

THERMAL INSULATION EVALUATION BY CALCULATION

TILED ROOF, VENTILATED ATTIC, 25MM TRIPLE-LAYER SILVER BATTS (2 x 25MM AIR SPACES) ABOVE 90MM JOISTS, PLASTERBOARD CEILING

Calculation: 138.4w

Evaluation for Winter, 12.0°C ambient air temperature, 18.0°C inside air temperature.

Roof Element	m ² .K/W	°C in	°C out	°C avg.	ΔT °C	Assumed Cavity Properties				Note
						e1	e2	mm	Heat Flow	
Outside air film:	0.040	12.00	12.11	12.06	0.11					1
Clay tiles:	0.023	12.11	12.18	12.15	0.07					3
Ventilated semi-reflective attic:	0.240	12.18	12.86	12.52	0.68	0.87	0.28			4
RFL on Silver Batt:	0.000	12.86	12.86	12.86	0.00					
Silverbatt 25mm cavity:	0.522	12.86	14.33	13.60	1.48	0.03	0.87	25	Up	5,6
RFL on Silver Batt:	0.000	14.33	14.33	14.33	0.00					
Silverbatt 25mm cavity:	0.541	14.33	15.86	15.10	1.53	0.03	0.03	25	Up	5,6
RFL on Silver Batt:	0.000	15.86	15.86	15.86	0.00					
Unventilated 90mm cavity:	0.586	15.86	17.52	16.69	1.66	0.03	0.87	90	Up	5,6
10mm plasterboard:	0.059	17.52	17.69	17.61	0.17					3
Indoor air film (non-reflective surface):	0.110	17.69	18.00	17.84	0.31					2
Total R:		2.12	m ² .K/W							

Corresponding Total Conductance (k_t): 0.47 W/(m².K)

NOTES:

Calculated 28/11/07 16:15

Ref: 138G.xls

Determinations based upon AS/NZS 4859.1:2002/Amdt 1 2006, Materials for the thermal insulation of buildings

- 1 AS/NZS 4859.1:2002/Amdt 1, Clause K5(a)
 - 2 AS/NZS 4859.1:2002/Amdt 1, Table K1
 - 3 2000 AIRAH Handbook pages 622-639
 - 4 AS/NZS 4859.1:2002/Amdt 1, Table K2 linear interpolation
- "RFL" = Reflective Foil Laminate
- The calculations incorporate the pessimistic dust assumptions of AS/NZS 4859.1:2002/Amdt 1, Clauses K3.2 & K4.2a iii (e+0.25)
- 5 Reflective air space insulation values (shown in italics) were estimated using Reflect3 software. These are iterative calculations per the USA Division of Housing Research Paper 32. Each calculation assumes an air cavity of the gap shown, with uniform parallel surfaces.
 - 6 The calculations incorporate the assumption of no dust on downward facing reflective surfaces.
- The contribution from the Triple Layer Silver Batt is R1.84**
- 7 Indoor & outdoor air temperatures per AS/NZS 4859.1:2002/Amdt 1, Clause K3.1
 - 8 Thermal short-circuiting by frames is not considered here as evaluation is for the insulation path only.
 - 9 This report may not be reproduced except in full. Results may not be quoted without reference to the assumptions.
 - 10 Calculated by James Fricker, M.AIRAH, M.IEAust, CPEng.
 - 11 For regulatory use, this report may require a supportive independent infrared emissivity test certificate.

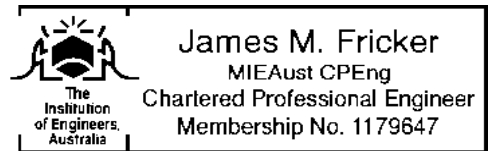
CONCLUSION:

For the above roof arrangement having Silverbatt infrared emittances of 0.03, 0.87/0.03, 0.03/0.03, 0.03, the WINTER Total R-values per AS4859.1:2002 Clause K3.1 is:

R2.12 m².K/W for an air temperature difference of 18°-12° = 6K

Signed:

James Fricker



THERMAL INSULATION EVALUATION BY CALCULATION

TILED ROOF, VENTILATED ATTIC, 25MM TRIPLE-LAYER SILVER BATTS (2 x 25MM AIR SPACES) ABOVE 90MM JOISTS, PLASTERBOARD CEILING

Calculation: 138.4s

Evaluation for Summer, 36.0°C ambient air temperature, 24.0°C inside air temperature.

Roof Element	m ² .K/W	°C in	°C out	°C avg.	ΔT °C	Assumed Cavity Properties				Note
						e1	e2	mm	Heat Flow	
Outside air film:	0.040	36.00	35.90	35.95	0.10					1
Clay tiles:	0.023	35.90	35.84	35.87	0.06					3
Ventilated semi-reflective attic:	1.110	35.84	33.10	34.47	2.75	0.87	0.28			4
RFL on Silver Batt:	0.000	33.10	33.10	33.10	0.00					
Silverbatt 25mm cavity:	0.781	33.10	31.16	32.13	1.93	0.03	0.87	25	Down	5,6
RFL on Silver Batt:	0.000	31.16	31.16	31.16	0.00					
Silverbatt 25mm cavity:	0.849	31.16	29.06	30.11	2.10	0.03	0.03	25	Down	5,6
RFL on Silver Batt:	0.000	29.06	29.06	29.06	0.00					
Unventilated 90mm cavity:	1.824	29.06	24.54	26.80	4.52	0.03	0.87	90	Down	5,6
10mm plasterboard:	0.059	24.54	24.40	24.47	0.15					3
Indoor air film (non-reflective surface):	0.160	24.40	24.00	24.20	0.40					2
Total R:		4.85	m ² .K/W							

Corresponding Total Conductance (k_t): 0.21 W/(m².K)

NOTES:

Calculated 28/11/07 16:15

Ref: 138G.xls

Determinations based upon AS/NZS 4859.1:2002/Amdt 1 2006, Materials for the thermal insulation of buildings

- AS/NZS 4859.1:2002/Amdt 1, Clause K5(a)
 - AS/NZS 4859.1:2002/Amdt 1, Table K1
 - 2000 AIRAH Handbook pages 622-639
 - AS/NZS 4859.1:2002/Amdt 1, Table K2 linear interpolation
- "RFL" = Reflective Foil Laminate
- The calculations incorporate the pessimistic dust assumptions of AS/NZS 4859.1:2002/Amdt 1, Clauses K3.2 & K4.2a iii (e+0.25)
- Reflective air space insulation values (shown in italics) were estimated using Reflect3 software. These are iterative calculations per the USA Division of Housing Research Paper 32. Each calculation assumes an air cavity of the gap shown, with uniform parallel surfaces.
 - The calculations incorporate the assumption of no dust on downward facing reflective surfaces.
- The contribution from the Triple Layer Silver Batt is R4.10**
- Indoor & outdoor air temperatures per AS/NZS 4859.1:2002/Amdt 1, Clause K3.1
 - Thermal short-circuiting by frames is not considered here as evaluation is for the insulation path only.
 - This report may not be reproduced except in full. Results may not be quoted without reference to the assumptions.
 - Calculated by James Fricker, M.AIRAH, M.IEAust, CPEng.
 - For regulatory use, this report may require a supportive independent infrared emissivity test certificate.

CONCLUSION:

For the above roof arrangement having Silverbatt infrared emittances of 0.03, 0.87/0.03, 0.03/0.03, 0.03, the SUMMER Total R-value per AS4859.1:2002/Amdt 1 Clause K3.1 is:

R4.85 for an air temperature difference of 36°-24° = 12K

Signed:

James Fricker



**"EQUIVALENT R" DETERMINED BY
MATCHING OVERALL TOTAL R**

**TILED ROOF WITH TRIPLE-LAYER
SILVER BATTS OVER PINE JOISTS**

**TILED ROOF WITH BULK INSULATION
BETWEEN PINE JOISTS**

D R A F T 28/11/2007

Winter (heat flow up)

		Calc: 138.4w		Bulk R	
Thermal path area ratio:		Insul.	Frame	Insul.	Frame
		88.5%	11.5%	88.5%	11.5%
		R (m ² .K/W)		R (m ² .K/W)	
Outside air film:		0.040		0.040	:Outside air film
Clay tiles:		0.023		0.023	:Clay tiles
Ventilated semi-reflective attic:		0.240		0.000	:Ventilated unreflective attic
Triple Layer Silver Batts:		1.063		-	
Unventilated 90mm reflective cavity:		0.586	-	2.243	:Bulk Insulation batt on plasterboard
90mm pine:		-	0.900	-	:90mm pine
10mm plasterboard:		0.059		0.059	:10mm plasterboard
Indoor air film:		0.110		0.110	:Indoor air film
Path Total R:		2.12	2.44	2.48	1.13
Overall Total R:		2.15		2.15	

Summer (heat flow down)

		Calc: 138.4s		Bulk R	
Thermal path area ratio:		Insul.	Frame	Insul.	Frame
		88.5%	11.5%	88.5%	11.5%
		R (m ² .K/W)		R (m ² .K/W)	
Outside air film:		0.040		0.040	:Outside air film
Clay tiles:		0.023		0.023	:Clay tiles
Ventilated semi-reflective attic:		1.110		0.460	:Ventilated unreflective attic
Triple Layer Silver Batts:		1.631		-	
Unventilated 90mm reflective cavity:		1.824	-	6.920	:Bulk Insulation batt on plasterboard
90mm pine:		-	0.900	-	:90mm pine
10mm plasterboard:		0.059		0.059	:10mm plasterboard
Indoor air film:		0.160		0.160	:Indoor air film
Path Total R:		4.85	3.92	7.66	1.64
Overall Total R:		4.65		4.65	

NOTES:

- 1 Refer JMF calculations 138.4s&w to AS/NZS 4859.1:2002/Amdt 1 for assumptions.
- 2 Indoor & outdoor air temperatures per AS/NZS 4859.1:2002/Amdt 1, Clause K3.1
- 3 The bulk insulation material R values (red) were iteratively found to obtain equal "Overall Total R" performance.
- 4 Overall result calculated by Isothermal Planes Method per AS/NZS 4859.1:2002/Amdt 1/2006
- 5 Calculations by James M Fricker, M.AIRAH CPeng

Calc: 138.5eRs

Calculated 28/11/07 16:15

CONCLUSION:

The above calculation tables reveal that Triple Layer Silver Batts installed on top of pine joists have equivalent thermal performance to R2.24 (winter) and R6.92 (summer) bulk insulation laid between pine joists, in a ventilated tiled roof without sarking.

**"EQUIVALENT R" DETERMINED BY
MATCHING OVERALL TOTAL R**

**TILED ROOF WITH TRIPLE-LAYER
SILVER BATTS OVER HARDWOOD JOISTS**

**TILED ROOF WITH BULK INSULATION
BETWEEN HARDWOOD JOISTS**

Winter (heat flow up)

Calc: 138.4w		Bulk R	
Insul.	Frame	Insul.	Frame
Thermal path area ratio: 88.5% 11.5%		88.5% 11.5%	
R (m ² .K/W)		R (m ² .K/W)	
Outside air film:	0.040	0.040	:Outside air film
Clay tiles:	0.023	0.023	:Clay tiles
Ventilated semi-reflective attic:	0.240	0.000	:Ventilated unreflective attic
Triple Layer Silver Batts:	1.063	-	
Unventilated 90mm reflective cavity:	0.586	3.030	:Bulk Insulation batt on plasterboard
90mm hardwood:	-	0.477	:90mm hardwood
10mm plasterboard:	0.059	0.059	:10mm plasterboard
Indoor air film:	0.110	0.110	:Indoor air film
Path Total R:	2.12	3.26	0.71
Overall Total R:	2.11	2.11	

Summer (heat flow down)

Calc: 138.4s		Bulk R	
Insul.	Frame	Insul.	Frame
Thermal path area ratio: 88.5% 11.5%		88.5% 11.5%	
R (m ² .K/W)		R (m ² .K/W)	
Outside air film:	0.040	0.040	:Outside air film
Clay tiles:	0.023	0.023	:Clay tiles
Ventilated semi-reflective attic:	1.110	0.460	:Ventilated unreflective attic
Triple Layer Silver Batts:	1.631	-	
Unventilated 90mm reflective cavity:	1.824	27.320	:Bulk Insulation batt on plasterboard
90mm hardwood:	-	0.477	:90mm hardwood
10mm plasterboard:	0.059	0.059	:10mm plasterboard
Indoor air film:	0.160	0.160	:Indoor air film
Path Total R:	4.85	28.06	1.22
Overall Total R:	4.40	4.40	

NOTES:

- 1 Refer JMF calculations 138.4s&w to AS/NZS 4859.1:2002/Amdt 1 for assumptions.
- 2 Indoor & outdoor air temperatures per AS/NZS 4859.1:2002/Amdt 1, Clause K3.1
- 3 The bulk insulation material R values (red) were iteratively found to obtain equal "Overall Total R" performance.
- 4 Overall result calculated by Isothermal Planes Method per AS/NZS 4859.1:2002/Amdt 1/2006
- 5 Calculations by James M Fricker, M.AIRAH CPeng

Calc: 138.5eRs

Calculated 28/11/07 15:51

CONCLUSION:

The above calculation tables reveal that Triple Layer Silver Batts installed on top of hardwood joists have equivalent thermal performance to R3.03 (winter) and R27.3 (summer) bulk insulation laid between hardwood joists, in a ventilated tiled roof without sarking.

SUMMARY

Total R Values

The following table shows Total R values for the **insulation path only** for a new house construction, calculated by independent consulting engineer James Fricker in accordance with AS/NZS 4859.1/Amdt 1 2006.

	Winter	Summer
Total R-value	R2.12	R4.85

(Pitched Tile Roof, ventilated attic, 50mm Triple Layer Silver Batts above 90mm air gap, plasterboard ceiling)

Equivalent R values

Although Bulk Insulation is tested for Material R Value, its in-situ performance is determined by 'Total R value', the same measure as for Reflective Insulation.

AS/NZS 4859.1/Amdt 1 2006 introduced adjustment for thermal bridging enabling fair comparison of systems having insulation that covers framework with systems having insulation installed only between frames. Thus Amdt 1 provides a calculation procedure for overall Total R-value.

An extension of this is the concept of "Equivalent R-Value" developed to allow a fair comparison between insulation systems. It also accounts for the impact of the heat bridges formed by ceiling joists that separate conventional insulation batts.

As defined by the author (James Fricker) Equivalent R-value is **"the material R-value required by bulk insulation laid between joists to obtain a specified Overall Total R-value"**, thus it is a system measure, not the property of an insulation alone.

The following table shows results for one system using Triple Layer Silver Batts.

(a) Pitched tiled roof, ventilated attic , 25mm Triple Layer Silver Batts above softwood joists, plasterboard

	Winter	Summer
Overall Total R-value	R2.15	R4.65
Equivalent R-value	R2.24	R6.92

(b) Pitched tiled roof, ventilated attic , 25mm Triple Layer Silver Batts above hardwood joists, plasterboard

	Winter	Summer
Overall Total R-value	R2.11	R4.40
Equivalent R-value	R3.03	R27.32

Thus fibrous batts installed between hardwood joists would need to be R3.03 to provide the same insulation in winter as Triple Layer Silver Batts installed above joists. To get the same effect as Triple Layer Silver Batts in summer, it would need R27.3 fibrous batts between hardwood joists because of the severe effect of thermal bridging in this system.

NOTES:

Calculated 28/11/07 15:52

- 1) The above "Equivalent R-values" apply to the specific pitched tiled roof system only. They do not apply to other roofs, or to walls or floors; or to roofs having sarking, or roofs which have bulk insulation installed on top of frames. (Each "Equivalent R-value" case is unique.)
- 2) R-values calculated assume reflective cavities within Silver Batts have parallel layers with 25mm air gap. (Resistance will derate with poor installation.)
- 3) **It is a condition of this report that "Equivalent R-values" shall never be quoted or published without full inclusion of the above notes which state necessary assumptions. "Equivalent R-values" shall not be quoted out of context as this would lead to misinterpretation.**

Signed: *James Fricker*

