

## Spær 145 mm og briiso u-værdi 0,10

### Thermal protection

$U = 0,10 \text{ W}/(\text{m}^2\text{K})$

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



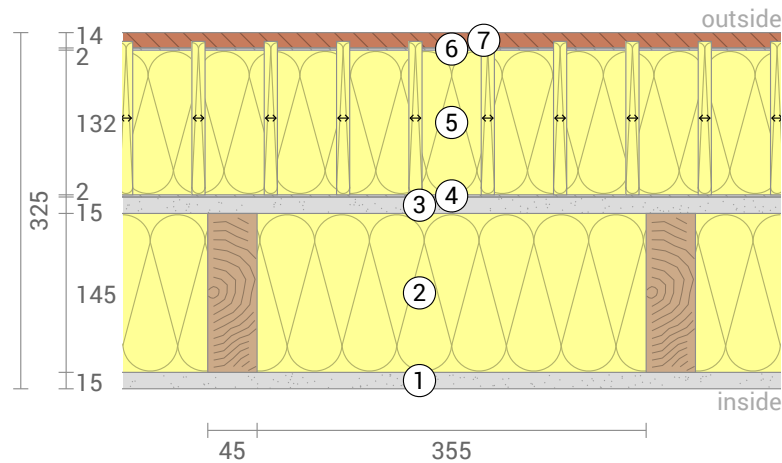
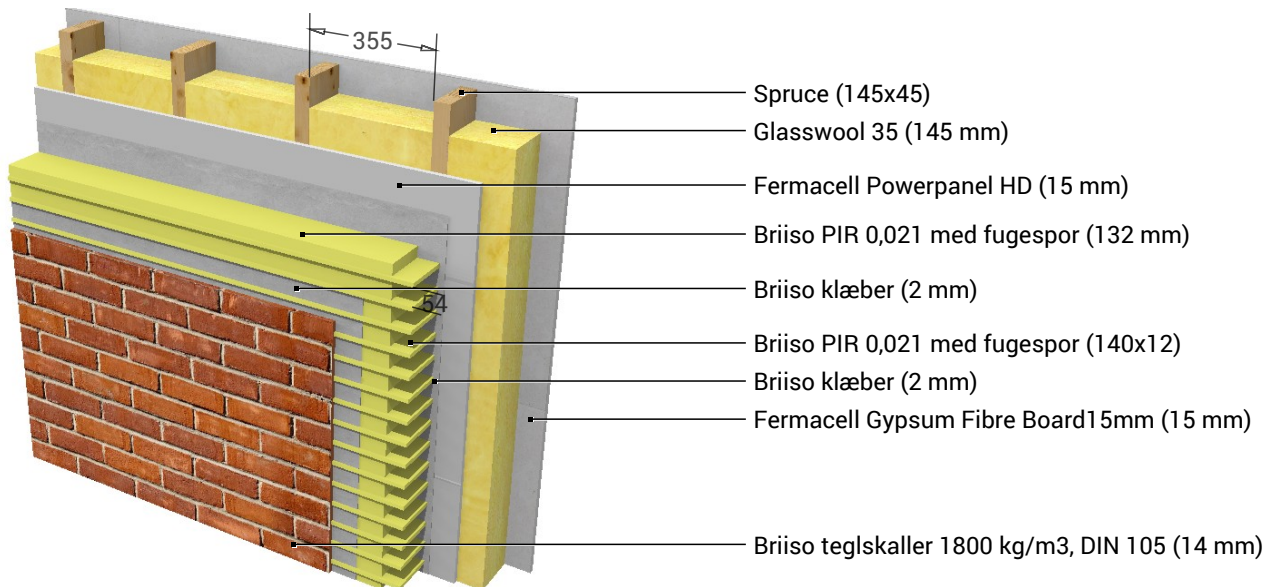
### Moisture proofing

Drying reserve:  $0 \text{ g}/\text{m}^2\text{a}$   
(leads to devaluation)  
No condensate



### Heat protection

Temperature amplitude damping: 64  
phase shift: 12,5 h  
Thermal capacity inside:  $44 \text{ kJ}/\text{m}^2\text{K}$



- ① Fermacell Gypsum Fibre Board 15mm (15 mm)
- ② Glasswool 35 (145 mm)
- ③ Fermacell Powerpanel HD (15 mm)
- ④ Briiso klæber (2 mm)
- ⑤ Briiso PIR 0,021 med fugespor (132 mm)
- ⑥ Briiso klæber (2 mm)
- ⑦ Briiso teglskaller  $1800 \text{ kg}/\text{m}^3$ , DIN 105 (14 mm)

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



briiso giver ingen garanti for beregninger i dette dokument.

Spær 145 mm og briiso u-værdi 0,10, U=0,10 W/(m<sup>2</sup>K)

Inside air :	20,0°C / 50%		Thickness:	32,5 cm	
Outside air:	-5,0°C / 80%	sd-value:	1321,4 m	Weight:	77 kg/m <sup>2</sup>
Surface temperature.:	19,0°C / -4,9°C	Drying reserve:	0 g/m <sup>2</sup> a	Heat capacity:	87 kJ/m <sup>2</sup> K

EnEV Bestand     BEG Einzelmaßn.     GEG 2020 Bestand     GEG 2020 Neubau

Spær 145 mm og briiso u-værdi 0,10,  $U=0,10 \text{ W}/(\text{m}^2\text{K})$

## 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)			0,130
1	Fermacell Gypsum Fibre Board 15mm	1,50	0,320	0,047
2	Glasswool 35	14,50	0,035	4,143
	Spruce (11%)	14,50	0,130	1,115
3	Fermacell Powerpanel HD	1,50	0,400	0,038
4	Briiso klæber	0,20	1,400	0,001
5	Briiso PIR 0,021 med fugespor	13,20	0,021	6,286
	Briiso PIR 0,021 med fugespor (Width: 1,2 cm)	14,00	0,021	6,667
6	Briiso klæber	0,20	1,400	0,001
7	Briiso teglskaller 1800 kg/m <sup>3</sup> , DIN 105	1,40	0,810	0,017
	Thermal contact resistance outside (Rse)			0,040

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  $R_{\text{tot;upper}} = 10,315 \text{ m}^2\text{K}/\text{W}$ .

Lower limit of thermal resistance  $R_{\text{tot;lower}} = 9,736 \text{ m}^2\text{K}/\text{W}$ .

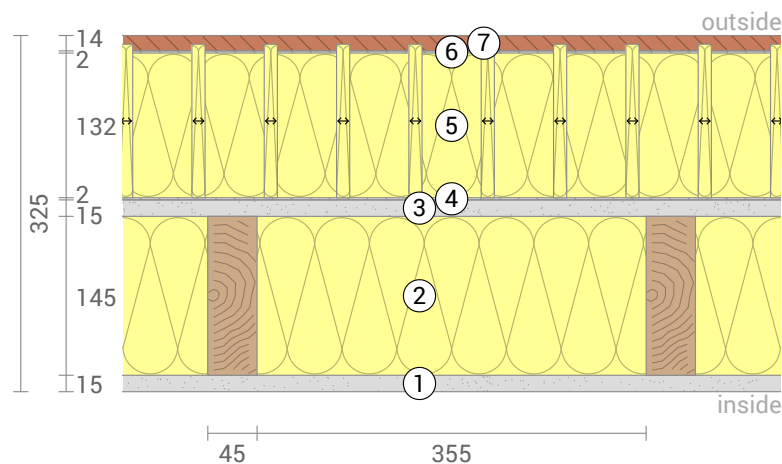
Check applicability:  $R_{\text{tot;upper}} / R_{\text{tot;lower}} = 1,059$  (maximum allowed: 1,5)

The procedure may be used.

Thermal resistance  $R_{\text{tot}} = (R_{\text{tot;upper}} + R_{\text{tot;lower}})/2 = 10,03 \text{ m}^2\text{K}/\text{W}$

Estimated maximum relative uncertainty according to section 6.7.2.5: 2,9%

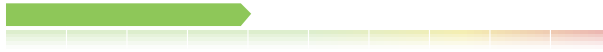
Heat transfer coefficient  $U = 1/R_{\text{tot}} = 0,10 \text{ W}/(\text{m}^2\text{K})$



Spær 145 mm og briiso u-værdi 0,10,  $U=0,10 \text{ W}/(\text{m}^2\text{K})$

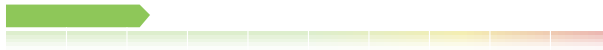
## LCA

Heat loss: 8 kWh/m<sup>2</sup> 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): 77 kWh/m<sup>2</sup>



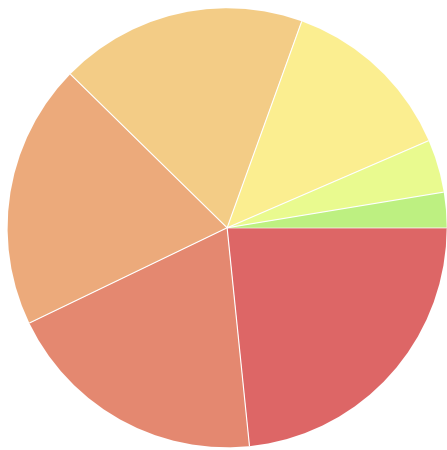
Non-renewable primary energy (= energy from fossil fuels and nuclear energy) that was used to produce the new building materials ("cradle to gate").

Green house gas potential: 62 kg CO<sub>2</sub> Äqv./m<sup>2</sup>



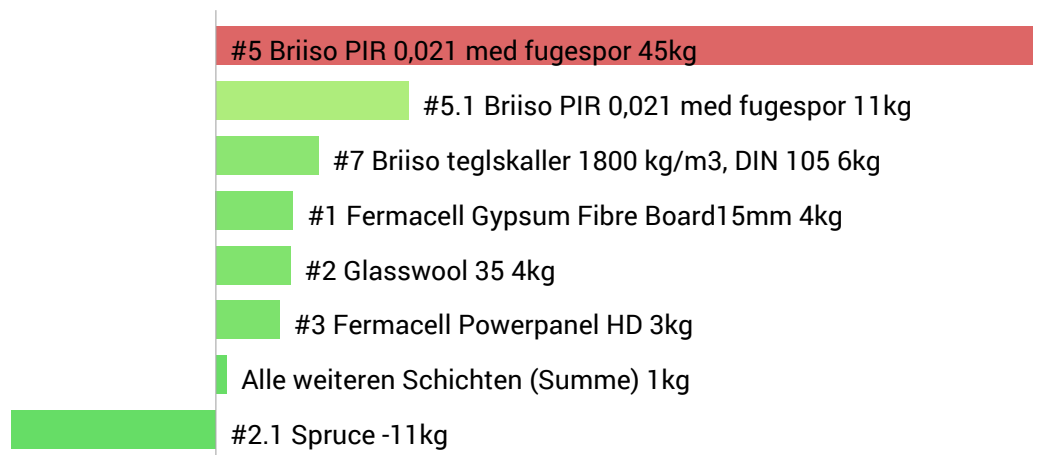
Quantity of released greenhouse gases in the production of building materials used ("cradle to gate").

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



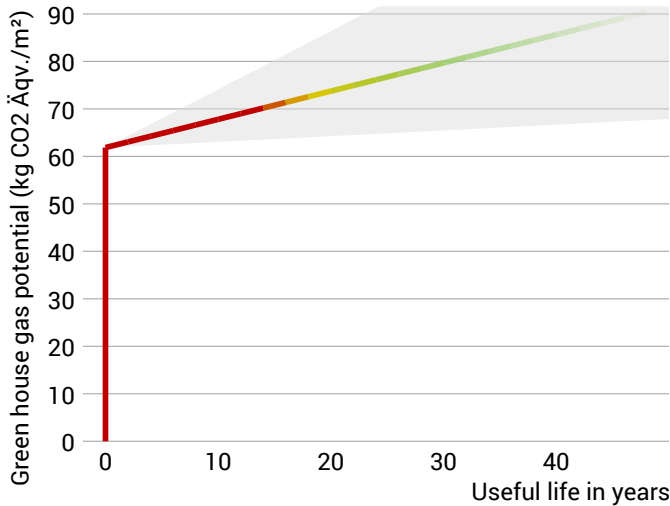
- Fermacell Gypsum Fibre Board 15mm (15 mm) 23%
- Fermacell Powerpanel HD (15 mm) 19%
- Briiso teglskaller 1800 kg/m<sup>3</sup>, DIN 105 (14 mm) 19%
- Glasswool 35 (145 mm) 18%
- Briiso PIR 0,021 med fugespor (132 mm) 13%
- Spruce (145x45) 4%
- Briiso PIR 0,021 med fugespor (140x12) 3%

### Composition of the greenhouse potential of production:



Spær 145 mm og briiso u-værdi 0,10,  $U=0,10 \text{ W}/(\text{m}^2\text{K})$

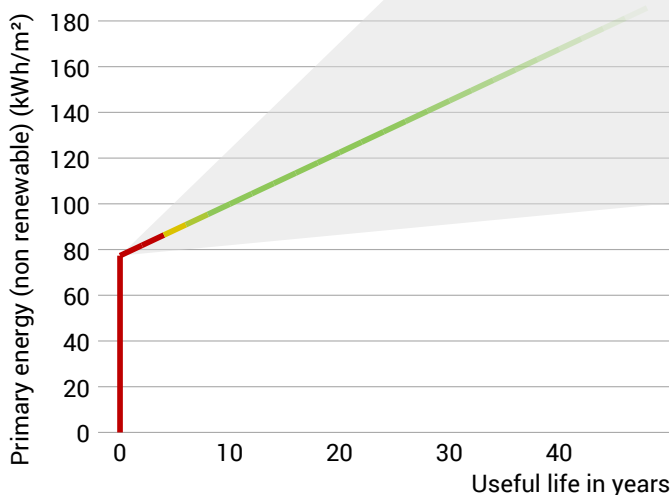
## Global warming potential and primary energy for construction and use



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).

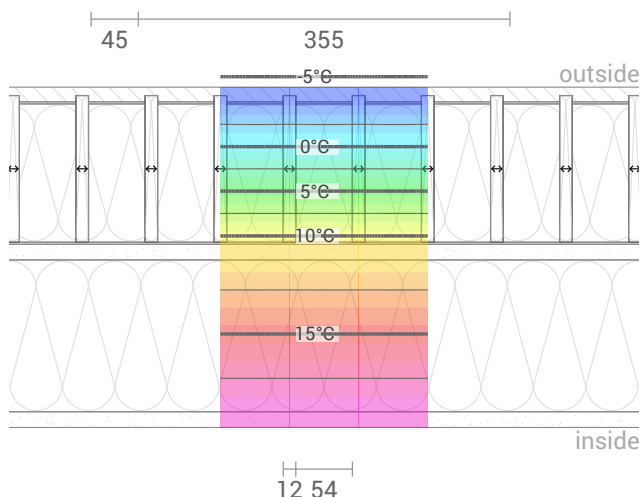
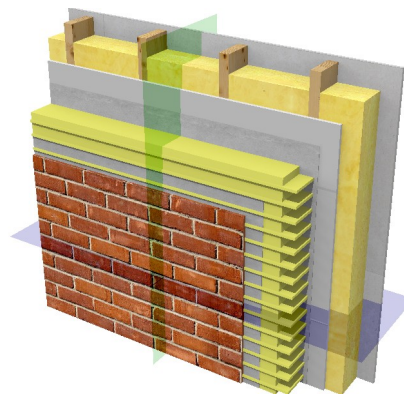
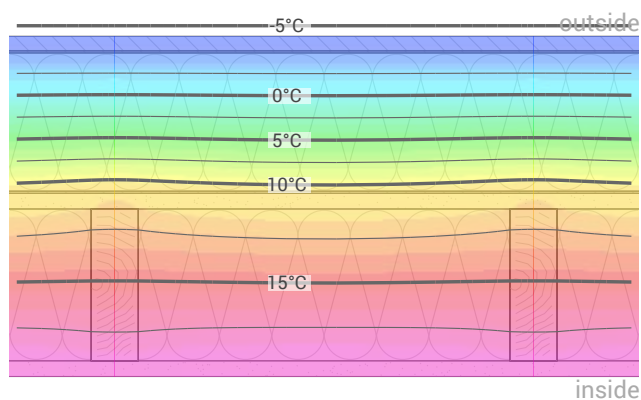
### Hints

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.

Spær 145 mm og briiso u-værdi 0,10, U=0,10 W/(m<sup>2</sup>K)

## Temperature profile



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	λ [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	1,5 cm Fermacell Gypsum Fibre Board15mm	0,320	0,047	18,8	19,5	17,3
2	14,5 cm Glasswool 35	0,035	4,143	10,8	19,4	2,6
	14,5 cm Spruce (11%)	0,130	1,115	11,6	18,9	7,3
3	1,5 cm Fermacell Powerpanel HD	0,400	0,038	10,7	11,6	14,3
4	0,2 cm Briiso klæber	1,400	0,001	10,7	11,4	4,0
5	13,2 cm Briiso PIR 0,021 med fugespor	0,021	6,286	-4,9	11,4	3,8
	14 cm Briiso PIR 0,021 med fugespor (Width: 1,2 cm)	0,021	6,667			0,9
6	0,2 cm Briiso klæber	1,400	0,001	-4,9	-4,9	3,3
7	1,4 cm Briiso teglskaller 1800 kg/m3, DIN 105	0,810	0,017	-4,9	-4,9	23,2
	Thermal contact resistance*		0,040	-5,0	-4,9	
	32,5 cm Whole component		10,025			76,6

\*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 19,4°C 19,5°C  
 Surface temperature outside (min / average / max): -4,9°C -4,9°C -4,9°C

Spær 145 mm og briiso u-værdi 0,10,  $U=0,10 \text{ W}/(\text{m}^2\text{K})$

## 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°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.

Drying reserve according to DIN 4108-3:2001: 0 g/(m<sup>2</sup>a)

At least required by DIN 68800-2: 100 g/(m<sup>2</sup>a)

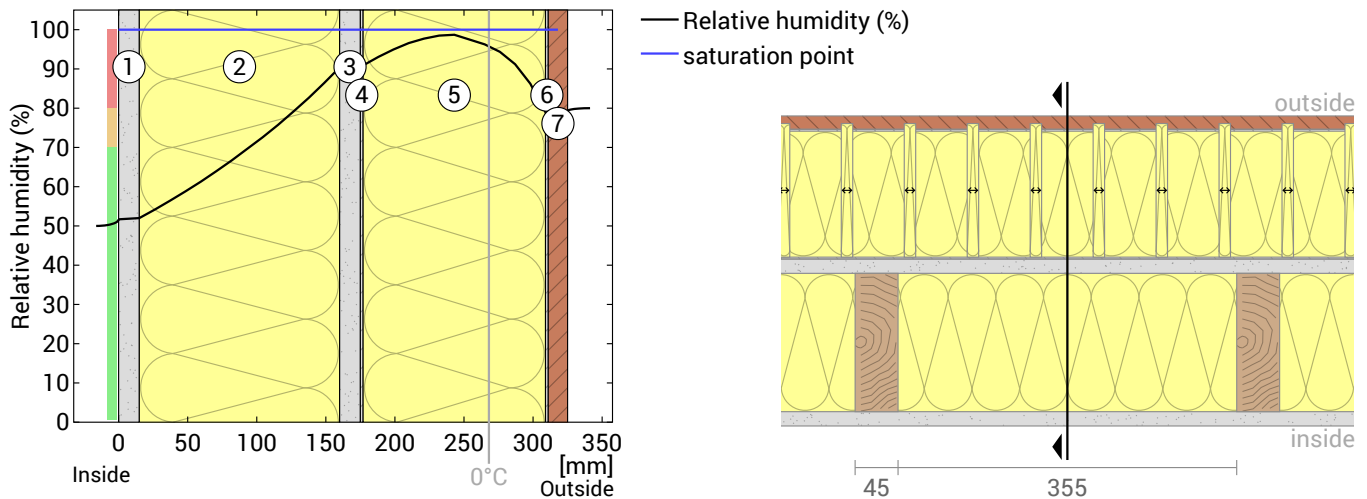
The moisture protection of this component is therefore rated poorly.

#	Material	sd-value [m]	Condensate		Weight
			[kg/m <sup>2</sup> ]	[Gew.-%]	[kg/m <sup>2</sup> ]
1	1,5 cm Fermacell Gypsum Fibre Board15mm	0,20	-		17,3
2	14,5 cm Glasswool 35	0,15	-		2,6
	14,5 cm Spruce (11%)	2,90	-	-	7,3
3	1,5 cm Fermacell Powerpanel HD	0,60	-		14,3
4	0,2 cm Briiso klæber	0,03	-		4,0
5	13,2 cm Briiso PIR 0,021 med fugespor	1320	-		3,8
	14 cm Briiso PIR 0,021 med fugespor (Width: 1,2 cm)		-		0,9
6	0,2 cm Briiso klæber	0,07	-		3,3
7	1,4 cm Briiso teglskaller 1800 kg/m3, DIN 105	0,14	-		23,2
	32,5 cm Whole component	1.321,42			76,6

## Humidity

The temperature of the inside surface is 19,0 °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 Gypsum Fibre Board15...    ④ Briiso klæber (2 mm)    ⑦ Briiso teglskaller 1800 kg/m3, DIN...  
 ② Glasswool 35 (145 mm)    ⑤ Briiso PIR 0,021 med fugespor (132 mm)  
 ③ Fermacell Powerpanel HD (15 mm)    ⑥ Briiso klæber (2 mm)

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.



Spær 145 mm og briiso u-værdi 0,10,  $U=0,10 \text{ W}/(\text{m}^2\text{K})$

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

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

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			19,42	2256	0
1	1,5 cm Fermacell Gypsum Fibre Board15mm	0,320	0,047	0,2	1150	19,31	2240	0,2
2	14,5 cm Glasswool 35	0,035	4,143	0,15	20	9,74	1207	0,34
3	1,5 cm Fermacell Powerpanel HD	0,400	0,038	0,6	950	9,66	1200	0,94
4	0,2 cm Briiso klæber	1,400	0,001	0,03	2000	9,65	1199	0,97
5	13,2 cm Briiso PIR 0,021 med fugespor	0,021	6,286	1320	35	-4,86	406	1321
6	0,2 cm Briiso klæber	1,400	0,001	0,07	2000	-4,87	406	1321
7	1,4 cm Briiso teglskaller 1800 kg/m3, DIN 105	0,810	0,017	0,14	1800	-4,91	404	1321
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

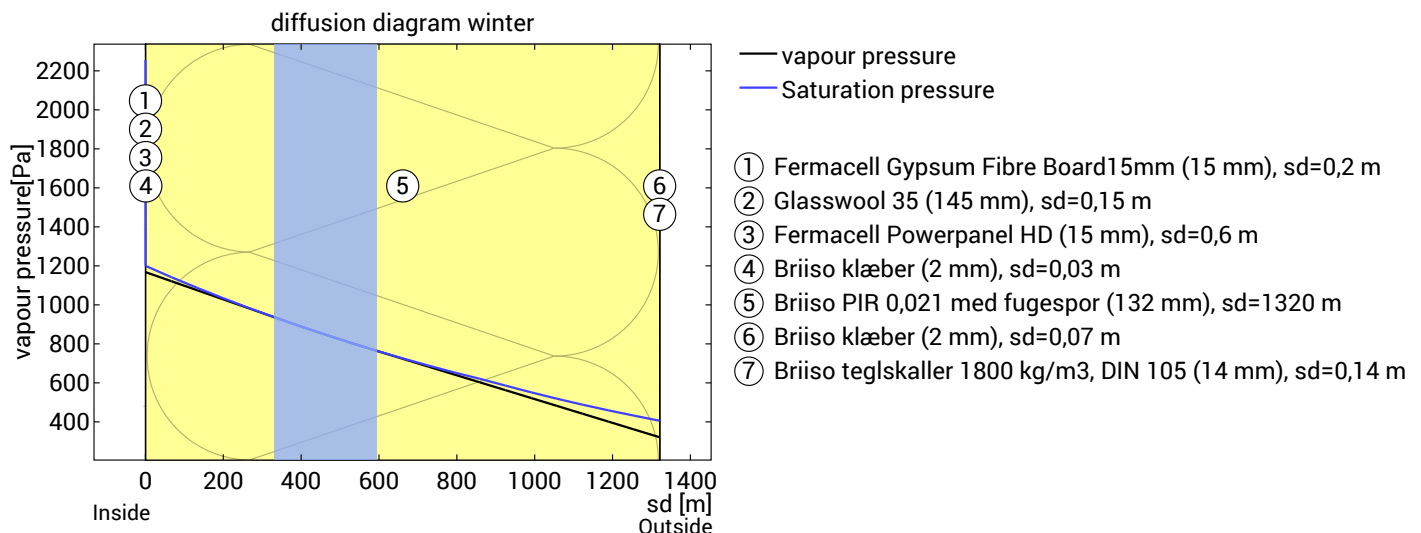
The relative humidity on the interior surface is 52%. Requirements for the prevention of building material corrosion depend on material and coating and have not been investigated.



### 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	$\delta_0 = 2.0E-10 \text{ kg}/(\text{m}^*\text{s}*\text{Pa})$
sd-value (Whole component.)	$s_{de} = 1.321,18 \text{ m}$



**Condensation area  $c_1$ :** Condensate in layer Briiso PIR 0,021 med fugespor  
 von  $s_{d_{c1i}}=330,97 \text{ m}$  until  $s_{d_{c1e}}=594,97 \text{ m}$ ;  $p_{c1i}=937 \text{ Pa}$  until  $p_{c1e}=764 \text{ Pa}$ ;  $x \sim 21 \text{ cm}$

Condensate amount:  $M_c = t_c * \delta_0 * ((p_i - p_{c1i})/s_{d_{c1i}} - (p_{c1e} - p_e)/(s_{d_e} - s_{d_{c1e}})) = 0,000 \text{ kg}/\text{m}^2$

No layer boundary in the condensation water area.

Condensation occurs within a layer. The maximum allowed amount of condensation water is therefore  $1 \text{ kg}/\text{m}^2$ .

Total amount of condensate:  $M_c = 0,000 \text{ kg}/\text{m}^2$



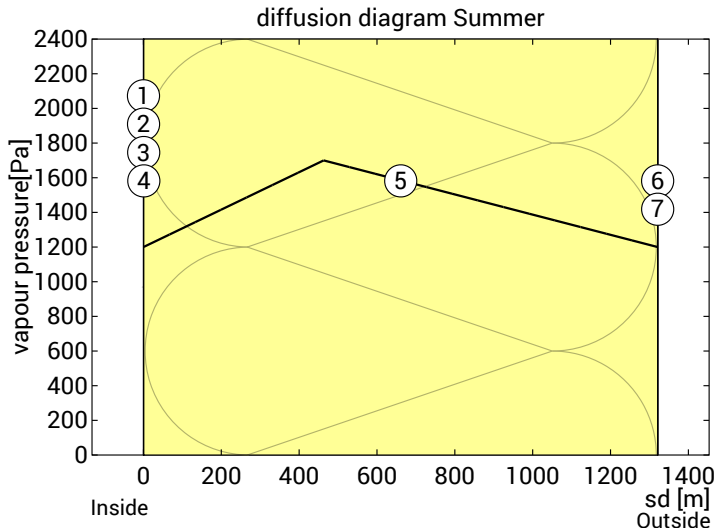


Spær 145 mm og briiso u-værdi 0,10,  $U=0,10 \text{ W}/(\text{m}^2\text{K})$

## 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.	



— vapour pressure

- ① Fermacell Gypsum Fibre Board 15mm (15 mm),  $s_d=0,2 \text{ m}$
- ② Glasswool 35 (145 mm),  $s_d=0,15 \text{ m}$
- ③ Fermacell Powerpanel HD (15 mm),  $s_d=0,6 \text{ m}$
- ④ Briiso klæber (2 mm),  $s_d=0,03 \text{ m}$
- ⑤ Briiso PIR 0,021 med fugespor (132 mm),  $s_d=1320 \text{ m}$
- ⑥ Briiso klæber (2 mm),  $s_d=0,07 \text{ m}$
- ⑦ Briiso teglskaller 1800 kg/m<sup>3</sup>, DIN 105 (14 mm),  $s_d=0,14 \text{ m}$

Condensation water from area  $c_1$  is added to the center of the area in the diffusion diagram,  $s_{d,c_1} = 462,97 \text{ m}$

Maximum possible evaporation mass

$$M_{ev} = t_c \cdot \delta_0 \cdot ((p_s - p_i) / s_{d,c_1} + (p_s - p_e) / (s_{d,e} - s_{d,c_1})) = 0,003 \text{ kg/m}^2$$

The condensation water can dry completely.



## Drying reserve (DIN 68800-2)

Using the block climate from DIN 4108-3:2001 for the calculation of the drying reserve. This climate was used when the limits were set in DIN 68800-2.

#	Material	$\lambda$ [W/mK]	R [m <sup>2</sup> K/W]	$s_d$ [m]	$\rho$ [kg/m <sup>3</sup> ]	T [°C]	$p_s$ [Pa]	$\Sigma s_d$ [m]
Thermal contact resistance			0,130					
1	1,5 cm Fermacell Gypsum Fibre Board 15mm	0,320	0,047	0,2	1150	19,64	2286	0
2	14,5 cm Glasswool 35	0,035	4,143	0,15	20	19,50	2267	0,2
3	1,5 cm Fermacell Powerpanel HD	0,400	0,038	0,6	950	7,89	1064	0,34
4	0,2 cm Briiso klæber	1,400	0,001	0,07	2000	7,79	1057	0,94
5	13,2 cm Briiso PIR 0,021 med fugespor	0,021	6,286	1320	35	7,78	1057	1,01
6	0,2 cm Briiso klæber	1,400	0,001	0,07	2000	-9,84	263	1321
7	1,4 cm Briiso teglskaller 1800 kg/m <sup>3</sup> , DIN 105	0,810	0,017	0,14	1800	-9,84	263	1321
Thermal contact resistance			0,040					
						-9,89	262	1321

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

## Dew period (winter)

### Boundary conditions

Vapor pressure inside at 20°C and 50% humidity	$p_i = 1168 \text{ Pa}$
Vapor pressure outside at -10°C and 80% humidity	$p_e = 208 \text{ Pa}$
Duration of condensation period (60 days)	$t_c = 5184000 \text{ s}$
Water vapor diffusion coefficient in static air	$\delta_0 = 1.852\text{E-}10 \text{ kg}/(\text{m}^2\text{s}\cdot\text{Pa})$
sd-value (Whole component.)	$s_{d,e} = 1.321,22 \text{ m}$

**Condensation area c<sub>1</sub>:** Layers Glasswool 35 and Fermacell Powerpanel HD  
 von  $sd_{c1i}=0,34m$  until  $sd_{c1e}=529,01m$ ;  $p_{c1i}=1064Pa$  until  $p_{c1e}=644Pa$ ;  $x \sim 16$  cm

Condensate amount:  $Mc1 = tc * \delta_0 * ((p_i - p_{c1i}) / sd_{c1i} - (p_{c1e} - p_{c2i}) / (sd_{c2i} - sd_{c1e})) = 0,293 \text{ kg/m}^2$

Glasswool 35 wird als nicht wasseraufnahmefähig eingestuft weil  $A_w < 0.1$  ist.  
 Fermacell Powerpanel HD wird als wasseraufnahmefähig eingestuft weil  $A_w \geq 0.1$  ist.

**Condensation area c<sub>2</sub>:** Condensate in layer Briiso PIR 0,021 med fugespor  
 von  $sd_{c2i}=661,01m$  until  $sd_{c2e}=793,01m$ ;  $p_{c2i}=561Pa$  until  $p_{c2e}=484Pa$ ;  $x \sim 24,3$  cm

Condensate amount:  $Mc2 = tc * \delta_0 * ((p_{c1e} - p_{c2i}) / (sd_{c2i} - sd_{c1e}) - (p_{c2e} - p_e) / (sd_e - sd_{c2e})) = 0,000 \text{ kg/m}^2$

No layer boundary in the condensation water area.

At least one moistened layer is not classified as water absorptive. The maximum allowed amount of condensation water is therefore  $0.5 \text{ kg/m}^2$ .

Total amount of condensate:  $Mc = 0,293 \text{ kg/m}^2$

## Evaporation period (summer)

### Boundary conditions

Interior vapor pressure	$p_i = 982 \text{ Pa}$
Exterior vapor pressure	$p_e = 982 \text{ Pa}$
Saturation vapour pressure in the condensation area	$p_s = 1403 \text{ Pa}$
Length of drying season (90 days)	$tev = 7776000 \text{ s}$

sd-values remain unchanged.

Condensation water from area c<sub>1</sub> is added to the center of the area in the diffusion diagram,  $sd_{c1} = 264,68$  m  
 Condensation water from area c<sub>2</sub> is added to the center of the area in the diffusion diagram,  $sd_{c2} = 727,01$  m  
 Tauwasserausfall in zwei Ebenen. Berechnung der von den beiden Tauwasserebenen weg diffundierenden Diffusionsstromdichten:

$gev1 = \delta_0 * (ps - pi) / sd_{c1} = 2.945e-10 \text{ kg/(m}^2\text{s)}$

$gev2 = \delta_0 * (ps - pe) / (sde - sd_{c2}) = 1.312e-10 \text{ kg/(m}^2\text{s)}$

Evaporation times:

$tev1 = Mc1 / gev1 = 995083978 \text{ s (11.517,2 Tage)}$

$tev2 = Mc2 / gev2 = 777733 \text{ s (9,0 Tage)}$

Layer 2 dries first. Calculate the total potential evaporation mass:

$Mev2 = gev2 * tev2 = 0,000 \text{ kg/m}^2$

$Mev1 = gev1 * tev1 + [\delta_0 * (ps - pe) / (1321.22 - 264.675)] * (tev1 - tev2) = 0,003 \text{ kg/m}^2$

Evaporation mass:  $Mev = Mev1 + Mev2 = 0,003 \text{ kg/m}^2$

The condensation amount of  $0,293 \text{ kg/m}^2$  can not dry completely.

### No drying reserve! ( $Mev < Mc$ )

Minimum requested for walls and ceilings:  $100 \text{ g/m}^2/\text{a}$

Demand not met!

## Evaluation according to DIN 4108-3

The component is not permissible regarding the moisture protection.

## Hints

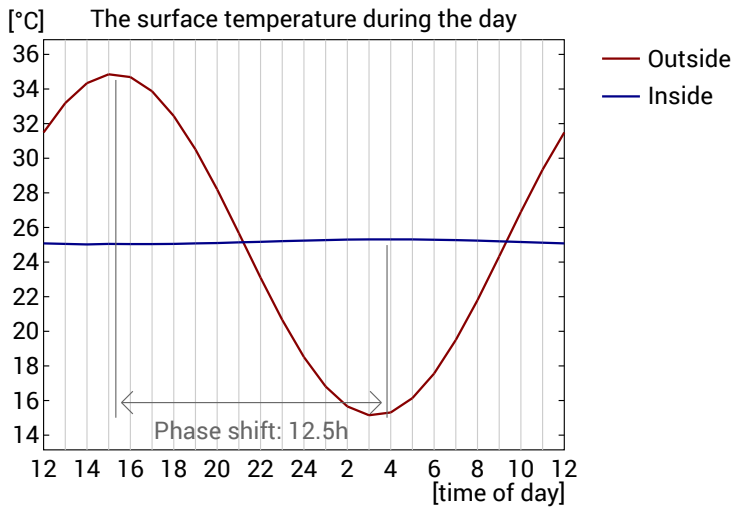
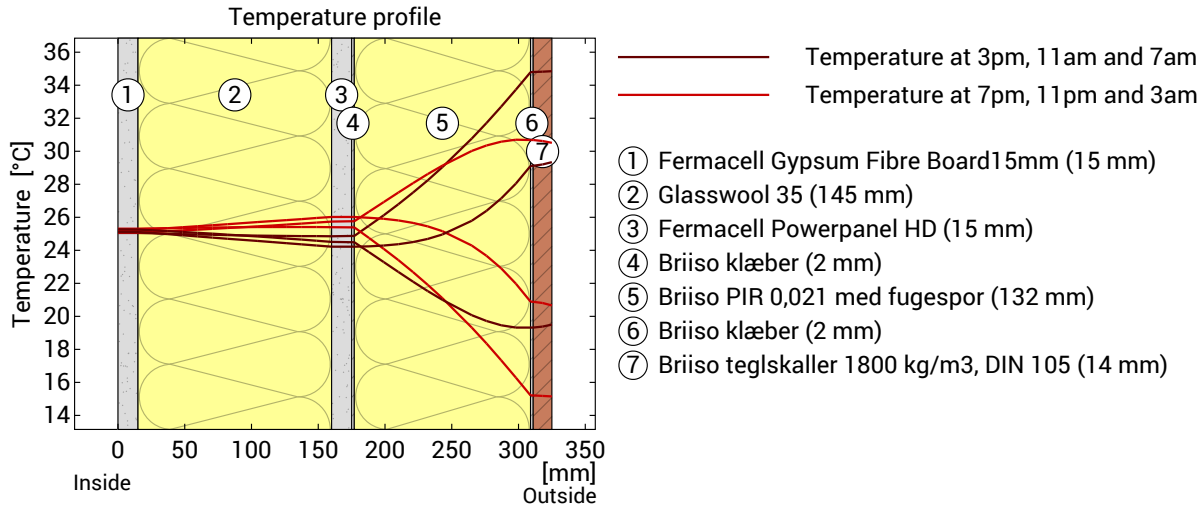
In the case of inhomogeneous constructions, such as skeleton-, stand- or frame constructions, as well as in wooden beam, rafter or half-timbered constructions or the like, the one-dimensional diffusion calculations are only to be demonstrated for the compartment area. Exceptional cases are special constructions 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.

Spær 145 mm og briiso u-værdi 0,10,  $U=0,10 \text{ W}/(\text{m}^2\text{K})$

## 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*	12,5 h	Heat storage capacity (whole component):	87 kJ/m <sup>2</sup> K
Amplitude attenuation **	63,7	Thermal capacity of inner layers:	44 kJ/m <sup>2</sup> K
TAV ***	0,016		

\* 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.



briiso giver ingen garanti for beregninger i dette dokument.

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Spær 145 mm og briiso u-værdi 0,10,  $U=0,10 \text{ W}/(\text{m}^2\text{K})$

## Hints

There are no hints available for your calculation.