

## Gasbeton 250 mm og briiso u-værdi 0,15

### Thermal protection

$U = 0,15 \text{ W}/(\text{m}^2\text{K})$

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



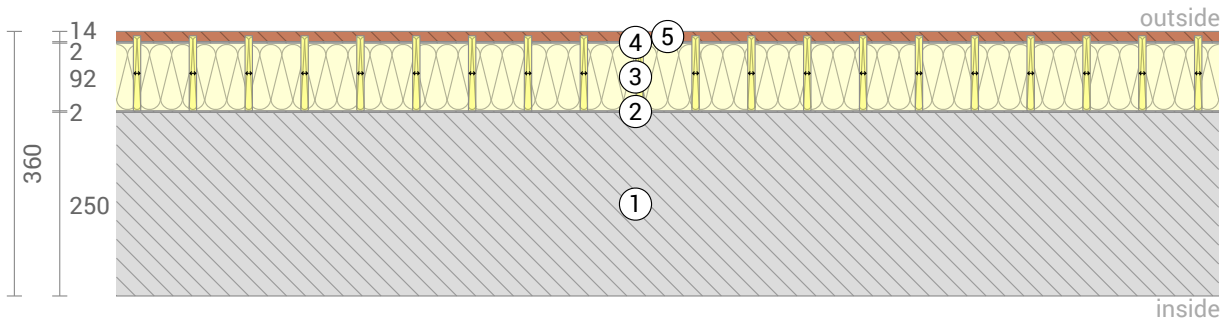
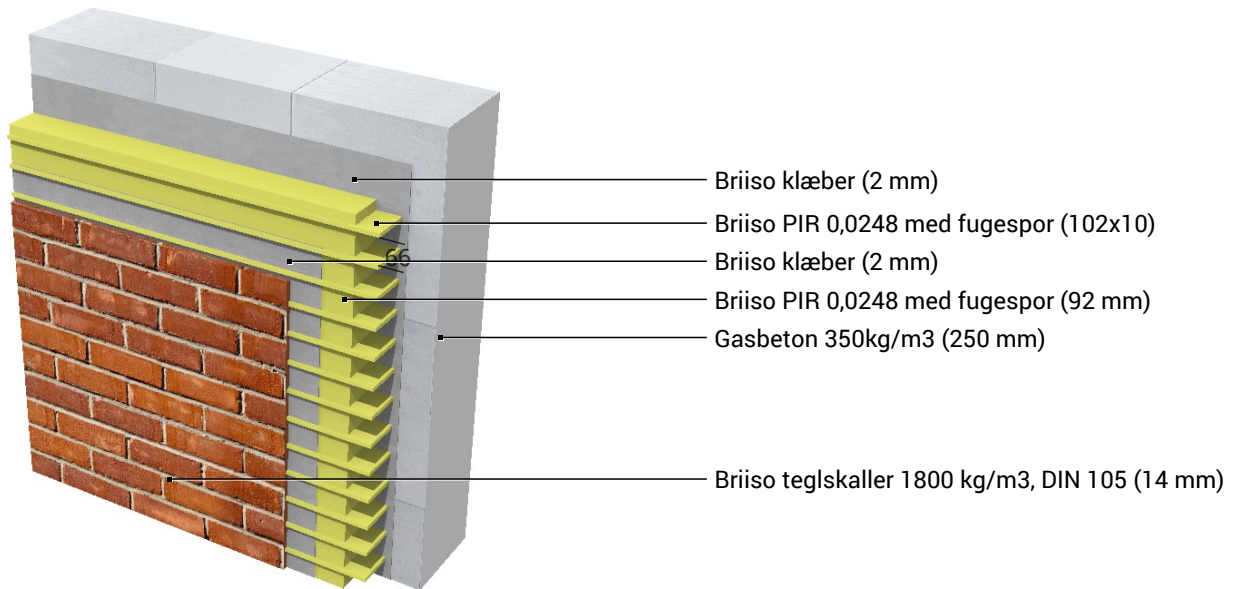
### Moisture proofing

Dries 6 days  
Condensate:  $40 \text{ g}/\text{m}^2$



### Heat protection

Temperature amplitude damping: 80  
phase shift: 15,3 h  
Thermal capacity inside:  $72 \text{ kJ}/\text{m}^2\text{K}$



- ① Gasbeton 350kg/m<sup>3</sup> (250 mm)
- ② Briiso klæber (2 mm)
- ③ Briiso PIR 0,0248 med fugespor (92 mm)
- ④ Briiso klæber (2 mm)
- ⑤ Briiso teglskaller 1800 kg/m<sup>3</sup>, DIN 105 (14 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.: 19,1°C / -4,9°C

sd-value: 9201,5 m  
Drying reserve: 0 g/m<sup>2</sup>a

Thickness: 36,0 cm  
Weight: 122 kg/m<sup>2</sup>  
Heat capacity: 126 kJ/m<sup>2</sup>K

EnEV Bestand     ESanMV     EnEV16 Neubau     EnEV14 Neubau

Gasbeton 250 mm og briiso u-værdi 0,15,  $U=0,15 \text{ W}/(\text{m}^2\text{K})$

## 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	Gasbeton (aerated concrete) 350kg/m <sup>3</sup>	25,00	0,090	2,778
2	Briiso klæber	0,20	1,400	0,001
3	Briiso PIR 0,0248 med fugespor	9,20	0,025	3,710
	Briiso PIR 0,0248 med fugespor (Width: 1 cm)	10,20	0,025	4,113
4	Briiso klæber	0,20	1,400	0,001
5	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  $R_{\text{tot;upper}} = 6,727 \text{ m}^2\text{K}/\text{W}$ .

Lower limit of thermal resistance  $R_{\text{tot;lower}} = 6,679 \text{ m}^2\text{K}/\text{W}$ .

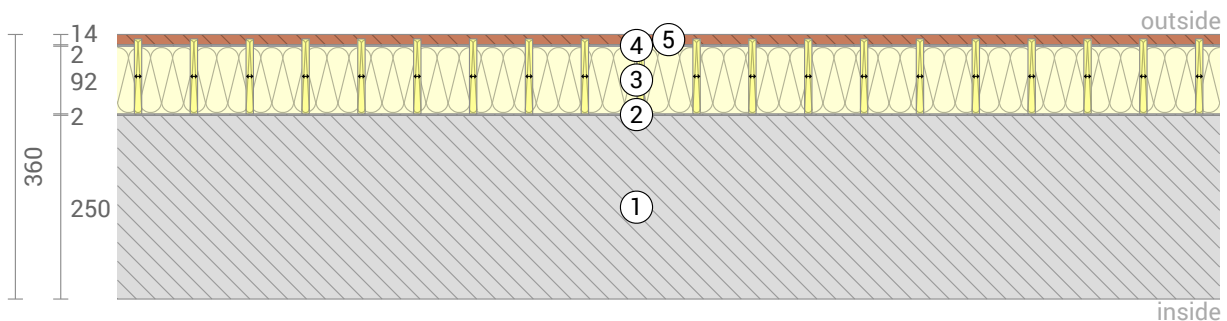
Check applicability:  $R_{\text{tot;upper}} / R_{\text{tot;lower}} = 1,007$  (maximum allowed: 1,5)

The procedure may be used.

Thermal resistance  $R_{\text{tot}} = (R_{\text{tot;upper}} + R_{\text{tot;lower}})/2 = 6,703 \text{ m}^2\text{K}/\text{W}$

Estimated maximum relative uncertainty according to section 6.7.2.5: 0,35%

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



Gasbeton 250 mm og briiso u-værdi 0,15, U=0,15 W/(m²K)

## LCA

Heat loss: 12 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): 221 kWh/m²



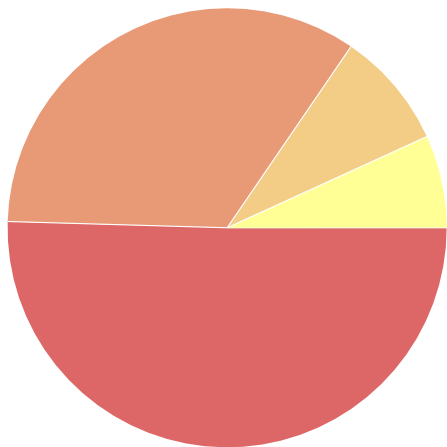
Non-renewable primary energy (= energy from fossil fuels and nuclear energy) that was used to produce the new building materials ("cradle to gate").

Green house gas potential: 71 kg CO2 Äqv./m²



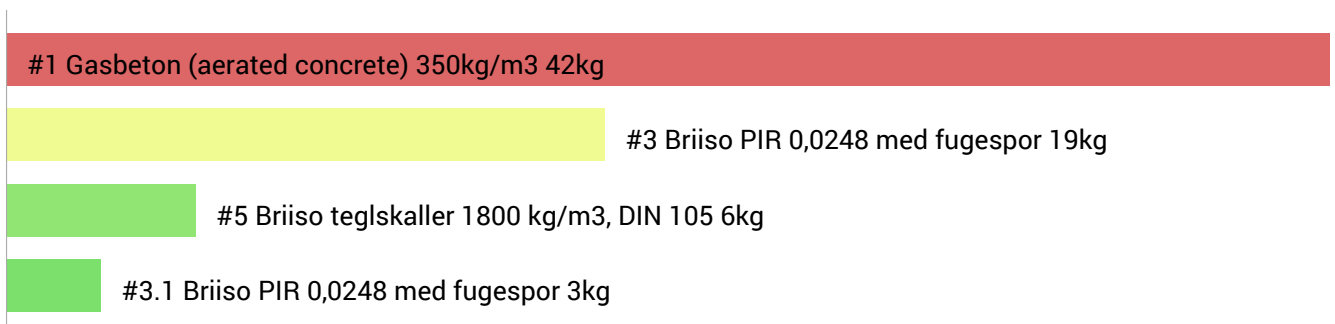
Quantity of released greenhouse gases in the production of building materials used ("cradle to gate").

Composition of non-renewable primary energy of production:



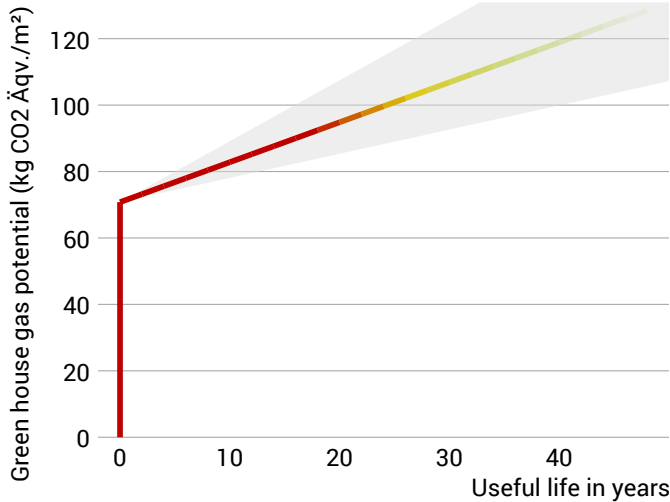
- Briiso PIR 0,0248 med fugespor (92 mm) 50%
- Gasbeton 350kg/m3 (250 mm) 34%
- Briiso PIR 0,0248 med fugespor (102x10) 9%
- Briiso teglskaller 1800 kg/m3, DIN 105 (14 mm) 7%

Composition of the greenhouse potential of production:



Gasbeton 250 mm og briiso u-værdi 0,15,  $U=0,15 \text{ W}/(\text{m}^2\text{K})$

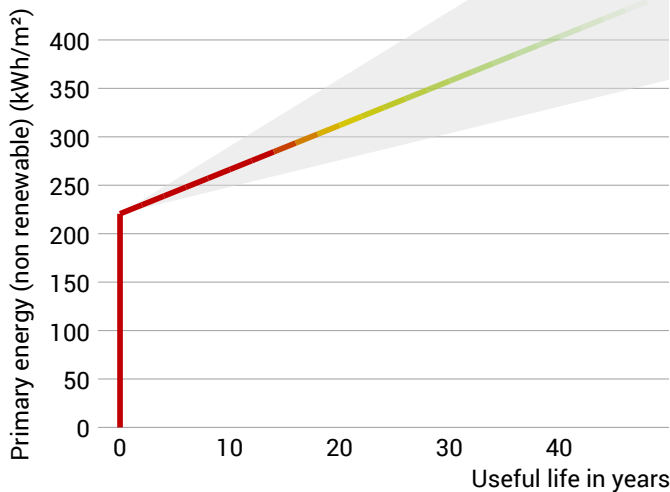
## Global warming potential and primary energy for construction and use



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).

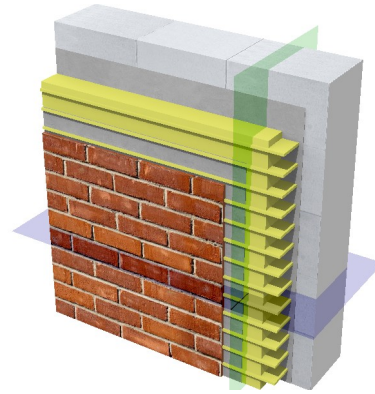
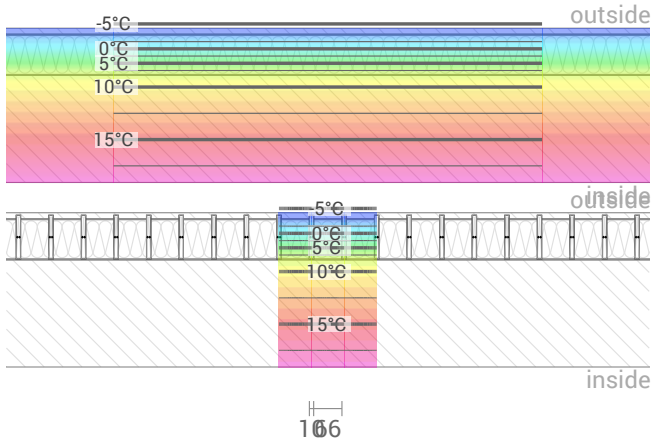
### Hints

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.

Gasbeton 250 mm og briiso u-værdi 0,15, U=0,15 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	$\lambda$ [W/mK]	R [m <sup>2</sup> K/W]	Temperatur [°C]		Weight [kg/m <sup>2</sup> ]
				min	max	
	Thermal contact resistance*		0,250	19,1	20,0	
1	25 cm Gasbeton (aerated concrete) 350kg/m <sup>3</sup>	0,090	2,778	8,9	19,1	87,5
2	0,2 cm Briiso klæber	1,400	0,001	8,9	8,9	4,0
3	9,2 cm Briiso PIR 0,0248 med fugespor	0,025	3,710	-4,8	8,9	3,2
	10,2 cm Briiso PIR 0,0248 med fugespor (Width: 1 cm)	0,025	4,113			0,5
4	0,2 cm Briiso klæber	1,400	0,001	-4,8	-4,8	3,5
5	1,4 cm Briiso teglskaller 1800 kg/m <sup>3</sup> , DIN 105	0,810	0,017	-4,9	-4,8	23,3
	Thermal contact resistance*		0,040	-5,0	-4,9	
	36 cm Whole component		6,703			122,0

\*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

Gasbeton 250 mm og briiso u-værdi 0,15,  $U=0,15 \text{ W}/(\text{m}^2\text{K})$

## 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.

Under these conditions, a total of 0,040 kg of condensation water per square meter is accumulated. This quantity dries in summer in 6 days (Drying season according to DIN 4108-3:2018-10).

#	Material	sd-value [m]	Condensate [kg/m <sup>2</sup> ] [Gew.-%]	Weight [kg/m <sup>2</sup> ]
1	25 cm Gasbeton (aerated concrete) 350kg/m <sup>3</sup>	1,25	0,031	87,5
2	0,2 cm Briiso klæber	0,07	0,040	4,0
3	9,2 cm Briiso PIR 0,0248 med fugespor	9200	0,0086	3,2
	10,2 cm Briiso PIR 0,0248 med fugespor (Width: 1 cm)		-	0,5
4	0,2 cm Briiso klæber	0,07	-	3,5
5	1,4 cm Briiso teglskaller 1800 kg/m <sup>3</sup> , DIN 105	0,14	-	23,3
	36 cm Whole component	9.201,53	0,040	122,0

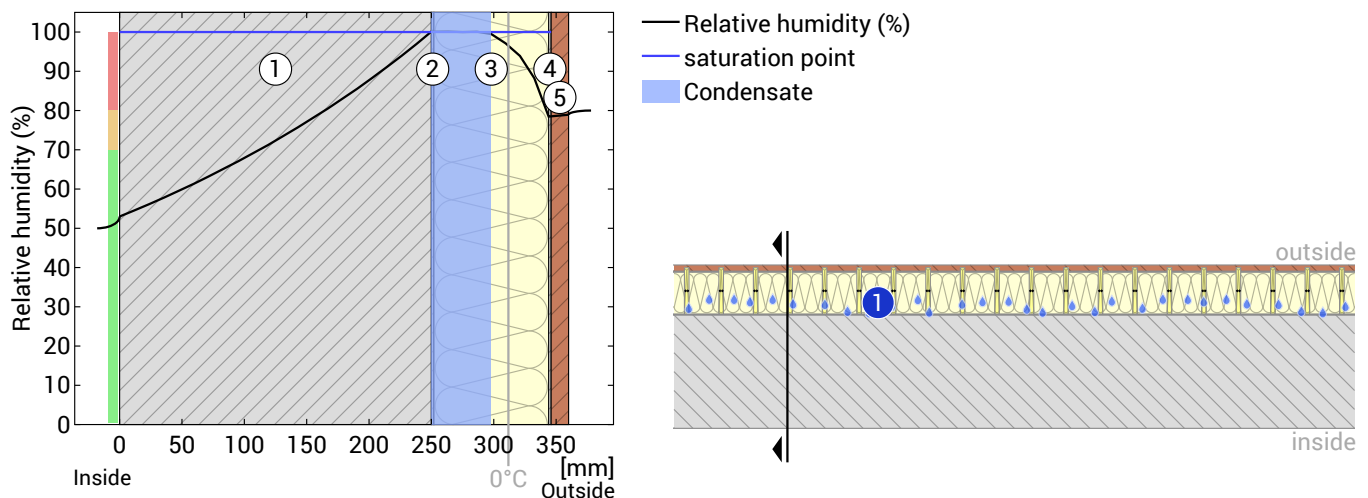
## Condensation areas

- ① Condensate: 0,04 kg/m<sup>2</sup> Affected layers: Briiso klæber, Gasbeton (aerated concrete) 350kg/m<sup>3</sup>, Briiso PIR 0,0248 med fugespor

## 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 Gasbeton 350kg/m<sup>3</sup> (250 mm)      ③ Briiso PIR 0,0248 med fugespor (92 m)      ⑤ Briiso teglskaller 1800 kg/m<sup>3</sup>, DIN...  
 ② Briiso klæber (2 mm)                      ④ 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.

Gasbeton 250 mm og briiso u-værdi 0,15,  $U=0,15 \text{ W}/(\text{m}^2\text{K})$

## 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			19,08	2207	0
1	25 cm Gasbeton (aerated concrete) 350kg/m <sup>3</sup>	0,090	2,778	1,25	350			
2	0,2 cm Briiso klæber	1,400	0,001	0,07	2000	8,86	1137	1,25
3	9,2 cm Briiso PIR 0,0248 med fugespor	0,025	3,710	9200	40	8,86	1136	1,32
4	0,2 cm Briiso klæber	1,400	0,001	0,07	2000	-4,78	409	9201
5	1,4 cm Briiso teglskaller 1800 kg/m <sup>3</sup> , DIN 105	0,810	0,017	0,14	1800	-4,79	409	9201
Thermal contact resistance			0,040			-4,85	406	9202

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

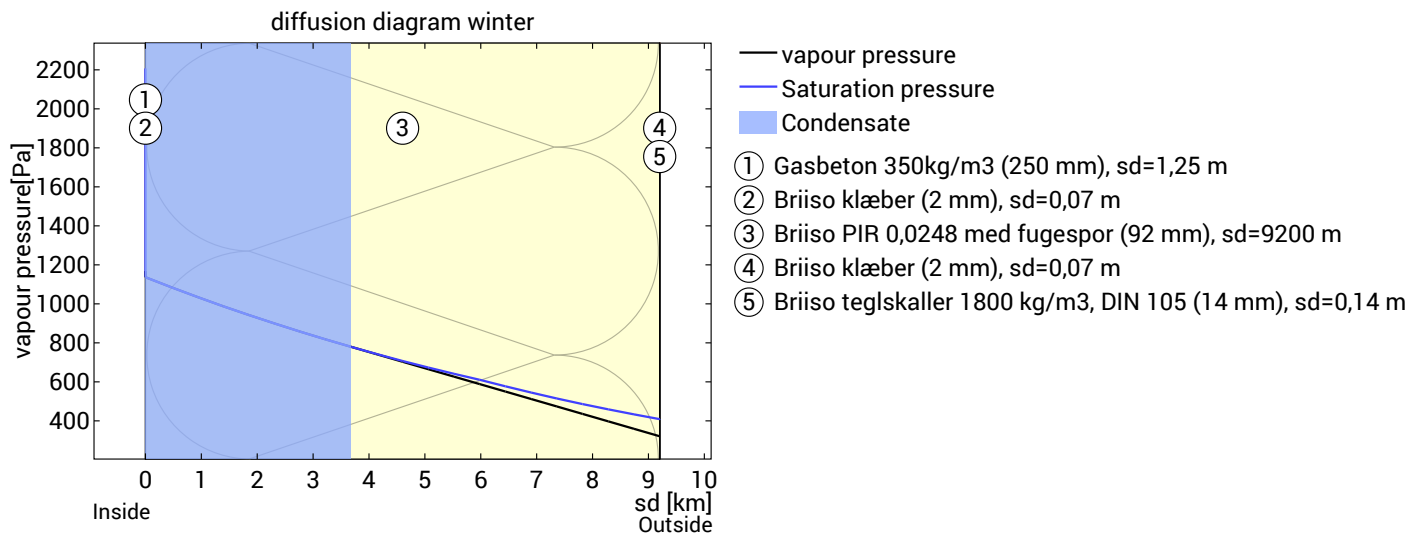
The relative humidity on the interior surface is 53%. Requirements for the prevention of building material corrosion depend on material and coating and have not been investigated.



### Dew period (winter)

#### Boundary conditions

Vapor pressure inside at 20°C and 50% humidity	$p_i = 1168 \text{ Pa}$
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.)	$s_{de} = 9.201,53 \text{ m}$



**Condensation area  $c_1$ :** Layers Gasbeton (aerated concrete) 350kg/m<sup>3</sup> and Briiso klæber von  $s_{d_{ci}}=1,25\text{m}$  until  $s_{d_{ce}}=3.681,32\text{m}$ ;  $p_{ci}=1137\text{Pa}$  until  $p_{ce}=780\text{Pa}$ ;  $x \sim 25 \text{ cm}$

Condensate amount:  $M_c = t_c * \delta_0 * ((p_i - p_{ci}) / s_{d_{ci}} - (p_{ce} - p_e) / (s_{de} - s_{d_{ce}})) = 0,038 \text{ kg}/\text{m}^2$

Gasbeton (aerated concrete) 350kg/m<sup>3</sup> wird als wasseraufnahmefähig eingestuft weil  $A_w \geq 0.1$  ist.

Für Schicht Briiso klæber wurde noch kein Wasseraufnahmekoeffizient hinterlegt. Es wird deshalb angenommen, dass mindestens eine Schicht nicht kapillar wasseraufnahmefähig ist.

The maximum allowed amount of condensation water is at least 0,5 kg/m<sup>2</sup>.

Total amount of condensate:  $M_c = 0,038 \text{ kg}/\text{m}^2$

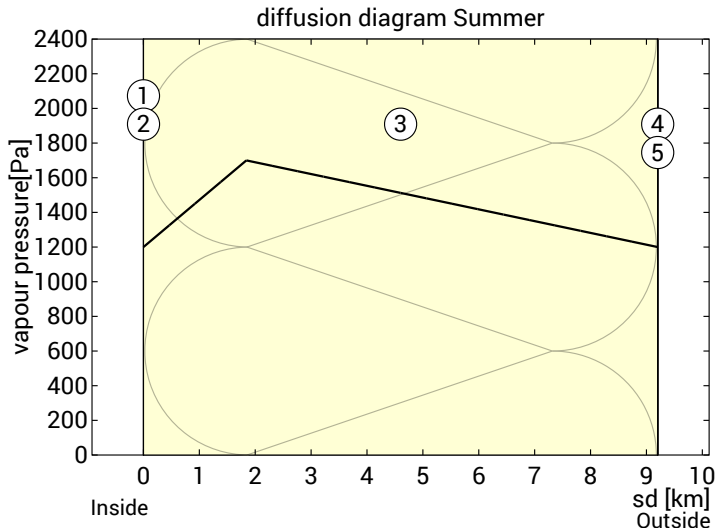


Gasbeton 250 mm og briiso u-værdi 0,15,  $U=0,15 \text{ W}/(\text{m}^2\text{K})$

## 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 Gasbeton 350kg/m<sup>3</sup> (250 mm),  $s_{d1}=1,25 \text{ m}$
- ② Briiso klæber (2 mm),  $s_{d2}=0,07 \text{ m}$
- ③ Briiso PIR 0,0248 med fugespor (92 mm),  $s_{d3}=9200 \text{ m}$
- ④ Briiso klæber (2 mm),  $s_{d4}=0,07 \text{ m}$
- ⑤ Briiso teglskaller 1800 kg/m<sup>3</sup>, DIN 105 (14 mm),  $s_{d5}=0,14 \text{ m}$

Condensation water from area  $c_1$  is added to the center of the area in the diffusion diagram,  $s_{d_{c1}} = 1.841,29 \text{ m}$

Maximum possible evaporation mass

$$M_{ev} = t_c \cdot \delta_0 \cdot ((p_s - p_i) / s_{d_{c1}} + (p_s - p_e) / (s_{d_e} - s_{d_{c1}})) = 0,001 \text{ kg/m}^2$$

The condensation amount of  $0,038 \text{ kg/m}^2$  can not dry completely.

Demand not met!

## 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	25 cm Gasbeton (aerated concrete) 350kg/m <sup>3</sup>	0,090	2,778	1,25	350	19,42	2255	0
2	0,2 cm Briiso klæber	1,400	0,001	0,07	2000	6,94	997	1,25
3	9,2 cm Briiso PIR 0,0248 med fugespor	0,025	3,710	9200	40	6,93	996	1,32
4	0,2 cm Briiso klæber	1,400	0,001	0,07	2000	-9,74	265	9201
5	1,4 cm Briiso teglskaller 1800 kg/m <sup>3</sup> , DIN 105	0,810	0,017	0,14	1800	-9,74	265	9201
	Thermal contact resistance		0,040			-9,82	263	9202

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	$\delta_0 = 1.852E-10 \text{ kg}/(\text{m}^2\text{sPa})$
sd-value (Whole component.)	$s_{de} = 9.201,53 \text{ m}$

Condensation area  $c_1$ : Layers Gasbeton (aerated concrete) 350kg/m<sup>3</sup> and Briiso klæber



von  $sd_{c1i}=1,25\text{m}$  until  $sd_{c1e}=3.221,32\text{m}$ ;  $p_{c1i}=997\text{Pa}$  until  $p_{c1e}=661\text{Pa}$ ;  $x \sim 25\text{ cm}$

Condensate amount:  $Mc1 = tc * \delta_0 * ((p_i - p_{c1i}) / sd_{c1i} - (p_{c1e} - p_{c2i}) / (sd_{c2i} - sd_{c1e})) = 0,131\text{ kg/m}^2$

Gasbeton (aerated concrete) 350kg/m<sup>3</sup> wird als wasseraufnahmefähig eingestuft weil  $Aw \geq 0.1$  ist.

Für Schicht Briiso kläber wurde noch kein Wasseraufnahmekoeffizient hinterlegt. Es wird deshalb angenommen, dass mindestens eine Schicht nicht kapillar wasseraufnahmefähig ist.

**Condensation area  $c_2$ :** Condensate in layer Briiso PIR 0,0248 med fugespor

von  $sd_{c2i}=4.601,32\text{m}$  until  $sd_{c2e}=5.521,32\text{m}$ ;  $p_{c2i}=544\text{Pa}$  until  $p_{c2e}=472\text{Pa}$ ;  $x \sim 29,8\text{ cm}$

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.

The maximum allowed amount of condensation water is at least 0,5 kg/m<sup>2</sup>.

Total amount of condensate:  $Mc = 0,131\text{ kg/m}^2$

## 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  $c_1$  is added to the center of the area in the diffusion diagram,  $sd_{c1} = 1.611,29\text{ m}$

Condensation water from area  $c_2$  is added to the center of the area in the diffusion diagram,  $sd_{c2} = 5.061,32\text{ m}$

Tauwasserausfall in zwei Ebenen. Berechnung der von den beiden Tauwasserebenen weg diffundierenden

Diffusionsstromdichten:

$gev1 = \delta_0 * (p_s - p_i) / sd_{c1} = 4.838e-11\text{ kg/(m}^2\text{s)}$

$gev2 = \delta_0 * (p_s - p_e) / (sde - sd_{c2}) = 1.883e-11\text{ kg/(m}^2\text{s)}$

Evaporation times:

$tev1 = Mc1 / gev1 = 2713159269\text{ s (31.402,3 Tage)}$

$tev2 = Mc2 / gev2 = 665332\text{ s (7,7 Tage)}$

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

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

$Mev1 = gev1 * tev2 + [gev1 + \delta_0 * (p_s - p_e) / (9201.53 - 1611.285)] * (tev - tev2) = 0,000\text{ kg/m}^2$

Evaporation mass:  $Mev = Mev1 + Mev2 = 0,000\text{ kg/m}^2$

The condensation amount of 0,131 kg/m<sup>2</sup> can not dry completely.

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

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 not permissible regarding the moisture protection.

## Hints

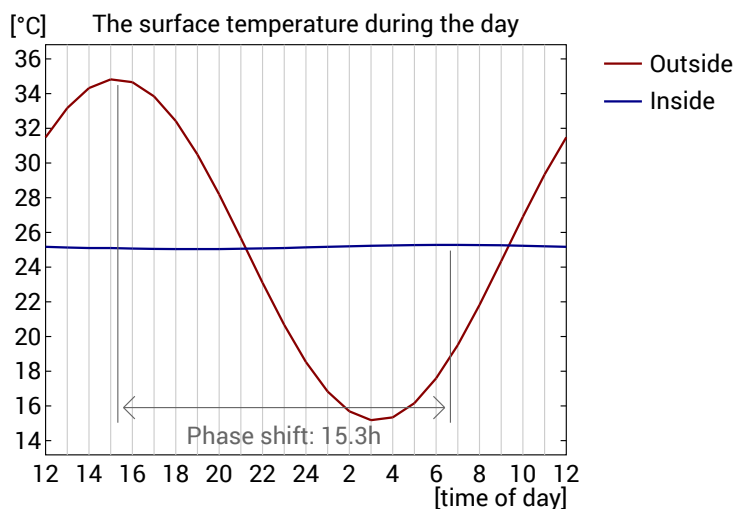
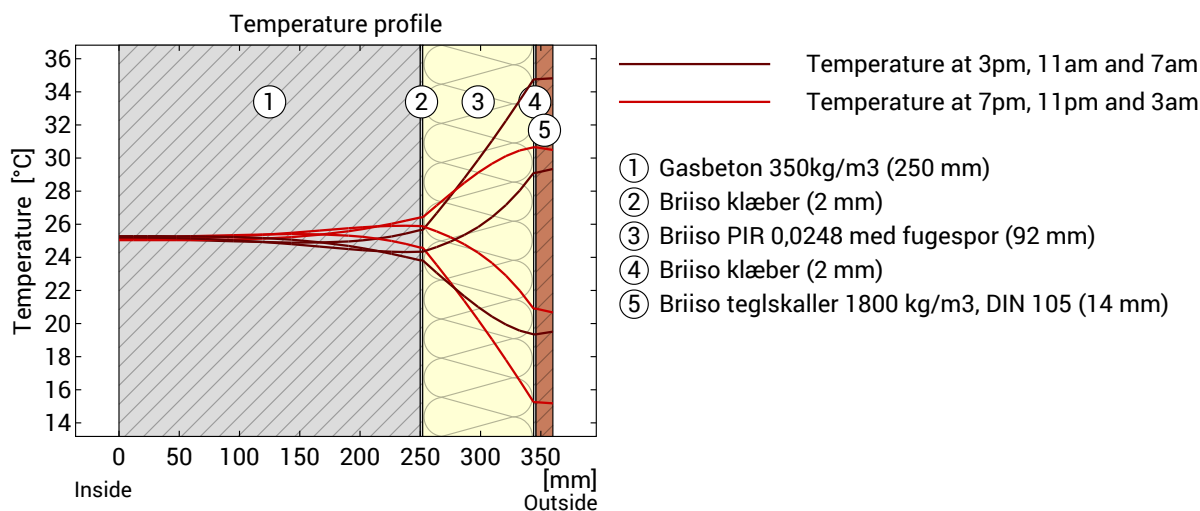
In the case of inhomogeneous constructions, such as skeleton-, stand- or frame constructions, as well as in wooden beam, rafter or half-timbered constructions or the like, the one-dimensional diffusion calculations are only to be demonstrated for the compartment area. Exceptional cases are special constructions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

Gasbeton 250 mm og briiso u-værdi 0,15, U=0,15 W/(m²K)

## 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*	15,3 h	Heat storage capacity (whole component):	126 kJ/m²K
Amplitude attenuation **	80,0	Thermal capacity of inner layers:	72 kJ/m²K
TAV ***	0,013		

\* 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.

Gasbeton 250 mm og briiso u-værdi 0,15,  $U=0,15 \text{ W}/(\text{m}^2\text{K})$

## Hints

### **All timber layers are rotated**

In this construction, all timber layers were rotated by 90°. They therefore run parallel to the cutting plane of the 2D moisture protection calculation and were NOT included in the moisture protection calculation.