Documentation of the component
Thermal transmittance (U-value) according to BS EN ISO 6946
Source: **own catalogue - Future SIPs wall systems**
Component: **Future SIPS Wall - 150mm EPS and 25mm PIR**

OUTSIDE INSIDE

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.

Assignment: External wall

		Manufacturer	Name	Thickness [m], number	Lambda [W/(mK)]	Q	R [m²K/W]
		Rse					0.0400
☐	1	BS EN 12524	Hardwood Timber [700 kg/m³]	0.0250	0.180	D	~~0.1389~~
☑	2	Inhomogeneous material layer	consisting of:	0.0250	ø 0.137		0.1822
	2a	BS EN ISO 6946	Unventilated air layer: 25 mm, horiz. heat flow	80.00 %	0.139	D	-
	2b	BS EN 12524	Softwood Timber [500 kg/m³]	20.00 %	0.130	D	-
☑	3	Klober Ltd	Klober Permo Easy Breather Membrane	0.0003	0.100	D	0.0030
☑	4	BS EN 12524	Oriented strand board (OSB)	0.0150	0.130	D	0.1154
☑	5	Inhomogeneous material layer	consisting of:	0.1500	ø 0.045		3.3437
	5a	Lambdatherm Grey EPS Air gaps	Expanded polystyrene (EPS) - Variable thickness Level 1: dU'' = 0.01 W/(m²K)	86.00 %	0.031	E	-
	5b	BS EN 12524	Softwood Timber [500 kg/m³]	14.00 %	0.130	D	-
☑	6	BS EN 12524	Oriented strand board (OSB)	0.0150	0.130	D	0.1154
☑	7	Generic Building Materials Air gaps	Polyisocyanurate (PIR) - General Purpose Level 0: dU'' = 0.00 W/(m²K)	0.0250	0.020	D	1.2500
☑	8	Visqueen Building Products	Visqueen Vapour Barrier	0.0001	0.330	D	0.0004
☑	9	Inhomogeneous material layer	consisting of:	0.0250	ø 0.137		0.1822
	9a	BS EN ISO 6946	Unventilated air layer: 25 mm, horiz. heat flow	80.00 %	0.139	D	-
	9b	BS EN 12524	Softwood Timber [500 kg/m³]	20.00 %	0.130	D	-
☑	10	Knauf Drywall	Knauf Wallboard	0.0095	0.160	D	0.0594
		Rsi					0.1300
				0.2899			

☐ was not taken into consideration in the calculation

$R_T = (R_T' + R_T'')/2 = 5.69$ m²K/W

Correction to U-value for	according to	delta U [W/(m²K)]
Air gaps	BS EN ISO 6946 Annex F	~~0.0034~~

Air gaps and fixings corrections need not be applied, as their total effect is less than 3% (Annex D BS 6946:1996).

0.0000

$U = 1/R_T + \Sigma\Delta U = 0.18$ W/(m²K)

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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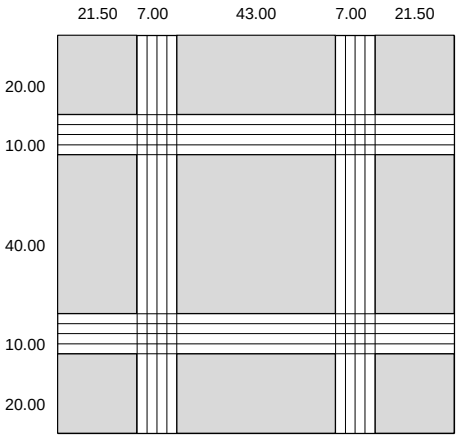
Source: **own catalogue - Future SIPs wall systems**
Component: **Future SIPS Wall - 150mm EPS and 25mm PIR**

Draft of the component (portion in %):



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

A	4.30 + 8.60 + 4.30 + 8.60 + 17.20 + 8.60 + 4.30 + 8.60 + 4.30 consisting of material layers: 2a, 3, 4, 5a, 6, 7, 8, 9a, 10	= 68.80%
B	1.40 + 2.80 + 1.40 + 1.40 + 2.80 + 1.40 consisting of material layers: 2b, 3, 4, 5a, 6, 7, 8, 9b, 10	= 11.20%
C	2.15 + 4.30 + 2.15 + 2.15 + 4.30 + 2.15 consisting of material layers: 2a, 3, 4, 5b, 6, 7, 8, 9a, 10	= 17.20%
D	0.70 + 0.70 + 0.70 + 0.70 consisting of material layers: 2b, 3, 4, 5b, 6, 7, 8, 9b, 10	= 2.80%

Upper limit of the thermal transfer resistance R

$$U_A\ [W/(m^2K)] = \frac{1}{(\Sigma R_{i,A}) + R_{si} + R_{se}} = \frac{1}{6.74 + 0.13 + 0.04} = 0.14$$

$$U_B\ [W/(m^2K)] = \frac{1}{(\Sigma R_{i,B}) + R_{si} + R_{se}} = \frac{1}{3.06 + 0.13 + 0.04} = 0.31$$

$$U_C\ [W/(m^2K)] = \frac{1}{(\Sigma R_{i,C}) + R_{si} + R_{se}} = \frac{1}{6.77 + 0.13 + 0.04} = 0.14$$

$$U_D\ [W/(m^2K)] = \frac{1}{(\Sigma R_{i,D}) + R_{si} + R_{se}} = \frac{1}{3.08 + 0.13 + 0.04} = 0.31$$

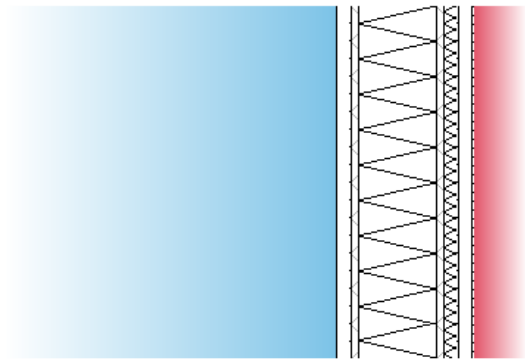
$$R_T' = \frac{1}{A * U_A + B * U_B + C * U_C + D * U_D} = 5.96\ m^2K/W$$

Lower limit of the thermal transfer resistance R

R_{se} [m²K/W]		= 0.04
R_2'' [m²K/W] = $d_2/(\lambda_{2a} * (A + B) + \lambda_{2b} * (C + D))$ =	0.0250 /(0.139 * 80.00% + 0.130 * 20.00%)	= 0.18
R_3'' [m²K/W] = d_3/λ_3 =	0.0003 / 0.100	= 0.00
R_4'' [m²K/W] = d_4/λ_4 =	0.0150 / 0.130	= 0.12
R_5'' [m²K/W] = $d_5/(\lambda_{5a} * (A + C) + \lambda_{5b} * (B + D))$ =	0.1500 /(0.031 * 86.00% + 0.130 * 14.00%)	= 3.34
R_6'' [m²K/W] = d_6/λ_6 =	0.0150 / 0.130	= 0.12
R_7'' [m²K/W] = d_7/λ_7 =	0.0250 / 0.020	= 1.25
R_8'' [m²K/W] = d_8/λ_8 =	0.0001 / 0.330	= 0.00
R_9'' [m²K/W] = $d_9/(\lambda_{9a} * (A + B) + \lambda_{9b} * (C + D))$ =	0.0250 /(0.139 * 80.00% + 0.130 * 20.00%)	= 0.18
R_{10}'' [m²K/W] = d_{10}/λ_{10} =	0.0095 / 0.160	= 0.06
R_{si} [m²K/W]		= 0.13

$$R_T'' = \Sigma R_i'' + R_{si} + R_{se} = 5.42\ m^2K/W$$

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 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. For further information the user is advised to follow the guidance in BS 5250:2021 Management of moisture in buildings

Assignment: External wall

Name	Thickn. [m]	lambda [W/(mK)]	Q	μ [-]	Q	sd [m]	R [m²K/W]
Unventilated air layer: 25 mm, horiz. heat flow	0.0250	0.139	D	1.00	D	0.03	0.1799
Klober Permo Easy Breather Membrane	0.0003	0.100	D	67.00	C	0.02	0.0030
Oriented strand board (OSB)	0.0150	0.130	D	30.00	D	0.45	0.1154
Expanded polystyrene (EPS) - Variable thickness	0.1500	0.031	E	20.00	E	3.00	4.8387
Oriented strand board (OSB)	0.0150	0.130	D	30.00	D	0.45	0.1154
Polyisocyanurate (PIR) - General Purpose	0.0250	0.020	D	50.00	D	1.25	1.2500
Visqueen Vapour Barrier	0.0001	0.330	D	333333.0 0	D	40.00	0.0004
Unventilated air layer: 25 mm, horiz. heat flow	0.0250	0.139	D	1.00	D	0.03	0.1799
Knauf Wallboard	0.0095	0.160	D	4.00	D	0.04	0.0594

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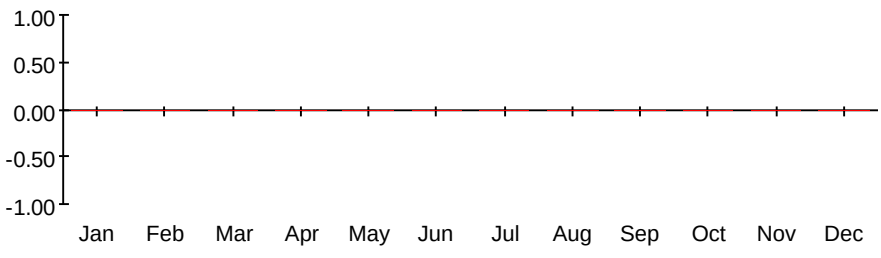
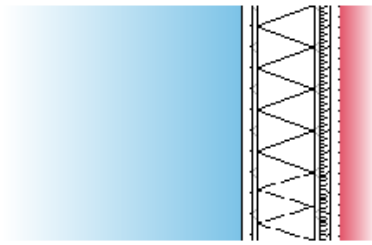
Condensation risk analysis - summary of main results
Calculation according BS EN ISO 13788

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

Condensation Risk Analysis calculations according to BS EN ISO 13788 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. For further information the user is advised to follow the prescriptive guidance in BS 5250:2021 Management of moisture in buildings – Code of practice & BRE Information Paper:IP2/O5 (Feb. 2005) 'Modelling and controlling interstitial condensation

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

Location: Manchester Airport; Humidity class according BS EN ISO 13788 annex A: legacy; Dwellings with high occupancy; Return period according BS 5250:2021 No Corrections

		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]
I	January	4.2	0.830	20.0	0.694	684	939	1623	2028	17.7	0.857	19.4	4.3
	February	4.1	0.800	20.0	0.684	655	944	1599	1999	17.5	0.843	19.4	4.2
	March	5.8	0.760	20.0	0.661	701	843	1544	1930	16.9	0.785	19.5	5.9
	April	7.8	0.710	20.0	0.631	751	725	1476	1845	16.2	0.691	19.6	7.9
	May	11.3	0.680	20.0	0.611	910	517	1427	1784	15.7	0.507	19.7	11.3
	June	14.1	0.710	20.0	0.639	1142	350	1492	1865	16.4	0.391	19.8	14.1
	July	16.1	0.720	20.0	0.663	1317	232	1548	1936	17.0	0.229	19.9	16.1
	August	15.8	0.740	20.0	0.675	1328	249	1577	1971	17.3	0.353	19.9	15.8
	September	13.3	0.770	20.0	0.673	1175	398	1573	1967	17.2	0.589	19.8	13.3
	October	10.3	0.810	20.0	0.681	1014	576	1590	1988	17.4	0.733	19.7	10.4
	November	6.7	0.820	20.0	0.682	804	790	1594	1993	17.5	0.808	19.5	6.8
	December	5.2	0.840	20.0	0.694	743	879	1622	2027	17.7	0.846	19.5	5.3

- The critical month is January with $f_{Rsi,max}$ = 0.857
  f_{Rsi} = 0.964

$f_{Rsi} > f_{Rsi,max}$, 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.

Climatic conditions
Location: Manchester Airport; Humidity class according BS EN ISO 13788 annex A: legacy; Dwellings with high occupancy; Return period according BS 5250:2021 No Corrections

		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	69.4	68.4	66.1	63.1	61.1	63.9	66.3	67.5	67.3	68.1	68.2	69.4
External temperature [°C]	Te	4.2	4.1	5.8	7.8	11.3	14.1	16.1	15.8	13.3	10.3	6.7	5.2
External rel. humidity [%]	phi_e	83.0	80.0	76.0	71.0	68.0	71.0	72.0	74.0	77.0	81.0	82.0	84.0

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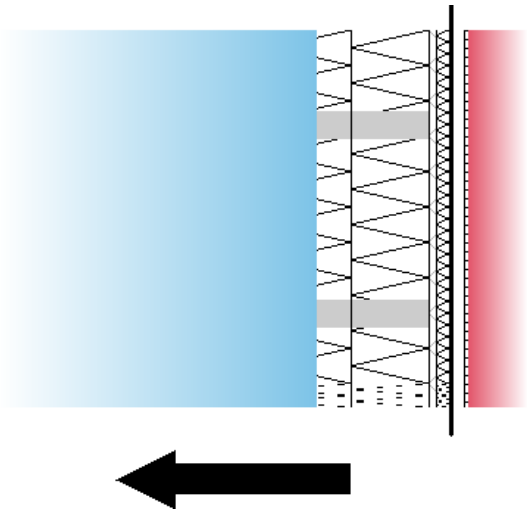
Component: **Future SIPS Wall - 150mm EPS and 25mm PIR**

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	Hardwood Timber [700 kg/m³]	0.0250	0.180	D	1.60	D	700.0	D	~~28.0~~	A, -, C
2	Inhomogeneous material layer consisting of:	0.0250							~~4.0~~	A, -, C
2a	Unventilated air layer: 25 mm, horiz. heat flow	80.00%	0.139	D	1.01	D	1.2	D	~~0.0~~	A, -, C
2b	Softwood Timber [500 kg/m³]	20.00%	0.130	D	1.60	D	500.0	D	~~4.0~~	A, -, -
3	Klober Permo Easy Breather Membrane	0.0003	0.100	D	1.45	D	416.0	D	~~0.2~~	A, -, C
4	Oriented strand board (OSB)	0.0150	0.130	D	1.70	D	650.0	D	~~16.6~~	A, -, C
5	Inhomogeneous material layer consisting of:	0.1246							~~14.0~~	A, -, C
5a	Expanded polystyrene (EPS) - Variable thickness	86.00%	0.031	E	1.45	E	15.0	E	~~2.3~~	A, -, C
5b	Softwood Timber [500 kg/m³]	14.00%	0.130	D	1.60	D	500.0	D	~~14.0~~	A, -, -
5	Inhomogeneous material layer consisting of:	0.0254							~~2.8~~	-, -, C
5a	Expanded polystyrene (EPS) - Variable thickness	86.00%	0.031	E	1.45	E	15.0	E	~~0.5~~	-, -, C
5b	Softwood Timber [500 kg/m³]	14.00%	0.130	D	1.60	D	500.0	D	2.8	-, -, -
6	Oriented strand board (OSB)	0.0150	0.130	D	1.70	D	650.0	D	~~16.6~~	-, -, C
7	Polyisocyanurate (PIR) - General Purpose	0.0250	0.020	D	0.92	D	32.0	D	~~0.0~~	-, -, C
8	Visqueen Vapour Barrier	0.0001	0.330	D	2.20	D	920.0	D	0.2	-, -, -
9	Inhomogeneous material layer consisting of:	0.0250							4.0	-, -, -
9a	Unventilated air layer: 25 mm, horiz. heat flow	80.00%	0.139	D	1.01	D	1.2	D	0.0	-, -, -
9b	Softwood Timber [500 kg/m³]	20.00%	0.130	D	1.60	D	500.0	D	4.0	-, -, -
10	Knauf Wallboard	0.0095	0.160	D	1.00	D	650.0	D	6.2	-, -, -
	Start of calculation - Warm									
		0.2899							**10.4**	

Heat capacity = 10.4 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)).

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