose the mild steel sheeting with subsequent corrosion setting in.

With respect to the roof fastener it could not only eventually break off but the backward/forward movement will cause the fastner to loosen and/or the aperture to be increased in size. With regards to the above, whether a roof is of asbestos or iron sheeting, degradation will occur.

Problems Due To Thermal Shock

Hairline Cracks appear on asbestos, fibrous ad concrete substrates and causes leaking problems and deterioration of substrates.

IBR metal stress, the result of thermal shock, is caused by expansion and contraction of the metal roof sheeting. The deteriorating metal curls, causing roof bolt shearing, rusting and leaking.

Distinctive Forms Of Heat

Radiation is electro magnetic energy.

Conductive heat Molecular heat.

Convection is the moving of heat from one place to another by way of fluid or air.

Conduction is the flow of heat between parts of a substance or between two substances in direct contact.

Heat Transfer by one or more of the above. Heat always flows from a warmer to a colder substance.

Dewpoint is the temperature below which water vapour in the air will start to condense.

Humidity Factor The hotter the air, the more moisture is absorbed and contained. Relative humidity (RH) = The amount of moisture dissolved in the air. Thermal resistance is known as the **R-Value**. It is the reciprocal of conductance (C) or the overall heat transfer (U). R-value in terms of heat gain and heat loss is reflected as watts per $\frac{m^2.°C}{w}$

environmentally **safe**

Thermoshield was the first manufacturer of external insulation coatings to gain ISO:14025 accreditation. This Environmental Product Declaration assures that Thermoshield is suitable for rain water harvesting as well as for use in food industries.

Thermoshield has also been recognised by the Green Building Council of Australia (GBCA) and also by Good Environment Choice Australia (GECA) with Green Star rating.

Solar Energy continued

Effectiveness of Reducing Heat Transfer Depends on:

Temperature (Difference between the two surfaces)
Thickness
Type of material (with a specific K-value)

Certain materials have resistance values whilst other have reflective values.

For effectiveness of the Coating

For 100% effectiveness we need 100% of UV, visible, near and far infrared.

UV-Rays	5%	Absorbed by Ozone- layer	Product is UV-stable
Visible light	45%	Filtered by smoke, clouds, etc	Reflected by whiteness
Infrared Rays	50%	Reflected by CO_2, H^2O and glass	Reflected by ceramics

Paint Failures

De-Polymerisation - This is the point where the material begins to breakdown.

Chalking - The condition of paint surface which, having lost most of its gloss, is coated with a white powdery residue due to erosion form exposure to the weather. Unless this occurs prematurely, chalking is not usually considered to be a defect.

Factors Promoting Corrosion Moisture,Temperature and Oxygen.

Addendum The first law of thermo dynamics heat and mechanical energy are mutually convertible.

°C	=	Degrees Celsius	
°F	=	Degrees Fahrenheit	
K	=	Kelvin	Absolute temperatures
R	=	Rankine	Absolute temperatures
Temp F	=	($^0/_5$ x °C) + 32	
°C	=	$^9/_5$ x (F - 32)	
R	=	- 460°F	
K	=	- 273°C	
0K = 0R	=	- 460 °F = - 273 °C	

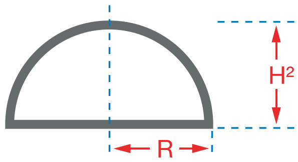
To convert

$\frac{Ft^2}{GAL} \rightarrow \frac{m^2}{Lt} = \frac{Ft^2}{GAL} \times \frac{0.093}{3.78} = 0.02457$ AND $\frac{1}{0.02457} = 40.7$

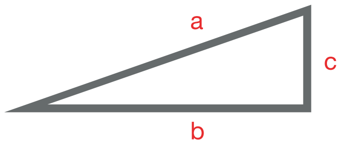
Eg: $300 \frac{Ft^2}{GAL} \div 40.7 = 7.4 \frac{m^2}{Lt}$

Square or Rectangle Area = L x W (+ profile allowance).

Circle area	=	$\frac{\pi D^2}{4}$
Circumference	=	πD
Area of Cylinder	=	$\pi D \times H$
Surface area of sphere	=	$2 \pi RH^2$



Area of double ended (domed) tank
$2 (2\pi RH^2) + \pi D \times H$



$a = \sqrt{b^2 + c^2}$

Coefficients of Linear Thermal Expansion

The coefficients of linear thermal expansion in the following list are average values from various sources. Minor variations may be expected in metals, but larger variations occur in concrete and masonry depending on the combinations of constituents. Coefficients apply in general to a temperature range form 0°C to 100°C. The values of the coefficients listed are per °C x 10^6

Metal	
Aluminium	23
Steel, Structural	11.7

Non Metal	
Concrete, Stone	10
Masonry, Brick	6.1
Plaster	16

To Calculate Expansion

Change in temp (°C) x length of material (mm) x coefficient of linear thermal expansion = expansion of material in mm

eg: temp. rise from 20°C to 80°C = 60° change in temperature
length of roof sheet = 10m = 10,000mm
material = steel

therefore: 60 x 10,000 x 11.7 x 10^6
= 6.0 x 10 x 1 x 10^4 x 1.17 x 10^1 x 10^6
= 6 x 1 x 1.17
= 7.02mm / 10m length

i.e. 7.02 ÷ 10 = 0.702mm / m /60°C

A	B	°C x LLMM x 11.7 x 10^6 = Thermal Expansion
20°C	-	-
30°C	10°C	10 x 10,000 x 11.7 x 10^6 = 1.17mm /10m
40°C	20°C	20 x 10,000 x 11.7 x 10^6 = 1.34mm /10m
50°C	30°C	30 x 10,000 x 11.7 x 10^6 = 3.51mm /10m
60°C	40°C	40 x 10,000 x 11.7 x 10^6 = 4.7mm /10m
70°C	50°C	50 x 10,000 x 11.7 x 10^6 = 5.84mm /10m
80°C	60°C	60 x 10,000 x 11.7 x 10^6 = 7.02mm /10m
90°C	70°C	70 x 10,000 x 11.7 x 10^6 = 8.2mm /10m
100°C	80°C	80 x 10,000 x 11.7 x 10^6 = 9.36mm /10m

A = At Roof Temp.
B = Temp. Difference