Straw Biobuilds

Exterior wall
created on 26.4.2019

Thermal protection

U = 0,103 W/(m²K)

EnEV Bestand*: U<0,24 W/(m²K)

excellent insufficient

Moisture proofing

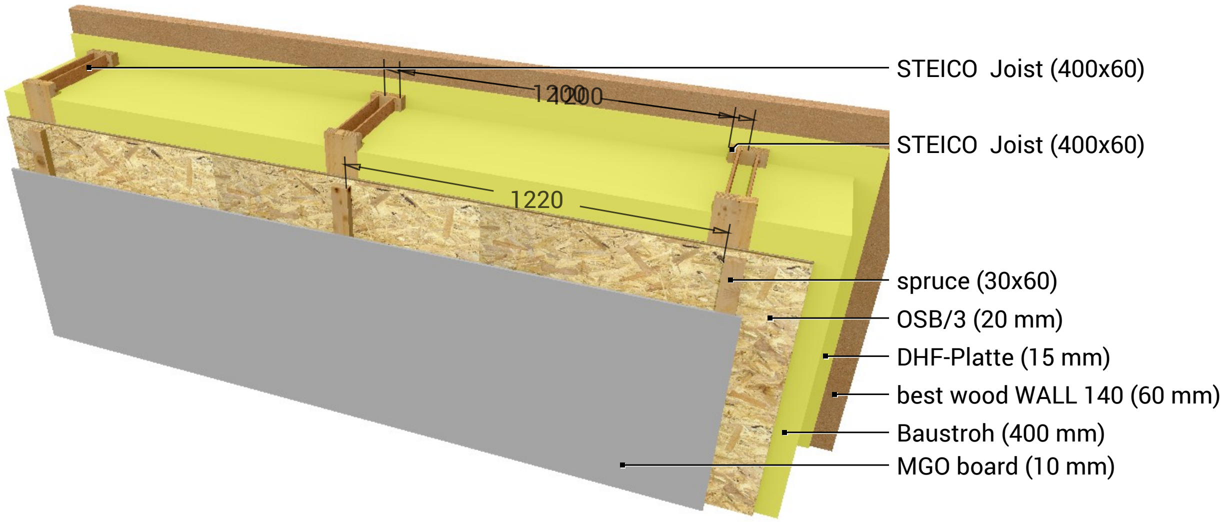
Drying reserve: 1535 g/m²a
No condensate

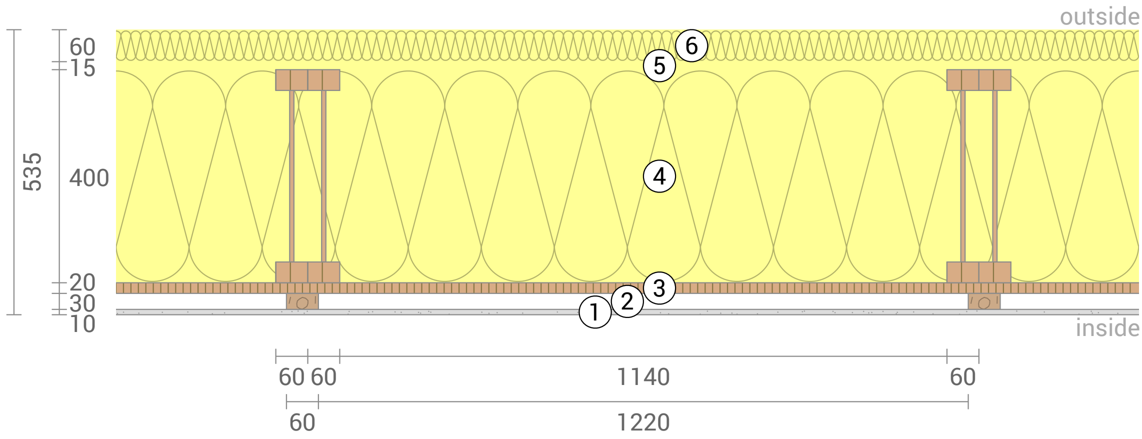
excellent insufficient

Heat protection

Temperature amplitude damping: >100
phase shift: non relevant
Thermal capacity inside: 85 kJ/m²K

excellent insufficient





1. MGO board (10 mm)
2. Installation level (30 mm)
3. OSB/3 (20 mm)
4. Baustroh (400 mm)
5. DHF-Platte (15 mm)
6. best wood WALL 140 (60 mm)

Inside air :	20,0°C / 50%			Thickness:	53,5 cm
Outside air:	-15,0°C / 90%	sd-value:	4,6 m	Weight:	89 kg/m²
Surface temperature.:	18,9°C / -14,9°C	Drying reserve:	1535 g/m²a	Heat capacity:	148 kJ/m²K

☑ EnEV Bestand ☑ EnEV16 Neubau ☑ EnEV14 Neubau ☑ EnEV Bestand (Nichtwohngeb.)

*Comparison of the U-value with den Höchstwerten aus EnEV 2014 Anlage 3 Tabelle 1 (EnEV Bestand); den Höchstwerten aus EnEV 2014 Anlage 3 Tabelle 1 (EnEV Bestand, niedrige InnenTemp.); 80% des U-Werts der Referenzausführung aus EnEV 2014 Anlage 1 Tabelle 1 (EnEV16 Neubau); der Referenzausführung aus EnEV 2014 Anlage 1 Tabelle 1 (EnEV14 Neubau)

Straw Biobuilds, U=0,103 W/(m²K)

U-Value calculation according to DIN EN ISO 6946

#	Material	Dicke [cm]	λ [W/mK]	R [m²K/W]
	Thermal contact resistance inside (Rsi)			0,130
1	MGO board	1,00	0,640	0,016
2	Installation level	3,00	0,167	0,180
	spruce (4,7%)	3,00	0,130	0,231
3	OSB/3	2,00	0,130	0,154
4	Baustroh	40,00	0,049	8,163
	Hartfasersteg (Width: 0,8 cm)	32,20	0,308	1,045
	Furnierschichtholzgurt (Width: 6 cm)	3,90	0,130	0,300
	Furnierschichtholzgurt (Width: 6 cm)	3,90	0,130	0,300
	Hartfasersteg (Width: 0,8 cm)	32,20	0,308	1,045
	Furnierschichtholzgurt (Width: 6 cm)	3,90	0,130	0,300
	Furnierschichtholzgurt (Width: 6 cm)	3,90	0,130	0,300
5	DHF-Platte	1,50	0,100	0,150
6	best wood WALL 140	6,00	0,042	1,429
	Thermal contact resistance outside (Rse)			0,040
	Whole component	53,5		

Thermal contact resistances have been taken from DIN 6946 Table 7.
Rsi: heat flow direction horizontally
Rse: heat flow direction horizontally, outside: Direct contact to outside air

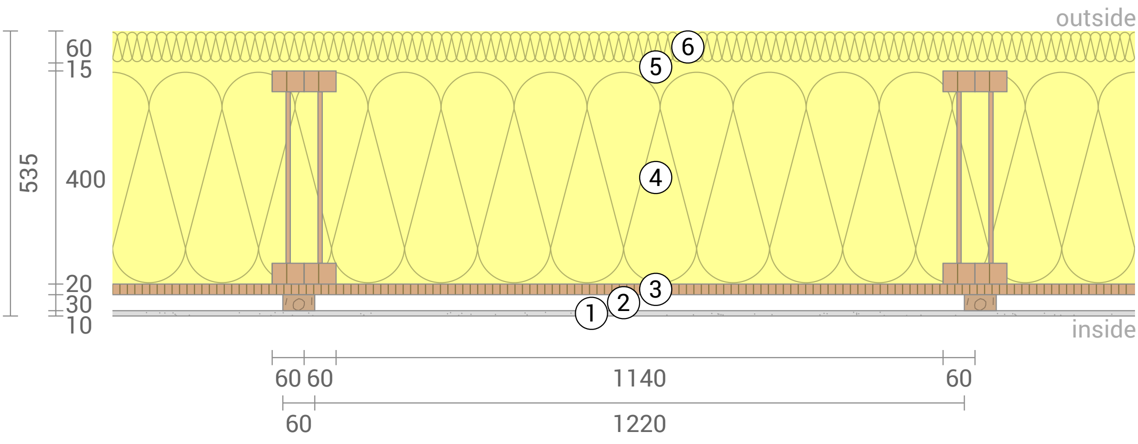
Upper limit of thermal resistance $R_{tot;upper}$ = 9,963 m²K/W.
Lower limit of thermal resistance $R_{tot;lower}$ = 9,642 m²K/W.
Check applicability: $R_{tot;upper}$ / $R_{tot;lower}$ = 1,033 (maximum allowed: 1,5)

The procedure may be used.

Thermal resistance R_{tot} = ($R_{tot;upper}$ + $R_{tot;lower}$)/2 = 9,802 m²K/W
Estimated maximum relative uncertainty according to section 6.7.2.5: 1,6%

Heat transfer coefficient U = 1/R_{tot} = **0,10 W/(m²K)**

This component includes several inhomogeneous layers of different overall width. For all the calculations it was assumed that the layer arrangement is repeated in width all 128 cm. This, however, is not true for at least layer 4 with a total width of 126 cm and can cause increased inaccuracy of the U-value.

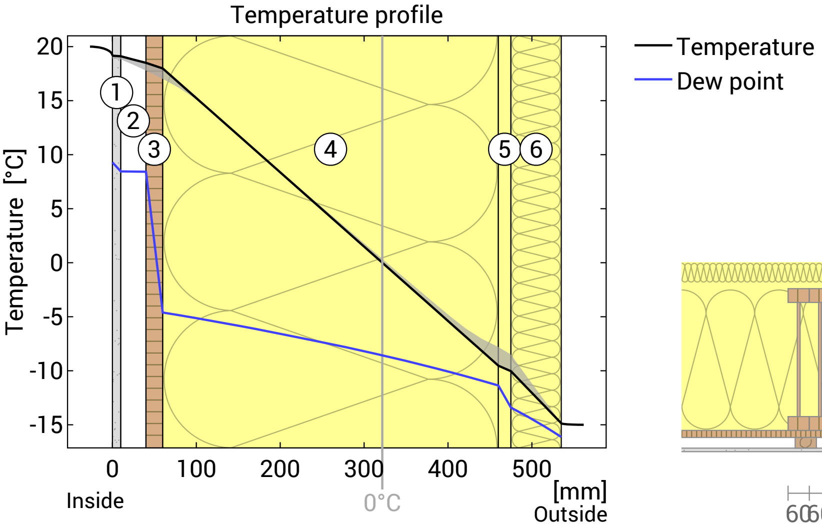


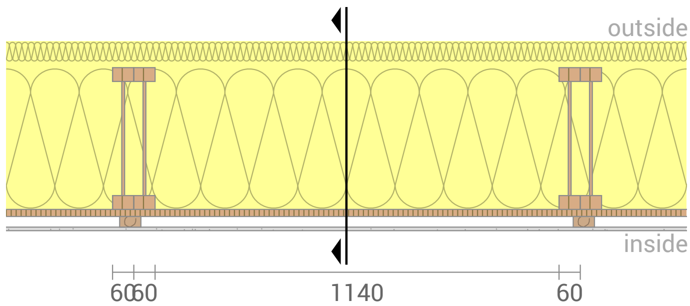
Yearly heat loss

Heat loss due to this component: 8,0 kWh per m² and heating period (approx. 0,79 liter of heating oil per m²)

Calculated for the location DIN V 18599, heating period from Mid of October to End of April. The calculation is based on monthly average temperatures. Source: DIN V 18599-10:2007-02
Note: The climate and energy data underlying this calculation vary and may deviate considerably from the actual value in some cases.

Temperature profile





① MGO board (10 mm)
② Installation level (30 mm)
③ OSB/3 (20 mm)
④ Baustroh (400 mm)
⑤ DHF-Platte (15 mm)
⑥ best wood WALL 140 (60 mm)

Left: Temperature and dew-point temperature at the place marked in the right figure. The dew-point indicates the temperature, at which water vapour condensates. As long as the temperature of the component is everywhere above the dew point, no condensation occurs. If the curves have contact, condensation occurs at the corresponding position.
Right: The component, drawn to scale.

Layers (from inside to outside)

#		Material	λ [W/mK]	R [m²K/W]	Temperatur [°C] min	max	Weight [kg/m²]
		Thermal contact resistance*		0,250	18,9	20,0	
1	1 cm	MGO board	0,640	0,016	18,8	19,2	10,0
2	3 cm	Installation level	0,167	0,180	17,8	19,1	0,0
	3 cm	spruce (4,7%)	0,130	0,231	17,8	18,9	0,8
3	2 cm	OSB/3	0,130	0,154	17,0	18,5	12,4
4	40 cm	Baustroh	0,049	8,163	-9,5	18,0	38,5
	32,2 cm	Hartfasersteg (Width: 0,8 cm)	0,308	1,045	-6,1	15,2	2,4
	3,9 cm	Furnierschichtholzgurt (Width: 6 cm)	0,130	0,300	15,2	17,3	1,2
	3,9 cm	Furnierschichtholzgurt (Width: 6 cm)	0,130	0,300	-8,2	-6,1	1,2
	32,2 cm	Hartfasersteg (Width: 0,8 cm)	0,308	1,045	-6,1	15,2	2,4
	3,9 cm	Furnierschichtholzgurt (Width: 6 cm)	0,130	0,300	15,2	17,3	1,2
	3,9 cm	Furnierschichtholzgurt (Width: 6 cm)	0,130	0,300	-8,1	-6,1	1,2
5	1,5 cm	DHF-Platte	0,100	0,150	-10,0	-7,8	9,0
6	6 cm	best wood WALL 140	0,042	1,429	-14,9	-8,5	8,4
		Thermal contact resistance*		0,040	-15,0	-14,8	
	53,5 cm	Whole component		9,723			88,6

*Thermal contact resistances according to DIN 4108-3 for moisture protection and temperature profile. The values for the U-value calculation can be found on the page 'U-value calculation'.

Surface temperature inside (min / average / max):	18,9°C	19,1°C	19,2°C
Surface temperature outside (min / average / max):	-14,9°C	-14,9°C	-14,8°C

Moisture proofing

For the calculation of the amount of condensation water, the component was exposed to the following constant climate for 90 days: inside: 20°C und 50% Humidity; outside: -15°C und 90% Humidity (Climate according to user input).

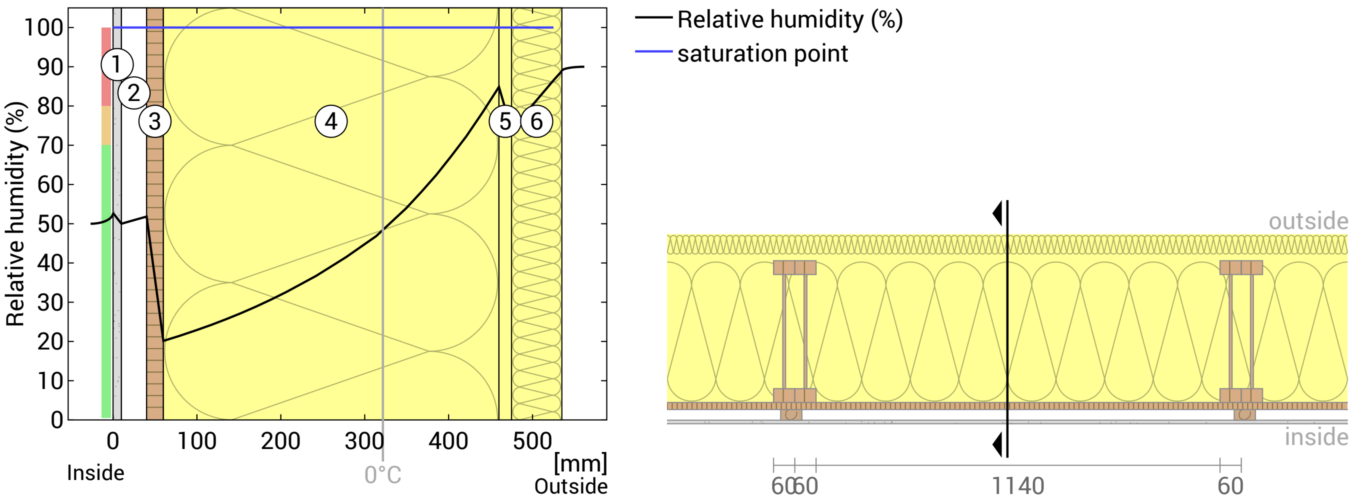
This component is free of condensate under the given climate conditions.

Drying reserve according to DIN 4108-3:2014: 1535 g/(m²a)
At least required by DIN 68800-2: 100 g/(m²a)

#		Material	sd-value [m]	Condensate [kg/m²]	Condensate [Gew.-%]	Weight [kg/m²]
1	1 cm	MGO board	0,28	-		10,0
2	3 cm	Installation level	0,01	-		0,0
	3 cm	spruce (4,7%)	0,60	-	-	0,8
3	2 cm	OSB/3	3,00	-	-	12,4
4	40 cm	Baustroh	0,80	-		38,5
	32,2 cm	Hartfasersteg (Width: 0,8 cm)	3,22	-	-	2,4
	3,9 cm	Furnierschichtholzgurt (Width: 6 cm)	0,78	-	-	1,2
	3,9 cm	Furnierschichtholzgurt (Width: 6 cm)	1,95	-	-	1,2
	32,2 cm	Hartfasersteg (Width: 0,8 cm)	3,22	-	-	2,4
	3,9 cm	Furnierschichtholzgurt (Width: 6 cm)	0,78	-	-	1,2
	3,9 cm	Furnierschichtholzgurt (Width: 6 cm)	1,95	-	-	1,2
5	1,5 cm	DHF-Platte	0,17	-		9,0
6	6 cm	best wood WALL 140	0,18	-		8,4
	53,5 cm	Whole component	4,60			88,6

Humidity

The temperature of the inside surface is 18,9 °C leading to a relative humidity on the surface of 54%.Mould formation is not expected under these conditions.
The following figure shows the relative humidity inside the component.



① MGO board (10 mm)
② Installation level (30 mm)
③ OSB/3 (20 mm)
④ Baustroh (400 mm)
⑤ DHF-Platte (15 mm)
⑥ best wood WALL 140 (60 mm)

Notes: Calculation using the Ubakus 2D-FE method. Convection and the capillarity of the building materials were not considered. The drying time may take longer under unfavorable conditions (shading, damp / cool summers) than calculated here.

Moisture protection in accordance with DIN 4108-3:2014 Appendix A

The temperatures and / or humidities you specified are not in accordance with DIN 4108-3. This analysis was carried out with the values specified by DIN 4108-3: 20°C / 50% humidity inside and -5°C / 80% humidity outside.

This moisture proofing is only valid for **non-air-conditioned** residential buildings.

Please note the hints at the end of these moisture proofing calculations.

#		Material	λ [W/mK]	R [m²K/W]	sd [m]	ρ [kg/m³]
		Thermal contact resistance		0,250		
1	1 cm	MGO board	0,640	0,016	0,28	1000
2	3 cm	Installation level	0,167	0,180	0,01	1
3	2 cm	OSB/3	0,130	0,154	3	620
4	40 cm	Baustroh	0,049	8,163	0,8	100
5	1,5 cm	DHF-Platte	0,100	0,150	0,17	600
6	6 cm	best wood WALL 140	0,042	1,429	0,18	140
		Thermal contact resistance		0,040		

T [°C]	ps [Pa]	∑sd [m]
19,40	2252	0
19,36	2247	0,28
18,93	2186	0,29
18,56	2137	3,29
-1,10	557	4,09
-1,46	541	4,26
-4,90	404	4,44

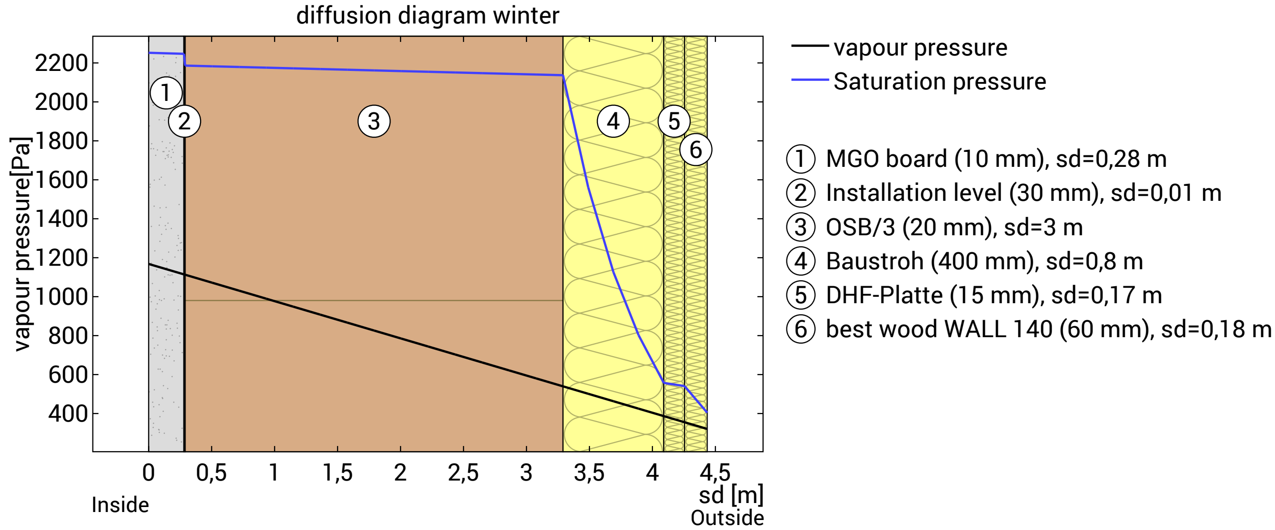
Temperature (T), vapor saturation pressure (ps), and the sum of the sd-values (Σsd) apply to the layer boundary.

Relative air humidity on the surface

The relative humidity on the interior surface is 52%. Requirements for the prevention of building material corrosion depend on material and coating and have not been investigated. ✓

Dew period (winter)

Boundary conditions	
Vapor pressure inside at 20°C and 50% humidity	pi = 1168 Pa
Vapor pressure outside at -5°C and 80% humidity	pe = 321 Pa
Duration of condensation period (90 days)	tc = 7776000 s
Water vapor diffusion coefficient in static air	δ0 = 2.0E-10 kg/(m*s*Pa)
sd-value (Whole component.)	sde = 4,44 m



The section under investigation is free of condensate under the given climate conditions. ✓

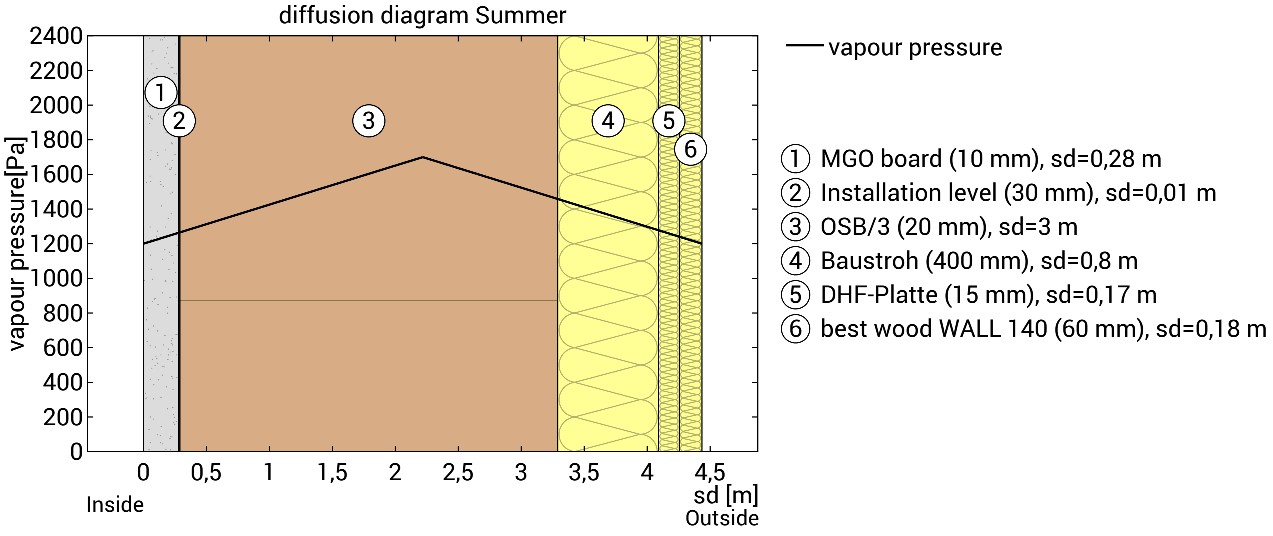
Calculate evaporation potential for the drying reserve in the dew period for the plane with the lowest evaporation potential:
sd=4,09 m; x=46 cm; ps=557 pa:
Layer boundary between Baustroh and DHF-Platte

$M_{ev,Tauperiode} = tc \cdot \delta 0 \cdot ((ps-pi)/sd_{ev} + (ps-pe)/(sd_e-sd_{ev}))$ = **0,833 kg/m²**

Straw Biobuilds, U=0,103 W/(m²K)

Evaporation period (summer)

Boundary conditions	
Interior vapor pressure	pi = 1200 Pa
Exterior vapor pressure	pe = 1200 Pa
Saturation vapour pressure in the condensation area	ps = 1700 Pa
Length of drying season (90 days)	tev = 7776000 s
sd-values remain unchanged.	



Condensate-free component: The maximum possible evaporation mass for the drying reserve is calculated. Considering the plane with the lowest evaporation mass within the wood-containing area:
at sd=2,22 m, within layer OSB/3:
Evaporation mass: Mev = δ0 * tev * [(ps-pi)/sd + (ps-pe)/(sde-sd)] = **0,70 kg/m²**

Evaluation according to DIN 4108-3

The component is permissible regarding the moisture protection.

Drying reserve (DIN 68800-2)

Dew-water-free component: The evaporation potential of the dew period is also taken into account.
Drying reserve: Mr = (Mev + Mev,Tauperiode) * 1000 = **1535 g/m²/a**
Minimum requested for walls and ceilings: 100 g/m²/a

✓

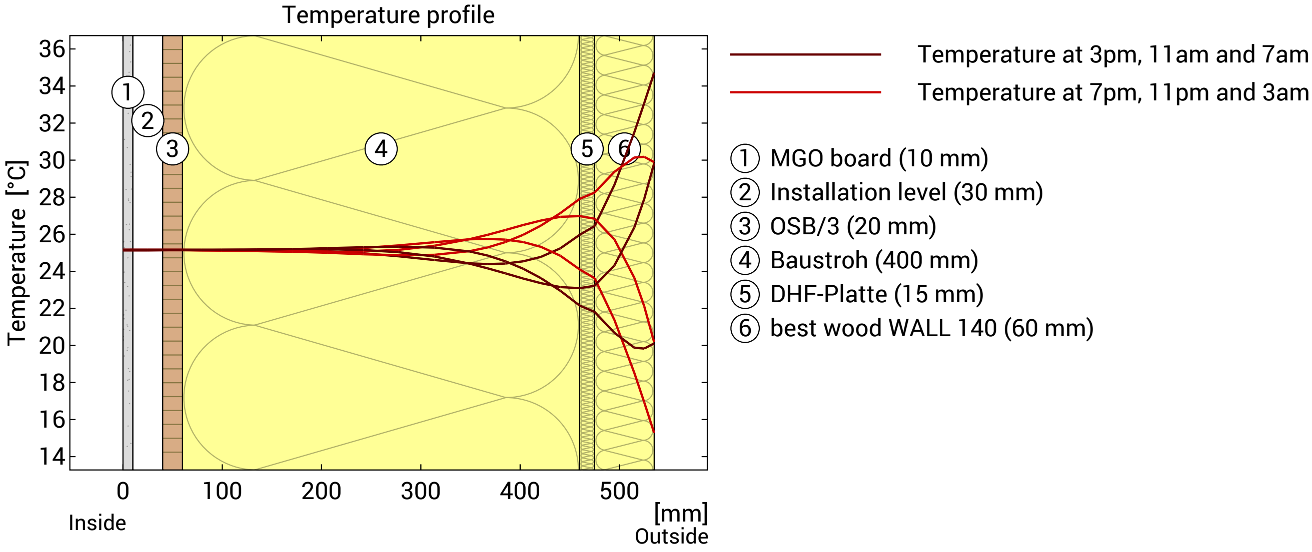
Hints

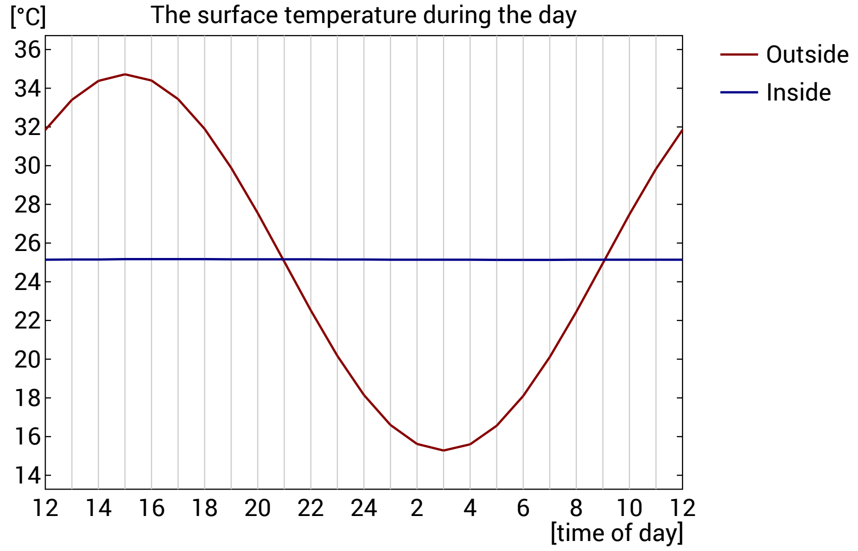
In the case of inhomogeneous constructions, such as skeleton-, stand- or frame constructions, as well as in wooden beam, rafter or half-timbered constructions or the like, the one-dimensional diffusion calculations are only to be demonstrated for the compartment area. Exceptional cases are special constructions in which, for example, The diffusion-inhibiting layer is also laid section-wise over the outer area. In these exceptional cases, the calculation performed here is invalid.

DIN 4108-3 describes in Section 5.3 components for which no moisture proofing is required as there is no risk of condensation water or the method is not suitable for the assessment. It is not possible to assess whether the component under test is underneath.

Heat protection

The following results are properties of the tested component alone and do not make any statement about the heat protection of the entire room:





Top: Temperature profile within the component at different times. From top to bottom, brown lines: at 3 pm, 11 am and 7 am and red lines at 7 pm , 11 pm and 3 am.
Bottom: Temperature on the outer (red) and inner (blue) surface in the course of a day. The arrows indicate the location of the temperature maximum values . The maximum of the inner surface temperature should preferably occur during the second half of the night.

Phase shift*	non relevant	Heat storage capacity (whole component):	148 kJ/m²K
Amplitude attenuation **	>100	Thermal capacity of inner layers:	85 kJ/m²K
TAV ***	0,002		

* The phase shift is the time in hours after which the temperature peak of the afternoon reaches the component interior.
** The amplitude attenuation describes the attenuation of the temperature wave when passing through the component. A value of 10 means that the temperature on the outside varies 10x stronger than on the inside, e.g. outside 15-35 °C, inside 24-26 °C.
*** The temperature amplitude ratio TAV is the reciprocal of the attenuation: TAV = 1 / amplitude attenuation

Note: The heat protection of a room is influenced by several factors, but essentially by the direct solar radiation through windows and the total amount of heat storage capacity (including floor, interior walls and furniture). A single component usually has only a very small influence on the heat protection of the room.

The calculations presented above have been created for a 1-dimensional cross-section of the component.

Hints

Layers of unequal width

This component includes several inhomogeneous layers of different overall width. For all the calculations it was assumed that the layer arrangement is repeated in width all 128 cm. This, however, is not true for at least layer 4 with a total width of 126 cm and can cause increased inaccuracy of the U-value.