Reflective Insulation Roof System

- Guesstimating roof components performance diligently
- Truth about Reflective Insulation

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Fundamentals of Heat Transfer
Heat Flows from a hot or warm medium to a cold medium in 3 ways:

- **Radiation** - Heat transfer from warm surface to cooler surface through air space

- **Conduction** - Heat transfer through solid or fluid materials

- **Convection** - Physical movement of air
Fundamentals Of Heat Transfer

93 Million Miles Total Vacuum

Only Heat Transfer via Radiation is Possible
Fundamentals Of Heat Transfer

- The first use of Radiant Barriers on commercial scale were in the application in old fashion Thermo Flasks.

- The Thermo Flask consisted of a double walled, vacuum glass with silver coating.
Fundamentals Of Heat Transfer

- With advent of the space race in the 60’s and 70’s
- Nasa Pioneered the use of RB in space craft &
- space suits without which survival in space is impossible
Fundamentals Of Heat Transfer

- Other Applications of Radiant Barriers
Radiant Heat Transfer

*Source: Reflective Insulation Manufacturers’ Association of America (RIMA)*
Emittance (Emissivity)
• Ability of material surface to emit radiant energy

• The lower the emittance, the lower heat radiated from material surface

Reflectance (Reflectivity)
• Ability to reflect incoming radiant energy

• The lower the emittance, the higher the reflectance

Aluminium Foil – Emissivity 0.03, Reflectivity 97%
Typical test method to measure Emissivity ASTM E408
Fundamentals Of Heat Transfer

Reflection

Emission
## Fundamentals Of Heat Transfer

<table>
<thead>
<tr>
<th>Material Surface</th>
<th>Emittance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asphalt</td>
<td>0.90-0.98</td>
</tr>
<tr>
<td>*Aluminium foil</td>
<td>0.03-0.05</td>
</tr>
<tr>
<td>Brick</td>
<td>0.93</td>
</tr>
<tr>
<td>Concrete</td>
<td>0.85-0.95</td>
</tr>
<tr>
<td>Glass</td>
<td>0.95</td>
</tr>
<tr>
<td>Fiberglass / Cellulose</td>
<td>0.8-1.0</td>
</tr>
<tr>
<td>Iron (polished)</td>
<td>0.06</td>
</tr>
<tr>
<td>Iron (rusty)</td>
<td>0.85</td>
</tr>
<tr>
<td>Limestone</td>
<td>0.36-0.90</td>
</tr>
<tr>
<td>Marble</td>
<td>0.93</td>
</tr>
<tr>
<td>Paint : white lacquer</td>
<td>0.80</td>
</tr>
<tr>
<td>Paint : white enamel</td>
<td>0.91</td>
</tr>
<tr>
<td>Paint : blank lacquer</td>
<td>0.80</td>
</tr>
<tr>
<td>Paint : black enamel</td>
<td>0.91</td>
</tr>
<tr>
<td>Paper</td>
<td>0.92</td>
</tr>
<tr>
<td>Plaster</td>
<td>0.91</td>
</tr>
<tr>
<td>Silver</td>
<td>0.02</td>
</tr>
<tr>
<td>Steel (mild)</td>
<td>0.12</td>
</tr>
<tr>
<td>Wood</td>
<td>0.90</td>
</tr>
</tbody>
</table>

*Source: Oak Ridge National Laboratory of America (ORNL)*
Radiant Barriers and How It Works
Radiant Barriers And How It Works

• R Value or Resistance is a measure of thermal resistance of Insulation Material. A higher R value typically translate to a higher thermal resistance.

• Conventional insulation like fiberglass or Rockwool are usually rated by the R value and the R value of these conventional insulation increases with the thickness.

• Conventional insulation works by trapping air within the insulation and thus reducing heat transfer by air movement (convection).

• However, this conventional and simple R value rating do not apply to Radiant Barriers as the performance of RB depends on many variables and more importantly not just on thickness alone.
Radiant Barriers And How It Works

• How do radiant barriers work?

• Solar Radiation is absorbed by the roof and heating the roof tiles and causing the roof tiles to become hot. The hot roof tiles then radiate heat downward towards the roof space below.

• If no Radiant Barrier is installed an only conventional insulation is used, the radiated heat from the hot tile will heat the insulation material and the insulation will thus become hot. The hot insulation material will then radiate heat into the living space.

• By having a Radiant Barrier below the roof tile, the amount of radiant heat emitted by the hot tile into the roof space will be significantly reduced as the RB will reflect the radiant heat away.
Radiant Barriers And How It Works

In the report published by Oak Ridge National Laboratory’s Energy and Transportation Science Division, a typical 2000ft2 home in Miami which had conventional R19 installed in attic, home owner could save an additional US$560 a year in heating & cooling cost by installing a Radiant Barrier in roof.
How are Radiant Barriers Used In Roofing?
How Are Radiant Barriers Used in Roofing

INSTALLATION GUIDE FOR NEW RESIDENTIAL HOUSE

Roof tile
Radiant barrier
Wooden rafter (2” x 3”)
Nail
Staple
3 inch overlapping
Main truss
How Are Radiant Barriers Used in Roofing

- Wooden rafter (2" x 3")
- Roof tile
- 2 ~ 3 inch air gap
- Radiant barrier
- Main truss
How Are Radiant Barriers Used in Roofing

INSTALLATION GUIDE FOR EXISTING RESIDENTIAL HOUSE

- Roof tile
- Wooden rafter
- Main truss
- Staple
- 3" overlapping
- Radiant barrier
How Are Radiant Barriers Used in Roofing

- Roof tile
- Wooden rafter (2" x 3")
- Radiant barrier
- Main truss
Monier Malaysia Sdn Bhd Research & Development Facility
24 hours live measurements

Test Cells (Bukit Kemuning, MY)
(3.011633, 101.514219)

- Real-time temperature & heat flux data logging – Roof performance
Weather Station
- Linking weather to roof performance

Weather Station (Bukit Kemuning, MY)
(3.011633, 101.514219)

- Real-time on-site weather data logging
- Measures: wind direction & speed, solar irradiation, temperature, relative humidity & rain presence
Heat Flux Plate & Thermocouples Placement
11 point of thermocouples & 1 heat flux plate

*Note: The location for the thermocouples are adjustable
Thermometry data – Heat Flux
- Actual measurement dated June 5th 2012
- Duration: 72 hours at 5 minutes recording intervals

\[
\frac{BRD - CR}{BRD} \times 100\% = 65\%
\]

Location: Bukit Kemuning 24 hours live measurements
Power consumption observation using Power meter
Attached directly to air-conditioner power source

Setup:
- Both air-conditioner was switched on almost simultaneously (less than 30 sec apart)
- Both air-conditioner is set to keep the living space temperature @ 25°C (± 2°C)
- Both air-conditioner is switched off @ 19:30hrs and being switched on again @ 07:30hrs using timer function.
- Both air-conditioner is attached to power meter to measure the power consumption of each air-cond.

Result:
- After 12 hours of operation, both air-conditioner power consumption is observed as follow;
  - Test cell 1 (Basic roof) power consumption = 3.4826 kWh
  - Test cell 2 (CoolRoof) power consumption = 2.6266 kWh

Efficiency calculation:
\[
\frac{PC_{tc1} - PC_{tc2}}{PC_{tc1}} \times 100\% = \frac{3.4826 - 2.6266}{3.4826} \times 100\% = 25\% *
\]

* % Reduction of air-conditioner power consumption in test cell 2 with CoolRoof setup