

I Domus G L Beam

Thermal protection

$U = 0,146 \text{ W}/(\text{m}^2\text{K})$

EnEV16 Neubau*: $U < 0,16 \text{ W}/(\text{m}^2\text{K})$



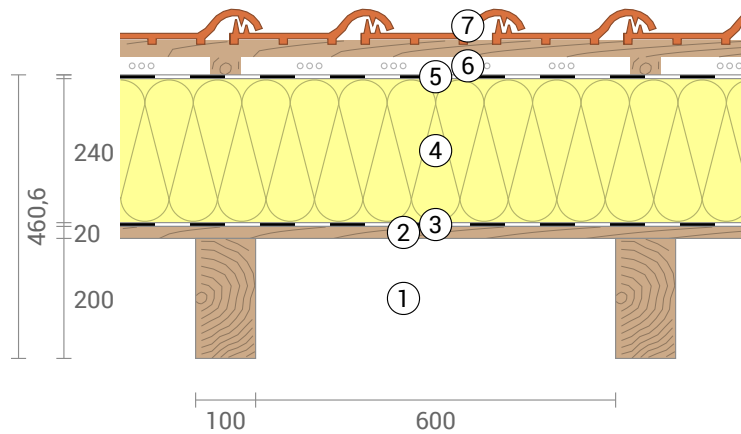
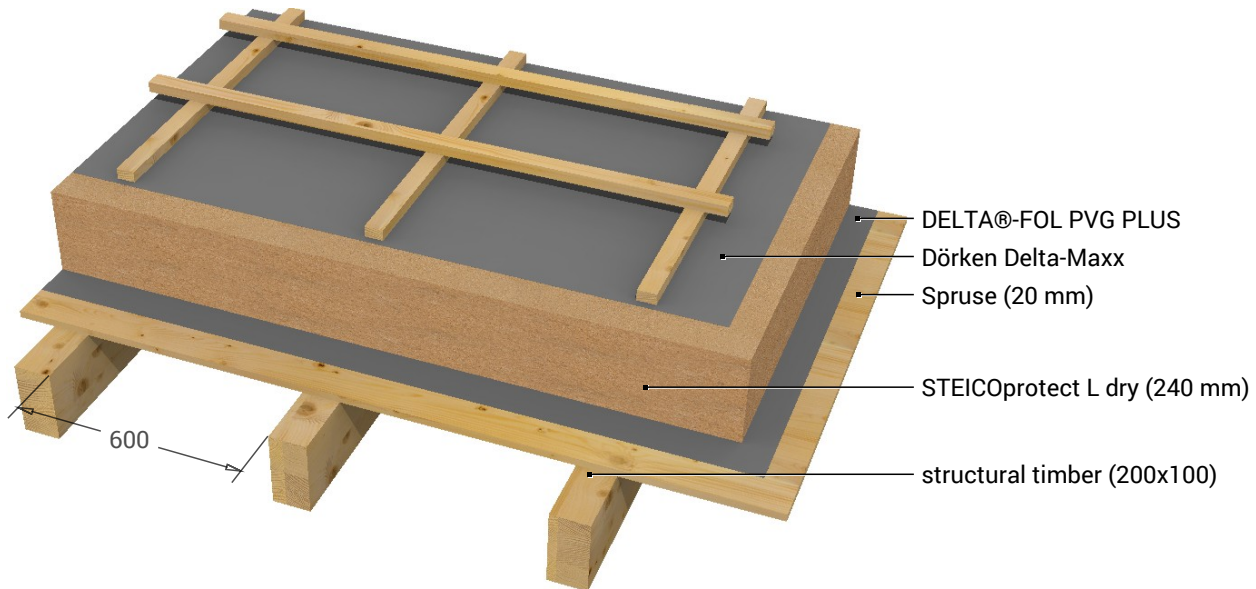
Moisture proofing

No condensate



Heat protection

Temperature amplitude damping: 46
phase shift: 15,5 h
Thermal capacity inside: $43 \text{ kJ}/\text{m}^2\text{K}$



- ① structural timber (200x100)
- ② Spruce (20 mm)
- ③ DELTA®-FOL PVG PLUS
- ④ STEICOpact L dry (240 mm)
- ⑤ Dörken Delta-Maxx
- ⑥ Rear ventilated level
- ⑦ Roofing tiles

Inside air : 20,0°C / 50%
Outside air: -5,0°C / 80%
Surface temperature.: 19,1°C / -4,9°C

sd-value: 21,3 m
Drying reserve: 9181 g/m²a

Thickness: 59,4 cm
Weight: 101 kg/m²
Heat capacity: 71 kJ/m²K

- EnEV16 Neubau BEG Einzelm. BEG Effizienzhaus 40 BEG Effizienzhaus 55

I Domus G L Beam , U=0,146 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)			0,100
2	Spruce	2,00	0,130	0,154
3	DELTA®-FOL PVG PLUS	0,03	0,170	0,002
4	STEICOprotect L dry	24,00	0,037	6,486
5	Dörken Delta-Maxx	0,03	0,500	0,001
	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: Rear ventilated roofing

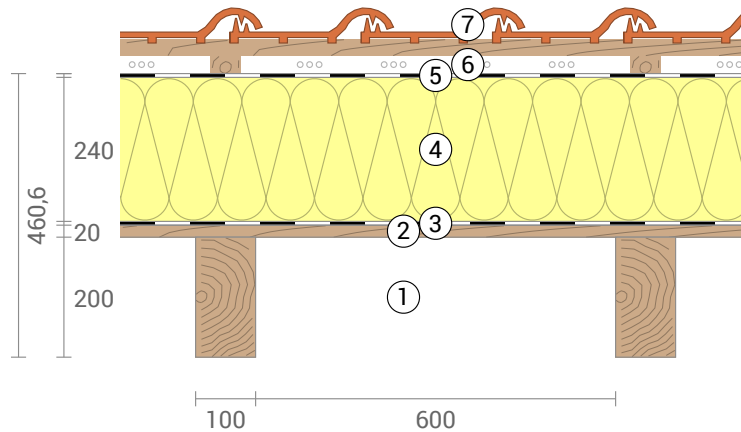
Upper limit of thermal resistance $R_{\text{tot;upper}} = 6,843 \text{ m}^2\text{K/W}$.

Lower limit of thermal resistance $R_{\text{tot;lower}} = 6,843 \text{ m}^2\text{K/W}$.

Check applicability: $R_{\text{tot;upper}} / R_{\text{tot;lower}} = 1,000$ (maximum allowed: 1,5)

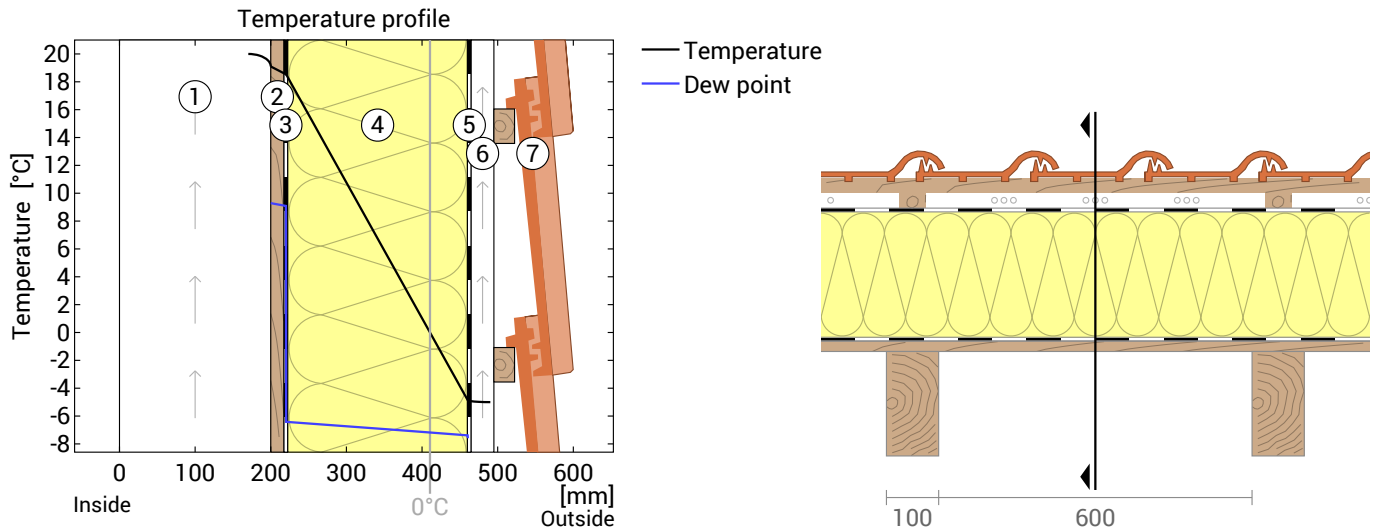
Thermal resistance $R_{\text{tot}} = 6,843 \text{ m}^2\text{K/W}$

Heat transfer coefficient $U = 1/R_{\text{tot}} = 0,15 \text{ W}/(\text{m}^2\text{K})$



I Domus G L Beam , U=0,146 W/(m²K)

Temperature profile



- ① Air layer (200 mm)
- ② Spruce (20 mm)
- ③ DELTA®-FOL PVG PLUS
- ④ STEICOprotect L dry (240 mm)
- ⑤ Dörken Delta-Maxx
- ⑥ Rear ventilated level
- ⑦ Roofing tiles

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]		Weight [kg/m²]
				min	max	
1	20 cm Air layer (ventilated) Thermal contact resistance*		0,250	19,1	20,0	0,2
2	2 cm Spruce	0,130	0,154	18,5	19,1	9,2
3	0,03 cm DELTA®-FOL PVG PLUS	0,170	0,002	18,5	18,5	0,3
4	24 cm STEICOprotect L dry	0,037	6,486	-4,9	18,5	26,4
5	0,03 cm Dörken Delta-Maxx Thermal contact resistance*	0,500	0,001 0,040	-4,9 -5,0	-4,9 -4,9	0,2
6	Rear ventilated level (outside air)			-5,0	-5,0	0,0
7	Roofing tiles (clay)			-5,0	-5,0	51,5
59,36 cm Whole component			6,843			101,2

*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): 19,1°C 19,1°C 19,1°C
 Surface temperature outside (min / average / max): -4,9°C -4,9°C -4,9°C

I Domus G L Beam , U=0,146 W/(m²K)

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: -5°C und 80% Humidity. This climate complies with DIN 4108-3.

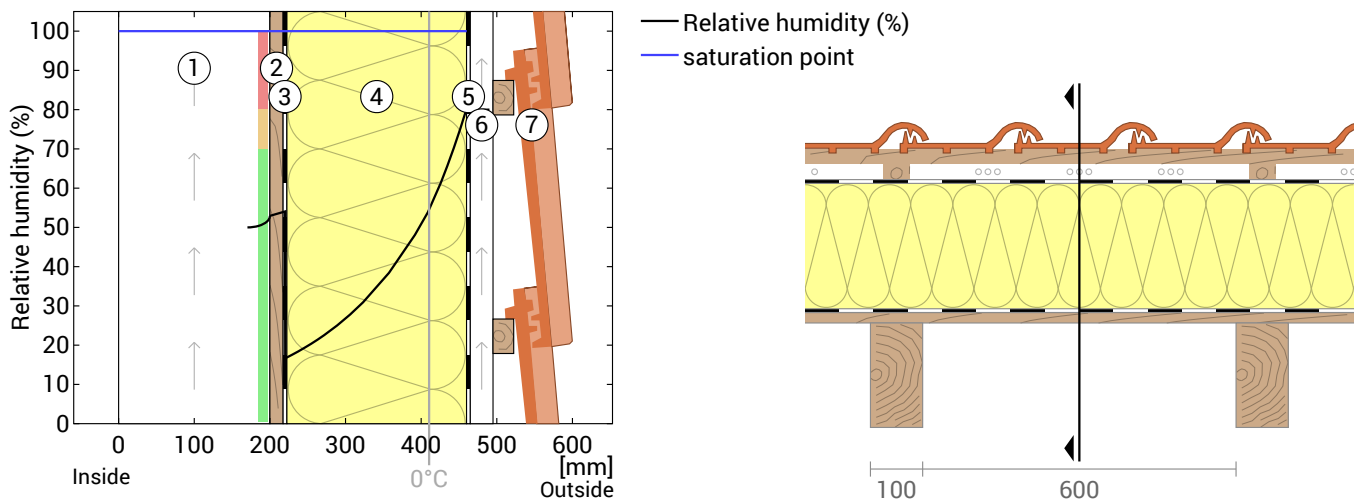
This component is free of condensate under the given climate conditions.

#	Material	sd-value [m]	Condensate [kg/m²]	Weight [kg/m²]
2	2 cm Spruce	0,40	-	9,2
3	0,03 cm DELTA®-FOL PVG PLUS	20,00	-	0,3
4	24 cm STEICOprotect L dry	0,72	-	26,4
5	0,03 cm Dörken Delta-Maxx	0,15	-	0,2
59,36 cm Whole component		21,27		101,2

Humidity

The temperature of the inside surface is 19,1 °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 Air layer (200 mm)
- ② Spruce (20 mm)
- ③ DELTA®-FOL PVG PLUS
- ④ STEICOprotect L dry (240 mm)
- ⑤ Dörken Delta-Maxx
- ⑥ Rear ventilated level
- ⑦ Roofing tiles

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.

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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	λ [W/mK]	R [m²K/W]	sd [m]	ρ [kg/m³]	T [°C]	ps [Pa]	Σ sd [m]
Thermal contact resistance			0,250			19,10	2210	0
2	2 cm Spruce	0,130	0,154	0,4	460	18,54	2135	0,4
3	0,03 cm DELTA®-FOL PVG PLUS	0,170	0,002	20	930	18,54	2134	20,4
4	24 cm STEICOprotect L dry	0,037	6,486	0,72	110	-4,85	406	21,1
5	0,03 cm Dörken Delta-Maxx	0,500	0,001	0,15	633	-4,86	406	21,3
Thermal contact resistance			0,040					

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

Relative air humidity on the surface

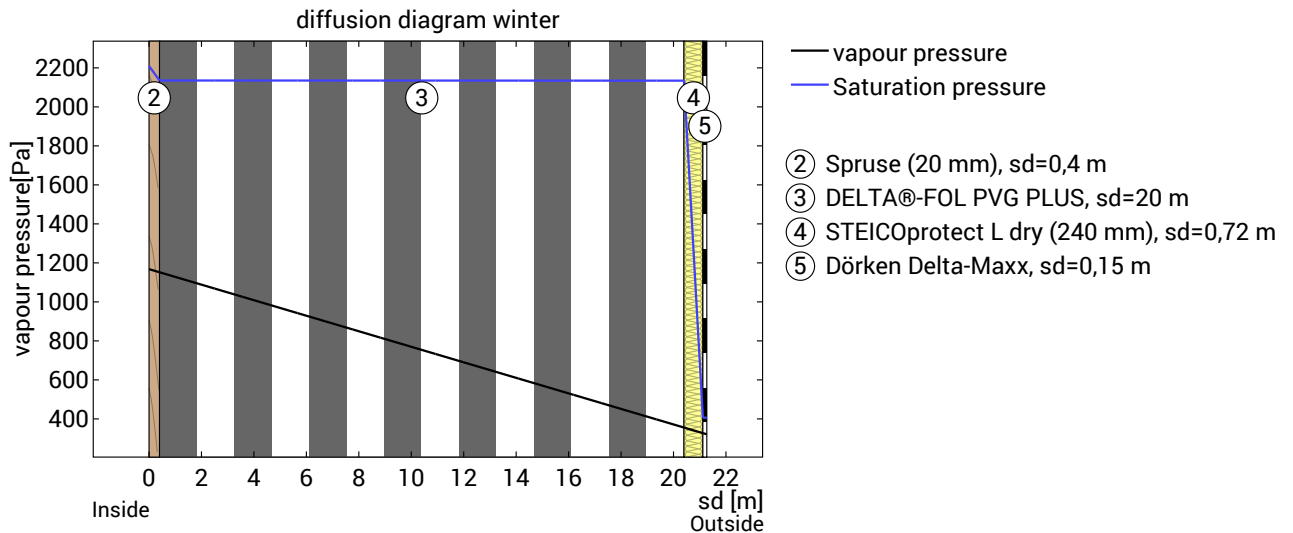
The relative humidity on the interior surface is 53%. Requirements for the prevention of building material corrosion depend on material and coating and have not been investigated.



Dew period (winter)

Boundary conditions

Vapor pressure inside at 20°C and 50% humidity	$p_i = 1168$ Pa
Vapor pressure outside at -5°C and 80% humidity	$p_e = 321$ Pa
Duration of condensation period (90 days)	$t_c = 7776000$ s
Water vapor diffusion coefficient in static air	$\delta_0 = 2.0E-10$ kg/(m*s*Pa)
sd-value (Whole component.)	$s_{de} = 21,27$ 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=21,12 m; x=26,03 cm; ps=406 pa:

Layer boundary between STEICOprotect L dry and Dörken Delta-Maxx

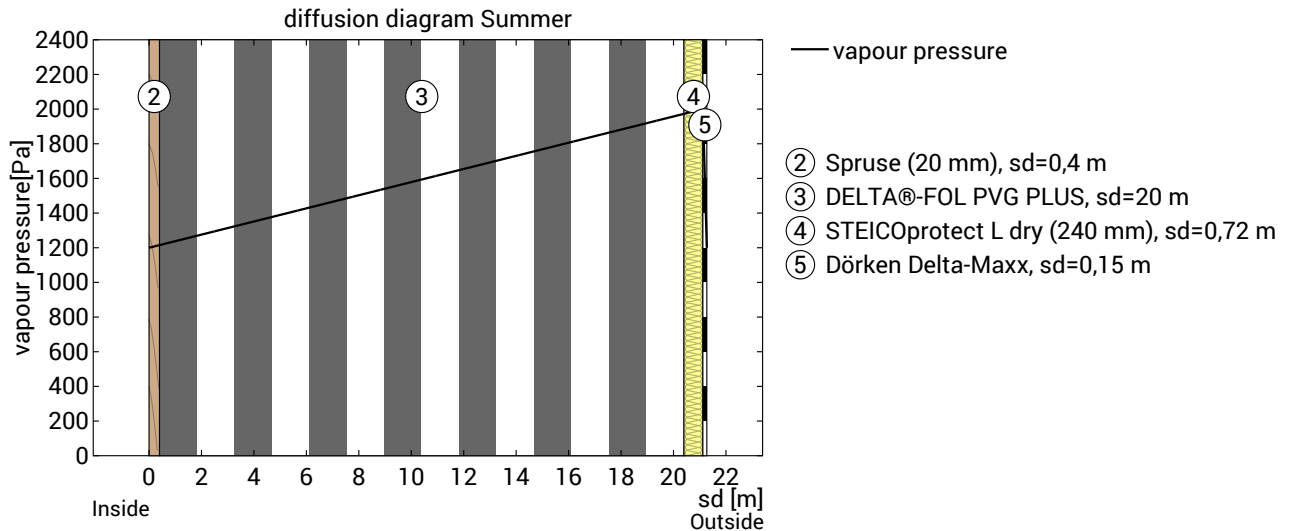
$$M_{ev, Tauperiode} = t_c * \delta_0 * ((p_s - p_i) / s_{d_{ev}} + (p_s - p_e) / (s_{d_e} - s_{d_{ev}})) = 0,828 \text{ kg/m}^2$$

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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 = 2000 Pa (Roof against outside air)
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. Consider the level that has the lowest evaporation potential in the dew period, at sd=21,12 m; x=26,03 cm:

Layer boundary between STEICOprotect L dry and Dörken Delta-Maxx

Evaporation mass: $M_{ev} = \delta_0 \cdot t_{ev} \cdot \left[\frac{(p_s - p_i)}{s_d} + \frac{(p_s - p_e)}{(s_{de} - s_d)} \right] = 8,35 \text{ kg/m}^2$

Drying reserve (DIN 68800-2)

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

Drying reserve: $M_r = (M_{ev} + M_{ev, Tauperiode}) \cdot 1000 = 9181 \text{ g/m}^2/\text{a}$

For components which do not contain wood there is no minimum requirement for the drying reserve.



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.

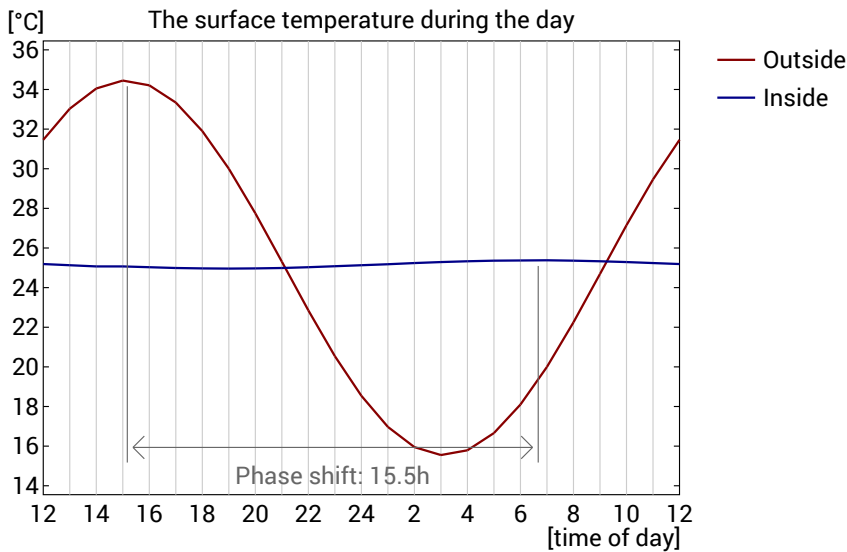
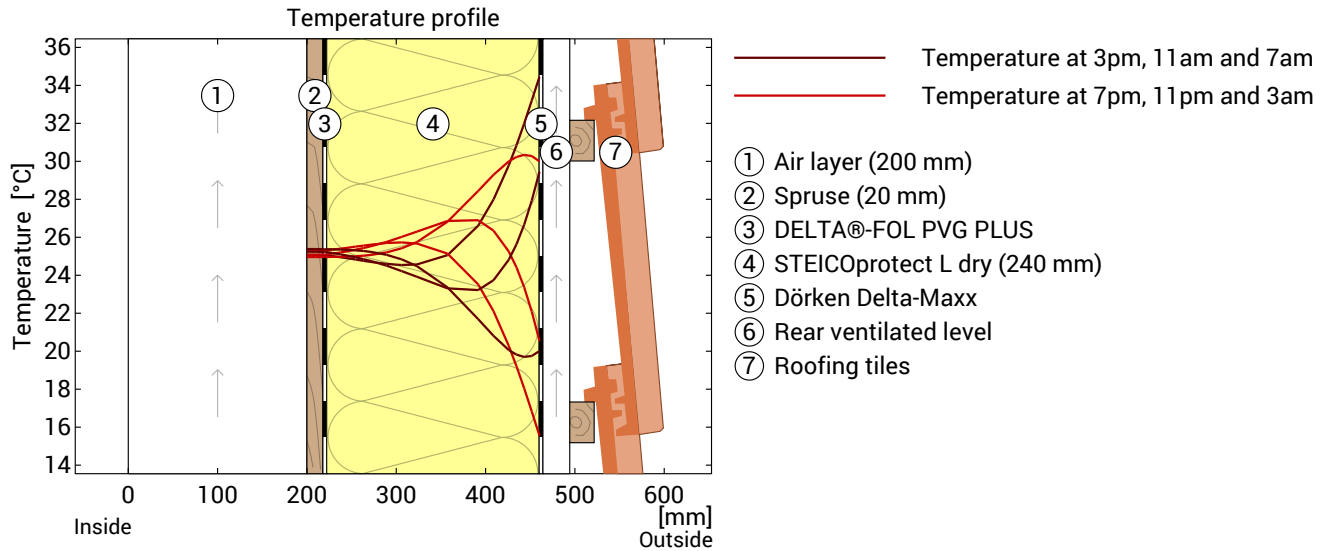
DIN 4108-3 describes in Section 5.3 components for which no moisture proofing is required as there is no risk of condensation water or the method is not suitable for the assessment. It is not possible to assess whether the component under test is underneath.

It is assumed that the roof is not predominantly shaded and does not have a very bright surface (as determined by the user). This has a positive effect on the drying capacity.

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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*	15,5 h	Heat storage capacity (whole component):	71 kJ/m ² K
Amplitude attenuation **	45,7	Thermal capacity of inner layers:	43 kJ/m ² K
TAV ***	0,022		

* 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.