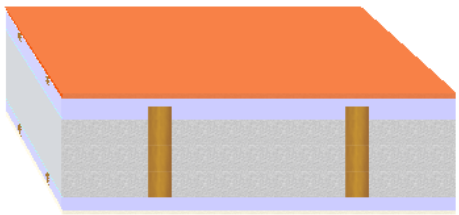
Niall Crosson
Group Technical Manager BTech, MEngSc,MIEI, CEPHC

Documentation of the component
Thermal transmittance (U-value) according to BS EN ISO 6946
Source: **own catalogue - Pitched roofs**
Component: **Passive360PitchedRoof**

OUTSIDE



This illustration of inhomogeneous layers is provided only to assist in visualising the arrangement.

On the basis of the given information about the inhomogeneous layers, it is not possible to estimate how and where bearing elements intersect each other. It was assumed that the layers intersect crosswise. The size of the areas was calculated corresponding to their percentage of the whole area.

INSIDE

Assignment: Pitched roof < 70°, with insulation between rafters

		Manufacturer	Name	Thickness [m], number	Lambda [W/(mK)]	Q	R [m²K/W]
		Rse					0.1000
☐	1	BS EN 12524	Tiles (roofing), clay	0.0200	1.000	D	~~0.0200~~
☐	2	Inhomogeneous material layer	consisting of:	0.0300	ø 0.014		~~2.0979~~
	2a	BS EN ISO 6946	Well ventilated air layer	89.00 %	0.000	D	-
	2b	BS EN 12524	Softwood Timber [500 kg/m³]	11.00 %	0.130	D	-
☐	3	Inhomogeneous material layer	consisting of:	0.0500	ø 0.016		~~3.2051~~
	3a	BS EN ISO 6946	Well ventilated air layer	88.00 %	0.000	D	-
	3b	BS EN 12524	Softwood Timber [500 kg/m³]	12.00 %	0.130	D	-
☑	4	pro clima	Solitex PLUS	0.0007	0.100	E	0.0065
☑	5	Inhomogeneous material layer	consisting of:	0.2950	ø 0.048		6.1254
	5a	Dammstatt	Dammstatt	88.00 %	0.037	E	-
	5b	BS EN 12524	Softwood Timber [500 kg/m³]	12.00 %	0.130	D	-
☑	6	pro clima	INTELLO PLUS	0.0002	0.170	E	0.0012
☑	7	Inhomogeneous material layer	consisting of:	0.0500	ø 0.293		0.1707
	7a	BS EN ISO 6946	Unventilated air layer: 50 mm, upwards heat flow	89.00 %	0.313	D	-
	7b	BS EN 12524	Softwood Timber [500 kg/m³]	11.00 %	0.130	D	-
☑	8	British Gypsum Limited	Gyproc Wallboard	0.0150	0.190	D	0.0789
		Rsi					0.1000
				0.4609			

☐ was not taken into consideration in the calculation

$R_T = (R_T' + R_T'')/2 = 6.67$ m²K/W

$U = 1/R_T = 0.15$ W/(m²K)

Q .. The physical values of the building materials has been graded by their level of quality. These 5 levels are the following
A .. A: Data is entered and validated by the manufacturer or supplier. Data is continuously tested by 3rd party.
B .. B: Data is entered and validated by the manufacturer or supplier. Data is certified by 3rd party
C .. C: Data is entered and validated by the manufacturer or supplier.
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U = 0.15 W/(m²K) R_T= 6.67 m²K/W

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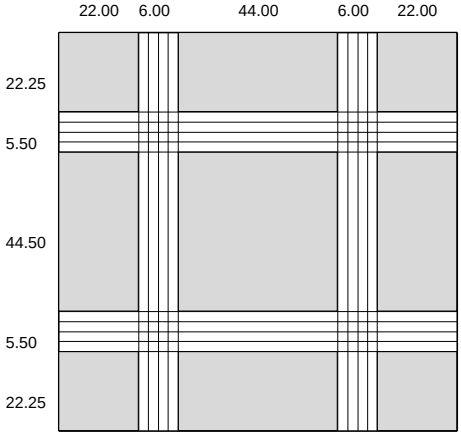
Documentation of the component
Thermal transmittance (U-value) according to BS EN ISO 6946
Source: **own catalogue - Pitched roofs**
Component: **Passive360PitchedRoof**

Draft of the component (portion in %):



The intersection of the inhomogeneous layers results in 4 Zones (A, B, C, D). Information given in %.

A	4.90 + 9.79 + 4.90 + 9.79 + 19.58 + 9.79 + 4.90 + 9.79 + 4.90 consisting of material layers: 4, 5a, 6, 7a, 8	= 78.32%
B	1.34 + 2.67 + 1.34 + 1.34 + 2.67 + 1.34 consisting of material layers: 4, 5b, 6, 7a, 8	= 10.68%
C	1.21 + 2.42 + 1.21 + 1.21 + 2.42 + 1.21 consisting of material layers: 4, 5a, 6, 7b, 8	= 9.68%
D	0.33 + 0.33 + 0.33 + 0.33 consisting of material layers: 4, 5b, 6, 7b, 8	= 1.32%

Upper limit of the thermal transfer resistance R

$$U_A\ [W/(m^2K)] = \frac{1}{(\Sigma R_{i,A}) + R_{si} + R_{se}} = \frac{1}{8.22 + 0.1 + 0.1} = 0.12$$

$$U_B\ [W/(m^2K)] = \frac{1}{(\Sigma R_{i,B}) + R_{si} + R_{se}} = \frac{1}{2.52 + 0.1 + 0.1} = 0.37$$

$$U_C\ [W/(m^2K)] = \frac{1}{(\Sigma R_{i,C}) + R_{si} + R_{se}} = \frac{1}{8.44 + 0.1 + 0.1} = 0.12$$

$$U_D\ [W/(m^2K)] = \frac{1}{(\Sigma R_{i,D}) + R_{si} + R_{se}} = \frac{1}{2.74 + 0.1 + 0.1} = 0.34$$

$$R_T' = \frac{1}{A * U_A + B * U_B + C * U_C + D * U_D} = 6.75\ m^2K/W$$

Lower limit of the thermal transfer resistance R

R_{se} [m^2K/W]		= 0.1
R_4 '' [m^2K/W] = d_4/λ_4 =	0.0007 / 0.100	= 0.01
R_5 '' [m^2K/W] = $d_5/(\lambda_{5a} * (A + C) + \lambda_{5b} * (B + D))$ =	0.2950 /(0.037 * 88.00% + 0.130 * 12.00%)	= 6.13
R_6 '' [m^2K/W] = d_6/λ_6 =	0.0002 / 0.170	= 0.00
R_7 '' [m^2K/W] = $d_7/(\lambda_{7a} * (A + B) + \lambda_{7b} * (C + D))$ =	0.0500 /(0.313 * 89.00% + 0.130 * 11.00%)	= 0.17
R_8 '' [m^2K/W] = d_8/λ_8 =	0.0150 / 0.190	= 0.08
R_{si} [m^2K/W]		= 0.1

$$R_T'' = \Sigma R_i'' + R_{si} + R_{se} = 6.58\ m^2K/W$$

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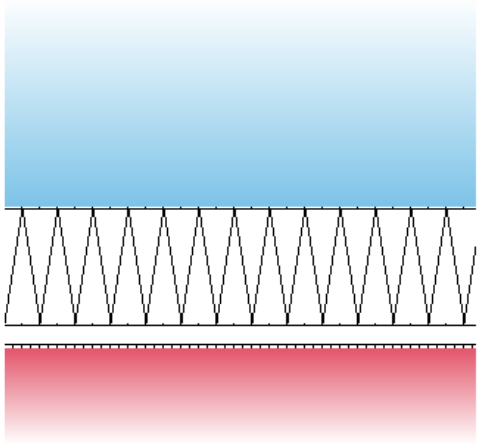
Documentation of the component
Calculation according BS EN ISO 13788
Source: **own catalogue - Pitched roofs**
Component: **Passive360PitchedRoof**

OUTSIDE



INSIDE

The list of material layers shown below may differ from those in the U-value calculation printout. Only material layers which are used in the Condensation Risk Analysis are listed.

This calculation of the Condensation risk analysis according to BS EN ISO 13788:2002 has been performed on a construction containing inhomogeneous layers. This calculation is only valid through the selected section. It is advisable that you should also select the alternative position and recalculate the Condensation Risk Analysis for a more complete assessment of the construction.

The CRA calculation for pitched roofs can be very unreliable and caution should be used when interpreting these results. For further guidance the user is advised to follow the recommendation of BS 5250:202 (currently under review).

Assignment: Pitched roof < 70°, with insulation between rafters

Name	Thickn. [m]	lambda [W/(mK)]	Q	μ [-]	Q	sd [m]	R [m²K/W]
Solitex PLUS	0.0007	0.100	E	45.00	E	0.03	0.0065
Dammstatt	0.2950	0.037	E	1.40	E	0.41	7.9730
INTELLO PLUS	0.0002	0.170	E	37500.00	E	7.50	0.0012
Unventilated air layer: 50 mm, upwards heat flow	0.0500	0.313	D	1.00	D	0.05	0.1597
Gyproc Wallboard	0.0150	0.190	D	10.00	D	0.15	0.0789

Q .. The physical values of the building materials has been graded by their level of quality. These 5 levels are the following
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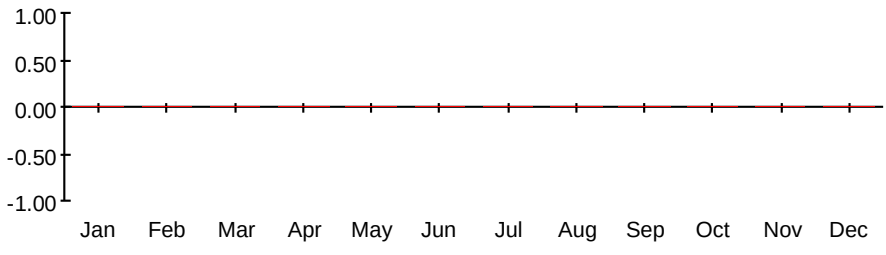
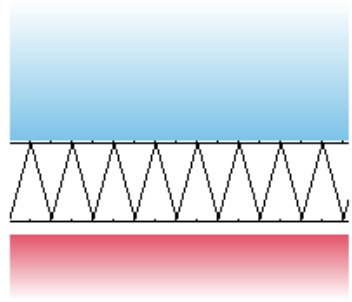
Condensation risk analysis - summary of main results
Calculation according BS EN ISO 13788

Surface temperature to avoid critical surface moisture:
No danger of mould growth is expected.

Interstitial condensation:
No condensation is predicted at any interface in any month.

Interstitial condensation and evaporation per month gc [g/m²]





Component, condensation range

CRA calculations according to BS EN ISO 13788:2002 are used as a guide in predicting interstitial condensation. This methodology uses some simplifications of the dynamic processes involved and subsequently does have some limitations. Further information can be found in Information Paper IP 2/05 'Modelling and controlling interstitial condensation in buildings" Feb 2005.

The CRA calculation for pitched roofs can be very unreliable and caution should be used when interpreting these results. For further guidance the user is advised to follow the recommendation of BS 5250:202 (currently under review).

Surface temperature to avoid critical surface humidity
Calculation according BS EN ISO 13788

Location: Galway/Gaillimh; Humidity class according BS EN ISO 13788 annex A: Dwellings with low occupancy

		1	2	3	4	5	6	7	8	9	10	11	12
	Month	Te [°C]	phi_e ---	Ti [°C]	phi_i ---	pe [Pa]	delta p [Pa]	pi [Pa]	ps(Tsi) [Pa]	Tsi,min [°C]	fRsi ---	Tsi [°C]	Tse [°C]
	January	5.1	0.870	20.0	0.611	764	664	1428	1785	15.7	0.712	19.6	5.2
	February	5.2	0.830	20.0	0.596	734	659	1393	1741	15.3	0.685	19.6	5.3
	March	6.7	0.820	20.0	0.598	804	593	1397	1746	15.4	0.652	19.6	6.8
	April	8.5	0.780	20.0	0.589	865	512	1378	1722	15.2	0.579	19.7	8.6
	May	10.8	0.770	20.0	0.602	997	410	1407	1758	15.5	0.509	19.7	10.8
	June	13.3	0.810	20.0	0.657	1237	298	1535	1919	16.9	0.530	19.8	13.3
	July	15.2	0.810	20.0	0.690	1398	214	1612	2015	17.6	0.506	19.9	15.2
	August	14.9	0.830	20.0	0.699	1406	227	1633	2041	17.8	0.575	19.9	14.9
	September	13.3	0.840	20.0	0.676	1282	298	1581	1976	17.3	0.600	19.8	13.3
	October	10.5	0.860	20.0	0.648	1091	423	1515	1893	16.6	0.647	19.7	10.5
	November	7.7	0.870	20.0	0.626	914	548	1462	1827	16.1	0.682	19.6	7.8
I	December	6.3	0.890	20.0	0.625	849	610	1460	1824	16.1	0.713	19.6	6.4

- The critical month is December with $f_{Rsi,max}$ = 0.713
  f_{Rsi} = 0.971

$f_{Rsi} > f_{Rsi,max}$, the component complies.

Nr Explanation

1 External temperature
2 External rel. humidity
3 Internal temperature
4 Internal relative humidity
5 External partial pressure $p_e = \phi_e * p_{sat}(T_e)$; $p_{sat}(T_e)$ according formula E.7 and E.8 of BS EN ISO 13788
6 Partial pressure difference. The security factor of 1.10 according to BS EN ISO 13788, ch.4.2.4 is already included.
7 Internal partial pressure $p_i = \phi_i * p_{sat}(T_i)$; $p_{sat}(T_i)$ according formula E.7 and E.8 of BS EN ISO 13788
8 Minimum saturation pressure on the surface obtained by $p_{sat}(T_{si}) = p_i / \phi_{si}$,
where ϕ_{si} = 0.8 (critical surface humidity)
9 Minimum surface temperature as function of $p_{sat}(T_{si})$, formula E.9 and E.10 of BS EN ISO 13788
10 Design temperature factor according 3.1.2 of BS EN ISO 13788
11 Internal surface temperature, obtained from $T_{si} = T_i - R_{si} * U * (T_i - T_e)$
12 External surface temperature, obtained from $T_{se} = T_e + R_{se} * U * (T_i - T_e)$

Interstitial condensation - main results
Calculation according BS EN ISO 13788

No condensation is predicted at any interface in any month.

Climcatic conditions
Location: Galway/Gaillimh; Humidity class according BS EN ISO 13788 annex A: Dwellings with low occupancy

		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Internal temperature [°C]	Ti	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Internal rel. humidity [%]	phi_i	61.1	59.6	59.8	58.9	60.2	65.7	69.0	69.9	67.6	64.8	62.6	62.5
External temperature [°C]	Te	5.1	5.2	6.7	8.5	10.8	13.3	15.2	14.9	13.3	10.5	7.7	6.3
External rel. humidity [%]	phi_e	87.0	83.0	82.0	78.0	77.0	81.0	81.0	83.0	84.0	86.0	87.0	89.0

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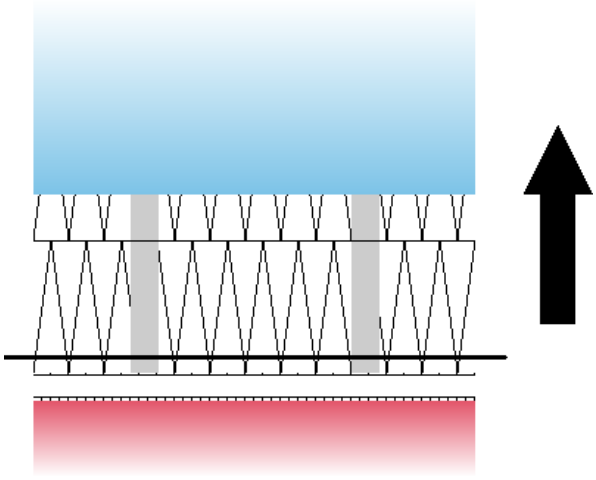
Documentation of the component
Heat capacity
Source: **own catalogue - Pitched roofs**
Component: **Passive360PitchedRoof**

OUTSIDE



INSIDE

The list of materials shown below may differ from those in the U-value calculation printout. Only material layers which are used in the heat capacity calculation are listed.

Single material layers shown in the U-value calculation printout may be separated to meet the exclusion criteria:

A .. The total thickness of the layers exceed 0.1 m.
B .. The mid point in the construction is reached.

For insulation layers the following criteria applies:

C .. An insulating layer is reached (defined as lambda <= 0.08 W/(mK)).

	Name	Thickness [m]	lambda [W/(mK)]	Q	Thermal capacity [kJ/(kgK)]	Q	Density [kg/m³]	Q	Thermal mass kJ/(m²K)	Criteria Exclusion
	End of calculation - Cold									
1	Tiles (roofing), clay	0.0200	1.000	D	0.80	D	2000.0	D	~~32.0~~	A, -, C
2	Inhomogeneous material layer consisting of:	0.0300							~~2.6~~	A, -, C
2a	Well ventilated air layer	89.00%	0.000	D	1.01	D	1.2	D	~~0.0~~	A, -, C
2b	Softwood Timber [500 kg/m³]	11.00%	0.130	D	1.60	D	500.0	D	~~2.6~~	A, -, C
3	Inhomogeneous material layer consisting of:	0.0500							~~4.8~~	A, -, C
3a	Well ventilated air layer	88.00%	0.000	D	1.01	D	1.2	D	~~0.1~~	A, -, C
3b	Softwood Timber [500 kg/m³]	12.00%	0.130	D	1.60	D	500.0	D	~~4.8~~	A, -, C
4	Solitex PLUS	0.0007	0.100	E	1.70	E	375.0	E	~~0.4~~	A, -, C
5	Inhomogeneous material layer consisting of:	0.2602							~~25.0~~	A, -, C
5a	Dammstatt	88.00%	0.037	E	2.10	E	55.0	E	~~26.4~~	A, -, C
5b	Softwood Timber [500 kg/m³]	12.00%	0.130	D	1.60	D	500.0	D	~~25.0~~	A, -, C
5	Inhomogeneous material layer consisting of:	0.0348							3.3	-, -, -
5a	Dammstatt	88.00%	0.037	E	2.10	E	55.0	E	~~3.5~~	-, -, C
5b	Softwood Timber [500 kg/m³]	12.00%	0.130	D	1.60	D	500.0	D	3.3	-, -, -
6	INTELLO PLUS	0.0002	0.170	E	1.00	E	625.0	E	0.1	-, -, -
7	Inhomogeneous material layer consisting of:	0.0500							4.5	-, -, -
7a	Unventilated air layer: 50 mm, upwards heat flow	89.00%	0.313	D	1.01	D	1.2	D	0.1	-, -, -
7b	Softwood Timber [500 kg/m³]	11.00%	0.130	D	1.60	D	500.0	D	4.4	-, -, -
8	Gyproc Wallboard	0.0150	0.190	D	1.00	D	680.0	D	10.2	-, -, -
	Start of calculation - Warm									
		0.4609							**18.1**	

Heat capacity = 18.1 kJ/(m²K)

The following exclusion criteria apply:
A .. The total thickness of the layers exceed 0.1 m.
C .. An insulating layer is reached (defined as lambda <= 0.08 W/(mK)).

Q .. The physical values of the building materials has been graded by their level of quality. These 5 levels are the following
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