**Efficiency Matrix Pty Ltd**

# Efficiency Matrix - Halogen Downlight Mitt - R Value Testing

# Halogen Light Mitt - Thermal Efficiency Analysis

**Report No. 30B-09-0338-TRP-445314-0**

**Vipac Engineers & Scientists Ltd**

**Melbourne VIC**

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# EXECUTIVE SUMMARY



Vipac Engineers & Scientists Ltd (VIPAC) has been commissioned by Efficiency Matrix Pty Ltd to determine the material R-value and Total R-Value of their Halogen Light Mitt product.

In order to determine the thermal conductivity of the Halogen Light Mitt, Vipac outsourced AS 4569 testing on the Halogen Light Mitt under ambient temperature conditions. This resulted in a thermal conductivity value of **k = 0.035 ± 0.003 mK/W** [1].

As stipulated by the BCA, the material R-value for the Halogen Light Mitt was calculated, in accordance with AS 4859.1:2002, to be $R_m$ = 0.514 $m^2$K/W, which projected onto the circular area covered by the base of the cone results in an equivalent material R-value of **$R_m$ = 0.238 $m^2$ K/W**.

Combining the Halogen Light Mitt with a plasterboard ceiling, for the circular area covered by the base of the cone, and appropriate air film and air space thermal resistances, a **Total System R-value of 0.62 $m^2$K/W for Heat flow out, and a Total R-value of 0.66 $m^2$K/W for Heat flow in** were obtained via calculations in accordance with AS4859.1:2002.

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# 1. INTRODUCTION

Vipac Engineers & Scientists Ltd (VIPAC) has been commissioned by Efficiency Matrix Pty Ltd to determine the material R-value and Total R-Value of their Halogen Light Mitt product.

# 2. SCOPE OF WORK

In order to determine the material R-value and Total R-Value of the Efficiency Matrix Halogen Light Mitt product, Vipac conducted the following tasks:

- Outsourced AS 4569 testing on the Halogen Light Mitt material under ambient temperature conditions in order to obtain the thermal conductivity of the material;
- Calculated an approximation of the R-value of a material with the equivalent surface area of the horizontal projection of the Halogen Light Mitt and the same conductive heat transfer;
- Combined this material R-value with the thermal resistances of a typical plasterboard ceiling, the air space in between them, and the boundary air films, in order to determine a Total R-value for the system.

# 3. ASSESSMENT

AS 4569 testing was carried out by Curtin University of Technology, Division of Science and Engineering, and resulted in a thermal conductivity value of $k = 0.035 \pm 0.003$ W/mK for a flat sample of the Halogen Light Mitt material, at a mean temperature of $22.6 \pm 0.1$ °C [1].

Customer supplied data defined the geometry of the Halogen Light Mitt, as shown in Figure 3.1

Base: 230mm outer diameter
Height: 220mm
Thickness: 22mm at base, 10mm near tip

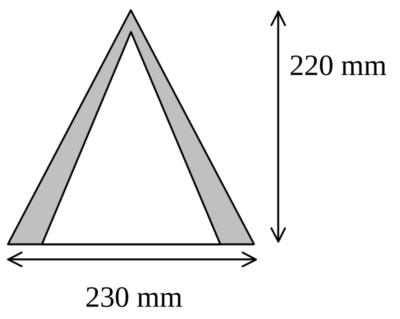


**Figure 3.1: Halogen Light Mitt**

The material R-value for the Halogen Light Mitt was then determined, based on an area-weighted average thickness of 18mm, to be $R_m = 0.514$ m$^2$K/W. Projecting this thermal resistance from the conical surface area (0.0897 m$^2$) onto the circular area covered by the base of the cone (0.0416 m$^2$) results in an equivalent material R-value of $R_m = 0.238$ m$^2$ K/W.

For the purposes of calculating the Total R-Value, it is assumed that the Halogen Light Mitt will typically be used in conjunction with a plasterboard ceiling of 10mm thickness (R = 0.059 $m^2K/W$) as stipulated by the default ceiling construction AS/NZS 4859.1:2002, and shown in Figure 3.2.

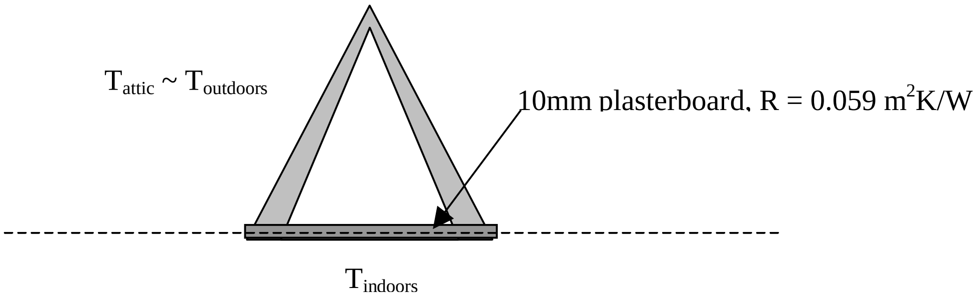


**Figure 3.2: Insulated ceiling system**

The thermal resistance of the air films above and below the combined system are dependent on the direction of heat flow. AS/NZS 4859.1:2002 requires the following temperatures, temperature differences and mean temperatures to be used in determining total thermal resistances:

- Heat flow out: Indoors 18°C, outdoors 12°C (6 K difference), mean 15 °C.
- Heat flow in: Indoors 24°C, outdoors 36°C (12 K difference), mean 30 °C.

In the absence of other documented values, and given the likely collection of dust on the upper surface of the thermal mitt, it is assumed that both the plasterboard ceiling and the thermal mitt are high emittance surfaces, with ε = 0.9,.

The resulting air film resistances are therefore as shown in Table 3.1.

| Surface | Direction of heat flow | Resistance |
|---|---|---|
| Lower face of plasterboard ceiling. | Up<br>Down | 0.11 $m^2K/W$<br>0.16 $m^2K/W$ |
| Upper face of thermal mitt (62.4° slope, from horizontal) | Up<br>Down | 0.11 $m^2K/W$<br>0.125 $m^2K/W$ |
| Upper face of thermal mitt (62.4° slope, from horizontal), projected onto circular area at base of cone. | Up<br>Down | 0.051 $m^2K/W$<br>0.058 $m^2K/W$ |

**Table 3.1: Air Film Thermal Resistances**

The thermal resistance of the enclosed air space was then determined by:

- Assuming the temperature of the air above the thermal mitt (the attic temperature) is at the Outdoor temperatures stated above, and the temperature of the air below the ceiling is at the Indoor temperatures stated above.
- Combining the thermal resistances for each system component into a thermal circuit.
- Using natural convection correlations and radiation laws to determine the thermal resistance provided by the air space, based on iteratively obtained surface temperatures for the upper surface of the plasterboard and the lower surface of the thermal mitt.
- Assuming that the surfaces of the plasterboard and thermal mitt are isothermal, and neglecting thermal bridging at their area of contact.
- Neglecting the effect of any air gaps in the plasterboard or thermal mitt.

Using the above method, the following air space thermal resistances, temperature profiles and Total R-values were obtained, and are included in Table 3.2 and Table 3.3.

| | Direction of heat flow | Resistance |
|---|---|---|
| Air Space Thermal Resistance | Up<br>Down | 0.166 $m^2K/W$<br>0.158 $m^2K/W$ |
| Total R-Value | Up<br>Down | 0.624 $m^2K/W$<br>0.673 $m^2K/W$ |

**Table 3.2: Air Space and Total Thermal Resistances**

| Location | Temperature during heat flow out (Up) | Temperature during heat flow in (Down) |
|---|---|---|
| Inside Air | 18°C | 24 °C |
| Lower Surface of Plasterboard | 16.94°C | 25.43 °C |
| Upper Surface of Plasterboard | 16.37°C | 25.95 °C |
| Air between Plasterboard and Thermal Mitt | 15.35 °C | 26.93 °C |
| Lower Surface of Thermal Mitt | 14.78°C | 27.36 °C |
| Upper Surface of Thermal Mitt | 12.49°C | 29.48 °C |
| Attic Air Temperature | 12 °C | 30 °C |

**Table 3.3: Temperature Profiles**

The calculated values for the thermal resistance of the air space compare reasonably to those provided in the AIRAH Technical Handbook [2].

The thermal resistance of the enclosed air space can be very sensitive to temperature and temperature difference. It is therefore determined not only at the temperatures stated above, but also, for standard temperature differences of 12K and 18K, as stipulated in AS/NZS 4859.1:2002. These were achieved by increasing the attic temperature from 36°C to 42°C and 48°C respectively. Note that these are not necessarily representative of the air space temperature when Halogen lights are in operation, which is expected to be significantly higher due to heat loss from the light.

The air space thermal resistances, temperature profiles and Total R-values were obtained for the above-mentioned temperature differences, as shown in Table 3.4 and Table 3.5.

| | Temperature Difference | Resistance |
|---|---|---|
| Air Space Thermal Resistance | 12 K<br>18 K | 0.151 $m^2K/W$<br>0.146 $m^2K/W$ |
| Total R-Value | 12 K<br>18 K | 0.666 $m^2K/W$<br>0.661 $m^2K/W$ |

**Table 3.4: Effect of Temperature Difference on Thermal Resistance**

| Location | Temperature difference of 12 K | Temperature difference of 18 K |
|---|---|---|
| Inside Air | 24°C | 24 °C |
| Lower Surface of Plasterboard | 26.88 °C | 28.36 °C |
| Upper Surface of Plasterboard | 27.94 °C | 29.96 °C |
| Air between Plasterboard and Thermal Mitt | 29.84 °C | 32.75 °C |
| Lower Surface of Thermal Mitt | 30.67 °C | 33.93 °C |
| Upper Surface of Thermal Mitt | 34.96 °C | 40.42 °C |
| Attic Air Temperature | 36 °C | 42 °C |

**Table 3.5: Temperature Profiles for Additional Temperature Differences**

The slight decrease in air space resistance as a function of temperature difference is to be expected, given that radiation is dominant for this air space. It is expected that, in practice attic temperatures may be higher that 30°C, and therefore that a Total R-value of 0.66 $m^2K/W$ is more appropriate.

# 4. CONCLUSIONS

The material R-value for the Halogen Light Mitt was determined to be $R_m$ = 0.514 $m^2K/W$, which, projected onto the circular area covered by the base of the cone, results in an equivalent material R-value of $R_m$ = 0.238 $m^2$ K/W.

Combining the Halogen Light Mitt with a plasterboard ceiling, for the circular area covered by the base of the cone, and appropriate air film and air space thermal resistances, a Total R-value of 0.62 $m^2K/W$ for Heat flow out, and a Total R-value of 0.66 $m^2K/W$ for Heat flow in were obtained.

# 5. BIBLIOGRAPHY

[1] Test Report, Curtin University of Technology, Division of Science and Engineering.

[2] AIRAH Technical Handbook, Edition 4, 2007