

## Back to Earth SW Ltd

7 Tuns Lane  
Silverton  
Exeter  
EX5 4HY

### Project Information

Reference

Date 17 November 2023

### Construction Type

Element : Pitched roof, ceiling at rafter line - Roof-pitched-over-75mm

Internal surface emissivity : High External surface emissivity : High

	Thickness (mm)	Thermal Conductivity (W/mK)	Thermal Resistance (m <sup>2</sup> K/W)	Pitch (°)	Bridge details Air gaps (Level, Delta U")
Outside surface resistance	-	-	0.040		
Ampatop Protecta	-	-	-		
Beltermo Ultra	40.0	0.042	0.950		L:0 0.000W/m <sup>2</sup> K
SteicoFlex	75.0	0.036	2.050		9.000% Softwood (75.0mm) L:0 0.000W/m <sup>2</sup> K
Oriented strandboard (OSB)	9.0	0.130	0.069		
Ampatex Sinco	-	-	-		
Airspace, heat flow upwards, 25 mm thick	25.0	-	0.160		11.800% Softwood (25.0mm)
Gyproc Wallboard	12.5	0.190	0.066		
Inside surface resistance	-	-	0.100		
<b>Total thickness</b>	<b>161.5mm</b>				

### U-value = 0.32W/m<sup>2</sup>K

U-value, Combined Method : 0.319W/m<sup>2</sup>K (upper/lower limit 3.222 / 3.055m<sup>2</sup>K/W, dUf 0.0064, dUg 0.0000, dUp0.0000, dUr0.0000, dUrc1 0.0000, dUrc2 0.0000)

### Correction factors

Mechanical fasteners :-

Warm pitched roof - insulation over rafters

Alpha : 0.80 per m lambda f : 50.0000W/mK nf : 6.700 per m<sup>2</sup> Af : 12.500mm<sup>2</sup> Recess : 0.0mm

Delta Uf for Beltermo Ultra : 0.0064

nf = fasteners per m<sup>2</sup> Af = fasteners cross-sectional area

Air gaps, Delta Ug = 0.000W/m<sup>2</sup>K

(Based on the combined method for determining U-values of structures containing repeating thermal bridges)

	Thickness (mm)	Thermal Conductivity (W/mK)	Thermal Resistance (m <sup>2</sup> K/W)	Vapour Resistivity (MNs/gm)	Vapour Resistance (MNs/g)
Outside surface resistance	-	-	0.040	-	-
Ampatop Protecta	-	-	-	-	0.50
Beltermo Ultra	40.0	0.042	0.950	15.00	0.60
SteicoFlex	75.0	0.036	2.050	5.00	0.38
Oriented strandboard (OSB)	9.0	0.130	0.069	250.00	2.25
Ampatex Sinco	-	-	-	-	25.00
Airspace, heat flow upwards, 25 mm thick	25.0	-	0.160	-	0.00
Gyproc Wallboard	12.5	0.190	0.066	50.00	0.63
Inside surface resistance	-	-	0.100	-	-
<b>Total thickness</b>	<b>161.5mm</b>				

## Detailed U-value Calculation Results

Construction includes 2 bridged layers

### Non-bridged layers

Outside surface resistance	0.040 m <sup>2</sup> K/W
Beltermo Ultra	0.950 m <sup>2</sup> K/W
Oriented strandboard (OSB)	0.069 m <sup>2</sup> K/W
Gyproc Wallboard	0.066 m <sup>2</sup> K/W
Inside surface resistance	0.100 m <sup>2</sup> K/W
<b>Resistance of non-bridged layers, R<sub>NB</sub> =</b>	<b><u>1.225 m<sup>2</sup>K/W</u></b>

### Bridged layers

SteicoFlex (L1) bridged by Softwood (B1)

Airspace, heat flow upwards, 25 mm thick (L2) bridged by Softwood (B2)

Path 1 - SteicoFlex

Path 2 - Softwood /

Path 3 - SteicoFlex

Path 4 - Softwood /

### Resistance and fraction of heat flow paths

$$R_{P1} = R_{NB} + R_{L1} = 1.225 + 2.210 = 3.435 \text{ m}^2\text{K/W} \quad F_{P1} = 80.262\%$$

$$R_{P2} = R_{NB} + R_{L2} = 1.225 + 0.737 = 1.962 \text{ m}^2\text{K/W} \quad F_{P2} = 7.938\%$$

$$R_{P3} = R_{NB} + R_{L3} = 1.225 + 2.242 = 3.468 \text{ m}^2\text{K/W} \quad F_{P3} = 10.738\%$$

$$R_{P4} = R_{NB} + R_{L4} = 1.225 + 0.769 = 1.994 \text{ m}^2\text{K/W} \quad F_{P4} = 1.062\%$$

### Upper resistance limit

$$R_{\text{upper}} = 1 / \left( \frac{F_{P1}}{R_{P1}} + \frac{F_{P2}}{R_{P2}} + \frac{F_{P3}}{R_{P3}} + \frac{F_{P4}}{R_{P4}} \right)$$

$$R_{\text{upper}} = 1 / \left( \frac{0.803}{3.435} + \frac{0.079}{1.962} + \frac{0.107}{3.468} + \frac{0.011}{1.994} \right) = 3.222 \text{ m}^2\text{K/W}$$

### Lower resistance limit

$$R_{\text{lower}} = R_{NB} + 1 / \left( \frac{F_{L1}}{R_{L1}} + \frac{F_{B1}}{R_{B1}} \right) + 1 / \left( \frac{F_{L2}}{R_{L2}} + \frac{F_{B2}}{R_{B2}} \right)$$

$$R_{\text{lower}} = 1.225 + 1 / \left( \frac{0.910}{2.050} + \frac{0.090}{0.577} \right) + 1 / \left( \frac{0.882}{0.160} + \frac{0.118}{0.192} \right) = 3.055 \text{ m}^2\text{K/W}$$

### Total resistance of roof

$$R_T = \left( R_{\text{upper}} + R_{\text{lower}} \right) / 2 = (3.222 + 3.055) / 2 = 3.14 \text{ m}^2\text{K/W}$$

### Mechanical fasteners :-

Calculations to BS EN ISO 6946:2007

Warm pitched roof - insulation over rafters

Alpha : 0.80 per m lambda f : 50.0000W/mK nf : 6.700 per m<sup>2</sup> Af : 12.500mm<sup>2</sup> Recess : 0.0mm

Delta Uf for Beltermo Ultra : 0.0064

Correction for air gaps, Delta Ug = 0.0000W/m<sup>2</sup>K

(Delta Uf + Delta Ug + Delta Up + Delta Ur) is less than 3% of (1 / Rt) so U = (1 / Rt) + (Delta Ur) + (Delta Urc) = 0.32 W/m<sup>2</sup>K

Structure element : Pitched roof, ceiling at rafter line  
Condensation calculations performed in accordance with BS5250:2021

**Condensation is occurring at the following layers interfaces:-**

Month	Int (C°)	Int (%RH)	Ext (C°)	Ext (%RH)
Jan	21.00	45.10	3.10	85.00
Feb	21.00	44.60	3.10	83.50
Mar	21.00	45.40	5.20	79.50
Apr	21.00	46.70	7.60	75.50
May	21.00	51.40	10.60	76.00
Jun	21.00	57.20	14.00	74.50
Jul	21.00	61.90	15.80	75.00
Aug	21.00	62.60	15.40	77.50
Sep	21.00	58.60	13.20	79.50
Oct	21.00	53.90	10.00	83.00
Nov	21.00	48.00	6.00	84.00
Dec	21.00	46.40	4.20	85.50

Gc = Monthly moisture accumulation per area at an interface

Ma = Accumulated moisture content per area at an interface

Peak accumulated moisture content per area at interface (Ma) = 0.00000 Kg/m<sup>2</sup>

Annual moisture accumulation = 0.00000 Kg/m<sup>2</sup>

**Project Information**

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Date 17 November 2023

**Thermal Mass Details**

	Thickness assessed (actual) (mm)	Density (kg/m <sup>3</sup> )	Specific heat capacity (J/kgK)	Heat capacity (kJ/m <sup>2</sup> K)
Ampatop Protecta	0.0 (-)	300.0	850.0	0.0
Beltermo Ultra	0.0 (40.0)	180.0	2100.0	0.0
SteicoFlex	0.0 (75.0)	60.0	2100.0	0.0
Oriented strandboard (OSB)	9.0 (9.0)	650.0	1700.0	9945000.0
Ampatex Sinco	0.0 (-)	280.0	850.0	0.0
Airspace, heat flow upwards, 25 mm thick	25.0 (25.0)	1.2	1008.0	30240.0
Gyproc Wallboard	12.5 (12.5)	0.0	0.0	0.0
Total				9975240.0
kappa value				9.9752
Limiting condition:	insulation			

Admittance : 0.96 W/m<sup>2</sup>K    Decrement : 0.84 factor    Decrement delay : -4.12 hours

## Condensation Risk Analysis (no account taken of thermal bridges)

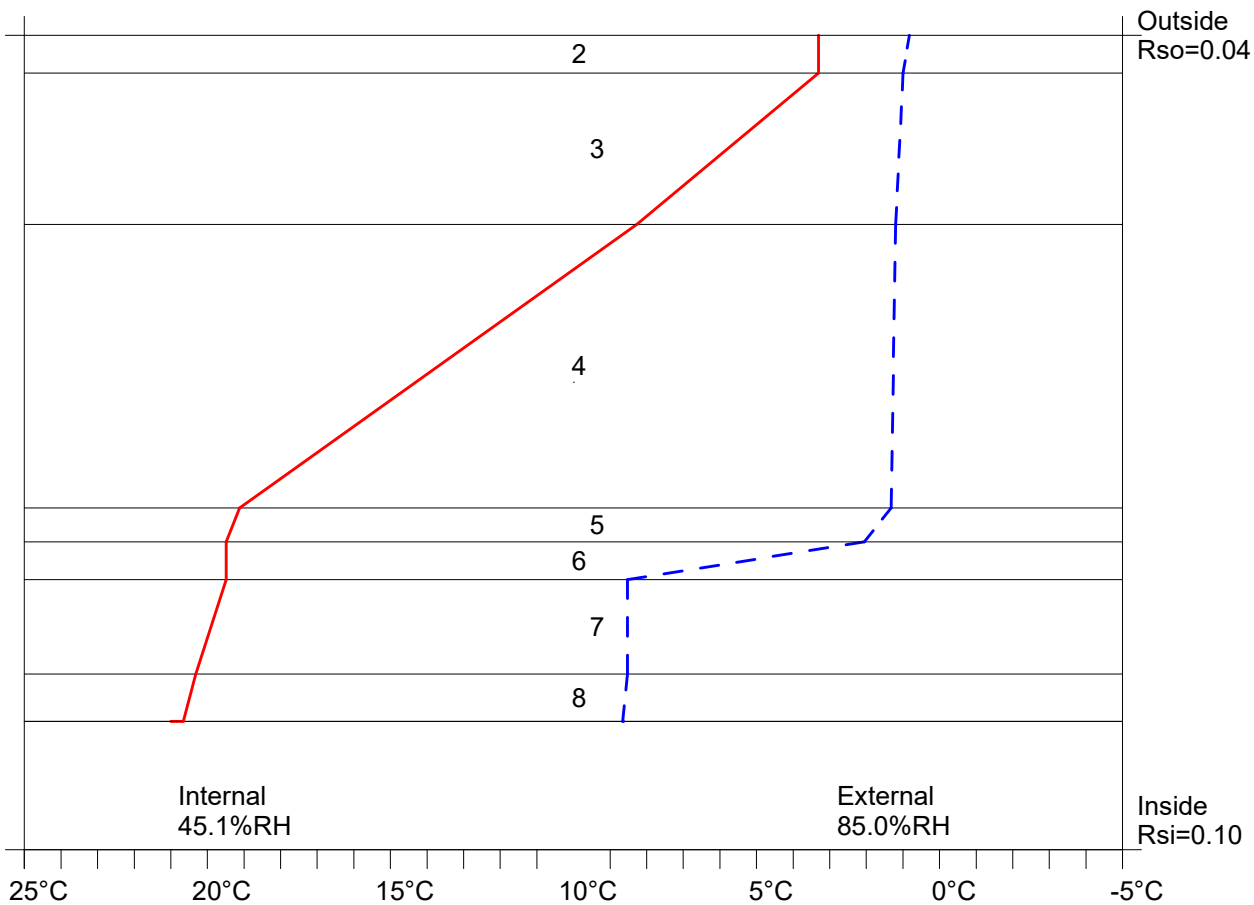
### 2 - Offices, shops and dwellings with low occupancy

Jan (worst)	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
21.0C 45.1%	21.0C 44.6%	21.0C 45.4%	21.0C 46.7%	21.0C 51.4%	21.0C 57.2%	21.0C 61.9%	21.0C 62.6%	21.0C 58.6%	21.0C 53.9%	21.0C 48.0%	21.0C 46.4%
3.1C 85.0%	3.1C 83.5%	5.2C 79.5%	7.6C 75.5%	10.6C 76.0%	14.0C 74.5%	15.8C 75.0%	15.4C 77.5%	13.2C 79.5%	10.0C 83.0%	6.0C 84.0%	4.2C 85.5%

	Interface Temp. °C	Dewpoint Temp. °C	Vapour Pressure (kPa)	Saturated V.P. (kPa)	Worst Cond. (g/m <sup>2</sup> )	Peak Buildup (g/m <sup>2</sup> )	Condensation
1 Outside surface resistance							
2 Ampatop Protecta	3.3	0.8	0.65	0.77			No
3 Beltermo Ultra	3.3	1.0	0.66	0.77			No
4 SteicoFlex	8.3	1.2	0.67	1.09			No
5 Oriented strandboard (OSB)	19.1	1.3	0.67	2.21			No
6 Ampatex Sinco	19.5	2.1	0.71	2.26			No
7 Airspace, heat flow upwards, 25 mm thick	19.5	8.5	1.11	2.26			No
8 Gyproc Wallboard	20.3	8.5	1.11	2.38			No
9 Inside surface resistance	20.7	8.7	1.12	2.43			No

Worst case internal / external conditions for graph : 21.0°C @ 45.1%RH / 3.1°C @ 85.0%RH

Scale 1:2



## Condensation Risk Analysis (no account taken of thermal bridges)

### 2 - Offices, shops and dwellings with low occupancy

Jan (worst)	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
21.0C 45.1%	21.0C 44.6%	21.0C 45.4%	21.0C 46.7%	21.0C 51.4%	21.0C 57.2%	21.0C 61.9%	21.0C 62.6%	21.0C 58.6%	21.0C 53.9%	21.0C 48.0%	21.0C 46.4%
3.1C 85.0%	3.1C 83.5%	5.2C 79.5%	7.6C 75.5%	10.6C 76.0%	14.0C 74.5%	15.8C 75.0%	15.4C 77.5%	13.2C 79.5%	10.0C 83.0%	6.0C 84.0%	4.2C 85.5%

	Interface Temp. °C	Dewpoint Temp. °C	Vapour Pressure (kPa)	Saturated V.P. (kPa)	Worst Cond. (g/m <sup>2</sup> )	Peak Buildup (g/m <sup>2</sup> )	Condensation
1 Outside surface resistance							
2 Ampatop Protecta	15.9	11.4	1.35	1.80			No
3 Beltermo Ultra	15.9	11.4	1.35	1.80			No
4 SteicoFlex	17.3	11.5	1.35	1.97			No
5 Oriented strandboard (OSB)	20.5	11.5	1.36	2.40			No
6 Ampatex Sinco	20.6	11.7	1.37	2.42			No
7 Airspace, heat flow upwards, 25 mm thick	20.6	13.4	1.53	2.42			No
8 Gyproc Wallboard	20.8	13.4	1.53	2.46			No
9 Inside surface resistance	20.9	13.4	1.54	2.47			No

Worst case internal / external conditions for graph : 21.0°C @ 61.9%RH / 15.8°C @ 75.0%RH

Scale 1:2

