**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-under-50mm
Internal surface emissivity : High External surface emissivity : High

| | Thickness (mm) | Thermal Conductivity (W/mK) | Thermal Resistance (m²K/W) | Pitch (º) | Bridge details Air gaps (Level, Delta U") |
|---|---|---|---|---|---|
| Outside surface resistance | - | - | 0.040 | | |
| Ampatop Protecta | - | - | - | | |
| SteicoFlex | 50.0 | 0.036 | 1.350 | | 9.000% Softwood (50.0mm) L:0 0.000W/m²K |
| UdiTHERM | 100.0 | 0.038 | 2.600 | | L:0 0.000W/m²K |
| Beltermo Ultra | 80.0 | 0.042 | 1.900 | | L:0 0.000W/m²K |
| Ampatex Sinco | - | - | - | | |
| SteicoFlex | 25.0 | 0.036 | 0.650 | | 11.800% Softwood (25.0mm) L:0 0.000W/m²K |
| Gyproc Wallboard | 12.5 | 0.190 | 0.066 | | |
| Inside surface resistance | - | - | 0.100 | | |
| **Total thickness** | **267.5mm** | | | | |

***U-value = 0.16W/m²K***

U-value, Combined Method : 0.164W/m²K (upper/lower limit 6.548 / 6.315m²K/W, dUf 0.0081, 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 m² Af : 12.000mm² Recess : 0.0mm
Delta Uf for UdiTHERM : 0.0048
Warm pitched roof - insulation over rafters
Alpha : 0.80 per m lambda f : 50.0000W/mK nf : 6.700 per m² Af : 12.000mm² Recess : 0.0mm
Delta Uf for Beltermo Ultra : 0.0032
nf = fasteners per m² Af = fasteners cross-sectional area
Air gaps, Delta Ug = 0.000W/m²K

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

| | Thickness (mm) | Thermal Conductivity (W/mK) | Thermal Resistance (m²K/W) | Vapour Resistivity (MNs/gm) | Vapour Resistance (MNs/g) |
|---|---|---|---|---|---|
| Outside surface resistance | - | - | 0.040 | - | - |
| Ampatop Protecta | - | - | - | - | 0.50 |
| SteicoFlex | 50.0 | 0.036 | 1.350 | 5.00 | 0.25 |
| UdiTHERM | 100.0 | 0.038 | 2.600 | 25.00 | 2.50 |
| Beltermo Ultra | 80.0 | 0.042 | 1.900 | 15.00 | 1.20 |
| Ampatex Sinco | - | - | - | - | 25.00 |
| SteicoFlex | 25.0 | 0.036 | 0.650 | 5.00 | 0.13 |
| Gyproc Wallboard | 12.5 | 0.190 | 0.066 | 50.00 | 0.63 |
| Inside surface resistance | - | - | 0.100 | - | - |
| **Total thickness** | **267.5mm** | | | | |

**Detailed U-value Calculation Results**

Construction includes 2 bridged layers

Non-bridged layers

| | |
|---|---|
| Outside surface resistance | 0.040 m²K/W |
| UdiTHERM | 2.600 m²K/W |
| Beltermo Ultra | 1.900 m²K/W |
| Gyproc Wallboard | 0.066 m²K/W |
| Inside surface resistance | 0.100 m²K/W |
| Resistance of non-bridged layers, $R_{NB}$ = | 4.706 m²K/W |

Bridged layers

SteicoFlex (L1) bridged by Softwood (B1)
SteicoFlex (L2) bridged by Softwood (B2)

Path 1 - SteicoFlex
Path 2 - Softwood /
Path 3 - SteicoFlex
Path 4 - Softwood /

Resistance and fraction of heat flow paths

$R_{P1} = R_{NB} + R_{L1} = 4.706 + 2.000 = 6.706$ m²K/W $F_{P1} = 80.262\%$
$R_{P2} = R_{NB} + R_{L2} = 4.706 + 1.035 = 5.741$ m²K/W $F_{P2} = 7.938\%$
$R_{P3} = R_{NB} + R_{L3} = 4.706 + 1.542 = 6.248$ m²K/W $F_{P3} = 10.738\%$
$R_{P4} = R_{NB} + R_{L4} = 4.706 + 0.577 = 5.283$ m²K/W $F_{P4} = 1.062\%$

Upper resistance limit

$R_{upper} = 1 / ( (F_{P1}/R_{P1}) + (F_{P2}/R_{P2}) + (F_{P3}/R_{P3}) + (F_{P4}/R_{P4}) )$
$R_{upper} = 1 / ( (0.803/6.706) + (0.079/5.741) + (0.107/6.248) + (0.011/5.283) ) = 6.548$m²K/W

Lower resistance limit

$R_{lower} = R_{NB} + 1 / ((F_{L1}/R_{L1}) + (F_{B1}/R_{B1})) + 1 / ((F_{L2}/R_{L2}) + (F_{B2}/R_{B2}))$
$R_{lower} = 4.706 + 1 / ((0.910/1.350) + (0.090/0.385)) + 1 / ((0.882/0.650) + (0.118/0.192)) = 6.315$m²K/W

Total resistance of roof

$R_T = ( R_{upper} + R_{lower} ) / 2 = (6.548 + 6.315) / 2 = 6.43$ m²K/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 m² Af : 12.000mm² Recess : 0.0mm
Delta Uf for UdiTHERM : 0.0048
Warm pitched roof - insulation over rafters
Alpha : 0.80 per m lambda f : 50.0000W/mK nf : 6.700 per m² Af : 12.000mm² Recess : 0.0mm
Delta Uf for Beltermo Ultra : 0.0032
Correction for air gaps, Delta Ug = 0.0000W/m²K

U = (1 / Rt) + (Delta Uf + Delta Ug + Delta Up + Delta Urc2 + Delta Urc2) = (1/6.4315) + 0.0081 + 0.0000 + 0.0000 + 0.0000 + 0.0000 = 0.16 W/m²K

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

**Condensation is occuring 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/m²

Annual moisture accumulation = 0.00000 Kg/m²

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***Thermal Mass Details***

| | Thickness assessed (actual) (mm) | Density (kg/m³) | Specific heat capacity (J/kgK) | Heat capacity (kJ/m²K) |
|---|---|---|---|---|
| Ampatop Protecta | 0.0 (-) | 300.0 | 850.0 | 0.0 |
| SteicoFlex | 0.0 (50.0) | 60.0 | 2100.0 | 0.0 |
| UdiTHERM | 0.0 (100.0) | 140.0 | 2100.0 | 0.0 |
| Beltermo Ultra | 0.0 (80.0) | 180.0 | 2100.0 | 0.0 |
| Ampatex Sinco | 0.0 (-) | 280.0 | 850.0 | 0.0 |
| SteicoFlex | 0.0 (25.0) | 60.0 | 2100.0 | 0.0 |
| Gyproc Wallboard | 12.5 (12.5) | 0.0 | 0.0 | 0.0 |
| Total | | | | 0.0 |
| kappa value | | | | 0.0000 |

Limiting condition: insulation

Admittance : 0.72 W/m²K Decrement : 0.15 factor Decrement delay : -13.05 hours

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

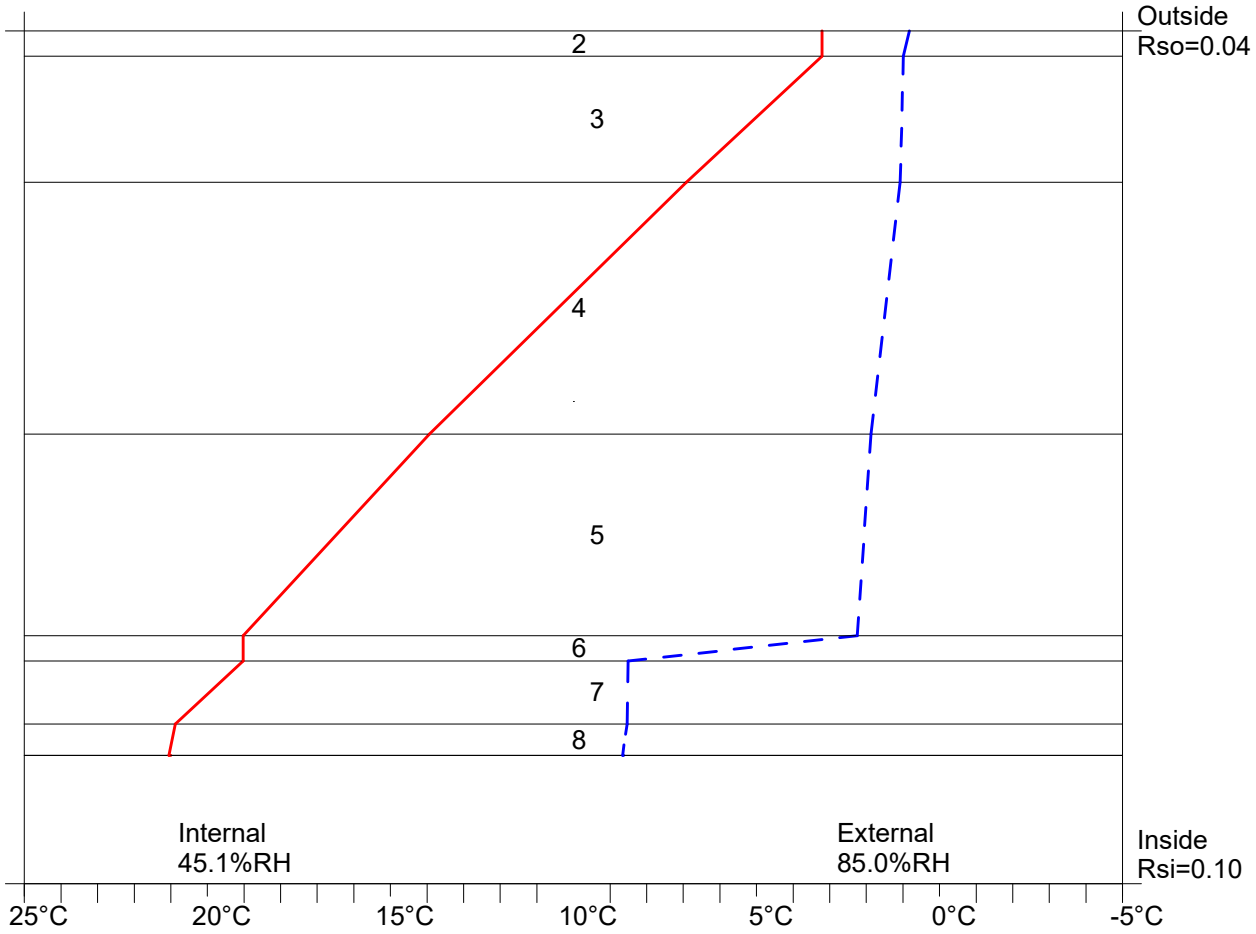
2 - Offices, shops and dwellings with low occupancy

| 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. ºC | Dewpoint Temp. ºC | Vapour Pressure (kPa) | Saturated V.P. (kPa) | Worst Cond. (g/m²) | Peak Buildup (g/m²) | Conden-sation |
|---|---|---|---|---|---|---|---|
| 1 Outside surface resistance | 3.2 | 0.8 | 0.65 | 0.77 | | | No |
| 2 Ampatop Protecta | 3.2 | 1.0 | 0.66 | 0.77 | | | No |
| 3 SteicoFlex | 6.9 | 1.1 | 0.66 | 1.00 | | | No |
| 4 UdiTHERM | 13.9 | 1.9 | 0.70 | 1.59 | | | No |
| 5 Beltermo Ultra | 19.0 | 2.2 | 0.72 | 2.20 | | | No |
| 6 Ampatex Sinco | 19.0 | 8.5 | 1.11 | 2.20 | | | No |
| 7 SteicoFlex | 20.9 | 8.5 | 1.11 | 2.47 | | | No |
| 8 Gyproc Wallboard | 21.1 | 8.7 | 1.12 | 2.49 | | | No |
| 9 Inside surface resistance | | | | | | | |

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

Scale 1:3



**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. ºC | Dewpoint Temp. ºC | Vapour Pressure (kPa) | Saturated V.P. (kPa) | Worst Cond. (g/m²) | Peak Buildup (g/m²) | Conden-sation |
|---|---|---|---|---|---|---|---|
| 1 Outside surface resistance | 15.8 | 11.4 | 1.35 | 1.80 | | | No |
| 2 Ampatop Protecta | 15.8 | 11.4 | 1.35 | 1.80 | | | No |
| 3 SteicoFlex | 16.9 | 11.4 | 1.35 | 1.93 | | | No |
| 4 UdiTHERM | 18.9 | 11.6 | 1.37 | 2.19 | | | No |
| 5 Beltermo Ultra | 20.4 | 11.7 | 1.37 | 2.40 | | | No |
| 6 Ampatex Sinco | 20.4 | 13.4 | 1.53 | 2.40 | | | No |
| 7 SteicoFlex | 21.0 | 13.4 | 1.53 | 2.48 | | | No |
| 8 Gyproc Wallboard | 21.0 | 13.4 | 1.54 | 2.49 | | | No |
| 9 Inside surface resistance | | | | | | | |

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

Scale 1:3