

# Wohnhauses mit 4 roof

Roof construction  
created on 2.10.2024

## Thermal protection

$U = 0,12 \text{ W}/(\text{m}^2\text{K})$

GEG 2020/24 Bestand\*:  $U < 0,24 \text{ W}/(\text{m}^2\text{K})$



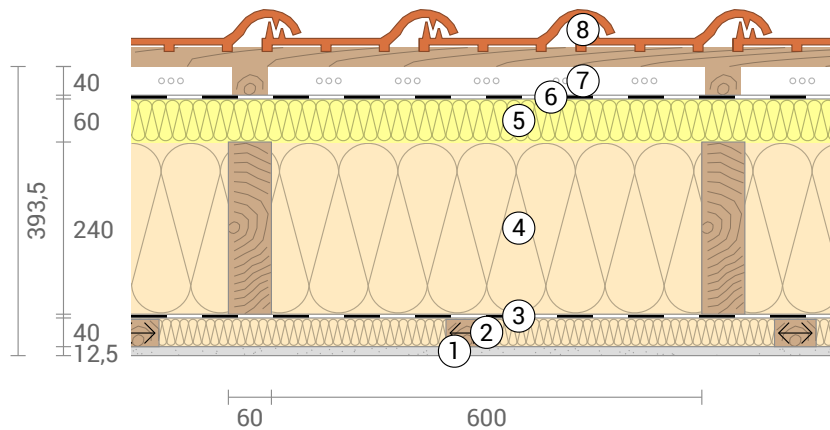
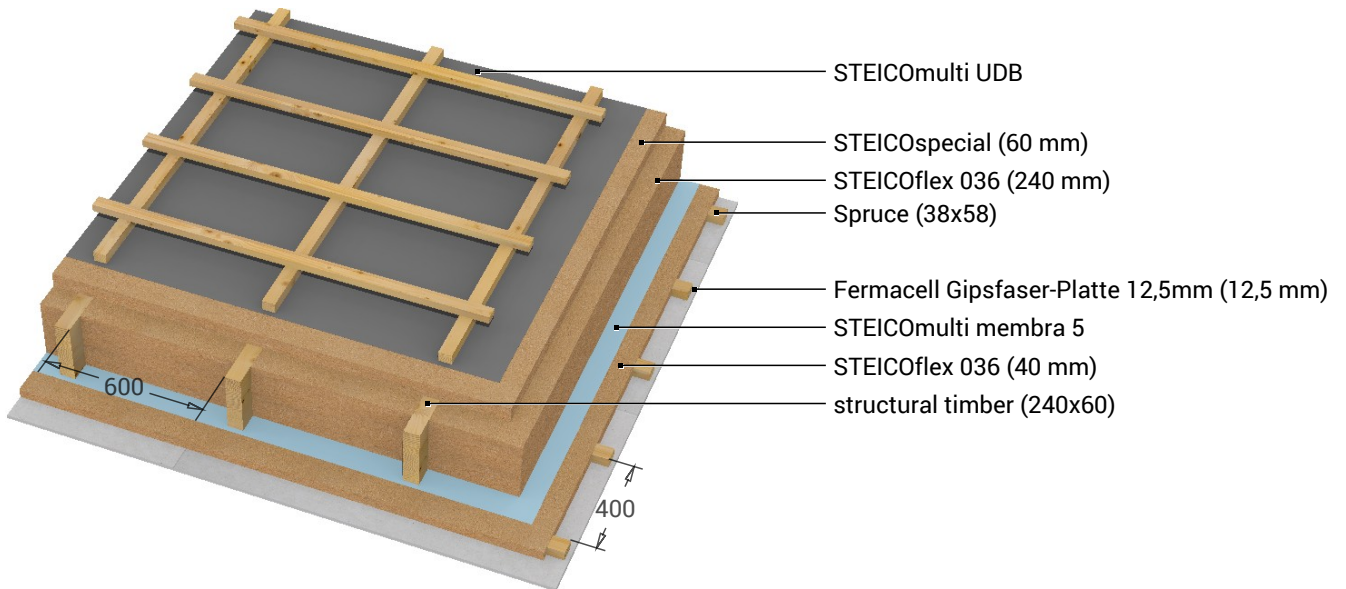
## Moisture proofing

Drying reserve: 2750 g/m<sup>2</sup>a  
No condensate



## Heat protection

Temperature amplitude damping: 67  
phase shift: 17,3 h  
Thermal capacity inside: 42 kJ/m<sup>2</sup>K



- |   |                                 |
|---|---------------------------------|
| ① Fermacell Gipsfaser-Platte 12,5mm (12,5 mm) | ⑤ STEICOspecial (60 mm)         |
| ② STEICOflex 036 (40 mm)                      | ⑥ STEICOmultip UDB              |
| ③ STEICOmultip membra 5                       | ⑦ Rear ventilated level (40 mm) |
| ④ STEICOflex 036 (240 mm)                     | ⑧ Roofing tiles (103 mm)        |

<-> Layers marked by arrows are perpendicular to the main axis.

Inside air : 20,0°C / 50%  
Outside air: -5,0°C / 80%  
Surface temperature.: 19,0°C / -4,9°C

sd-value: 6,3 m  
Drying reserve: 2750 g/m<sup>2</sup>a

Thickness: 49,6 cm  
Weight: 105 kg/m<sup>2</sup>  
Heat capacity: 88 kJ/m<sup>2</sup>K

- GEG 2020/24 Bestand     BEG Einzelmaßn.     GEG 2023/24 Neubau     DIN 4108

Wohnhauses mit 4 roof,  $U=0,12 \text{ W}/(\text{m}^2\text{K})$

## U-Value calculation according to DIN EN ISO 6946

#	Material	Dicke [cm]	$\lambda$ [W/mK]	R [m <sup>2</sup> K/W]
	Thermal contact resistance inside (Rsi)			0,100
1	Fermacell Gipsfaser-Platte 12,5mm	1,25	0,320	0,039
2	STEICOflex 036	4,00	0,036	1,111
	Spruce (Width: 5,8 cm)	3,80	0,130	0,292
3	STEICOmulti membra 5	0,05	0,170	0,003
4	STEICOflex 036	24,00	0,036	6,667
	structural timber (9,1%)	24,00	0,130	1,846
5	STEICOspecial	6,00	0,048	1,250
6	STEICOmulti UDB	0,05	0,170	0,003
	Thermal contact resistance outside (Rse)			0,100

Thermal contact resistances have been taken from DIN 6946 Table 7.

Rsi: heat flow direction upwards

Rse: heat flow direction upwards, outside: Ventilation level

Upper limit of thermal resistance  $R_{\text{tot};\text{upper}} = 8,326 \text{ m}^2\text{K}/\text{W}$ .

Lower limit of thermal resistance  $R_{\text{tot};\text{lower}} = 7,732 \text{ m}^2\text{K}/\text{W}$ .

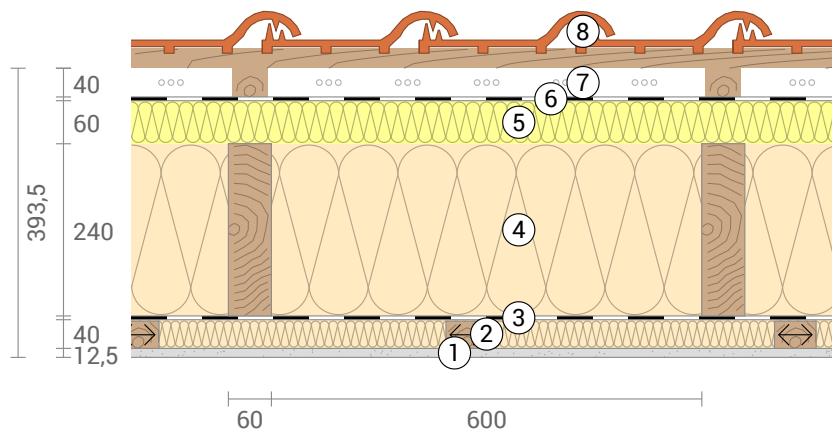
Check applicability:  $R_{\text{tot};\text{upper}} / R_{\text{tot};\text{lower}} = 1,077$  (maximum allowed: 1,5)

The procedure may be used.

Thermal resistance  $R_{\text{tot}} = (R_{\text{tot};\text{upper}} + R_{\text{tot};\text{lower}})/2 = 8,029 \text{ m}^2\text{K}/\text{W}$

Estimated maximum relative uncertainty according to section 6.7.2.5: 3,7%

Heat transfer coefficient  $U = 1/R_{\text{tot}} = 0,12 \text{ W}/(\text{m}^2\text{K})$



Wohnhauses mit 4 roof, U=0,12 W/(m²K)

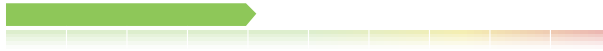
### LCA

Heat loss: 10 kWh/m² per heating season



Amount of heat that escapes through one square meter of this component during the heating period. Please note: Due to internal and solar gains, the heating demand is lower than the heat loss.

Primary energy (non renewable): 139 kWh/m²



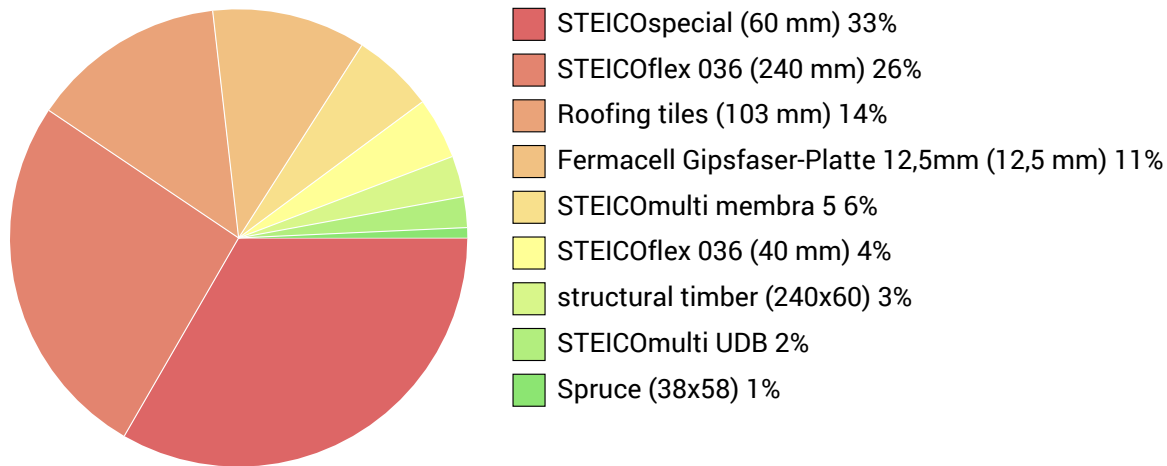
Non-renewable primary energy (= energy from fossil fuels and nuclear energy) that was used to produce the new building materials ("cradle to gate").

Green house gas potential: -32 kg CO2 Äqv./m²

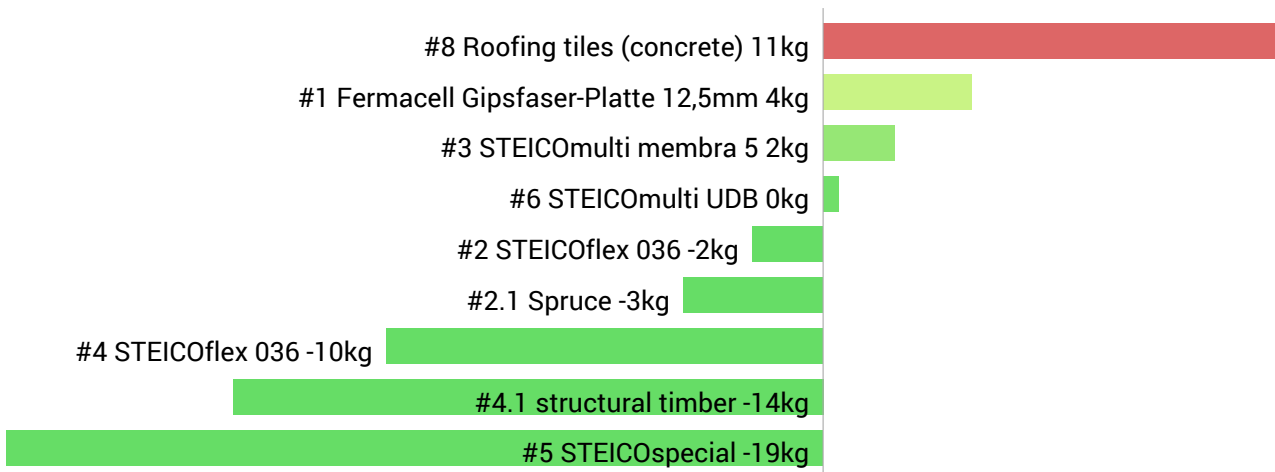


For the production of the building materials used, more greenhouse gases were withdrawn from the atmosphere than emitted.

### Composition of non-renewable primary energy of production:

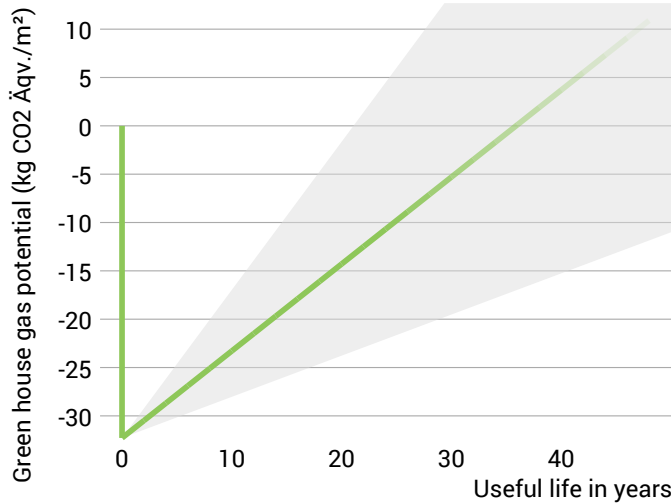


### Composition of the greenhouse potential of production:



Wohnhauses mit 4 roof,  $U=0,12 \text{ W}/(\text{m}^2\text{K})$

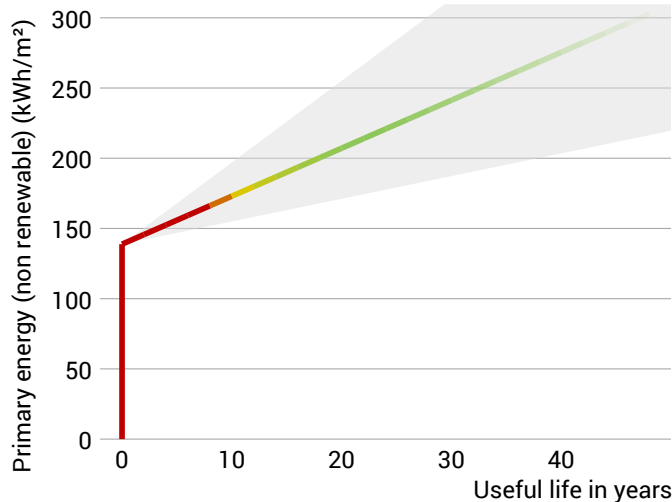
## Global warming potential and primary energy for construction and use



The **left figure** shows the global warming potential of the production of the component in the vertical part of the curve. Greenhouse gas emissions (through heating) arising during use of the building are indicated by the upward curve.

The **figure at the bottom left** shows the non-renewable primary energy expenditure for the production of the component in the vertical part of the curve. The primary energy required during use of the building (through heating) is represented by the upward curve.

The longer the component is used unchanged, the more environmentally friendly it is, because the production costs contribute less to the total emissions (indicated by the color of the curve).



Due to unknown solar and internal gains, the heating demand can only be estimated. Accordingly, primary energy consumption and global warming potential during the use phase are only vaguely known. For the estimation it was assumed that solar and internal profits contribute with  $4 \text{ kWh}/\text{a}/\text{m}^2$  component area. The light gray area indicates the area in which the curve is located with great certainty. For heat generation, a primary energy input of  $0,60 \text{ kWh}$  per  $\text{kWh}$  of heat and a global warming potential of  $0,16 \text{ kg CO}_2 \text{ eqv}/\text{m}^2$  per  $\text{kWh}$  of heat was used. Heat source: Heat pump (air-water).

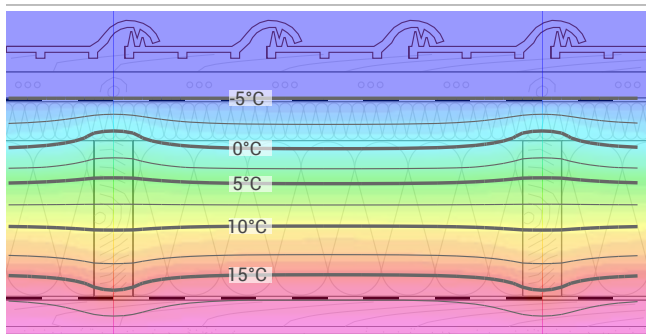
### Hints

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

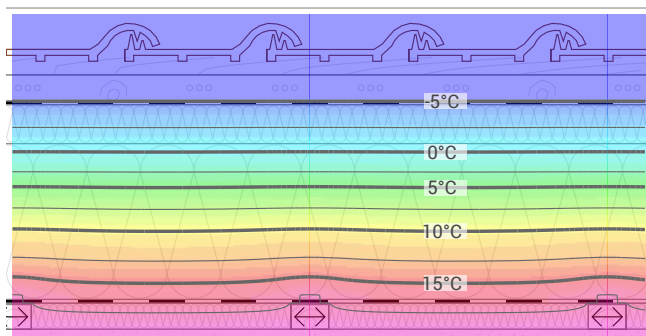
The climate and energy data on which this calculation is based can, in some cases, show considerable fluctuations and, in individual cases, deviate considerably from the actual value.

Wohnhauses mit 4 roof,  $U=0,12 \text{ W}/(\text{m}^2\text{K})$ 

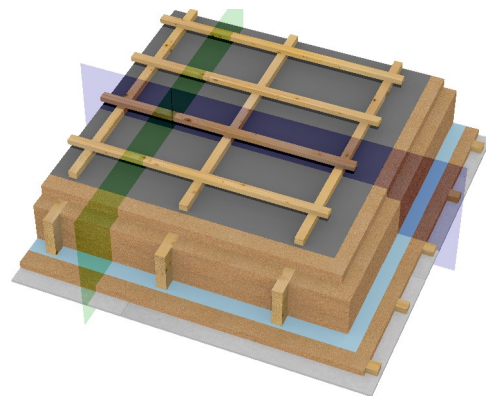
## Temperature profile



60                      600



58                      400



Top left: Temperature profile in the blue section (see right illustration). Bottom left: Temperature profile in the green section.

## Layers (from inside to outside)

#	Material	$\lambda$ [W/mK]	R [m <sup>2</sup> K/W]	Temperatur [°C]		Weight [kg/m <sup>2</sup> ]
				min	max	
	Thermal contact resistance*		0,250	19,0	20,0	
1	1,25 cm Fermacell Gipsfaser-Platte 12,5mm	0,320	0,039	18,9	19,3	14,4
2	4 cm STEICoflex 036	0,036	1,111	13,9	19,2	1,8
	3,8 cm Spruce (Width: 5,8 cm)	0,130	0,292			2,2
3	0,05 cm STEICOmulti membra 5	0,170	0,003	13,9	16,2	0,2
4	24 cm STEICoflex 036	0,036	6,667	-1,5	16,2	10,9
	24 cm structural timber (9,1%)	0,130	1,846	0,6	14,2	9,2
5	6 cm STEICOspecial	0,048	1,250	-4,9	0,7	14,4
6	0,05 cm STEICOmulti UDB	0,170	0,003	-4,9	-4,8	0,1
	Thermal contact resistance*		0,040	-5,0	-4,8	
7	4 cm Rear ventilated level (outside air)			-5,0	-5,0	0,0
8	10,3 cm Roofing tiles (concrete)			-5,0	-5,0	51,5
	49,65 cm Whole component		8,029			104,6

\*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):    19,0°C    19,2°C    19,3°C  
 Surface temperature outside (min / average / max):    -4,9°C    -4,9°C    -4,8°C

Wohnhauses mit 4 roof,  $U=0,12 \text{ W}/(\text{m}^2\text{K})$ 

## Moisture proofing

For the calculation of the amount of condensation water, the component was exposed to the following constant climate for 90 days: inside:  $20^\circ\text{C}$  und 50% Humidity; outside:  $-5^\circ\text{C}$  und 80% Humidity. This climate complies with DIN 4108-3.

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

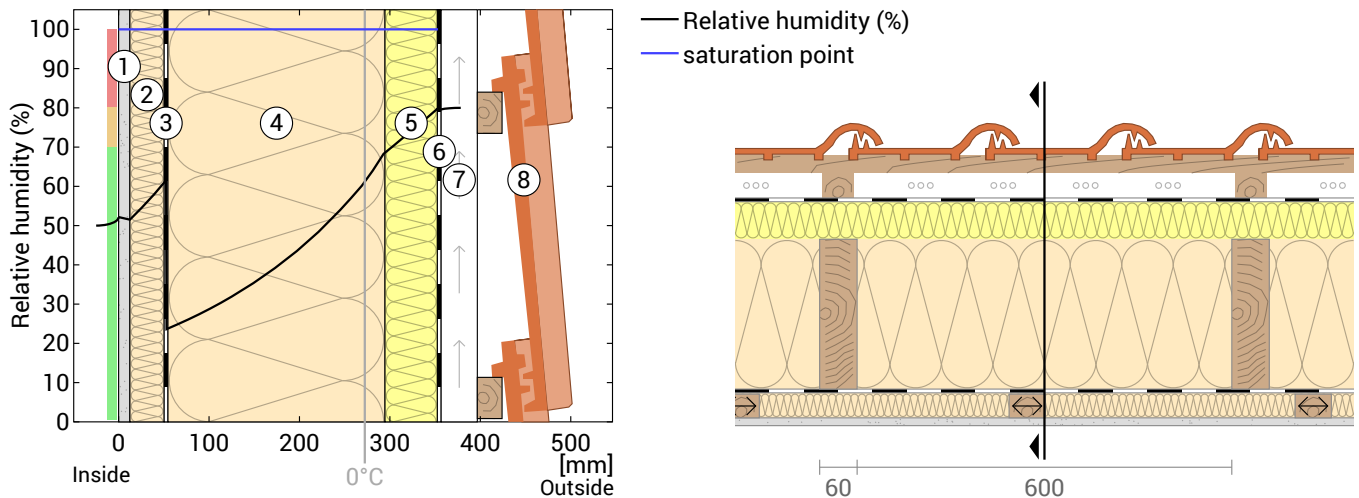
Drying reserve according to DIN 4108-3:2018:  $2750 \text{ g}/(\text{m}^2\text{a})$   
 At least required by DIN 68800-2:  $250 \text{ g}/(\text{m}^2\text{a})$

#	Material	sd-value [m]	Condensate		Weight [kg/m <sup>2</sup> ]
			[kg/m <sup>2</sup> ]	[Gew.-%]	
1	1,25 cm Fermacell Gipsfaser-Platte 12,5mm	0,16	-		14,4
2	4 cm STEICOflex 036	0,08	-		1,8
	3,8 cm Spruce (Width: 5,8 cm)		-	-	2,2
3	0,05 cm STEICOmulti membra 5	5,00	-		0,2
4	24 cm STEICOflex 036	0,48	-		10,9
	24 cm structural timber (9,1%)	9,60	-	-	9,2
5	6 cm STEICOspecial	0,30	-		14,4
6	0,05 cm STEICOmulti UDB	0,02	-		0,1
	49,65 cm Whole component	6,32	0		104,6

## Humidity

The temperature of the inside surface is  $19,0^\circ\text{C}$  leading to a relative humidity on the surface of 53%. Mould formation is not expected under these conditions.

The following figure shows the relative humidity inside the component.



- |  |                           |                                 |
|--|---------------------------|---------------------------------|
| ① Fermacell Gipsfaser-Platte 12,5mm... | ④ STEICOflex 036 (240 mm) | ⑦ Rear ventilated level (40 mm) |
| ② STEICOflex 036 (40 mm)               | ⑤ STEICOspecial (60 mm)   | ⑧ Roofing tiles (103 mm)        |
| ③ STEICOmulti membra 5                 | ⑥ STEICOmulti UDB         |                                 |

Layers marked with <-> run parallel to the illustrated cutting plane and were not taken into account in the moisture protection calculation.

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.

Wohnhauses mit 4 roof,  $U=0,12 \text{ W}/(\text{m}^2\text{K})$ 

## Moisture protection in accordance with DIN 4108-3:2018 Appendix A

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

 In the case of roof structures with **tile coverings and wooden gratings**, this standard may not be applied. Whether this construction falls under it, is to be examined by the planner.

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

#	Material	$\lambda$ [W/mK]	R [m <sup>2</sup> K/W]	sd [m]	$\rho$ [kg/m <sup>3</sup> ]	T [°C]	ps [Pa]	$\Sigma$ sd [m]
Thermal contact resistance			0,250			19,33	2243	0
1	1,25 cm Fermacell Gipsfaser-Platte 12,5mm	0,320	0,039	0,16	1150	19,23	2228	0,16
2	4 cm STEICOflex 036	0,036	1,111	0,08	50	16,26	1848	0,24
3	0,05 cm STEICOmultiphila 5	0,170	0,003	5	325	16,25	1847	5,24
4	24 cm STEICOflex 036	0,036	6,667	0,48	50	-1,55	537	5,72
5	6 cm STEICOspecial	0,048	1,250	0,3	240	-4,89	405	6,02
6	0,05 cm STEICOmultiphila UDB	0,170	0,003	0,1	270	-4,89	405	6,12
Thermal contact resistance			0,040					

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

### Relative air humidity on the surface

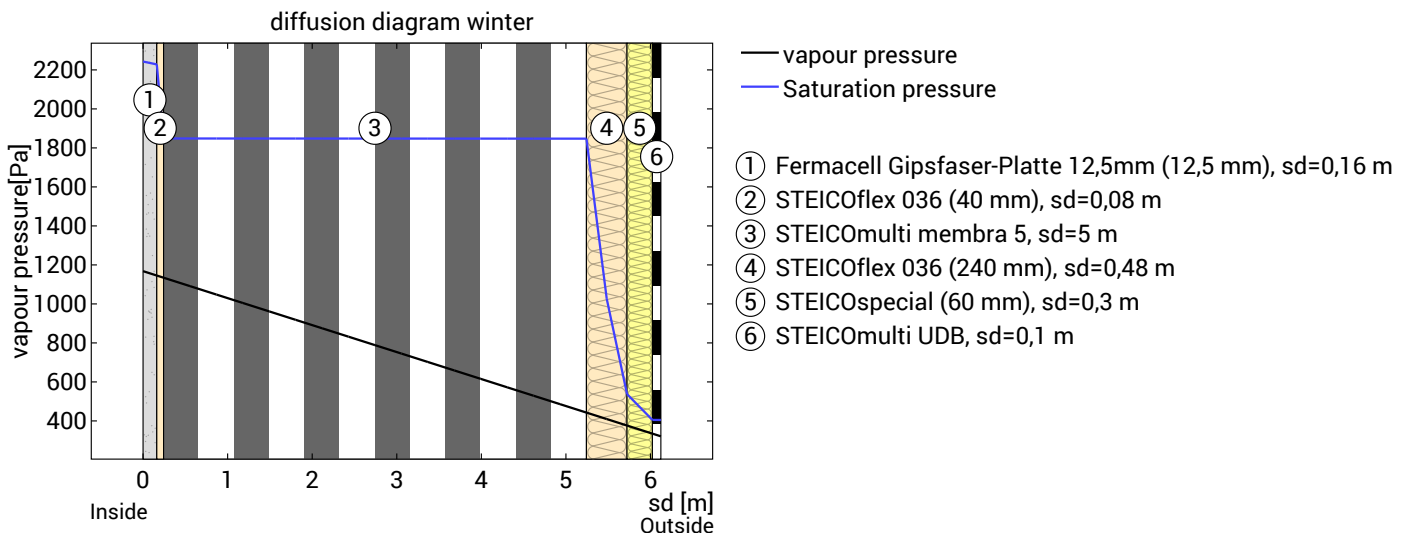
The relative humidity on the interior surface is 52%. Requirements for the prevention of building material corrosion depend on material and coating and have not been investigated.



### Dew period (winter)

#### Boundary conditions

Vapor pressure inside at 20°C and 50% humidity	$p_i = 1168 \text{ Pa}$
Vapor pressure outside at -5°C and 80% humidity	$p_e = 321 \text{ Pa}$
Duration of condensation period (90 days)	$t_c = 7776000 \text{ s}$
Water vapor diffusion coefficient in static air	$\delta_0 = 2.0E-10 \text{ kg}/(\text{m}^2\text{sPa})$
sd-value (Whole component.)	$s_{de} = 6,12 \text{ m}$



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:

 $s_d=5,72 \text{ m}$ ;  $x=29,3 \text{ cm}$ ;  $p_s=537 \text{ pa}$ :

Layer boundary between STEICOflex 036 and STEICOspecial

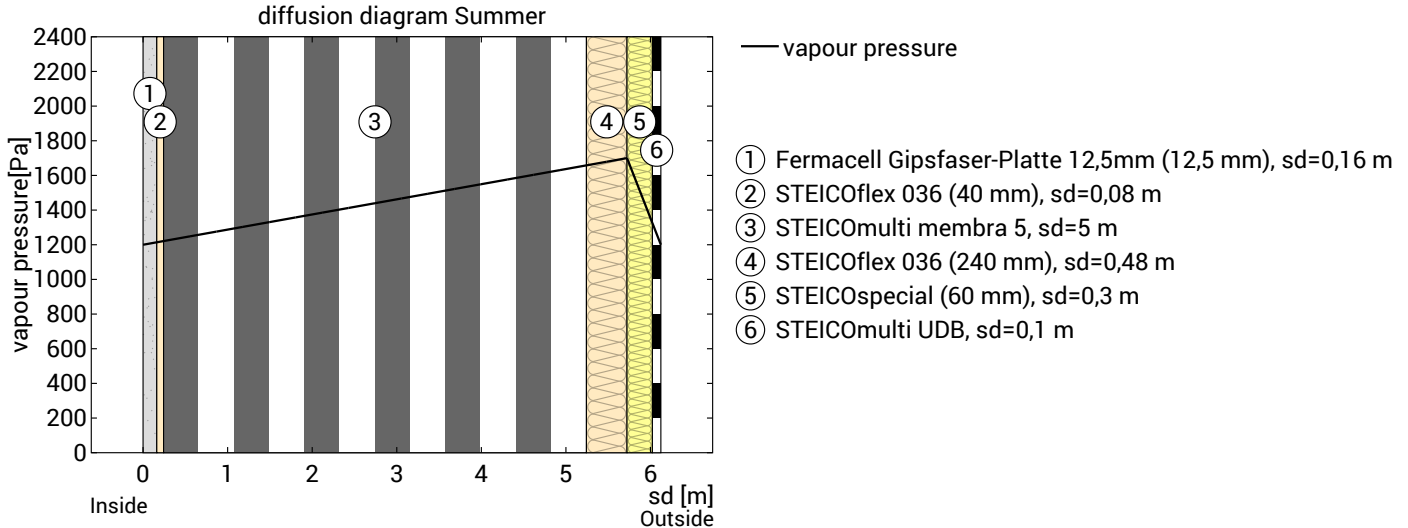
$$M_{ev, \text{Tauperiode}} = t_c \cdot \delta_0 \cdot ((p_s - p_i) / s_{d_{ev}} + (p_s - p_e) / (s_{de} - s_{d_{ev}})) = 0,670 \text{ kg/m}^2$$



Wohnhauses mit 4 roof, U=0,12 W/(m²K)

### Evaporation period (summer)

Boundary conditions	
Interior vapor pressure	$p_i = 1200 \text{ Pa}$
Exterior vapor pressure	$p_e = 1200 \text{ Pa}$
Saturation vapour pressure in the condensation area	$p_s = 1700 \text{ Pa}$
Length of drying season (90 days)	$t_{ev} = 7776000 \text{ s}$
sd-values remain unchanged.	



Condensate-free component: The maximum possible evaporation mass for the drying reserve is calculated. Consider the level that has the lowest evaporation potential in the dew period, at  $sd=5,72 \text{ m}$ ;  $x=29,3 \text{ cm}$ :

Layer boundary between STEICOflex 036 and STEICOspecial

$$\text{Evaporation mass: } M_{ev} = \delta_0 \cdot t_{ev} \cdot \left[ \frac{(p_s - p_i)}{sd} + \frac{(p_s - p_e)}{(s_{de} - sd)} \right] = 2,08 \text{ kg/m}^2$$

### Drying reserve (DIN 68800-2)

Dew-water-free component: The evaporation potential of the dew period is also taken into account.

$$\text{Drying reserve: } M_r = (M_{ev} + M_{ev, \text{Tauperiode}}) \cdot 1000 = 2750 \text{ g/m}^2/\text{a}$$

Minimum requested for roofs:  $250 \text{ g/m}^2/\text{a}$



### Evaluation according to DIN 4108-3

The component is permissible regarding the moisture protection.

### 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.

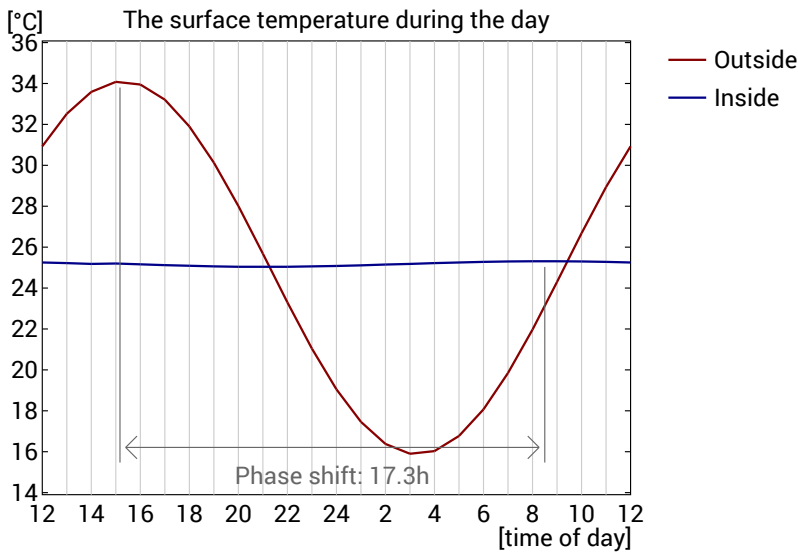
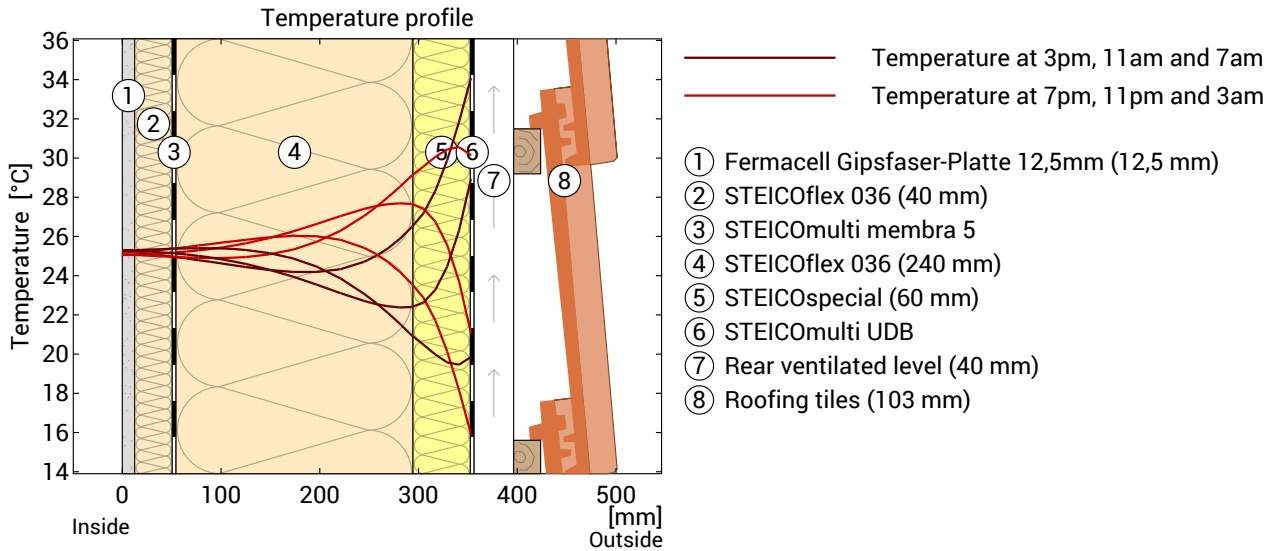
DIN 4108-3 describes in Section 5.3 components for which no moisture proofing is required as there is no risk of condensation water or the method is not suitable for the assessment. It is not possible to assess whether the component under test is underneath.



Wohnhauses mit 4 roof,  $U=0,12 \text{ W}/(\text{m}^2\text{K})$

## 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*	17,3 h	Heat storage capacity (whole component):	88 kJ/m <sup>2</sup> K
Amplitude attenuation **	66,7	Thermal capacity of inner layers:	42 kJ/m <sup>2</sup> K
TAV ***	0,015		

\* 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:  $TAV = 1 / \text{amplitude attenuation}$

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.

Wohnhauses mit 4 roof,  $U=0,12 \text{ W}/(\text{m}^2\text{K})$

## Hints

### Rear ventilation level

The thickness of the rear ventilation level is 4 cm. Generally, the thickness should be at least 3 cm. If the inclination of the rear ventilation plane is less than  $40^\circ$ , e.g. for (flat) roofs, a larger value must be selected. The same applies if the air inlet and the air outlet are particularly far apart.

The part of your component that is relevant to the calculation ends at the inside of the rear ventilation level. Outlying layers do not need to be entered.

Beams and joists which penetrate the rear ventilation level are only considered up to the inside of the rear ventilation level.

Please note: The U-value calculator basically assumes that a rear-ventilation level is adequately permeated by outside air. Whether this is actually the case depends not only on the thickness of the rear ventilation level, but also on their width and length and possible obstacles in the air inlet and outlet and can not be assessed by the U-value calculator.

### Exterior sd value