Report - Certified Passive House Component I Bericht - Zertifizierte Passivhaus Komponente

Passive House Institute

Recommended for | Empfohlen für

Warm, temperate climate | Clima caldo temperato

Window system
Sistema della finestra
1394ws04

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GERMANY

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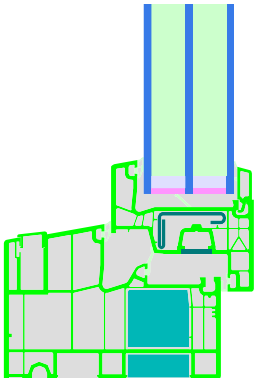
www.passiv.de

Product | Prodotto:	**PVC Piva Serie MD**
Client | Produttore:	**Piva Group S.p.A.**
Spacer | Distanziatore:	**Multitech**
Date | Data:	**31.05.2019**
Author | Autore:	**Dr.-Ing. Benjamin Krick**



Because a separate heating system is not necessarily required in Passive Houses, high demands are placed on the quality of the building components used. The colder the climate, the higher the requirements for the components. To cover this, PHI has identified regions of similar requirements, and defined certification criteria. These criteria are available for free download at the website of the Passive House Institute.

If no radiator is placed under the window, its thermal transmittance U_W (U-value) may not exceed a climate-dependent value in order to prevent unpleasant radiation losses and cold down droughts. For a given quality of glazing, this results in restriction of the thermal losses of the window frame and the glass edge. In that context, the installation situation of the window in the wall is relevant. Because of that, a $U_{W,installed}$ exemplary tested for the certification has been defined.

Also the hygiene criterion must be met. For reasons of hygiene, this criterion limits the minimum individual temperature on window surfaces to prevent condensate and mold growth.

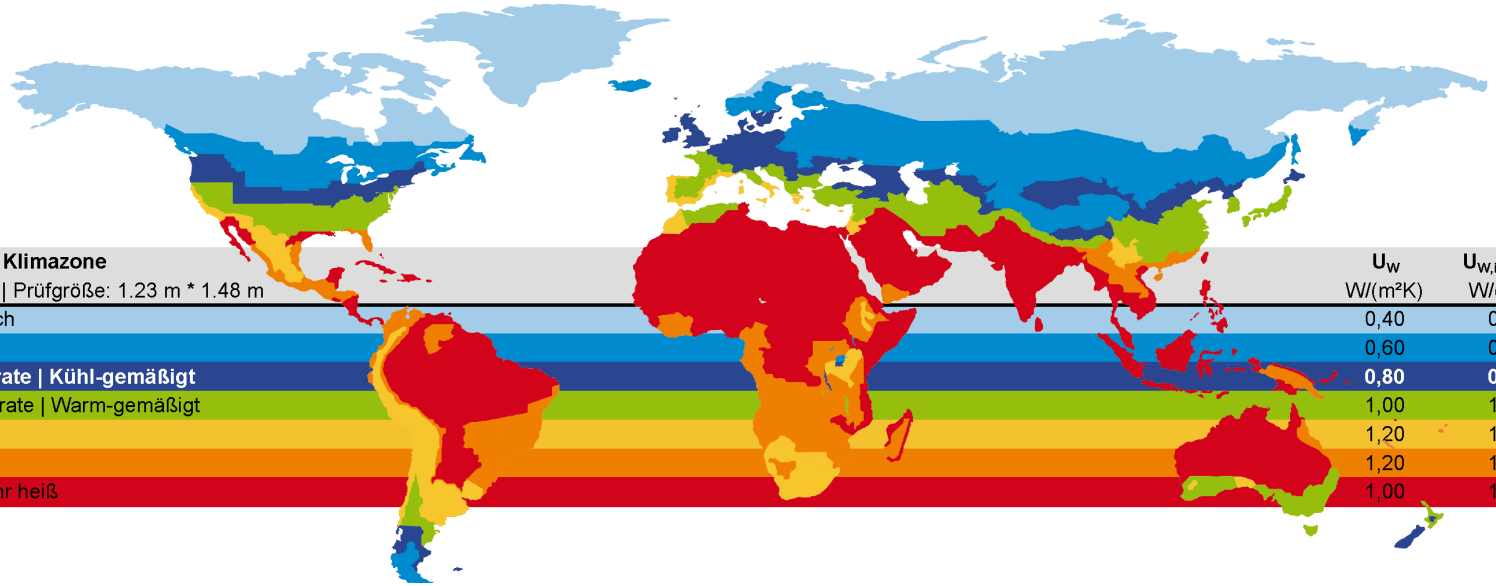
The below stated requirements for awarding the label "Certified Passive House Component" have been set by the Passive House Institute (PHI).

Poiché nelle Case Passive non è necessario un sistema di riscaldamento separato, vengono posti requisiti elevati sulla qualità dei componenti dell'edificio. Più il clima è freddo, più elevati sono i requisiti per i componenti. Per coprire questo aspetto, il PHI ha identificato delle regioni con requisiti simili e definito i criteri di certificazione. Questi criteri sono disponibili per il download gratuito sul sito web del Passive House Institute.

Se nessun radiatore è posizionato sotto la finestra, la sua trasmittanza termica UW (valore U) non può superare un valore dipendente dal clima per evitare spiacevoli perdite di radiazioni e siccità a freddo. Per una data qualità del pannello di vetro, ciò comporta una limitazione delle perdite termiche del telaio della finestra e del distanziatore. In questo contesto, la situazione di installazione della finestra nel muro è rilevante. Per questo motivo, è stato definito un UW, esemplare installato testato per la certificazione.

Anche il criterio d'igiene deve essere soddisfatto. Per ragioni d'igiene, questo criterio limita la temperatura individuale minima sulle superfici delle finestre per prevenire la formazione di condensa e muffa.

I seguenti requisiti per l'assegnazione dell'etichetta "Componente Certificato Passive House" sono stati stabiliti dal Passive House Institute (PHI).



Climate zone | Klimazone Reference size | Prüfgröße: 1.23 m * 1.48 m	U_W W/(m²K)	$U_{W,installed}$ W/(m²K)	U_g for cert. W/(m²K)	$f_{Rsi=0,25\ m^2K/W}$ -
1 Arctic | Arktisch	0,40	0,45	0,35	0,80
2 Cold | Kalt	0,60	0,65	0,52	0,75
3 Cool, temperate | Kühl-gemäßigt	**0,80**	**0,85**	**0,70**	**0,70**
4 Warm, temperate | Warm-gemäßigt	1,00	1,05	0,90	0,65
5 Warm | Warm	1,20	1,25	1,10	0,55
6 Hot | Heiß	1,20	1,25	1,10	-
7 Very hot | Sehr heiß	1,00	1,05	0,90	-

Certified windows are ranked by the thermal losses through the not transparent parts. These **efficiency classes** include the U-Value of the frame, the frame width, the Ψ-Value of the Glass edge and the length of the Glass edge.
Relevant for passive houses is the energy balance, the sum out of losses and gains. Because the solar gains are difficult to quote it is useful to rate the parts of the window, which do not allow solar gains. This is determined by Ψ_{opaque}.

The simulation of the thermal values of the frame sections are based on the regulations of the standard ISO 10077-1:2010 and 10077-2:2012. The thermal conductivities of the used materials refer to relevant standards, technical approvals or have been determined by measured values according to ISO 10077-2:2012, chapter 5.1. In case of one glazing, the models are to 40 cm height, in case of 2 glazing 60 cm in height.

The **spacers** were modeled according to the actual 2-Box-models of the working group “Warm Edge” of the Federal glass association (Bundesverband Flachglas) of Germany. Thermal bridge coefficients were calculated for typical **installation situations**. These values may be used in case of identical installations only in energy balance calculations. The wall-models are 1.41 m in height, glass and frame are 40 cm height, the installation gap is 1 cm.

For modeling and simulations, the software Flixo 7 of Infomind was used. For the used **boundary conditions**, please have a look at following drawings and tables.

Le finestre certificate vengono classificate in base alle perdite termiche attraverso le parti non trasparenti. Queste classi di efficienza includono il valore U del telaio, la larghezza del telaio, il valore del distanziatore e la sua relativa lunghezza.

Rilevante per le case passive è il bilancio energetico, la somma delle perdite e dei guadagni. Poiché i guadagni solari sono difficili da citare, è utile valutare le parti della finestra, che non consentono guadagni solari. Questo è determinato dallo Ψopaco

Le caratteristiche termiche delle sezioni del telaio sono state calcolate secondo la norma ISO 10077-1: 2010 e 10077-2: 2012. Le conduttività termiche dei materiali utilizzati si riferiscono a norme pertinenti, approvazioni tecniche o sono state determinate in base ai valori misurati secondo ISO 10077-2: 2012, capitolo 5.1. Nel caso di un componente vetrato i modelli sono due: 40 cm di altezza per un serramento ad un'anta e 60 cm di altezza per un serramento a due ante.

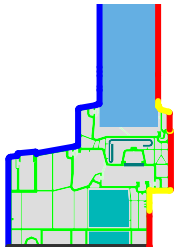
I distanziatori sono stati modellati in base agli attuali modelli "2-Box-models" per il gruppo di lavoro "Warm Edge" del "Bundesverband Flachglas".

I coefficienti del ponte termico sono stati calcolati per le situazioni d'installazione tipiche. Questi valori possono essere utilizzati in caso d'installazioni identiche solo nei calcoli del bilancio energetico. I modelli da parete hanno un'altezza di 1,41 m, il vetro e il telaio sono alti 40 cm, la distanza di installazione tra murature e telaio è di 1 cm.

Per la modellazione e le simulazioni, è stato utilizzato il software Flixo 7 di Infomind. Per le condizioni limite utilizzate, si prega di guardare i seguenti disegni e tabelle.

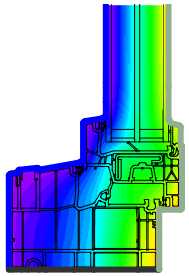
$$\Psi_{opak} = \Psi_g + \frac{U_f \cdot A_f}{l_g}$$

max. Ψ_{opak} [W/(mK)]	**Efficiency class Effizienzklasse**	**Name Bezeichnung**
0,065	phA+	Very advanced component
0,110	phA	Advanced component
0,155	phB	Basic component
0,200	phC	Certifiable component

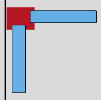


Randbedingung	q[W/m²]	θ[°C]	R[(m²·K)/W]	ε
Adiabatic | Adiabat	0,000			
Exterior | Außen		-10,000	0,040	
Interior, frame, normal		20,000	0,130	
Interior, frame, reduced		20,000	0,200	
e 0,9 Cavity I Hohlraum				0,900

Randbedingung	q[W/m²]	θ[°C]	R[(m²·K)/W]	ε
Adiabatic | Adiabat	0,000			
Exterior | Außen		-10,000	0,040	
e 0,9 Cavity I Hohlraum				0,900
fRsi: Interior | Innen		20,000	0,250	



frame values | Rahmenwerte

Piva Group S.p.A. PVC Piva Serie MD Spacer | Distanziatore: Multitech		bo Bottom Inferiore	to Top Superiore	si Side Laterale	bof Bottom fixed Inferiore fisso	tof Top fixed Superiore fisso	sif Side fixed Laterale fisso	th Thres-hold Soglia	sh Side door Porta laterale	fm Flying mullion Montante	m2 Mullion Montante	m1 Mullion Montante	m Mullion fixed Montante fisso	ec Corner Angolo	t2 Transom Traversa	t1 Transom Traversa	t Transom fixed Traversa fisso
																	
Temperaturefactor Fattore di temperatura	$f_{Rsi=0,25m^2k/W}$	0,71	0,73	0,71	0,72	0,72	0,72			0,62		0,67	0,69			0,67	0,69
Frame width Larghezza del telaio	b_f [mm]	116	116	116	82	82	82			146		132	98			132	98
U-value frame valore U telaio	**Uf** [W/(m²K)]	0,94	0,96	1,04	0,87	0,87	0,87			1,16		1,24	1,24			1,24	1,24
Ψ-glass edge valore Ψ distanziatore	**Ψg** [W/(mK)]	0,024	0,024	0,024	0,024	0,024	0,024			0,023		0,023	0,023			0,023	0,023
U-value window Valore U Finestra	Uw [W/(m²K)] @Ug= 0,9 W/(m²K)	**0,988**			**0,956**												
Ψ_{opaque}	Ψ_{opaque} W/(mK)	**0,151**			**0,100**												
Passive House effiziency class Classe di efficienza della Casa Passiva		**phB**			**phA**												

EIFS | Isolamento esterno a cappotto U-Wall = 0,168 W/(m²K)

$\Psi_{install}$ [W/(mK)]	0,040	0,011	0,011	0,036	0,009	0,009		
$U_{W, installed}$ [W/(m²K)]	1,04			1,00				

Solid timber | Costruzione in legno XLAM U-Wall = 0,166 W/(m²K)

$\Psi_{install}$ [W/(mK)]	0,024	0,016	0,016	0,021	0,015	0,015		
$U_{W, installed}$ [W/(m²K)]	1,04			1,00				

Monolithic wall | Muro monolitico U-Wall = 0,192 W/(m²K)

$\Psi_{install}$ [W/(mK)]	0,028	0,021	0,021	0,025	0,018	0,018		
$U_{W, installed}$ [W/(m²K)]	1,05			1,02				

Ventilated facade | Facciata ventilata U-Wall = 0 W/(m²K)

$\Psi_{install}$ [W/(mK)]								
$U_{W, installed}$ [W/(m²K)]								

Cavity wall | Muro con intercapedine U-Wall = 00 W/(m²K)

$\Psi_{install}$ [W/(mK)]								
$U_{W, installed}$ [W/(m²K)]								

Contact person | Ansprechpartner

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Construction:

PVC-windowframe with steel-reinforcements inside the bottom and lateral sash. Insulation fillings (0.035 W/(mK)) inside the bottom blind frame. The temperature factor is not achieved at the flying mullion. Pane thickness: 48 mm (4/18/4/18/4), spacer: Multitech.
The airtightness was tested at a single-sash tilt-and turn-window.
Pane thickness: 48 mm (4/18/4/18/4), rebate depth: 18 mm.

Descrizione:

Telaio in PVC con rinforzi in acciaio e fascia laterale. Inserti coibenti in EPS (0.035 W/(mK)) all'interno del telaio inferiore. Il fattore di temperatura non è raggiunto in corrispondenza del montante mobile. Spessore del vetro 48 mm (4/18/4/18/4). Distanziatore: Multitech.
L'ermeticità è stata testata su una finestra singola con anta a ribalta.
Spessore del vetro 48 mm (4/18/4/18/4), Profondità di montaggio: 18 mm.

Calculation | Calcolo

Passivhaus Institut Darmstadt 31.05.2019

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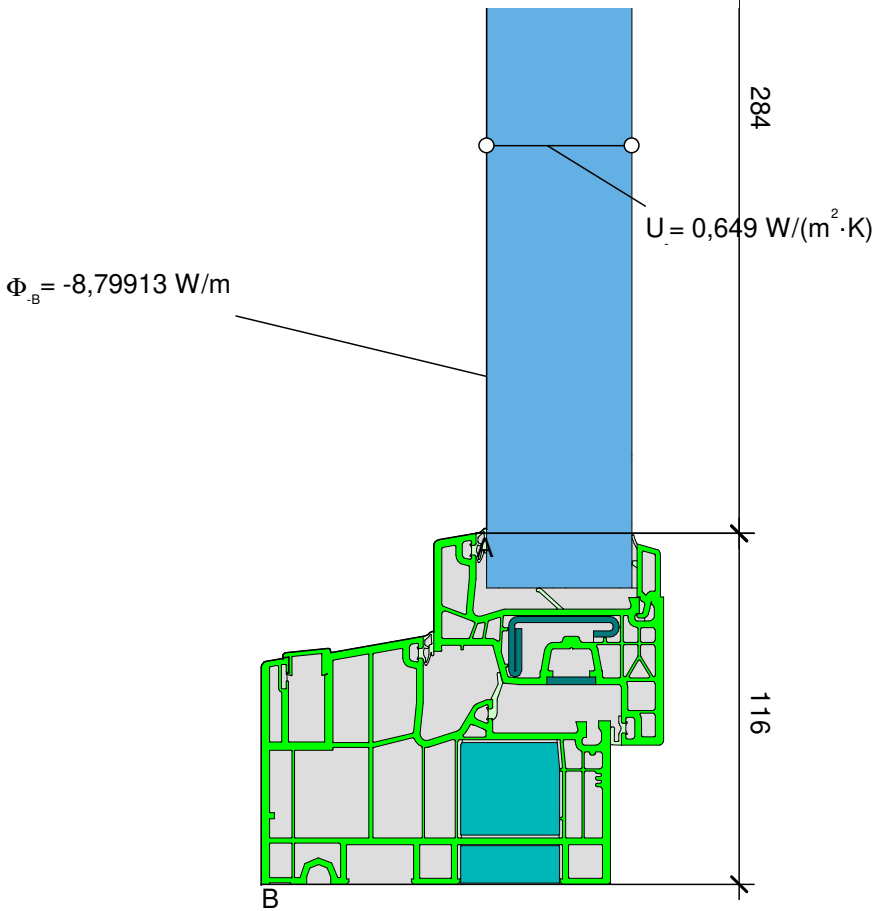
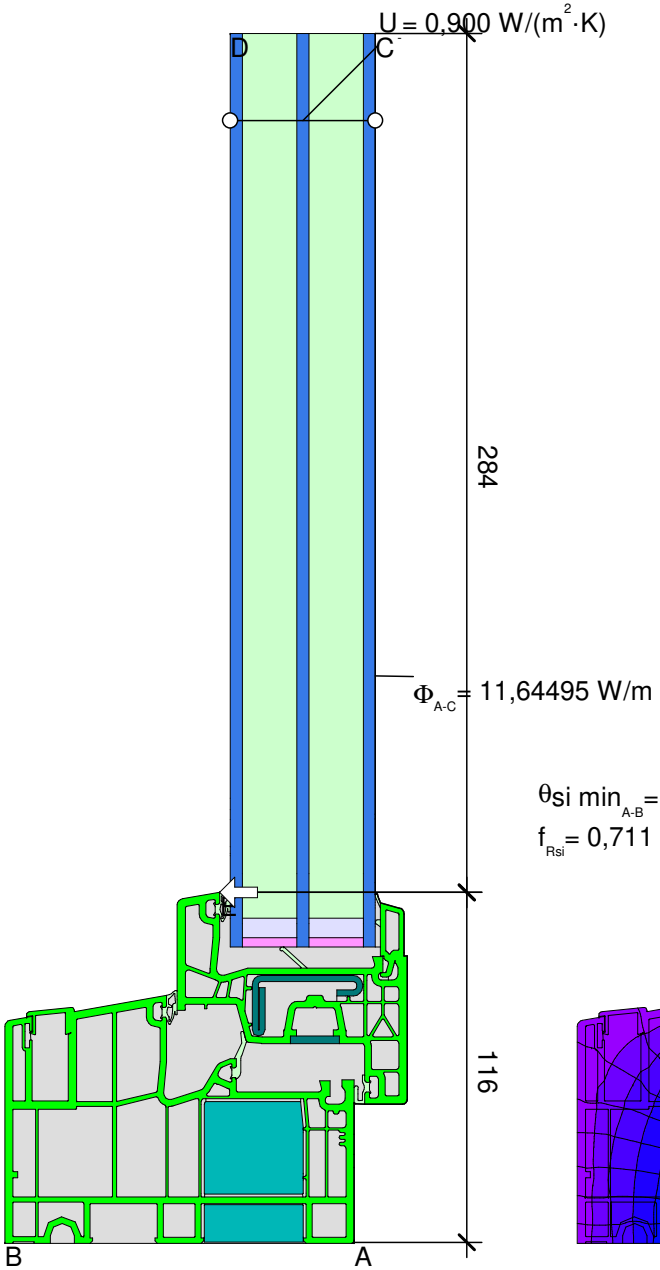
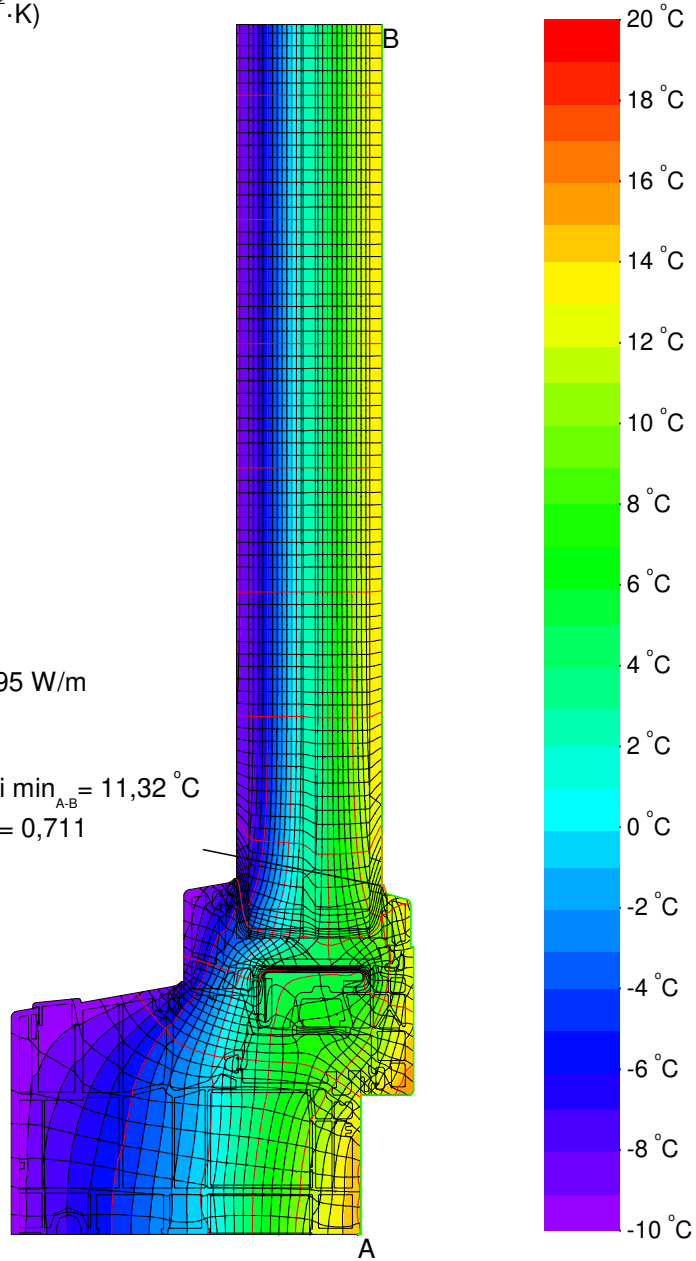
Material	λ[W/(m·K)]	ε
Ar18 in 48 mm U 0,9	0,039	
Glass I Glas	1,000	0,900
Insulation I Wärmedämmung 035	0,035	0,900
Polysulfide I Polysulfid	0,400	0,900
Polyvinylchloride (PVC)	0,170	0,900
Roll Tech Multitech Box 2 [cert]	0,130	
Soft PVC I Weich-PVC	0,140	0,900
Steel I Stahl	50,000	0,900
Unvent. cavity I unbel. Hohlr. **		

** EN ISO 10077-2:2017, 6.4.3

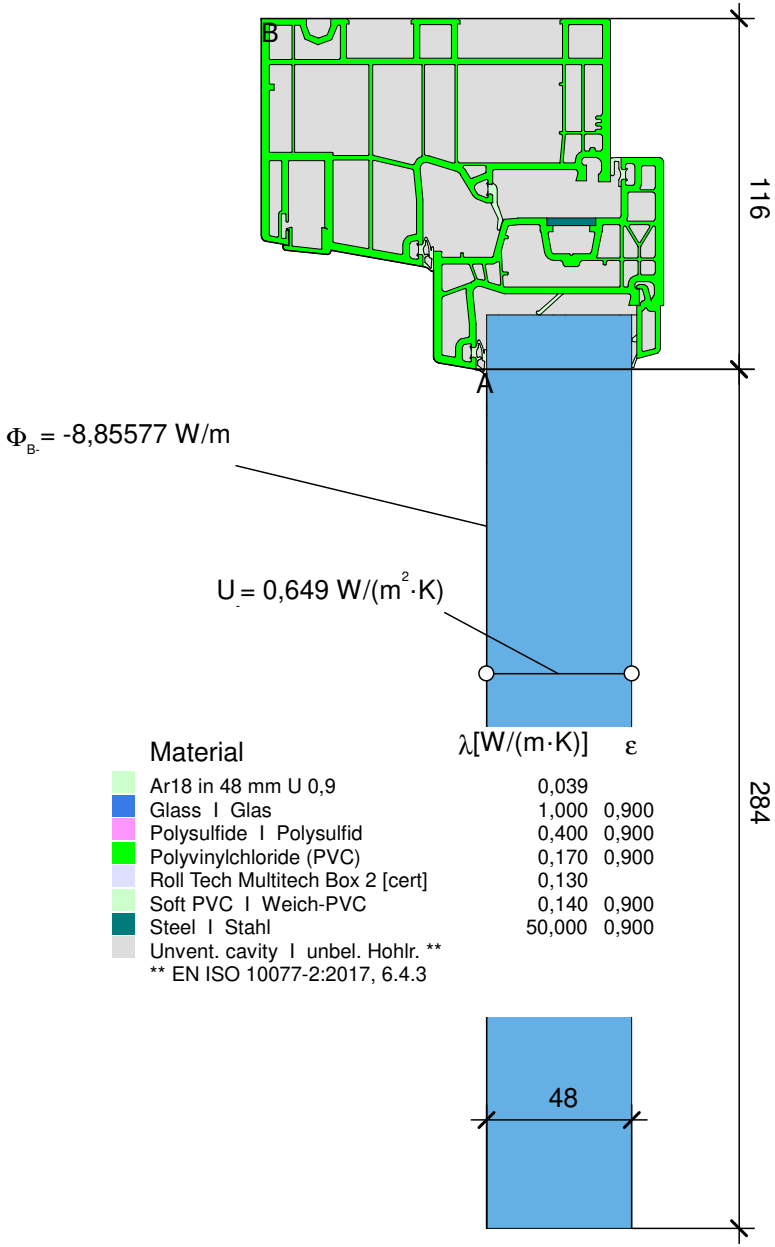






$$U_{f\,A,B} = \frac{\frac{\Phi}{\Delta T} - U_p \cdot b_p}{b_f} = \frac{\frac{8{,}799}{30{,}000} - 0{,}649 \cdot 0{,}284}{0{,}116} = 0{,}940\ W/(m^2 \cdot K)$$

$$\psi_{A\text{-}E\text{-}C,*} = \frac{\Phi}{\Delta T} - U_1 \cdot b_1 - U_2 \cdot b_2 = \frac{11{,}645}{30{,}000} - 0{,}940 \cdot 0{,}116 - 0{,}900 \cdot 0{,}284 = 0{,}024\ W/(m \cdot K)$$



Material	λ[W/(m·K)]	ε
Ar18 in 48 mm U 0,9	0,039	
Glass I Glas	1,000	0,900
Polysulfide I Polysulfid	0,400	0,900
Polyvinylchloride (PVC)	0,170	0,900
Roll Tech Multitech Box 2 [cert]	0,130	
Soft PVC I Weich-PVC	0,140	0,900
Steel I Stahl	50,000	0,900
Unvent. cavity I unbel. Hohlr. **		

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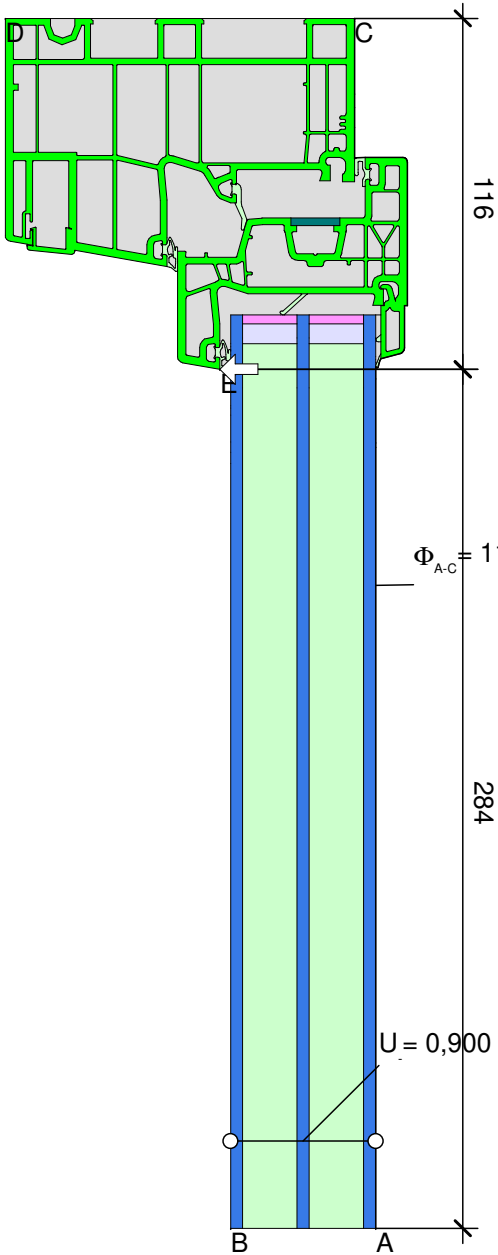
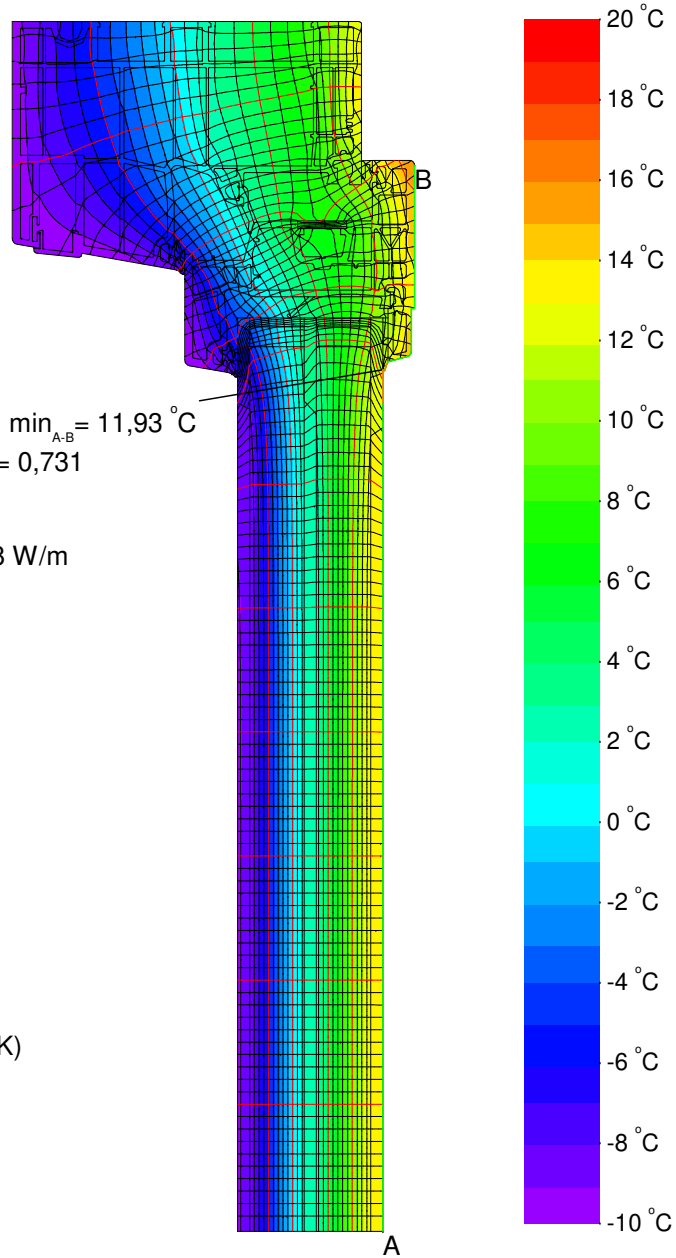
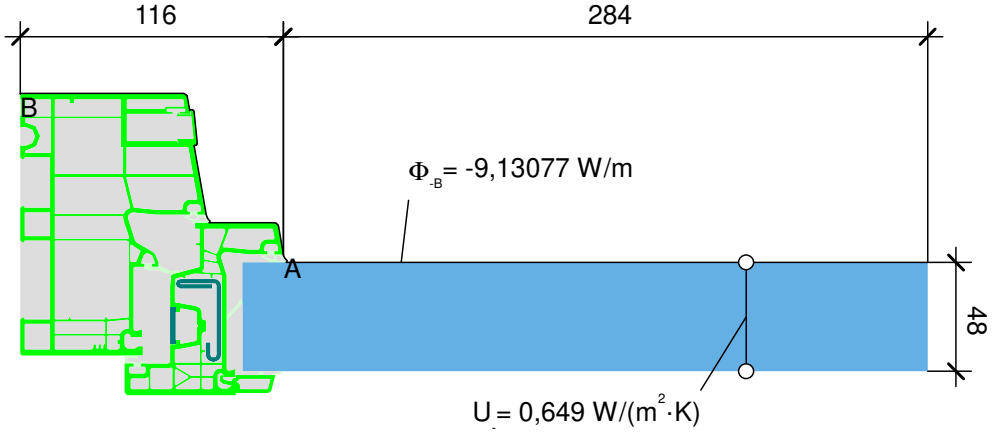
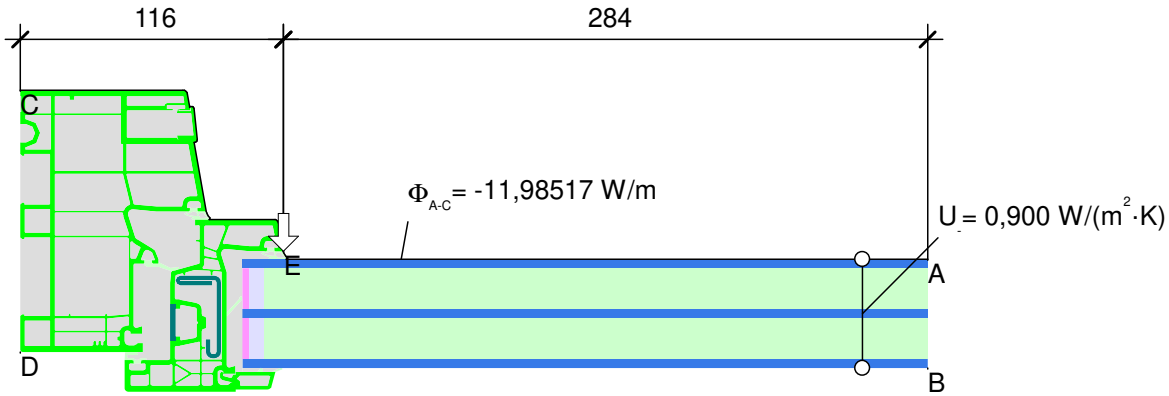




$$U_{f\,A,B} = \frac{\frac{\Phi}{\Delta T} - U_p \cdot b_p}{b_f} = \frac{\frac{8,856}{30,000} - 0,649 \cdot 0,284}{0,116} = 0,956\ W/(m^2 \cdot K)$$

$$\psi_{A-E-C,*} = \frac{\Phi}{\Delta T} - U_1 \cdot b_1 - U_2 \cdot b_2 = \frac{11,720}{30,000} - 0,900 \cdot 0,284 - 0,956 \cdot 0,116 = 0,024\ W/(m \cdot K)$$





Material	λ[W/(m·K)]	ε
Ar18 in 48 mm U 0,9	0,039	
Glass I Glas	1,000	0,900
Polysulfide I Polysulfid	0,400	0,900
Polyvinylchloride (PVC)	0,170	0,900
Roll Tech Multitech Box 2 [cert]	0,130	
Soft PVC I Weich-PVC	0,140	0,900
Steel I Stahl	50,000	0,900
Unvent. cavity I unbel. Hohlr. **		

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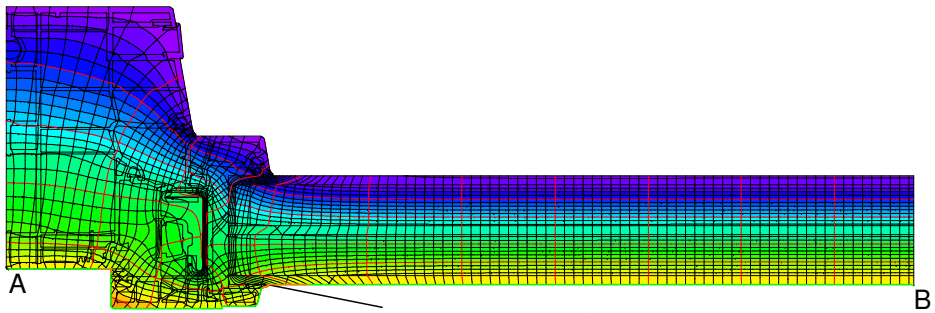
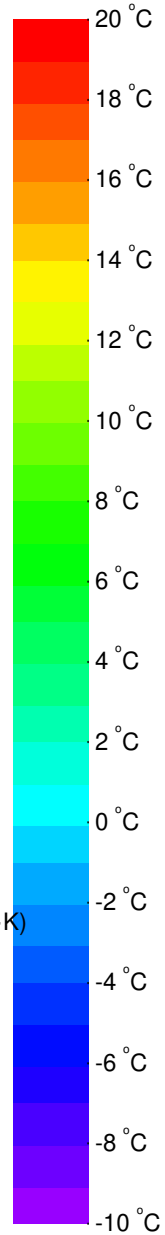
$$U_{f\,A,B} = \frac{\frac{\Phi}{\Delta T} - U_p \cdot b_p}{b_f} = \frac{\frac{9{,}131}{30{,}000} - 0{,}649 \cdot 0{,}284}{0{,}116} = 1{,}035\ \mathrm{W/(m^2 \cdot K)}$$

$$\psi_{A\text{-}E\text{-}C,\,*} = \frac{\Phi}{\Delta T} - U_1 \cdot b_1 - U_2 \cdot b_2 = \frac{11{,}985}{30{,}000} - 0{,}900 \cdot 0{,}284 - 1{,}035 \cdot 0{,}116 = 0{,}024\ \mathrm{W/(m \cdot K)}$$



$\theta_{si\ min_{A-B}}$ = 11,32 °C

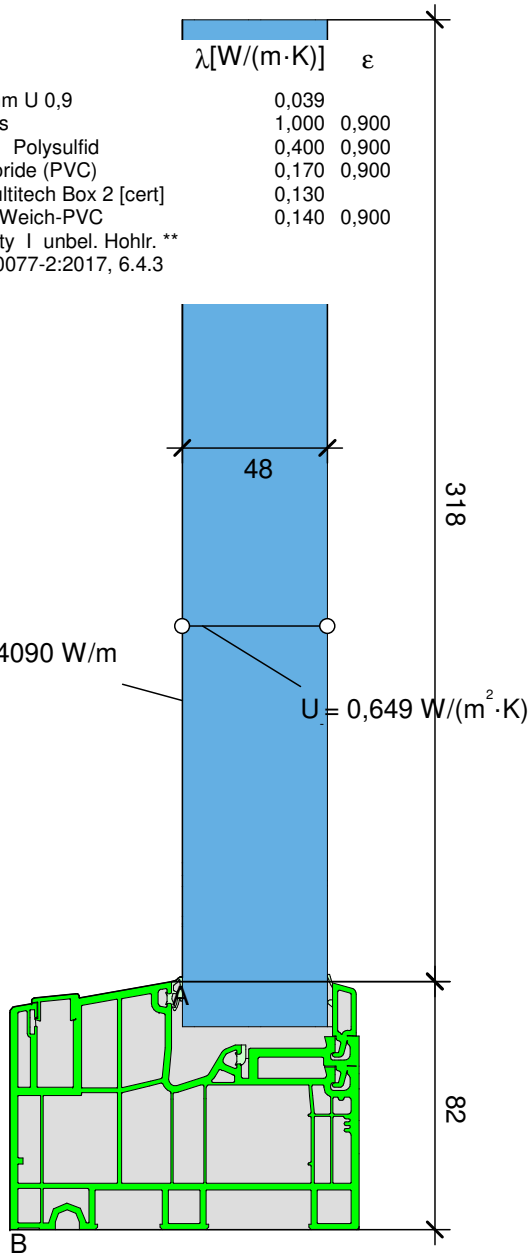
f_{Rsi} = 0,711

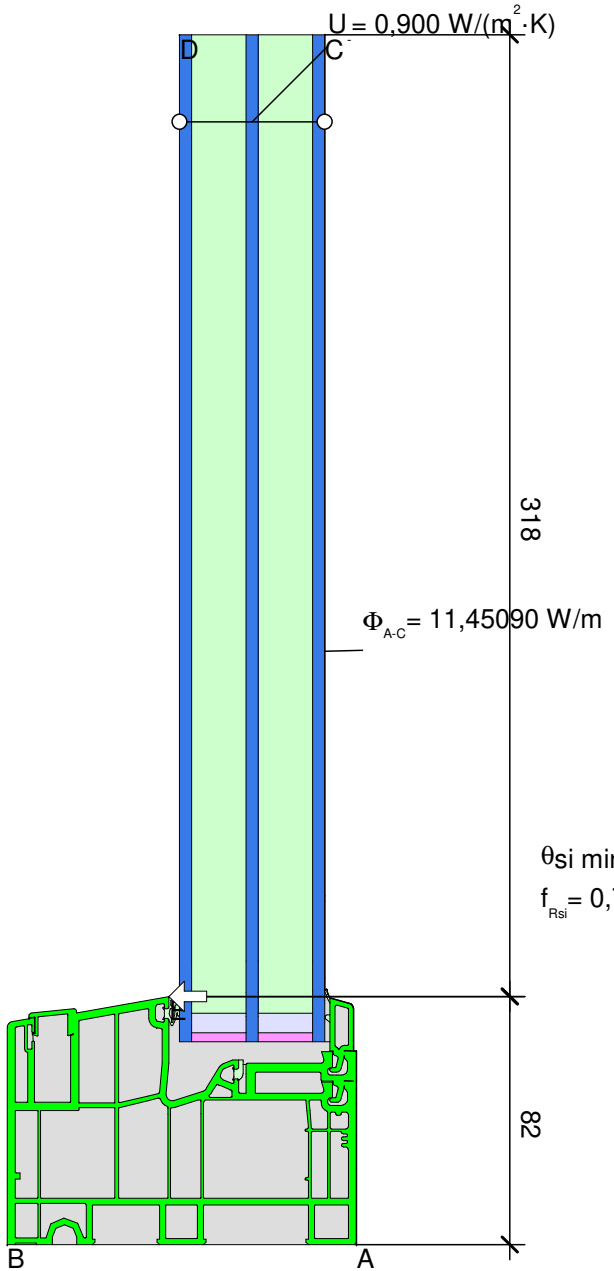


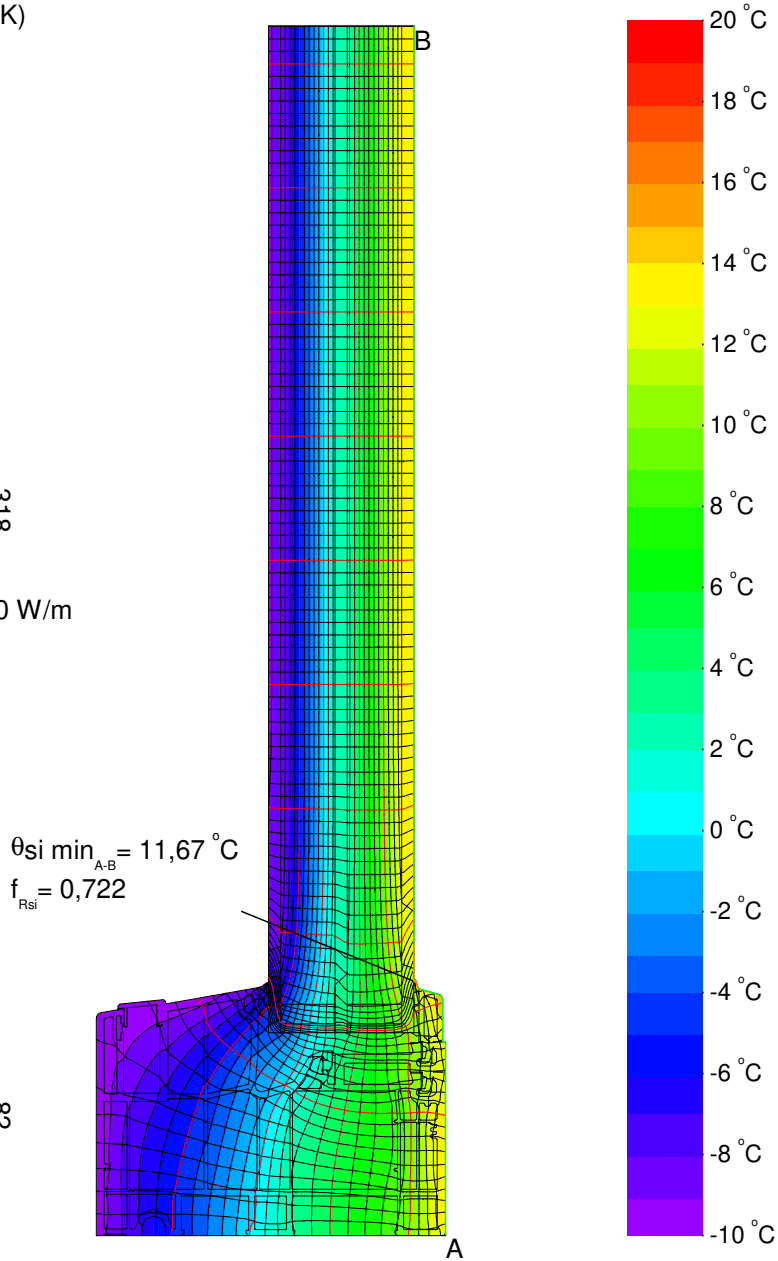
Passive House Institute

Material	λ[W/(m·K)]	ε
Ar18 in 48 mm U 0,9	0,039	
Glass I Glas	1,000	0,900
Polysulfide I Polysulfid	0,400	0,900
Polyvinylchloride (PVC)	0,170	0,900
Roll Tech Multitech Box 2 [cert]	0,130	
Soft PVC I Weich-PVC	0,140	0,900
Unvent. cavity I unbel. Hohlr. **		

** EN ISO 10077-2:2017, 6.4.3

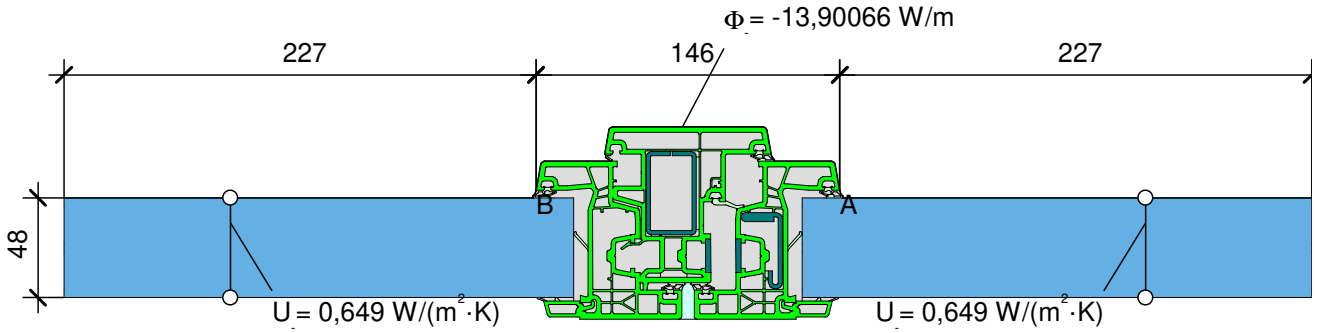






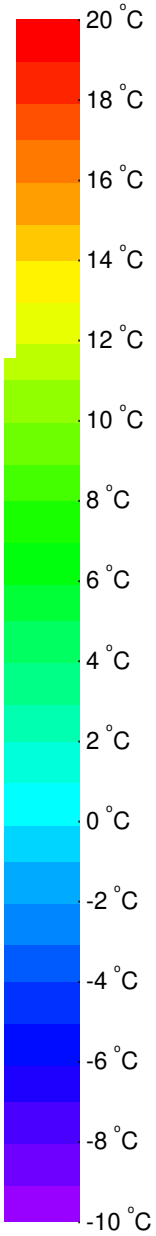
$$U_{f\,A,B} = \frac{\frac{\Phi}{\Delta T} - U_p \cdot b_p}{b_f} = \frac{\frac{8{,}341}{30{,}000} - 0{,}649 \cdot 0{,}318}{0{,}082} = 0{,}875\ W/(m^2 \cdot K)$$

$$\psi_{A-E-C,*} = \frac{\Phi}{\Delta T} - U_1 \cdot b_1 - U_2 \cdot b_2 = \frac{11{,}451}{30{,}000} - 0{,}875 \cdot 0{,}082 - 0{,}900 \cdot 0{,}318 = 0{,}024\ W/(m \cdot K)$$

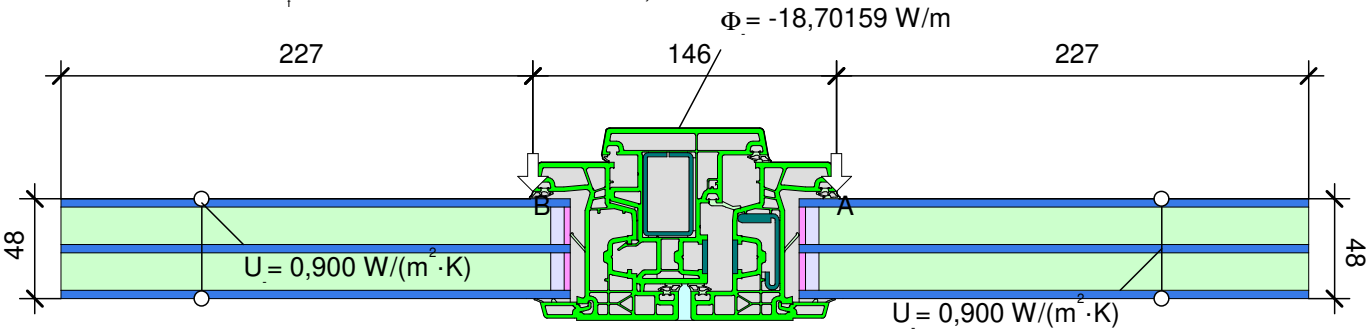


Material	λ[W/(m·K)]	ε
Ar18 in 48 mm U 0,9	0,039	
Glass I Glas	1,000	0,900
Nicht definiertes Material (1)	1,000	0,900
Polysulfide I Polysulfid	0,400	0,900
Polyvinylchloride (PVC)	0,170	0,900
Roll Tech Multitech Box 2 [cert]	0,130	
Soft PVC I Weich-PVC	0,140	0,900
Steel I Stahl	50,000	0,900
Unvent. cavity I unbel. Hohlr. **		
slightly vent. cav. I leicht bel. Hohlr. **		

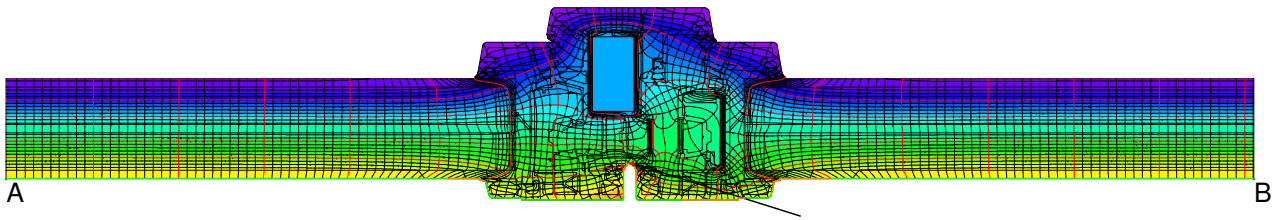
** EN ISO 10077-2:2017, 6.4.3



$$U_{f\,A,B} = \frac{\frac{\Phi}{\Delta T} - U_{p1}\cdot b_{p1} - U_{p2}\cdot b_{p2}}{b_f} = \frac{\frac{13{,}901}{30{,}000} - 0{,}649\cdot 0{,}227 - 0{,}649\cdot 0{,}227}{0{,}146} = 1{,}156\ \mathrm{W/(m^2\cdot K)}$$

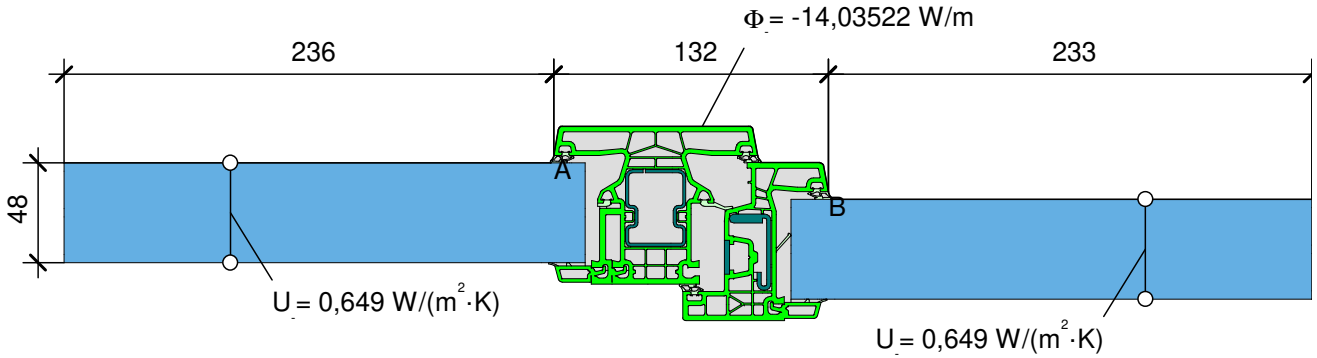


$$\psi_{A,B} = \frac{\frac{\Phi}{\Delta T} - U_{g1}\cdot b_{g1} - U_f\cdot b_f - U_{g2}\cdot b_{g2}}{2} = \frac{\frac{18{,}702}{30{,}000} - 0{,}900\cdot 0{,}227 - 1{,}156\cdot 0{,}146 - 0{,}900\cdot 0{,}227}{2} = 0{,}023\ \mathrm{W/(m\cdot K)}$$



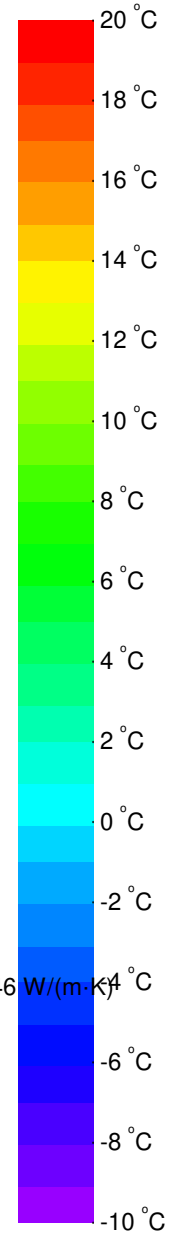
$\theta si\ min_{A\text{-}B} = 8{,}72\ ^\circ C$

$f_{Rsi} = 0{,}624$

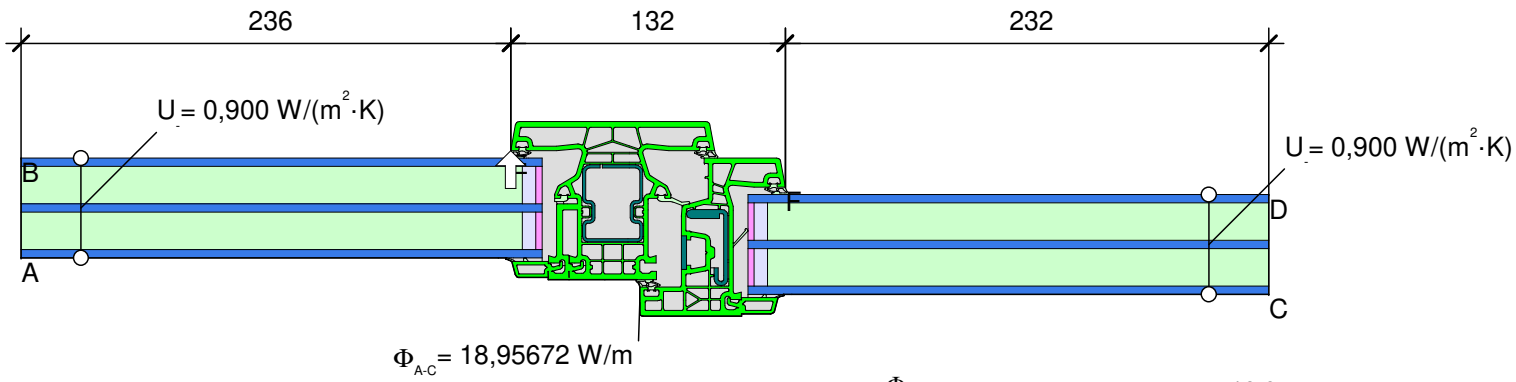


Material	λ[W/(m·K)]	ε
Ar18 in 48 mm U 0,9	0,039	
Glass I Glas	1,000	0,900
Polysulfide I Polysulfid	0,400	0,900
Polyvinylchloride (PVC)	0,170	0,900
Roll Tech Multitech Box 2 [cert]	0,130	
Soft PVC I Weich-PVC	0,140	0,900
Steel I Stahl	50,000	0,900
Unvent. cavity I unbel. Hohlr. **		

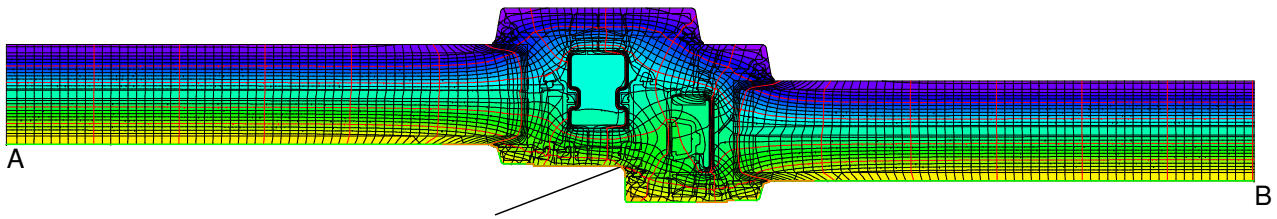
** EN ISO 10077-2:2017, 6.4.3



$$U_{f\,A,B} = \frac{\frac{\Phi}{\Delta T} - U_{p1}\cdot b_{p1} - U_{p2}\cdot b_{p2}}{b_f} = \frac{\frac{14{,}035}{30{,}000} - 0{,}649\cdot 0{,}236 - 0{,}649\cdot 0{,}233}{0{,}132} = 1{,}244\ \mathrm{W/(m^2\cdot K)}$$

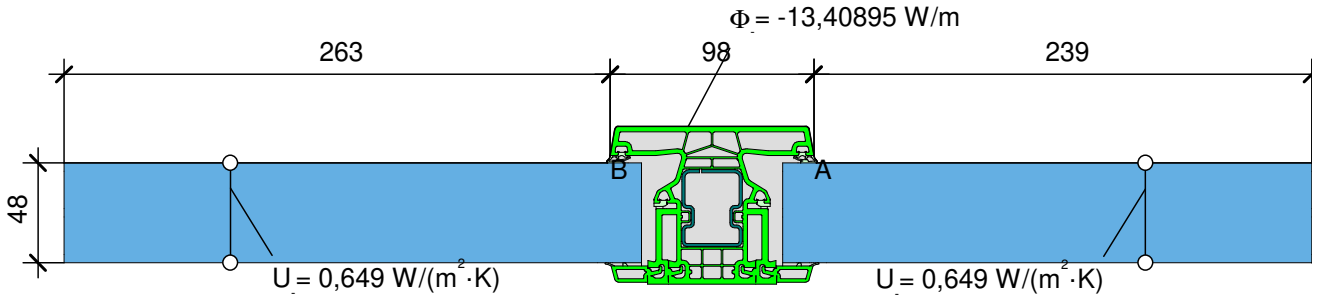


$$\psi_{A\text{-}E\text{-}C,\,*} = \frac{\Phi}{\Delta T} - U_1\cdot b_1 - U_2\cdot b_2 - U_3\cdot b_3 = \frac{18{,}957}{30{,}000} - 0{,}900\cdot 0{,}236 - 1{,}244\cdot 0{,}132 - 0{,}900\cdot 0{,}233 = 0{,}046\ \mathrm{W/(m\cdot K)}$$



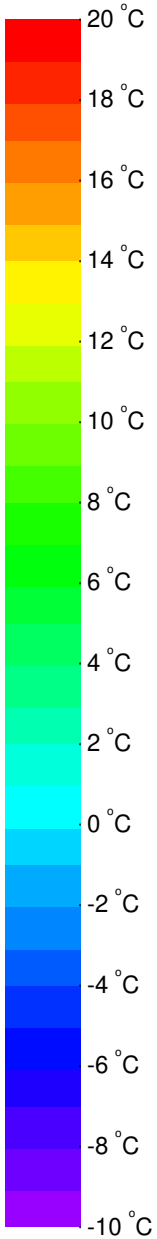
$\theta_{si\ min\,A\text{-}B}$ = 10,00 °C

f_{Rsi} = 0,667

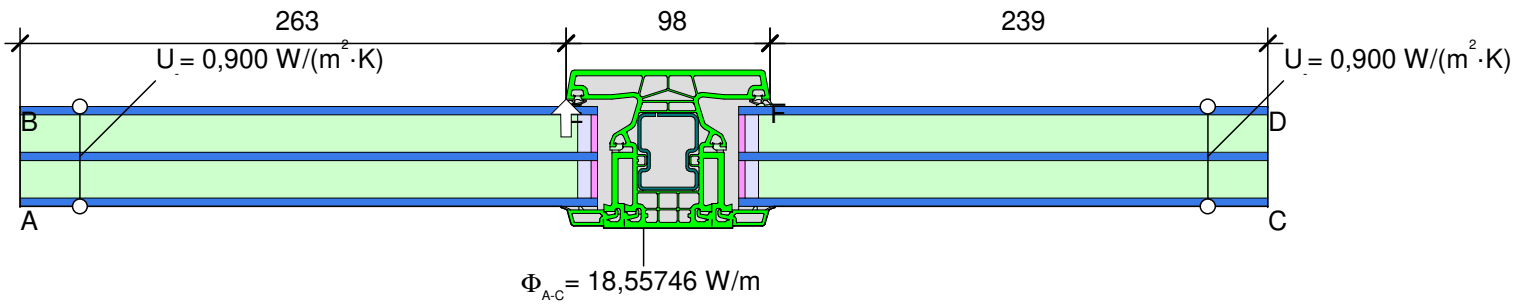


Material	λ[W/(m·K)]	ε
Ar18 in 48 mm U 0,9	0,039	
Glass I Glas	1,000	0,900
Nicht definiertes Material (1)	1,000	
Polysulfide I Polysulfid	0,400	0,900
Polyvinylchloride (PVC)	0,170	0,900
Roll Tech Multitech Box 2 [cert]	0,130	
Soft PVC I Weich-PVC	0,140	0,900
Steel I Stahl	50,000	0,900
Unvent. cavity I unbel. Hohlr. **		

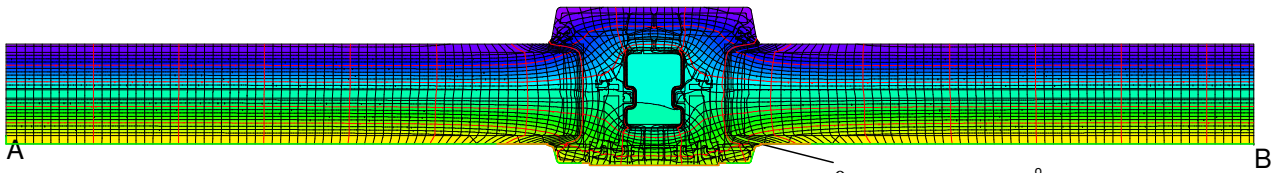
** EN ISO 10077-2:2017, 6.4.3



$$U_{f\,A,B} = \frac{\frac{\Phi}{\Delta T} - U_{p1}\cdot b_{p1} - U_{p2}\cdot b_{p2}}{b_f} = \frac{\frac{13,409}{30,000} - 0,649\cdot 0,239 - 0,649\cdot 0,263}{0,098} = 1,238\ W/(m^2\cdot K)$$

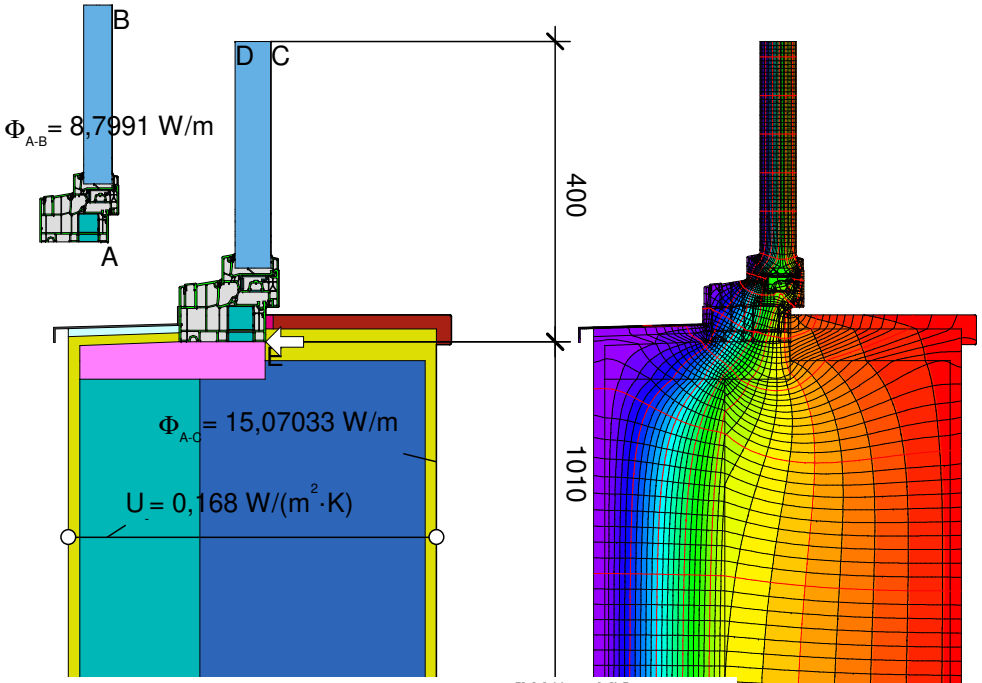


$$\psi_{A\text{-}E\text{-}C,*} = \frac{\Phi}{\Delta T} - U_1\cdot b_1 - U_2\cdot b_2 - U_3\cdot b_3 = \frac{18,557}{30,000} - 0,900\cdot 0,263 - 1,238\cdot 0,098 - 0,900\cdot 0,239 = 0,045\ W/(m\cdot K)$$



$\theta_{si\ min\,A\text{-}B} = 10,82\ ^\circ C$

$f_{Rsi} = 0,694$

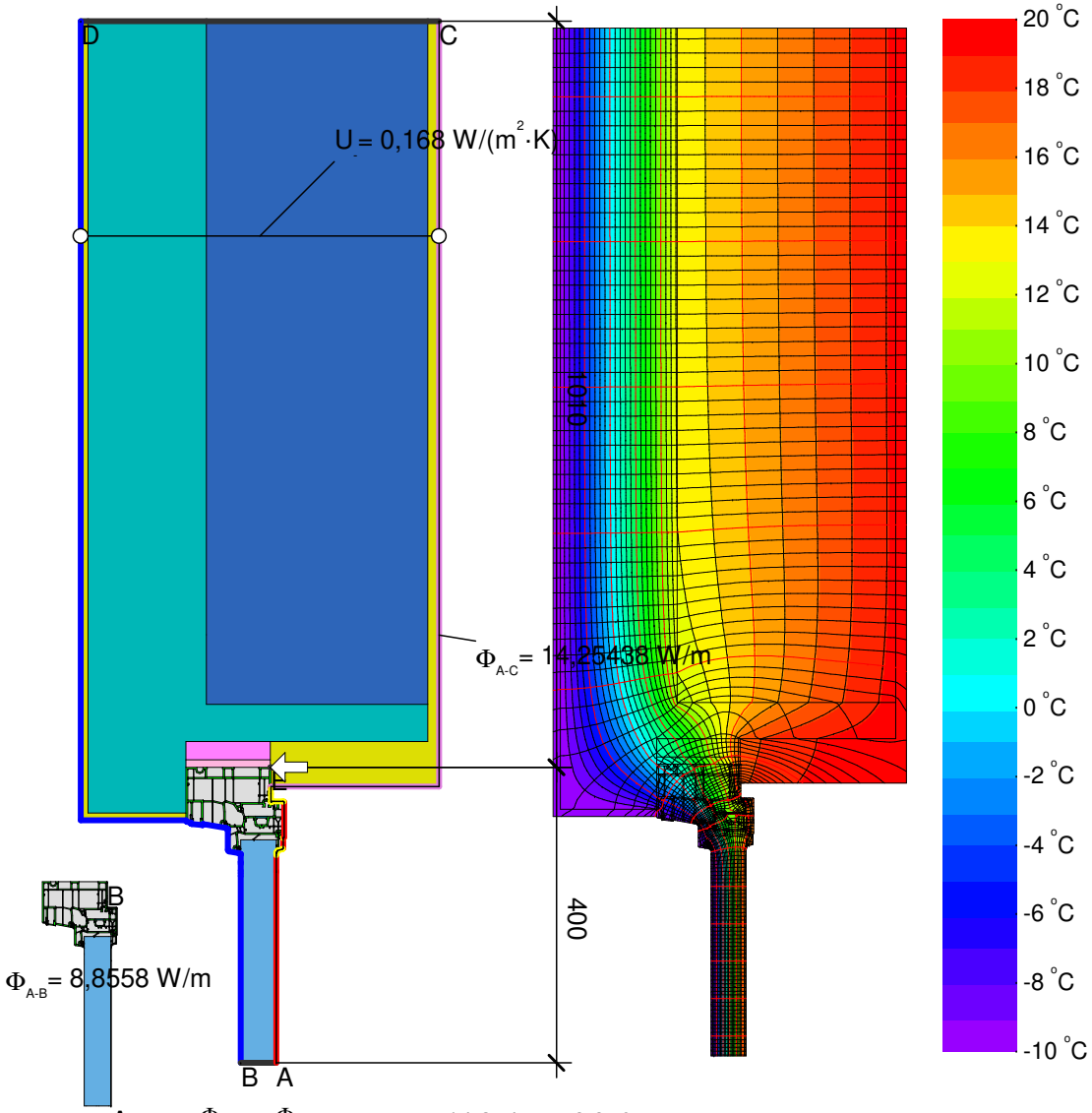


Material	λ[W/(m·K)]	ε
Aluminum I Aluminium 10456	160,000	0,900
Areated concrete, 800 kg/m³ 4108-2	0,250	
Hardwood I Hartholz 0.18 700 kg/m3 10456	0,180	
Insulation I Wärmedämmung 035	0,035	0,900
Lime Cement Plaster | Kalkzement Putz 10456	1,000	0,900
Panel I Maske	0,035	0,900
Polyvinylchloride (PVC)	0,170	0,900
Purenit 500 M	0,086	0,900
Silicone I Silikon	0,350	
Soft PVC I Weich-PVC	0,140	0,900
Steel I Stahl	50,000	0,900
Unvent. cavity I unbel. Hohlr. **		
slightly vent. cav. I leicht bel. Hohlr. **		

** EN ISO 10077-2:2017, 6.4.3

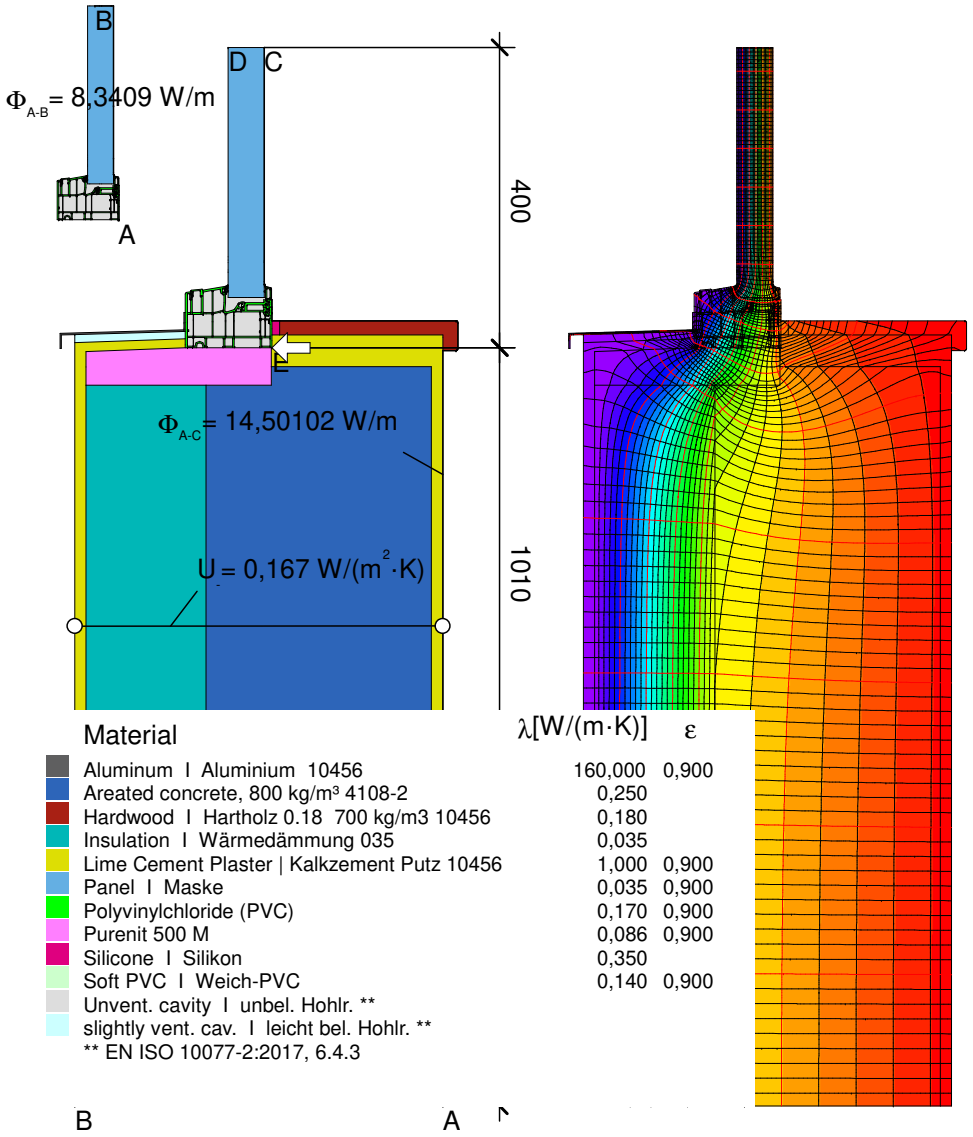
B A

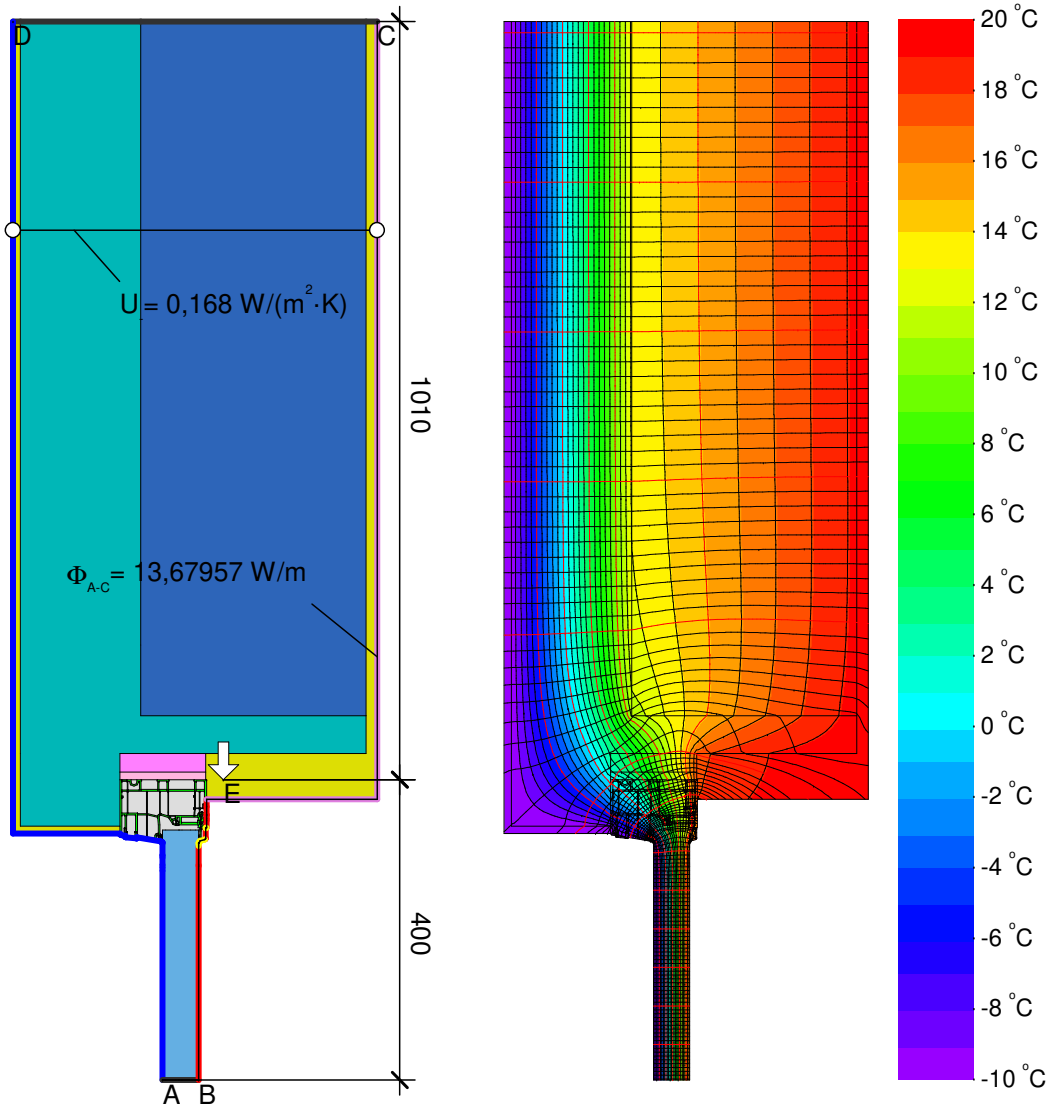
$$\psi_{A-E-C,*} = \frac{\Phi}{\Delta T} - U_1 \cdot b_1 - \frac{\Phi_2}{\Delta T} = \frac{15{,}070}{30{,}000} - 0{,}168 \cdot 1{,}010 - \frac{8{,}799}{30{,}000} = 0{,}040 \text{ W/(m·K)}$$



$$\psi_{A-E-C,*} = \frac{\Phi}{\Delta T} - \frac{\Phi_1}{\Delta T} - U_2 \cdot b_2 = \frac{14{,}254}{30{,}000} - \frac{8{,}856}{30{,}000} - 0{,}168 \cdot 1{,}010 = 0{,}011 \text{ W/(m·K)}$$

Randbedingung	q[W/m²]	θ[°C]	R[(m²·K)/W]	ε
Adiabatic | Adiabat	0,000			
Exterior | Außen		-10,000	0,040	
Interior | Innen		20,000	0,130	
Interior, frame, normal		20,000	0,130	
Interior, frame, reduced		20,000	0,200	
e 0,9 Cavity I Hohlraum				0,900





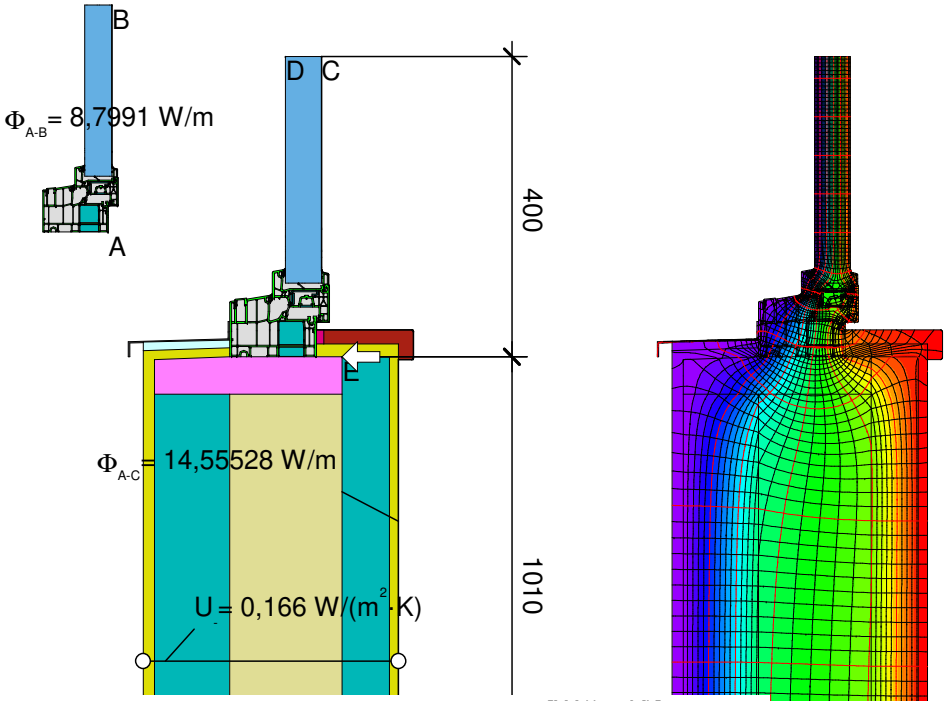
Material	λ[W/(m·K)]	ε
Aluminum I Aluminium 10456	160,000	0,900
Areated concrete, 800 kg/m³ 4108-2	0,250	
Hardwood I Hartholz 0.18 700 kg/m3 10456	0,180	
Insulation I Wärmedämmung 035	0,035	
Lime Cement Plaster | Kalkzement Putz 10456	1,000	0,900
Panel I Maske	0,035	0,900
Polyvinylchloride (PVC)	0,170	0,900
Purenit 500 M	0,086	0,900
Silicone I Silikon	0,350	
Soft PVC I Weich-PVC	0,140	0,900
Unvent. cavity I unbel. Hohlr. **		
slightly vent. cav. I leicht bel. Hohlr. **		

** EN ISO 10077-2:2017, 6.4.3

$$\psi_{A-E-C,*} = \frac{\Phi}{\Delta T} - U_1 \cdot b_1 - \frac{\Phi_2}{\Delta T} = \frac{14,501}{30,000} - 0,167 \cdot 1,010 - \frac{8,341}{30,000} = 0,036 \text{ W/(m·K)}$$

$$\psi_{A-E-C,*} = \frac{\Phi}{\Delta T} - \frac{\Phi_1}{\Delta T} - U_2 \cdot b_2 = \frac{13,680}{30,000} - \frac{8,341}{30,000} - 0,168 \cdot 1,010 = 0,009 \text{ W/(m·K)}$$

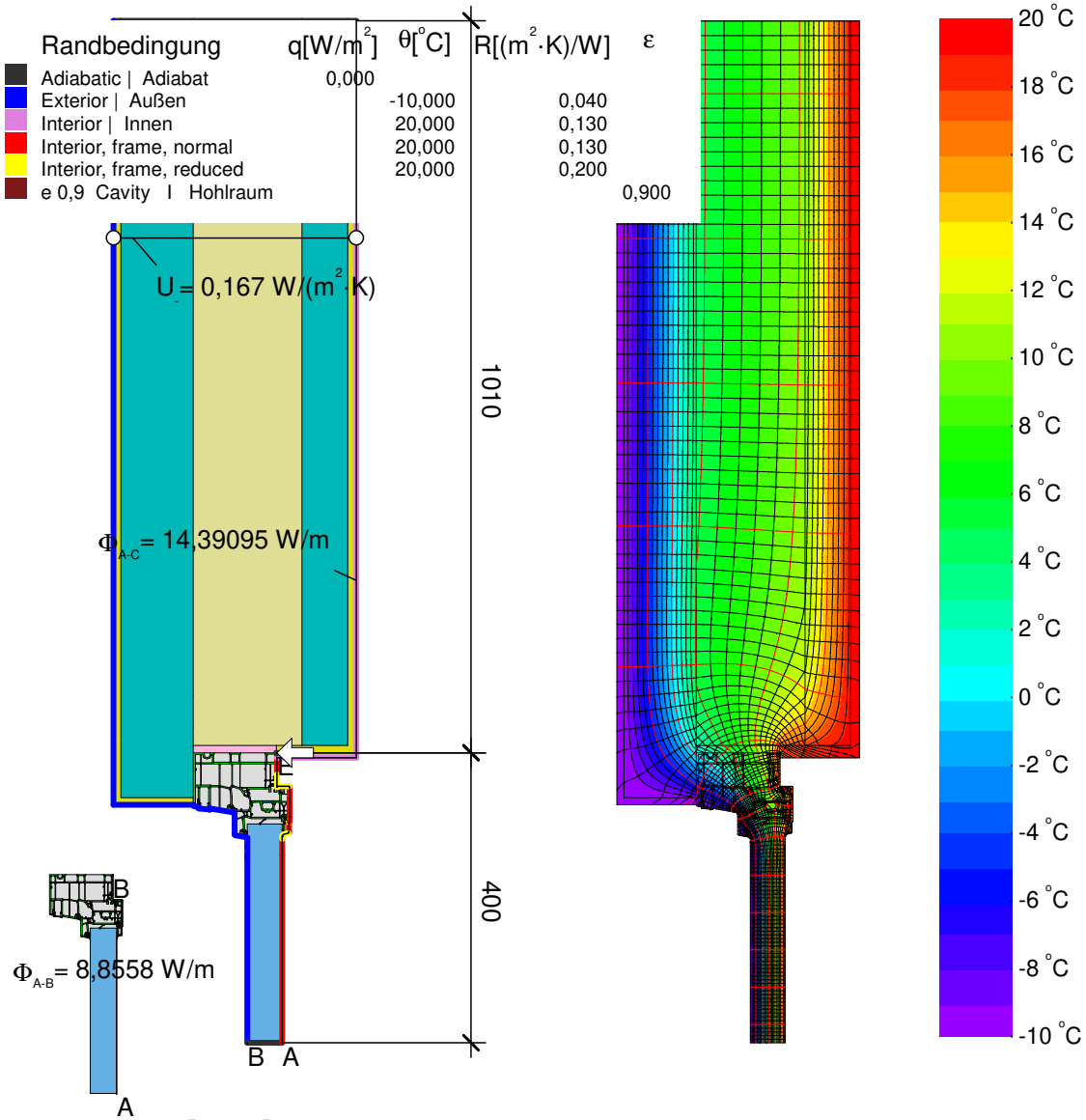
Randbedingung	q[W/m²]	θ[°C]	R[(m²·K)/W]	ε
Adiabatic | Adiabat	0,000			
Exterior | Außen		-10,000	0,040	
Interior | Innen		20,000	0,130	
Interior, frame, normal		20,000	0,130	
Interior, frame, reduced		20,000	0,200	
e 0,9 Cavity I Hohlraum				0,900



Material	λ[W/(m·K)]	ε
Aluminum I Aluminium 10456	160,000	0,900
Hardwood I Hartholz 0.18 700 kg/m3 10456	0,180	
Insulation I Wärmedämmung 035	0,035	0,900
Lime Cement Plaster | Kalkzement Putz 10456	1,000	0,900
Panel I Maske	0,035	0,900
Polyvinylchloride (PVC)	0,170	0,900
Purenit 500 M	0,086	0,900
Silicone I Silikon	0,350	
Soft PVC I Weich-PVC	0,140	0,900
Softwood, OSB I Weichholz, OSB 10456	0,130	
Steel I Stahl	50,000	0,900
Unvent. cavity I unbel. Hohlr. **		
slightly vent. cav. I leicht bel. Hohlr. **		

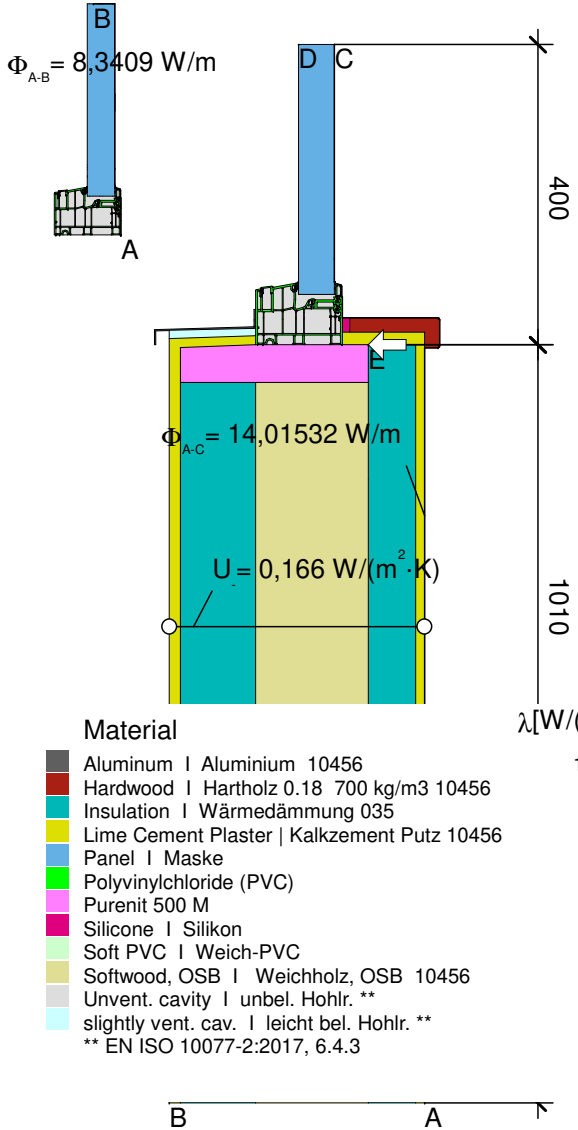
** EN ISO 10077-2:2017, 6.4.3

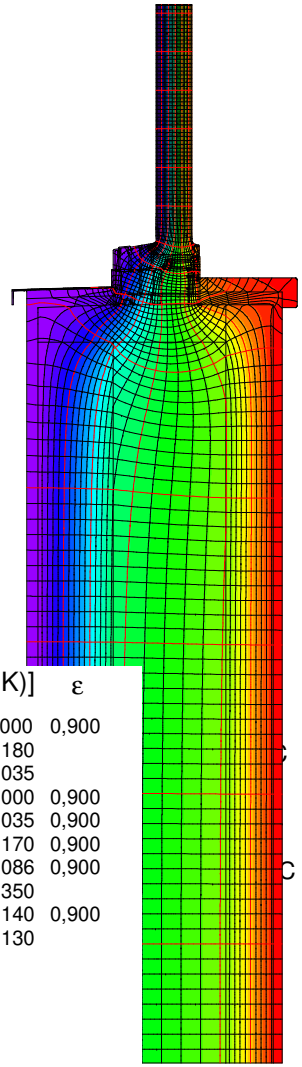
B A



$$\psi_{A-E-C,*} = \frac{\Phi}{\Delta T} - U_1 \cdot b_1 - \frac{\Phi_2}{\Delta T} = \frac{14,555}{30,000} - 0,166 \cdot 1,010 - \frac{8,799}{30,000} = 0,024 \text{ W/(m·K)}$$

$$\psi_{A-E-C,*} = \frac{\Phi}{\Delta T} - \frac{\Phi_1}{\Delta T} - U_2 \cdot b_2 = \frac{14,391}{30,000} - \frac{8,856}{30,000} - 0,167 \cdot 1,010 = 0,016 \text{ W/(m·K)}$$

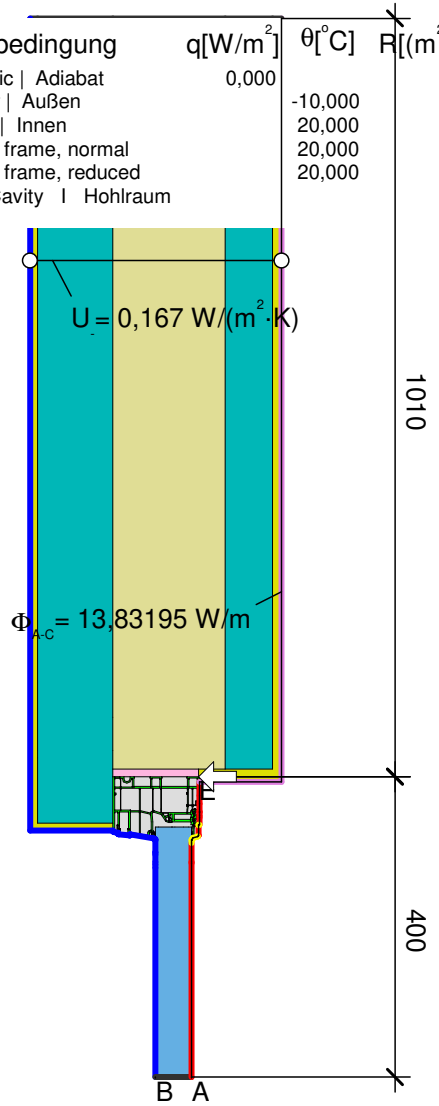


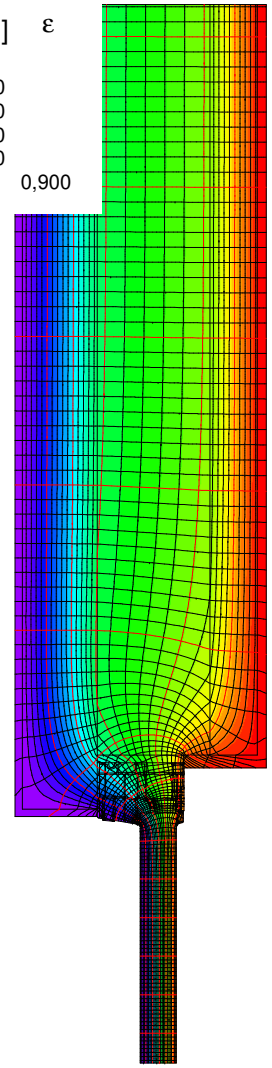


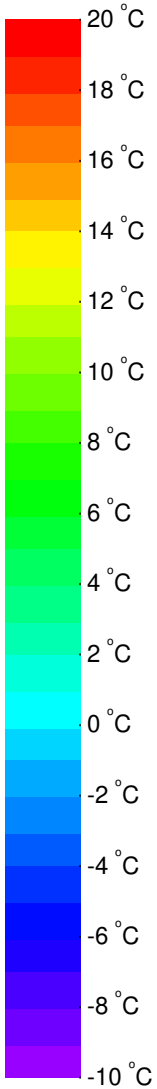
Material	λ[W/(m·K)]	ε
Aluminum I Aluminium 10456	160,000	0,900
Hardwood I Hartholz 0.18 700 kg/m3 10456	0,180	
Insulation I Wärmedämmung 035	0,035	
Lime Cement Plaster | Kalkzement Putz 10456	1,000	0,900
Panel I Maske	0,035	0,900
Polyvinylchloride (PVC)	0,170	0,900
Purenit 500 M	0,086	0,900
Silicone I Silikon	0,350	
Soft PVC I Weich-PVC	0,140	0,900
Softwood, OSB I Weichholz, OSB 10456	0,130	
Unvent. cavity I unbel. Hohlr. **		
slightly vent. cav. I leicht bel. Hohlr. **		

** EN ISO 10077-2:2017, 6.4.3

Randbedingung	q[W/m²]	θ[°C]	R[(m²·K)/W]	ε
Adiabatic | Adiabat	0,000			
Exterior | Außen		-10,000	0,040	
Interior | Innen		20,000	0,130	
Interior, frame, normal		20,000	0,130	
Interior, frame, reduced		20,000	0,200	
e 0,9 Cavity I Hohlraum				0,900

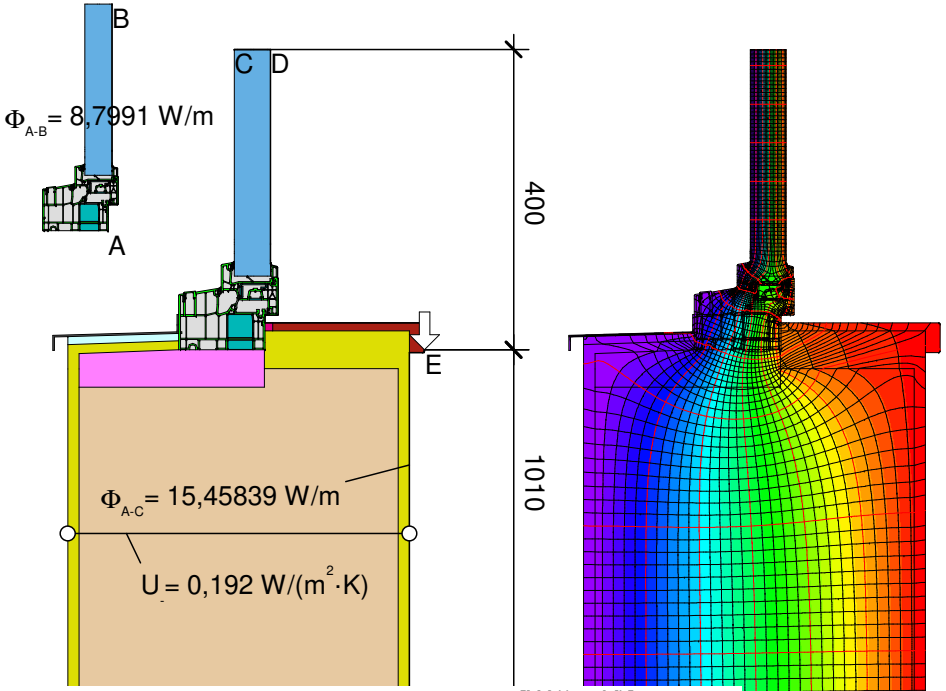






$$\psi_{A\text{-}E\text{-}C,*} = \frac{\Phi}{\Delta T} - U_1 \cdot b_1 - \frac{\Phi_2}{\Delta T} = \frac{14{,}015}{30{,}000} - 0{,}166 \cdot 1{,}010 - \frac{8{,}341}{30{,}000} = 0{,}021\ \mathrm{W/(m \cdot K)}$$

$$\psi_{A\text{-}E\text{-}C,*} = \frac{\Phi}{\Delta T} - \frac{\Phi_1}{\Delta T} - U_2 \cdot b_2 = \frac{13{,}832}{30{,}000} - \frac{8{,}341}{30{,}000} - 0{,}167 \cdot 1{,}010 = 0{,}015\ \mathrm{W/(m \cdot K)}$$

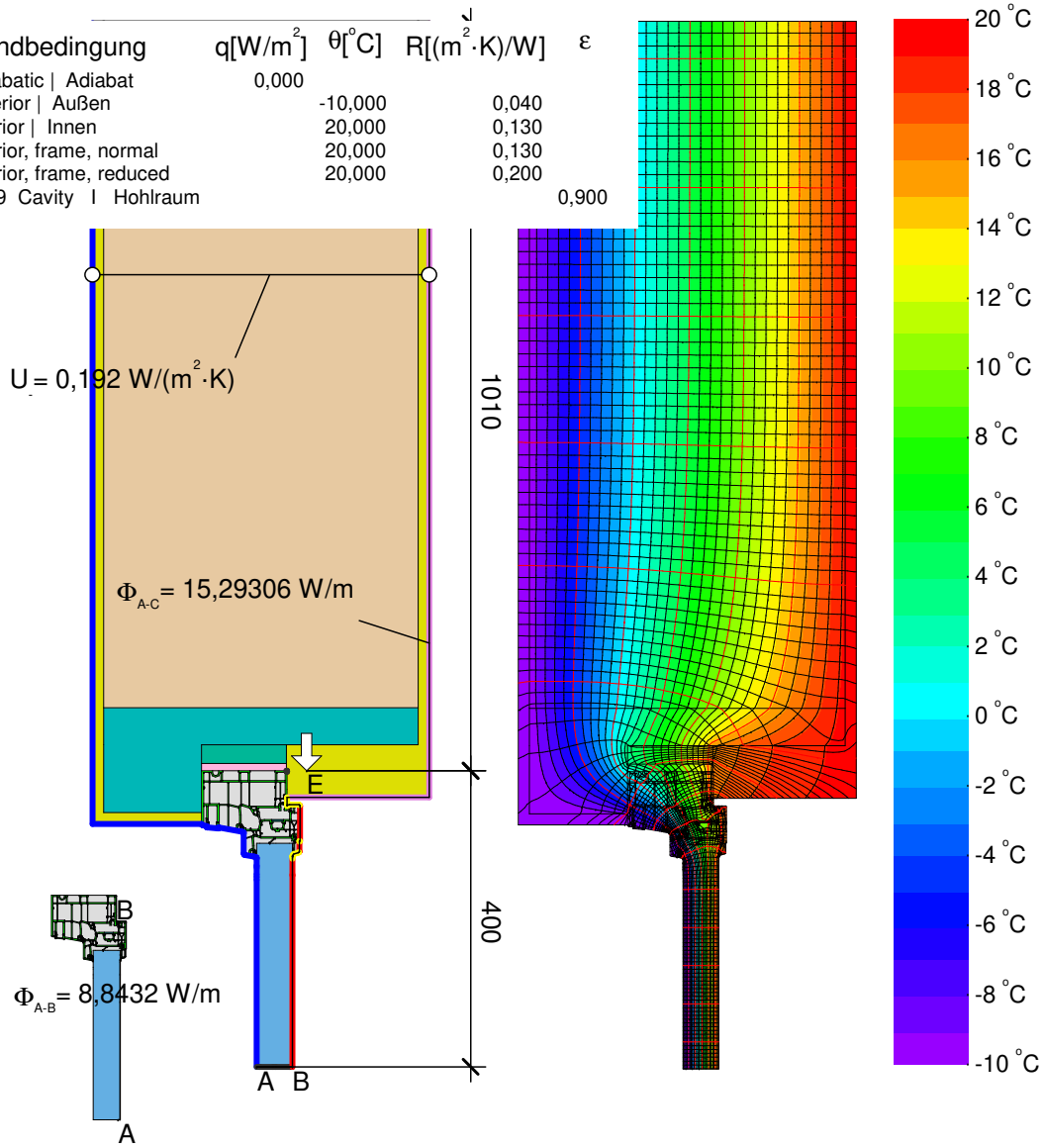


Material	λ[W/(m·K)]	ε
Aerated concrete	0,085	
Aluminum I Aluminium 10456	160,000	0,900
Hardwood I Hartholz 0.18 700 kg/m3 10456	0,180	
Insulation I Wärmedämmung 035	0,035	0,900
Lime Cement Plaster | Kalkzement Putz 10456	1,000	0,900
Panel I Maske	0,035	0,900
Polyvinylchloride (PVC)	0,170	0,900
Purenit 500 M	0,086	0,900
Silicone I Silikon	0,350	
Soft PVC I Weich-PVC	0,140	0,900
Steel I Stahl	50,000	0,900
Unvent. cavity I unbel. Hohlr. **		
slightly vent. cav. I leicht bel. Hohlr. **		

** EN ISO 10077-2:2017, 6.4.3

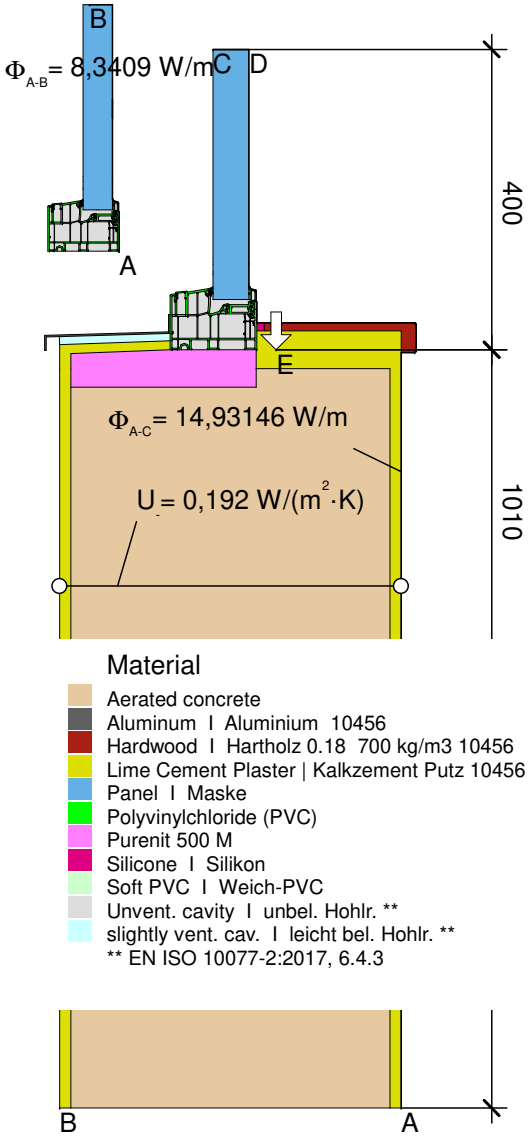
B A

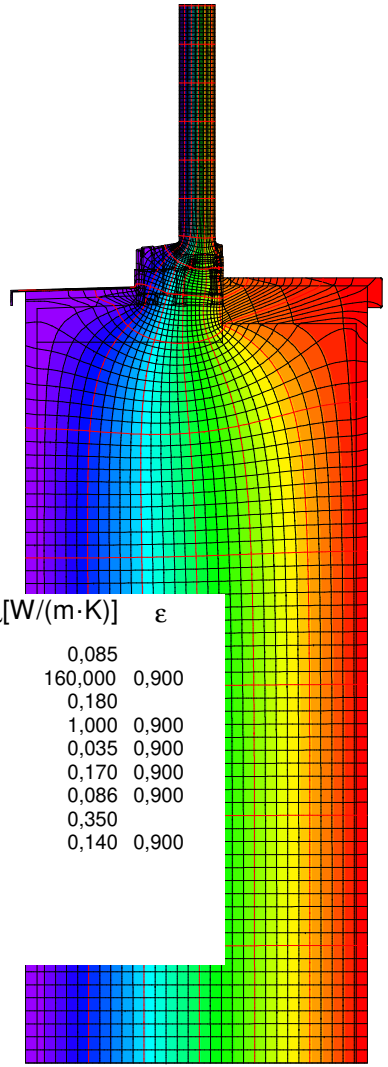
Randbedingung	q[W/m²]	θ[°C]	R[(m²·K)/W]	ε
Adiabatic | Adiabat	0,000			
Exterior | Außen		-10,000	0,040	
Interior | Innen		20,000	0,130	
Interior, frame, normal		20,000	0,130	
Interior, frame, reduced		20,000	0,200	
e 0,9 Cavity I Hohlraum				0,900

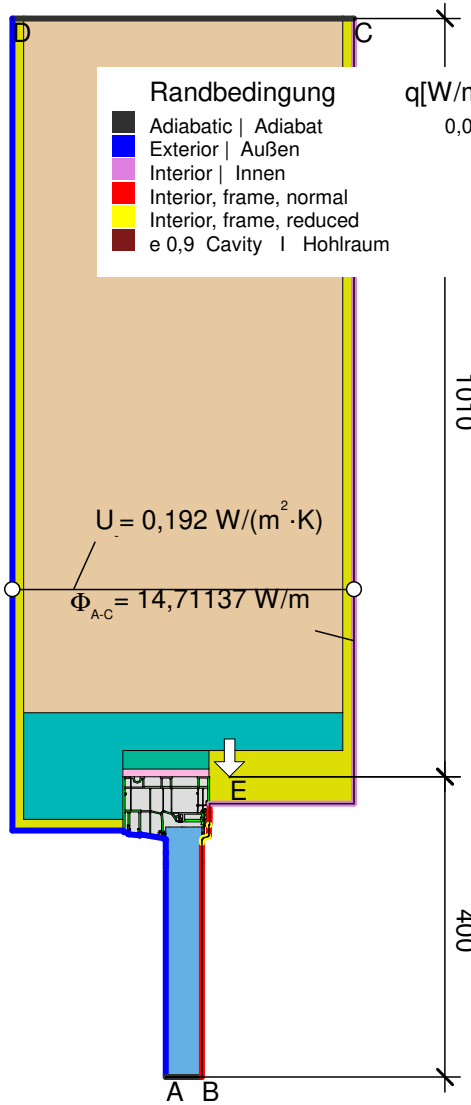


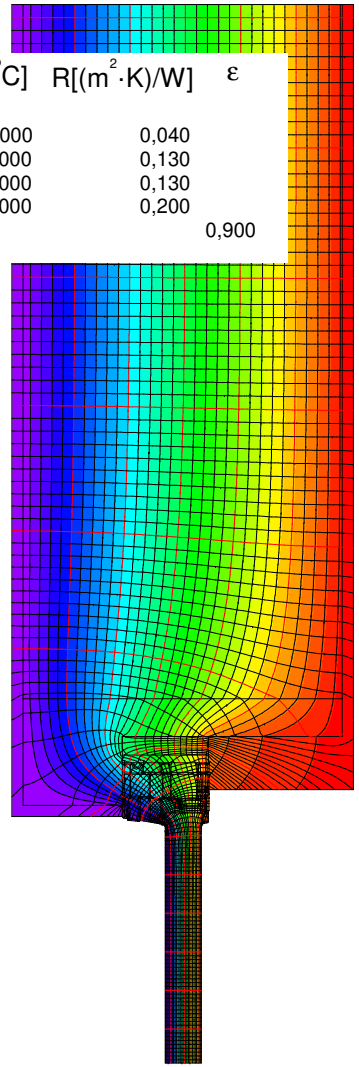
$$\psi_{A-E-C,*} = \frac{\Phi}{\Delta T} - U_1 \cdot b_1 - \frac{\Phi_2}{\Delta T} = \frac{15,458}{30,000} - 0,192 \cdot 1,010 - \frac{8,799}{30,000} = 0,028 \text{ W/(m·K)}$$

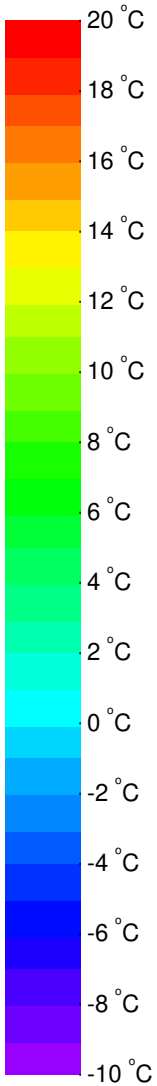
$$\psi_{A-E-C,*} = \frac{\Phi}{\Delta T} - \frac{\Phi_1}{\Delta T} - U_2 \cdot b_2 = \frac{15,293}{30,000} - \frac{8,843}{30,000} - 0,192 \cdot 1,010 = 0,021 \text{ W/(m·K)}$$











Material	λ[W/(m·K)]	ε
Aerated concrete	0,085	
Aluminum I Aluminium 10456	160,000	0,900
Hardwood I Hartholz 0.18 700 kg/m3 10456	0,180	
Lime Cement Plaster | Kalkzement Putz 10456	1,000	0,900
Panel I Maske	0,035	0,900
Polyvinylchloride (PVC)	0,170	0,900
Purenit 500 M	0,086	0,900
Silicone I Silikon	0,350	
Soft PVC I Weich-PVC	0,140	0,900
Unvent. cavity I unbel. Hohlr. **		
slightly vent. cav. I leicht bel. Hohlr. **		

** EN ISO 10077-2:2017, 6.4.3

Randbedingung	q[W/m²]	θ[°C]	R[(m²·K)/W]	ε
Adiabatic | Adiabat	0,000			
Exterior | Außen		-10,000	0,040	
Interior | Innen		20,000	0,130	
Interior, frame, normal		20,000	0,130	
Interior, frame, reduced		20,000	0,200	
e 0,9 Cavity I Hohlraum				0,900

$$\psi_{A-E-C,*} = \frac{\Phi}{\Delta T} - U_1 \cdot b_1 - \frac{\Phi_2}{\Delta T} = \frac{14{,}931}{30{,}000} - 0{,}192 \cdot 1{,}010 - \frac{8{,}341}{30{,}000} = 0{,}025 \text{ W/(m·K)}$$

$$\psi_{A-E-C,*} = \frac{\Phi}{\Delta T} - \frac{\Phi_1}{\Delta T} - U_2 \cdot b_2 = \frac{14{,}711}{30{,}000} - \frac{8{,}341}{30{,}000} - 0{,}192 \cdot 1{,}010 = 0{,}018 \text{ W/(m·K)}$$