



## Report - Certified Passive House Component | Bericht - Zertifizierte Passivhaus Komponente

Passive House Institute

Recommended for | Empfohlen für  
Warm, temperate climate | Clima cálido - templado



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Product | Producto:

Client | Fabricante:

Spacer | Separador:

Date | Fecha:

Author | Autor:

**Certification S9000**

**GEALAN Fenster-Systeme GmbH**

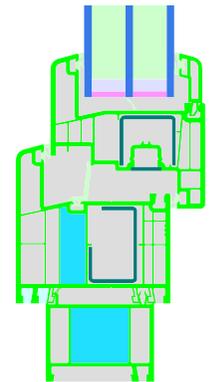
**SWISSPACER Ultimate**

**29.06.2018**

**Dr.-Ing. Benjamin Krick**

**Window system**  
**Sistema de ventana**

1239ws04



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.

La posibilidad de renunciar a un sistema de calefacción independiente de las viviendas pasivas implica unos requisitos de calidad muy elevados para los componentes empleados. Cuanto más frío es el clima, mayores son las exigencias. Por ese motivo, el Passivhaus Institut ha identificado las regiones con los mismos requisitos y fijado los criterios de certificación para estas. Estos están disponibles en la página del Passivhaus Institut para su descarga gratuita.

Si no se ha previsto ningún suministro de calefacción por debajo de las ventanas, el coeficiente de la transmitancia térmica de la

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 draughts. 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.

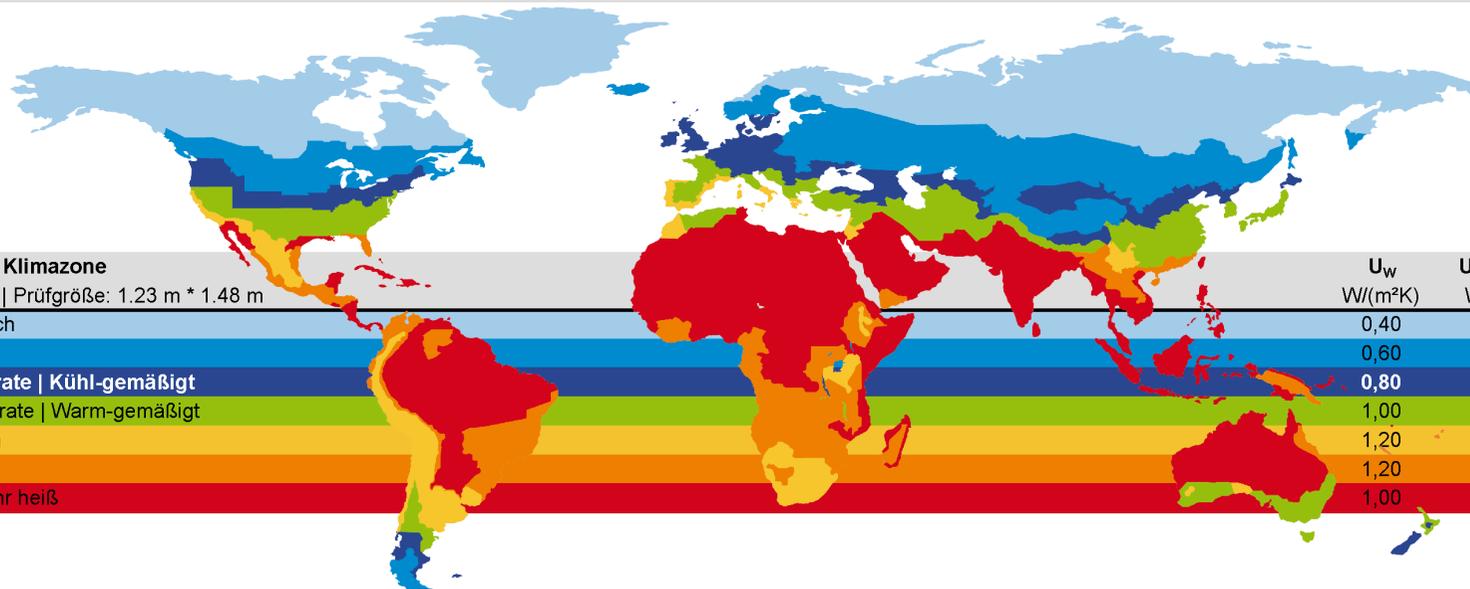
ventana empleada (valor U de la ventana)  $U_w$  no puede superar el valor máximo para el clima en cuestión a fin de evitar desagradables pérdidas por radiación y corrientes descendientes de aire frío. De esto resultan para una calidad de acristalamiento determinada los umbrales para la pérdida de calor en el área del marco de la ventana. En este contexto resulta relevante la situación constructiva de la ventana. Por ese motivo, también ha fijado un valor máximo para  $U_{w, instalado}$ , que se comprobó a modo de ejemplo en el marco de la certificación.

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).

Del mismo modo, se debe satisfacer el criterio de higiene. Este limita la temperatura individual mínima en el interior de la superficie de la ventana para evitar la aparición de agua condensada y moho.

El Passivhaus Institut (PHI) ha establecido los requisitos que aparecen a continuación para lograr al reconocimiento como "Componente certificado para vivienda pasiva".



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  $\Psi$ -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  $\Psi_{opak}$ .

Las ventanas se clasifican en categorías de eficiencia en función de las pérdidas de calor por la parte opaca. Estas categorías incluyen los valores U del marco, las anchuras del marco, los valores  $\Psi$  del borde del vidrio y las longitudes del borde del vidrio.

El balance entre la pérdida y la ganancia térmica es relevante para las viviendas pasivas. Debido a que las ganancias solares son difíciles de registrar, resulta útil cuantificar las pérdidas en función de las partes de la ventana y hacer un balance que no permite las ganancias solares. Esto es lo que determina  $\Psi_{opak}$ .

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

max. $\Psi_{opak}$ [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

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

El cálculo de los valores térmicos específicos de las secciones del marco se ha realizado sobre la base de la norma ISO 10077-1:2010 y 10077-2:2012. La conductividad térmica se ha tomado de las normas pertinentes o las autorizaciones de las autoridades constructivas, o se ha determinado según los valores de medición de la norma ISO 10077-2:2012 Parte 5.1 En el caso de una pieza de vidrio, los modelos tienen 40 cm de altura, y los modelos de dos piezas de vidrio, 60 cm de altura.

Los espaciadores se modelaron con arreglo a los modelos de dos cajas del grupo de trabajo "Warm Edge" de la asociación de vidrio plano (Bundesverband Flachglas) de Alemania.

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.

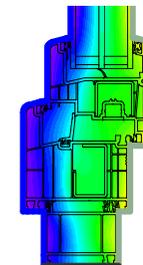
Los coeficientes de puentes térmicos se han calculado a modo de ejemplo para construcciones de paredes típicas. Estos valores solo pueden utilizarse en instalaciones idénticas para realizar el cálculo del balance energético. Los modelos para las paredes tienen 1,41 m de altura, y la altura del vidrio y del marco es de 40 cm. La ranura de instalación mide 1 cm.

Para elaborar los modelos y realizar el cálculo de los flujos de calor se empleó el programa Flixo 8 Professional de la empresa Infomind. A continuación, se pueden consultar las condiciones marco empleadas.



Randbedingung	$q$ [W/m <sup>2</sup> ]	$\theta$ [°C]	$R$ [(m <sup>2</sup> ·K)/W]	$\epsilon$
Adiabatic   Adiat	0,000			
Exterior   Außen		-10,000	0,040	
Interior, frame, normal		20,000	0,130	
Interior, frame, reduced		20,000	0,200	
e 0,3 Cavity in metal				0,300
e 0,9 Cavity   Hohlraum				0,900

Randbedingung	$q$ [W/m <sup>2</sup> ]	$\theta$ [°C]	$R$ [(m <sup>2</sup> ·K)/W]	$\epsilon$
Adiabatic   Adiat	0,000			
Exterior   Außen		-10,000	0,040	
e 0,3 Cavity in metal				0,300
e 0,9 Cavity   Hohlraum				0,900
fRsi: Interior   Innen		20,000	0,250	

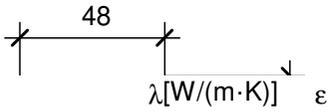


GEALAN Fenster-Systeme GmbH		bo	to	si	bof	tof	sif	th	sh	fm Flying	m2	m1	m	ec	t2	t1	t
		Bottom	Top	Side	Bottom fixed	Top fixed	Side fixed	Thres- hold	Side door	Mullion	Mullion	Mullion	Mullion fixed	Corner	Transom	Transom	Transom fixed
Certification S9000		Inferior	Superior	Lateral	Inferior fijo	Superior fijo	Lateral fijo	Umbral	Puerta lateral	Montante móvil	Montante	Montante	Montante fijo	Esquina	Trave- saño	Trave- saño	Trave- saño fijo
Spacer   Separador: SWISSPACER Ultimate																	
Temperaturefactor Factor de temp.	$f_{Rsi}=0,25m^2k/W$	0,73	0,73	0,73	0,71	0,72	0,72	0,63		0,65	0,68	0,69	0,71				
Frame width Ancho del marco	$b_f$ [mm]	148	118	118	100	70	70	92		170	188	140	92				
U-value frame Valor-U marco	$U_f$ [W/(m²K)]	0,97	1,02	1,02	0,91	0,96	0,96	1,71		1,08	1,07	1,07	1,05				
Ψ-glass edge Ψ borde del vidrio	$\Psi_g$ [W/(mK)]	0,023	0,023	0,023	0,022	0,023	0,023	0,023		0,022	0,024	0,023	0,023				
U-value window Valor-U ventana	$U_w$ [W/(m²K)] @ $U_g= 0,9$ W/(m²K)	<b>0,992</b>			<b>0,968</b>				<b>Contact person   Ansprechpartner</b> GEALAN Fenster-Systeme GmbH, Ute Richter +499286774105 ute.richter@gealan.de  <b>Construction:</b> PVC frame with PU foam (IKD®, 0.026 W/(mK)) insulated chamber. The required temperature factor is not achieved at the threshold. The airtightness was approved for a window with flying mullion (1650 mm * 1472 mm). Frame 6002 with reinforcement 6715 and bottom frame extension 7202 IKD, frame 6016 IKD with reinforcement 6716 and frame extension 7299 IKD, sash 6003 with reinforcement 6706, threshold 2596/2576 with 6431 and 6105, mullion 6012 with reinforcement 6711, mullion 6050 with reinforcement 6712. Pane thickness: 48 mm (4/18/4/18/4), rebate depth: 23 mm.								
Ψ <sub>opaque</sub>	$\Psi_{opaque}$ W/(mK)	<b>0,163</b>			<b>0,100</b>												
Passive House efficiency class Clasificación de eficiencia Passive House		<b>phC</b>			<b>phA</b>												
<b>EIFS   SATE U-Wall = 0,228 W/(m²K)</b>		<b>Descripción:</b> Marco de PVC con espuma (IKD®, 0,026 W/(mK)) en la camera. No se consigue los requisitos del factor de temperatura en la solera. Se certificó la estanquidad al aire en una ventana de dos hojas con batiente de 1650 mm * 1472 mm. Marco 6002 con refuerzo 6715 y ensanche inferior 7202 IKD, marco 6016 IKD con refuerzo 6716 y ensanche inferior 7299 IKD, hoja 6003 con refuerzo 6706, solera 2596/2576 con 6431 y 6105, batiente 6012 con refuerzo 6711, poste 6050 con refuerzo 6712. Espesor del acristalamiento 48 mm (4/18/4/18/4), Altura de junquillo: 23 mm.															
$\Psi_{install}$ [W/(mK)]																	
$U_{w, installed}$ [W/(m²K)]		1,03			0,99												
<b>Lightweight timber construction   Entramado ligero de madera U-Wall = 0,189 W/(m²K)</b>		<b>Descripción:</b> Marco de PVC con espuma (IKD®, 0,026 W/(mK)) en la camera. No se consigue los requisitos del factor de temperatura en la solera. Se certificó la estanquidad al aire en una ventana de dos hojas con batiente de 1650 mm * 1472 mm. Marco 6002 con refuerzo 6715 y ensanche inferior 7202 IKD, marco 6016 IKD con refuerzo 6716 y ensanche inferior 7299 IKD, hoja 6003 con refuerzo 6706, solera 2596/2576 con 6431 y 6105, batiente 6012 con refuerzo 6711, poste 6050 con refuerzo 6712. Espesor del acristalamiento 48 mm (4/18/4/18/4), Altura de junquillo: 23 mm.															
$\Psi_{install}$ [W/(mK)]																	
$U_{w, installed}$ [W/(m²K)]		1,01			0,99												
<b>Formwork blocks   Bloques de hormigón U-Wall = 0,251 W/(m²K)</b>		<b>Descripción:</b> Marco de PVC con espuma (IKD®, 0,026 W/(mK)) en la camera. No se consigue los requisitos del factor de temperatura en la solera. Se certificó la estanquidad al aire en una ventana de dos hojas con batiente de 1650 mm * 1472 mm. Marco 6002 con refuerzo 6715 y ensanche inferior 7202 IKD, marco 6016 IKD con refuerzo 6716 y ensanche inferior 7299 IKD, hoja 6003 con refuerzo 6706, solera 2596/2576 con 6431 y 6105, batiente 6012 con refuerzo 6711, poste 6050 con refuerzo 6712. Espesor del acristalamiento 48 mm (4/18/4/18/4), Altura de junquillo: 23 mm.															
$\Psi_{install}$ [W/(mK)]																	
$U_{w, installed}$ [W/(m²K)]		0,99			0,96												
<b>Ventillated facade   Fachada ventilada U-Wall = 0,133 W/(m²K)</b>		<b>Descripción:</b> Marco de PVC con espuma (IKD®, 0,026 W/(mK)) en la camera. No se consigue los requisitos del factor de temperatura en la solera. Se certificó la estanquidad al aire en una ventana de dos hojas con batiente de 1650 mm * 1472 mm. Marco 6002 con refuerzo 6715 y ensanche inferior 7202 IKD, marco 6016 IKD con refuerzo 6716 y ensanche inferior 7299 IKD, hoja 6003 con refuerzo 6706, solera 2596/2576 con 6431 y 6105, batiente 6012 con refuerzo 6711, poste 6050 con refuerzo 6712. Espesor del acristalamiento 48 mm (4/18/4/18/4), Altura de junquillo: 23 mm.															
$\Psi_{install}$ [W/(mK)]																	
$U_{w, installed}$ [W/(m²K)]																	
<b>Cavity wall   Muro con cámara U-Wall = 0,130 W/(m²K)</b>		<b>Calculation   Cálculo</b> Passivhaus Institut Darmstadt 29.06.2018															
$\Psi_{install}$ [W/(mK)]																	
$U_{w, installed}$ [W/(m²K)]																	



frame values   Rahmenwerte		GEALAN Fenster-Systeme GmbH						Classification according to EN 14351-1, carried out by ift Rosenheim											
		V1 bo Bottom	V1 to Top	V1 s Side	V1 bof Bottom fixed	V1 tof Top fixed	V1 sf Side fixed	Clasificación según EN 14351-1, realizada por ift Rosenheim											
		Inferior	Superior	Lateral	Inferior fijo	Superior fijo	Lateral fijo	Window-type Tipo de ventana	Reference number Número de referencia	Resistance to wind Resistencia al EN 12210	Water tightness Estanqueidad al agua EN 12208	Air tightness Luftdichtheit EN 1220 Q100							
Certification S9000																			
Spacer   Separador: SWISSPACER Ultimate																			
Temperature factor Factor de temp.	$f_{Rsi}=0,25m^2k/W$	0,73	0,73	0,73	0,72	0,72	0,72		12-002166-Pr02 PB-A01-0203-de-01	C3 / B4	8A	4	0,37 m³/hm						
Frame width Ancho del marco	$b_f$ [mm]	174	132	132	125	84	84	1572 * 2376 mm											
U-value frame Valor-U marco	$U_f$ [W/(m²K)]	1,04	0,98	0,98	1,01	0,89	0,89		12-002166-Pr03 PB-A01-0203-de-01	C4 / B4	9A	4	0,18 m³/hm						
Ψ-glass edge Ψ borde del vidrio	$\Psi_g$ [W/(mK)]	0,024	0,024	0,024	0,022	0,022	0,022	3290 * 2372 mm											
U-value window Valor-U ventana	$U_w$ [W/(m²K)] @ $U_g=0,9$ W/(m²K)	<b>0,993</b>			<b>0,965</b>				12-002166-Pr04 PB-A01-0203-de-01	C5 / B5	9A	4	0,16 m³/hm						
Ψ <sub>opaque</sub>	$\Psi_{opaque}$ W/(mK)	<b>0,184</b>			<b>0,116</b>			1650 * 1472 mm											
Passive House efficiency class Clasificación de eficiencia Passive House		<b>phC</b>			<b>phB</b>				12-002166-Pr05 PB-A01-0203-de-01	C2 / B3	9A	4	0,17 m³/hm						
<b>EIFS   SATE U-Wall = 0,228 W/(m²K)</b>																			
	$\Psi_{install}$ [W/(mK)]	0,036	0,008	0,008	0,035	-0,002	-0,002	1642 * 2372 mm					0,17 m³/hm						
	$U_{w, installed}$ [W/(m²K)]	1,04			0,98														
<b>Lightweight timber construction   Entramado ligero de madera U-Wall = 0,189 W/(m²K)</b>									12-002166-Pr05 PB-A01-0203-de-01	C4 / B5	9A	4	0,78 m³/hm						
	$\Psi_{install}$ [W/(mK)]	0,001	0,007	0,007	0,002	0,002	0,002	1642 * 2372 mm											
	$U_{w, installed}$ [W/(m²K)]	1,01			0,97														
<b>Formwork blocks   Bloques de hormigón U-Wall = 0,251 W/(m²K)</b>								Criterion achieved			Criterion not achieved								
	$\Psi_{install}$ [W/(mK)]	0,008	-0,004	-0,004	0,008	-0,011	-0,011												
	$U_{w, installed}$ [W/(m²K)]	0,99			0,94														
<b>Ventilated facade   Fachada ventilada U-Wall = 0,133 W/(m²K)</b>																			
	$\Psi_{install}$ [W/(mK)]																		
	$U_{w, installed}$ [W/(m²K)]																		
<b>Cavity wall   Muro con cámara U-Wall = 0,130 W/(m²K)</b>																			
	$\Psi_{install}$ [W/(mK)]																		
	$U_{w, installed}$ [W/(m²K)]																		

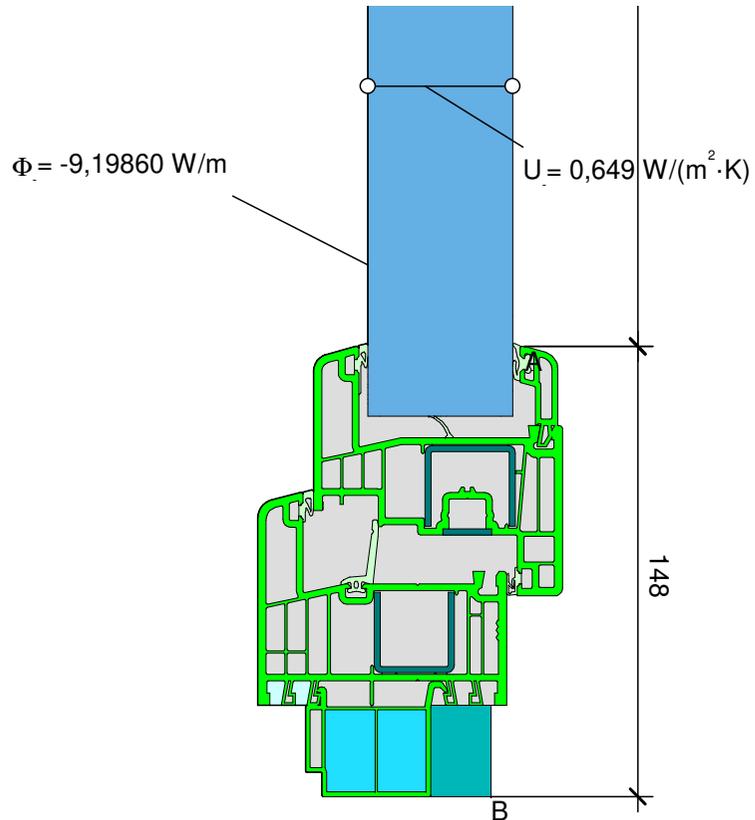




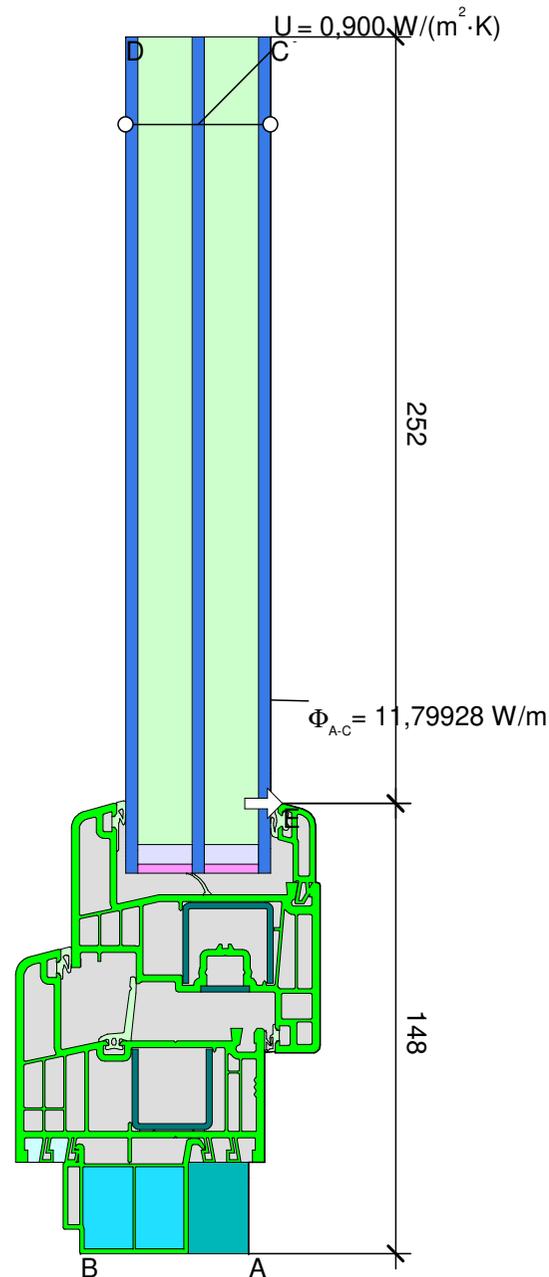
**Material**

Ar18 in 48 mm U 0,9	0,039	
Glass   Glas	1,000	0,900
Insulation   Wärmedämmung 034	0,034	0,900
PU foam 0,021*1.25	0,026	
Polysulfide   Polysulfid	0,400	0,900
Polyvinylchloride (PVC)	0,170	0,900
SWISSP. Ultimate Box 2 [cert]	0,140	
Soft PVC   Weich-PVC	0,140	0,900
Steel   Stahl	50,000	0,300
Steel   Stahl	50,000	0,900
Unbelüftete Hohlräume **		
Unvent. cavity   unbel. Hohlr. **		
slightly vent. cav.   leicht bel. Hohlr. **		

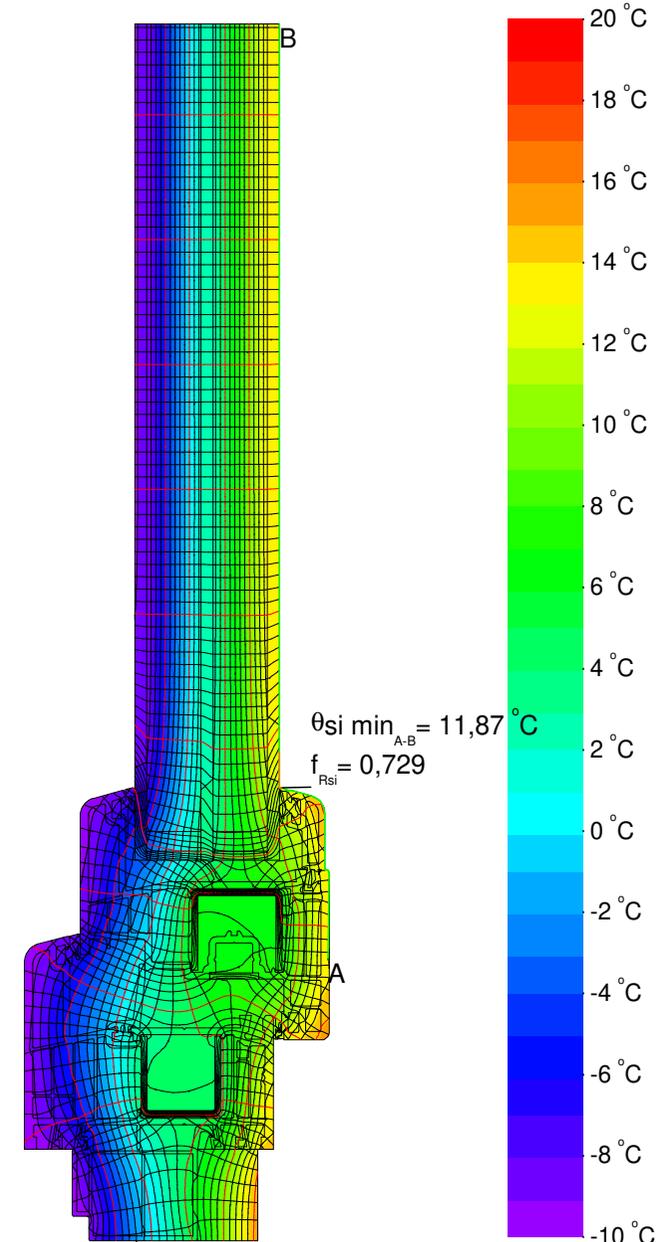
\*\* EN ISO 10077-2:2017, 6.4.3

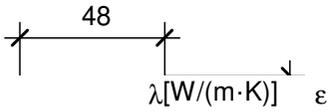


$$U_{fAB} = \frac{\Phi}{b_f} - U_p \cdot b_p = \frac{9,199}{30,000} - 0,649 \cdot 0,252 = 0,967 \text{ W/(m}^2 \cdot \text{K)}$$



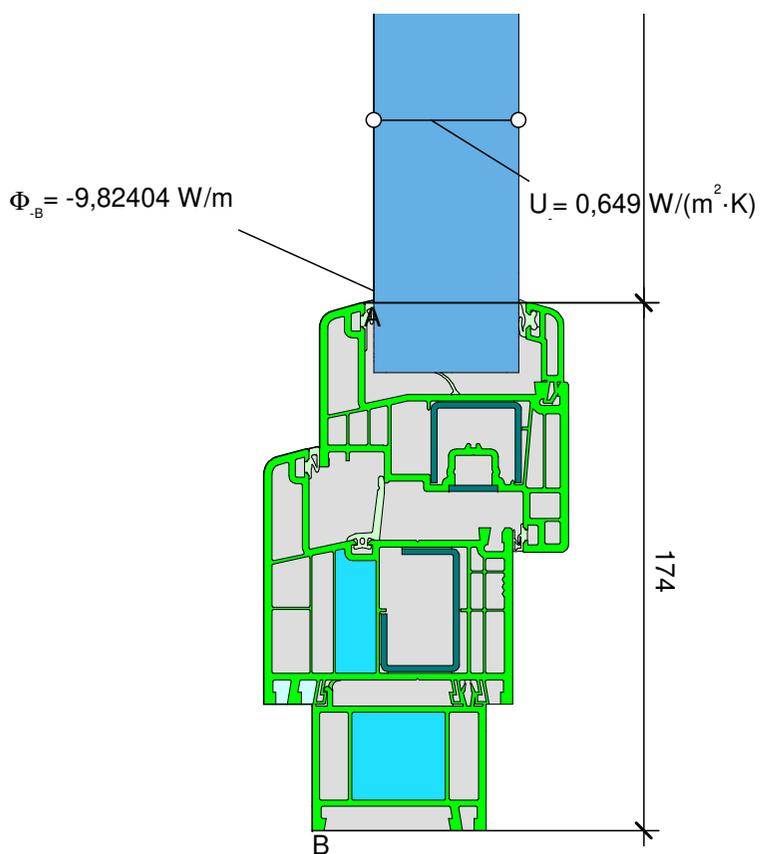
$$\psi_{A-E.C.} = \frac{\Phi}{\Delta T} - U_1 \cdot b_1 - U_2 \cdot b_2 = \frac{11,799}{30,000} - 0,967 \cdot 0,148 - 0,900 \cdot 0,252 = 0,023 \text{ W/(m} \cdot \text{K)}$$



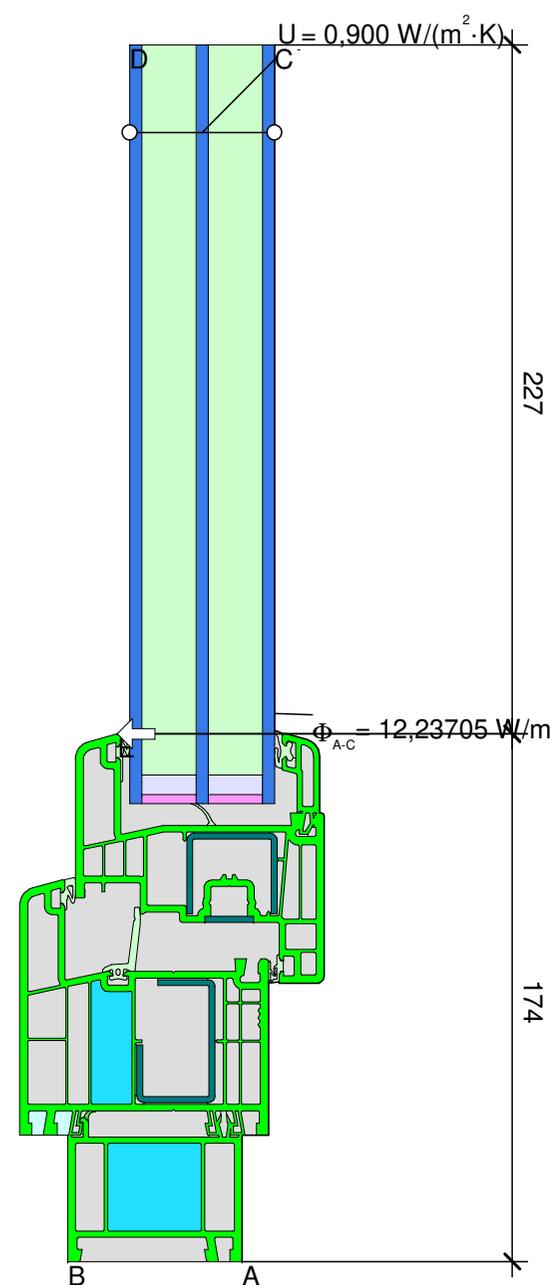


Material	$\lambda$ [W/(m·K)]	$\epsilon$
Ar18 in 48 mm U 0,9	0,039	
Glass   Glas	1,000	0,900
PU foam 0,021*1.25	0,026	
Polysulfide   Polysulfid	0,400	0,900
Polyvinylchloride (PVC)	0,170	0,900
SWISSP. Ultimate Box 2 [cert]	0,140	
Soft PVC   Weich-PVC	0,140	0,900
Steel   Stahl	50,000	0,300
Steel   Stahl	50,000	0,900
Unvent. cavity   unbel. Hohlr. **		
Weich-Polyvinylchlorit (PVC-P)	0,140	0,900
slightly vent. cav.   leicht bel. Hohlr. **		

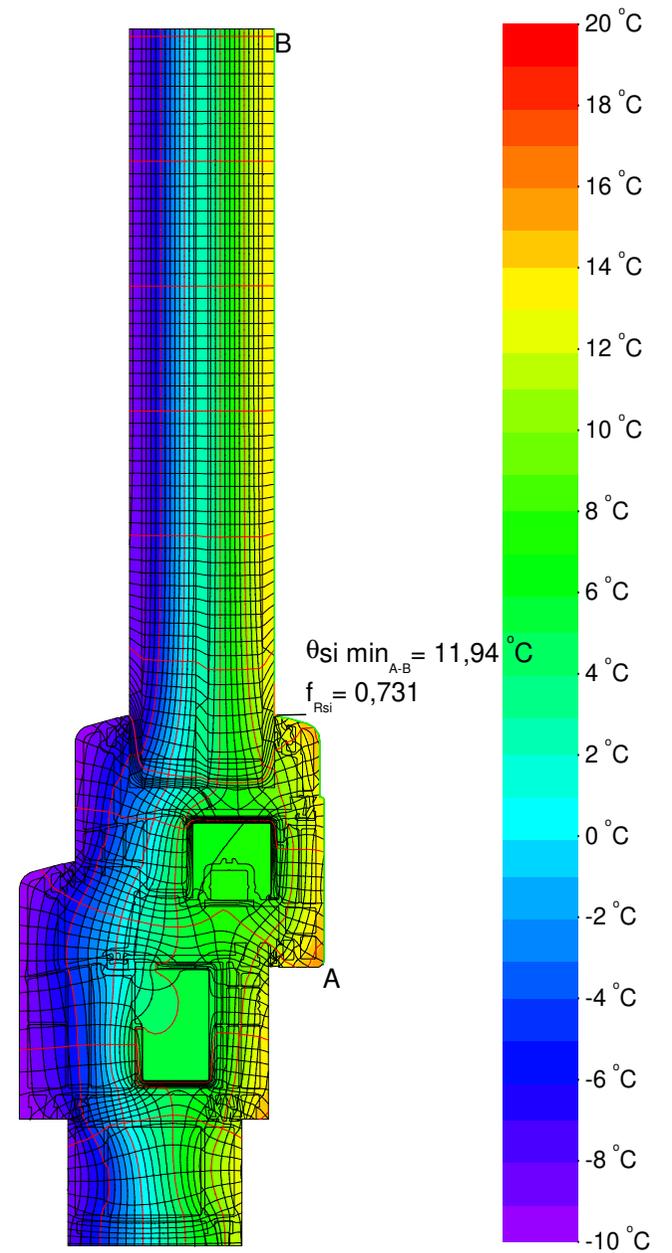
\*\* EN ISO 10077-2:2017, 6.4.3

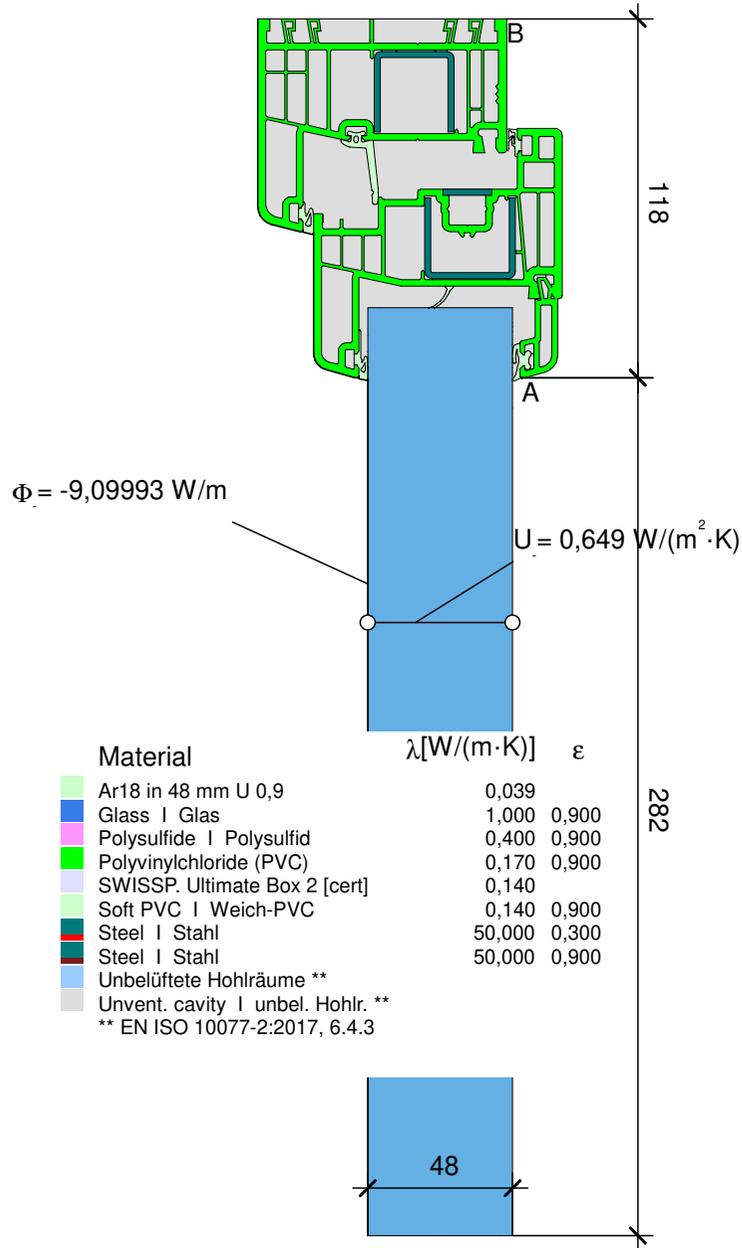


$$U_{fAB} = \frac{\Phi}{\Delta T} - \frac{U_p \cdot b_p}{b_f} = \frac{9,824}{30,000} - \frac{0,649 \cdot 0,227}{0,174} = 1,040 \text{ W/(m}^2 \cdot \text{K)}$$



$$\psi_{A-E.C.} = \frac{\Phi}{\Delta T} - U_1 \cdot b_1 - U_2 \cdot b_2 = \frac{12,237}{30,000} - 1,040 \cdot 0,174 - 0,900 \cdot 0,227 = 0,024 \text{ W/(m} \cdot \text{K)}$$





$$\Phi = -9,09993 \text{ W/m}$$

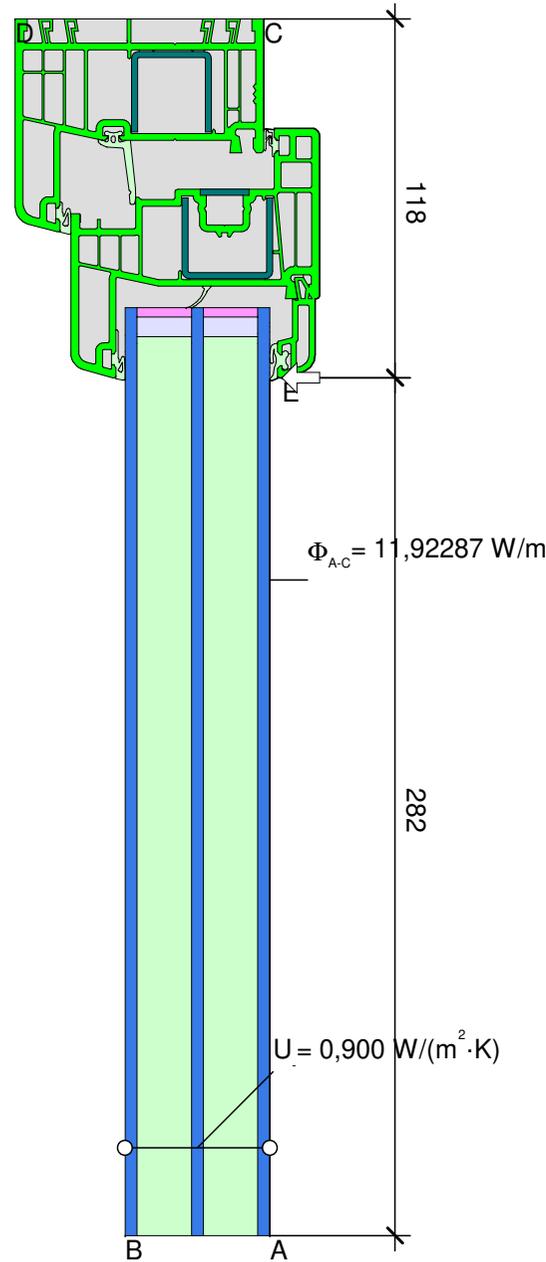
$$U = 0,649 \text{ W}/(\text{m}^2 \cdot \text{K})$$

**Material**

Material	$\lambda$ [W/(m·K)]	$\epsilon$
Ar18 in 48 mm U 0,9	0,039	
Glass   Glas	1,000	0,900
Polysulfide   Polysulfid	0,400	0,900
Polyvinylchloride (PVC)	0,170	0,900
SWISSP. Ultimate Box 2 [cert]	0,140	
Soft PVC   Weich-PVC	0,140	0,900
Steel   Stahl	50,000	0,300
Steel   Stahl	50,000	0,900
Unbelüftete Hohlräume **		
Unvent. cavity   unbel. Hohlr. **		

\*\* EN ISO 10077-2:2017, 6.4.3

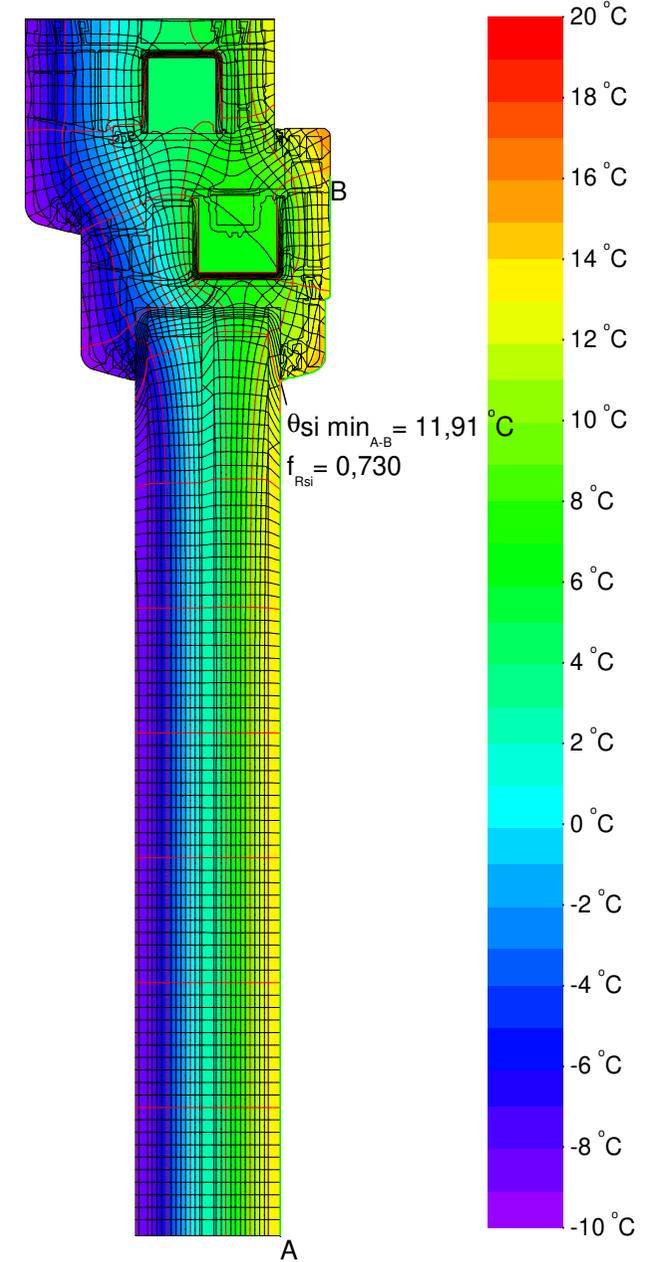
$$U_{IAB} = \frac{\frac{\Phi}{\Delta T} - U_p \cdot b_p}{b_f} = \frac{\frac{9,100}{30,000} - 0,649 \cdot 0,282}{0,118} = 1,020 \text{ W}/(\text{m}^2 \cdot \text{K})$$



$$\Phi_{A-C} = 11,92287 \text{ W/m}$$

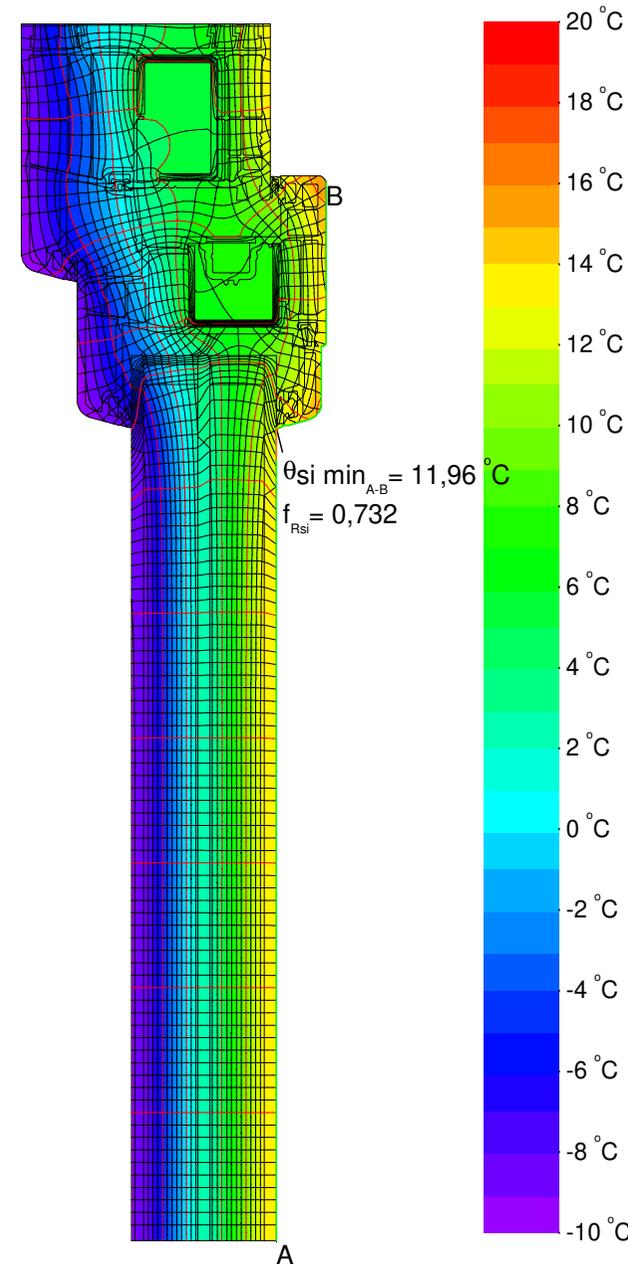
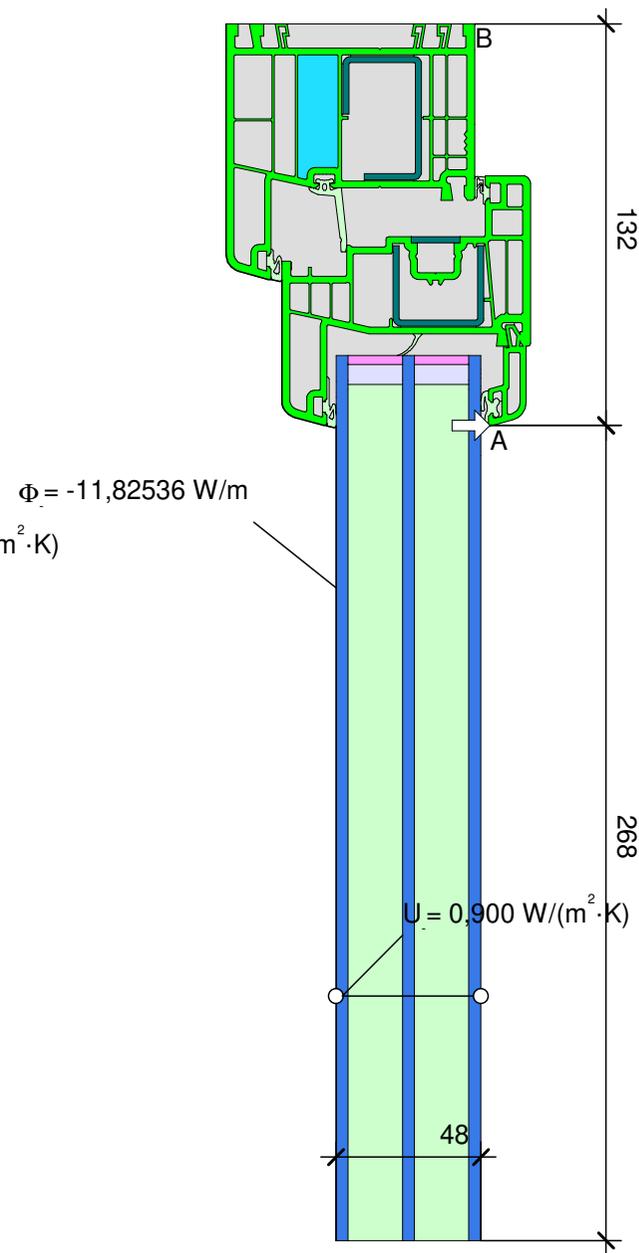
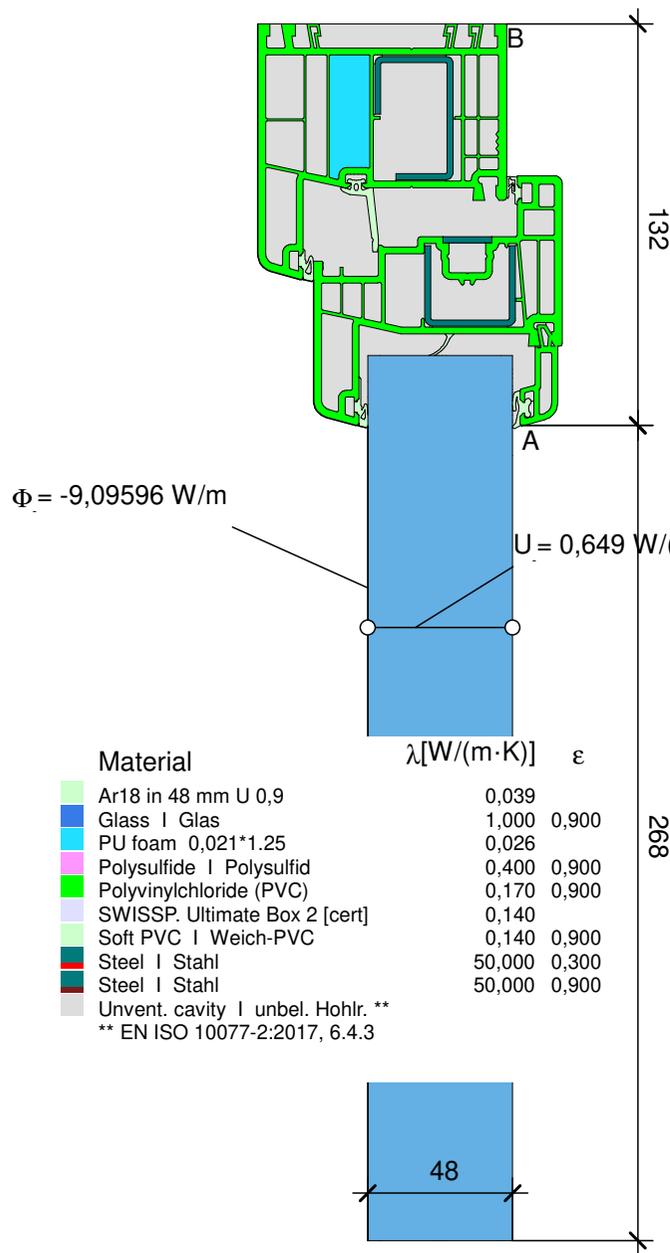
$$U = 0,900 \text{ W}/(\text{m}^2 \cdot \text{K})$$

$$\Psi_{A-E-C} = \frac{\Phi}{\Delta T} - U_1 \cdot b_1 - U_2 \cdot b_2 = \frac{11,923}{30,000} - 0,900 \cdot 0,282 - 1,020 \cdot 0,118 = 0,023 \text{ W}/(\text{m} \cdot \text{K})$$



$$\theta_{si \min_{A-B}} = 11,91 \text{ } ^\circ\text{C}$$

$$f_{Rsi} = 0,730$$



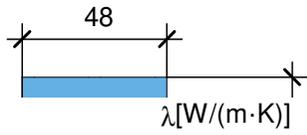
Material	$\lambda$ [W/(m·K)]	$\epsilon$
Ar18 in 48 mm U 0,9	0,039	
Glass   Glas	1,000	0,900
PU foam 0,021*1.25	0,026	
Polysulfide   Polysulfid	0,400	0,900
Polyvinylchloride (PVC)	0,170	0,900
SWISSP. Ultimate Box 2 [cert]	0,140	
Soft PVC   Weich-PVC	0,140	0,900
Steel   Stahl	50,000	0,300
Steel   Stahl	50,000	0,900
Unvent. cavity   unbel. Hohlr. **		

\*\* EN ISO 10077-2:2017, 6.4.3

$$U_{i,A,B} = \frac{\frac{\Phi}{\Delta T} - U_p \cdot b_p}{b_f} = \frac{\frac{9,096}{30,000} - 0,649 \cdot 0,268}{0,132} = 0,980 \text{ W/(m}^2 \cdot \text{K)}$$

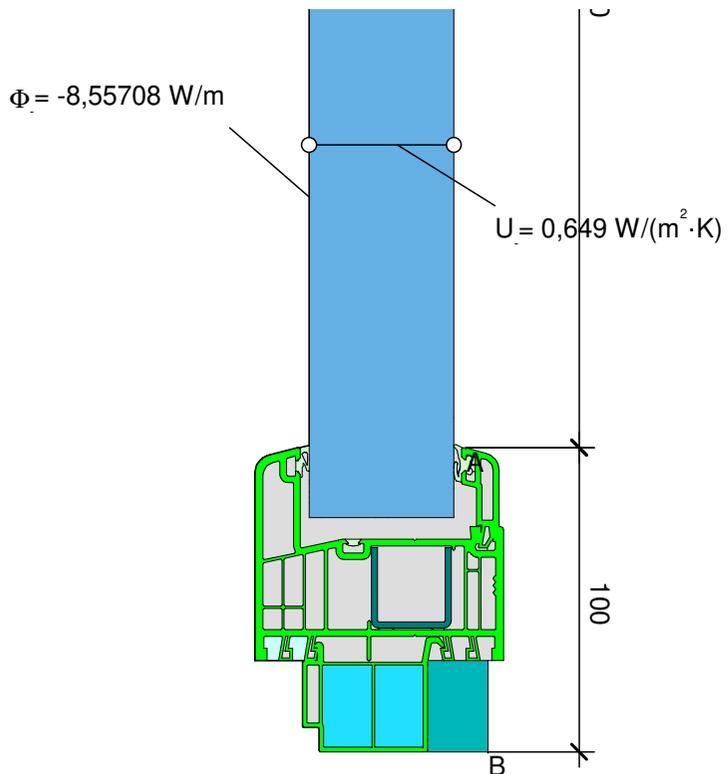
$$\psi_A = \frac{\Phi}{\Delta T} - U_g \cdot b_g - U_f \cdot b_f = \frac{11,825}{30,000} - 0,900 \cdot 0,268 - 0,980 \cdot 0,132 = 0,024 \text{ W/(m} \cdot \text{K)}$$



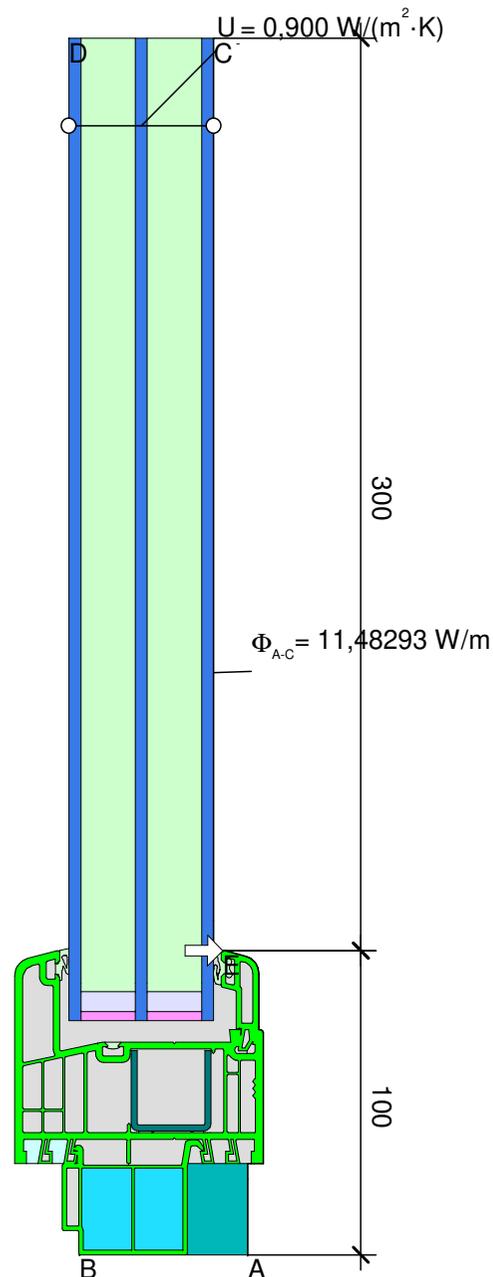


Material	$\lambda$ [W/(m·K)]	$\epsilon$
Ar18 in 48 mm U 0,9	0,039	
Glass I Glas	1,000	0,900
Insulation I Wärmedämmung 034 (1)	0,034	0,900
Maske	0,035	0,900
PU foam 0,021*1.25	0,026	
Polysulfide I Polysulfid	0,400	0,900
Polyvinylchloride (PVC)	0,170	0,900
Polyvinylchloride (PVC)	0,170	
SWISSP. Ultimate Box 2 [cert]	0,140	
Soft PVC I Weich-PVC	0,140	0,900
Steel I Stahl	50,000	0,300
Unvent. cavity I unbel. Hohlr. **		0,140 0,900
Weich-Polyvinylchlorit (PVC-P)		
slightly vent. cav. I leicht bel. Hohlr. **		

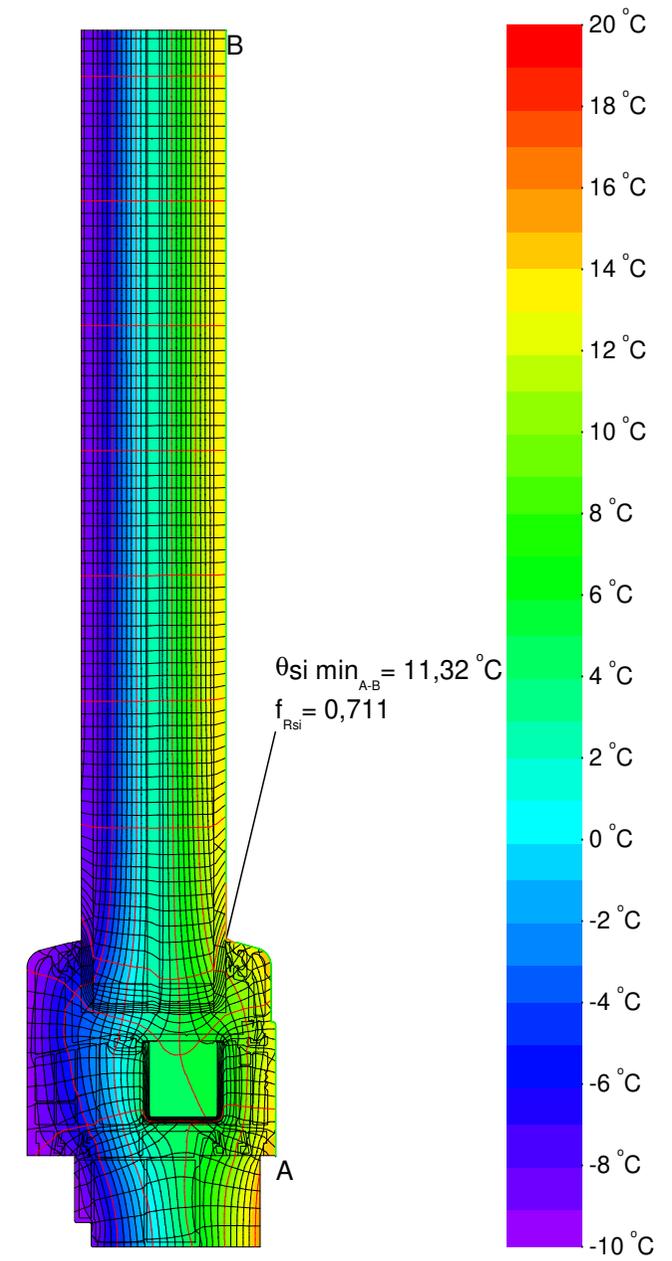
\*\* EN ISO 10077-2:2017, 6.4.3

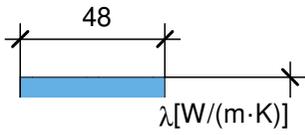


$$U_{fAB} = \frac{\frac{\Phi}{\Delta T} - U_p \cdot b_p}{b_f} = \frac{\frac{8,557}{30,000} - 0,649 \cdot 0,300}{0,100} = 0,906 \text{ W/(m}^2 \cdot \text{K)}$$



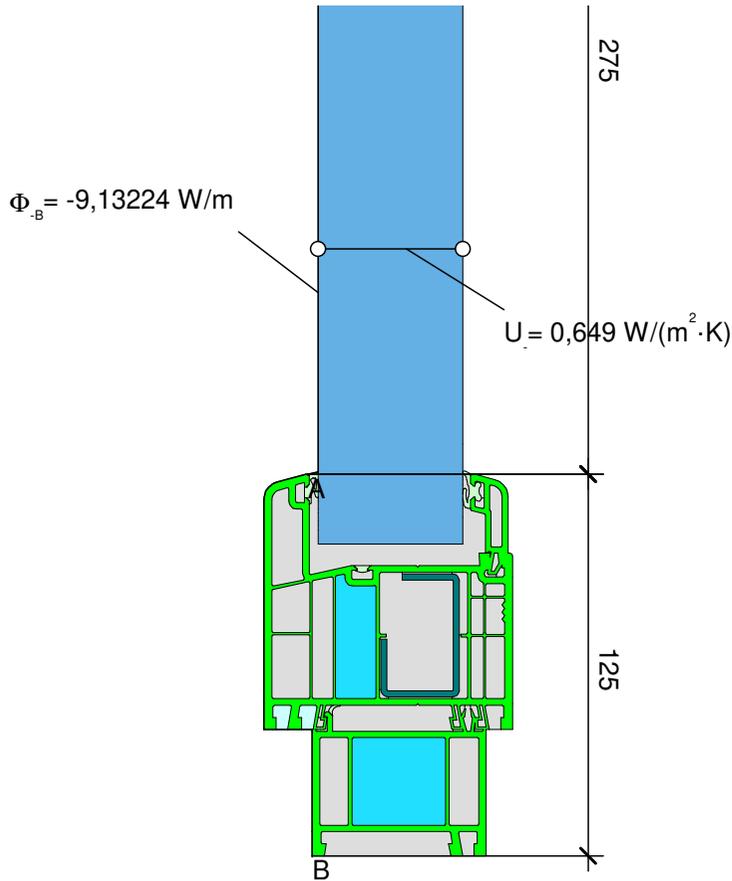
$$\psi_{A-E,C} = \frac{\Phi}{\Delta T} - U_1 \cdot b_1 - U_2 \cdot b_2 = \frac{11,483}{30,000} - 0,906 \cdot 0,100 - 0,900 \cdot 0,300 = 0,022 \text{ W/(m} \cdot \text{K)}$$



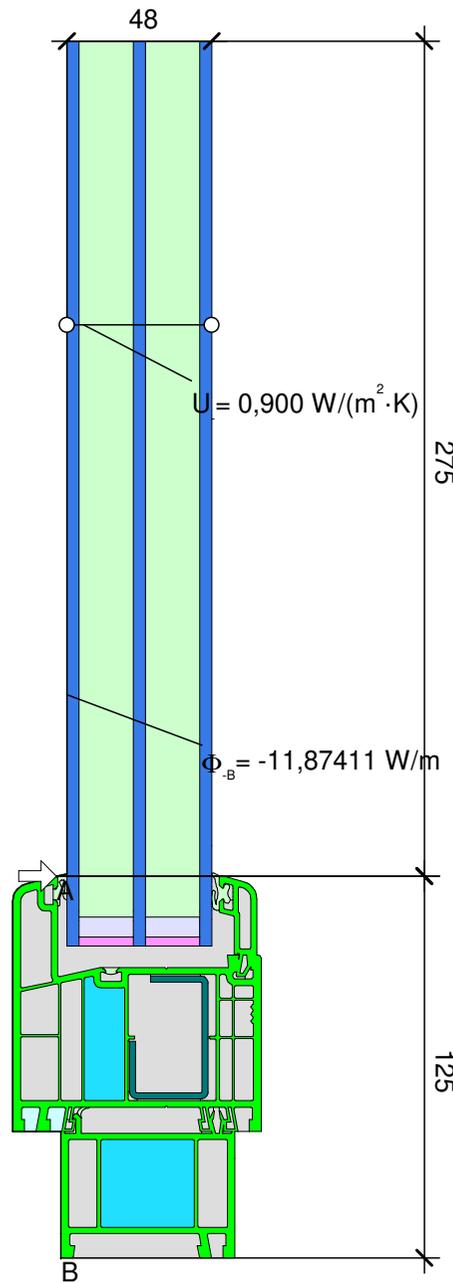


Material	$\lambda$ [W/(m·K)]	$\epsilon$
Ar18 in 48 mm U 0,9	0,039	
Glass I Glas	1,000	0,900
PU foam 0,021*1,25	0,026	
Polysulfide I Polysulfid	0,400	0,900
Polyvinylchloride (PVC)	0,170	0,900
SWISSP. Ultimate Box 2 [cert]	0,140	
Soft PVC I Weich-PVC	0,140	0,900
Steel I Stahl	50,000	0,300
Unvent. cavity I unbel. Hohlr. **		
slightly vent. cav. I leicht bel. Hohlr. **		

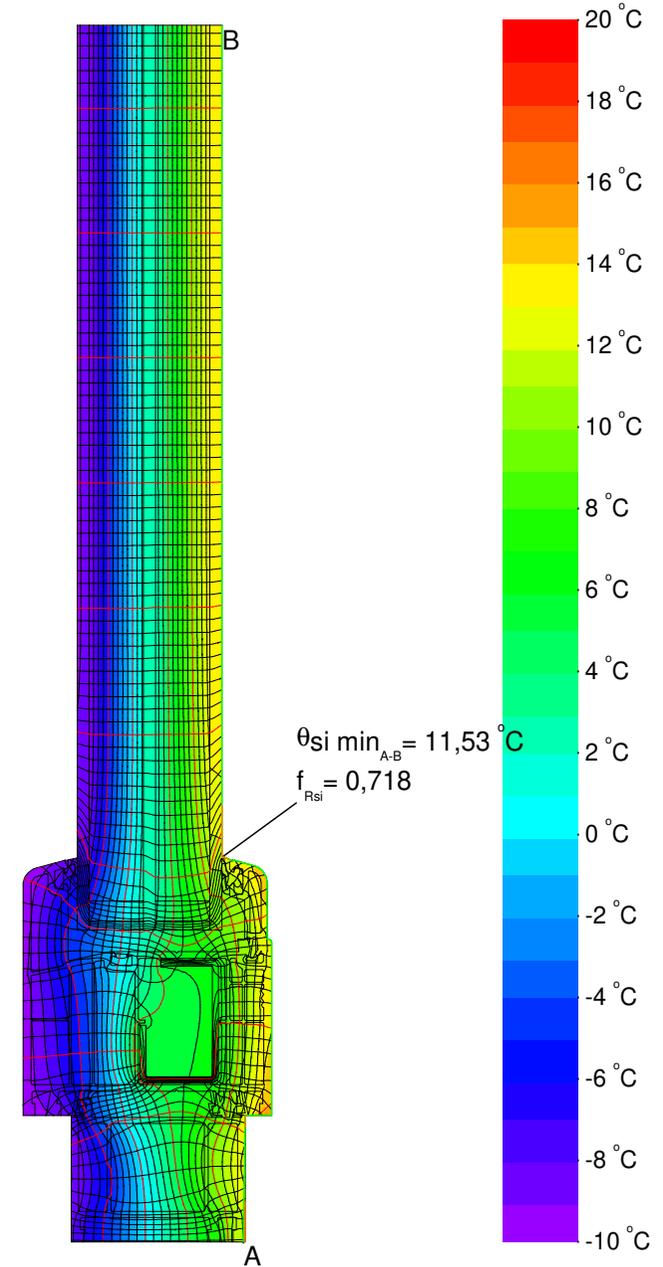
\*\* EN ISO 10077-2:2017, 6.4.3

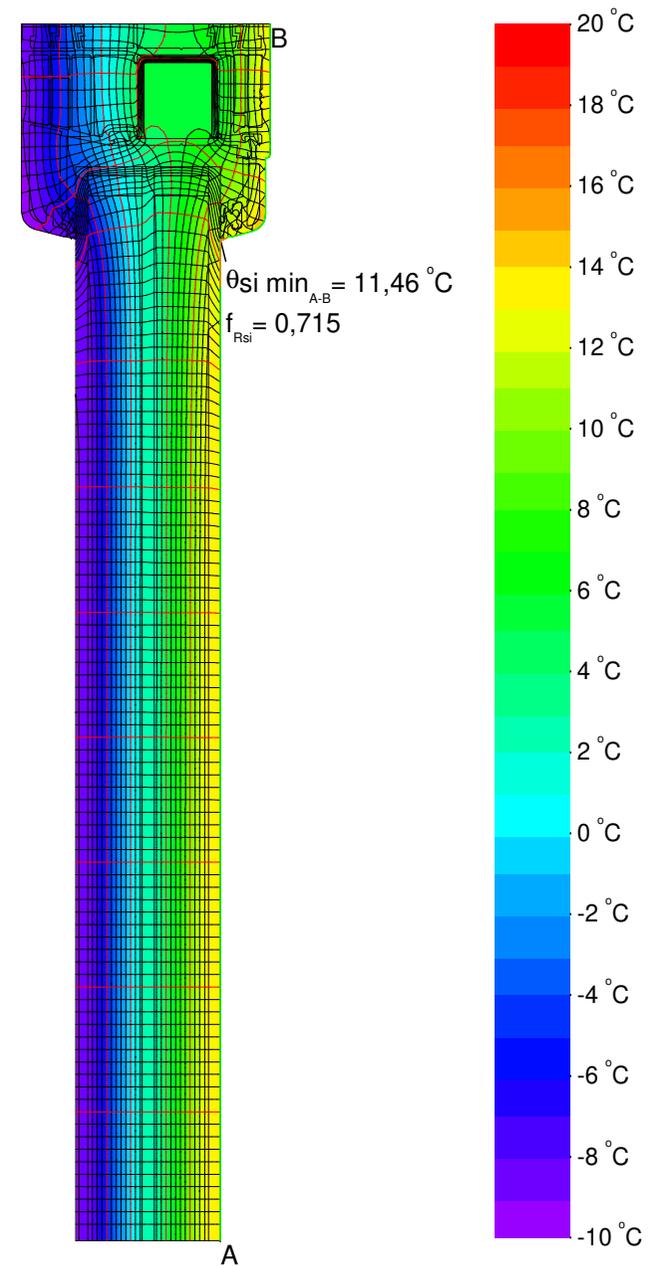
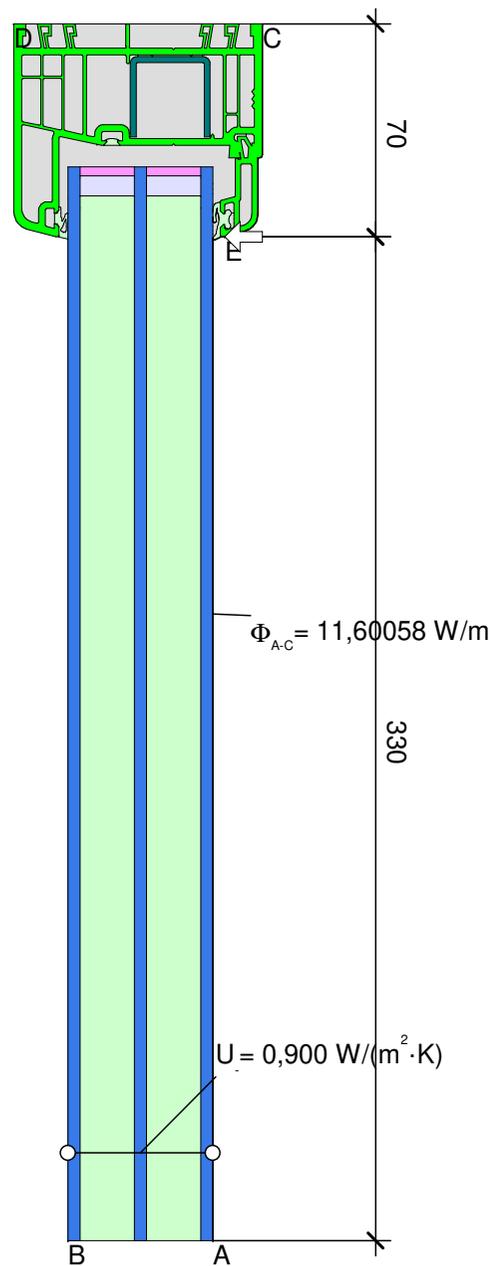
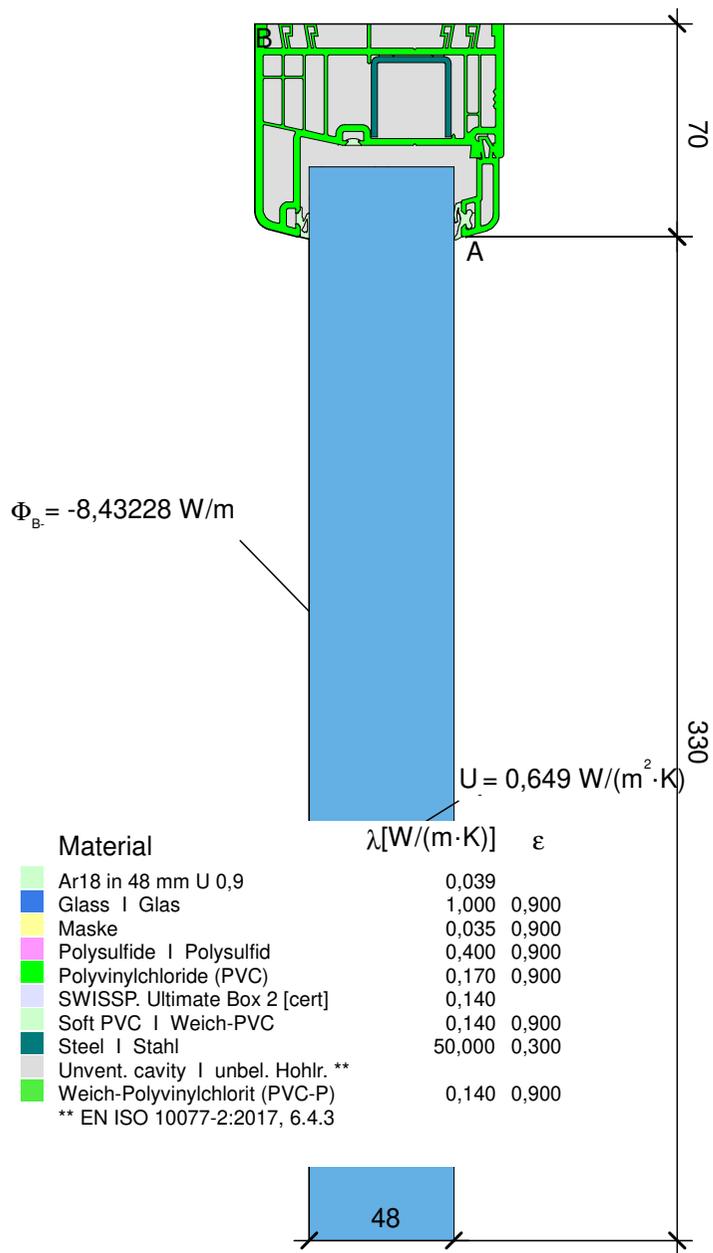


$$U_{fA,B} = \frac{\Phi}{\Delta T} - U_p \cdot b_p = \frac{9,132}{30,000} - 0,649 \cdot 0,275 = 1,007 \text{ W/(m}^2 \cdot \text{K)}$$



$$\psi_A = \frac{\Phi}{\Delta T} - U_g \cdot b_g - U_i \cdot b_i = \frac{11,874}{30,000} - 0,900 \cdot 0,275 - 1,007 \cdot 0,126 = 0,022 \text{ W/(m}^2 \cdot \text{K)}$$

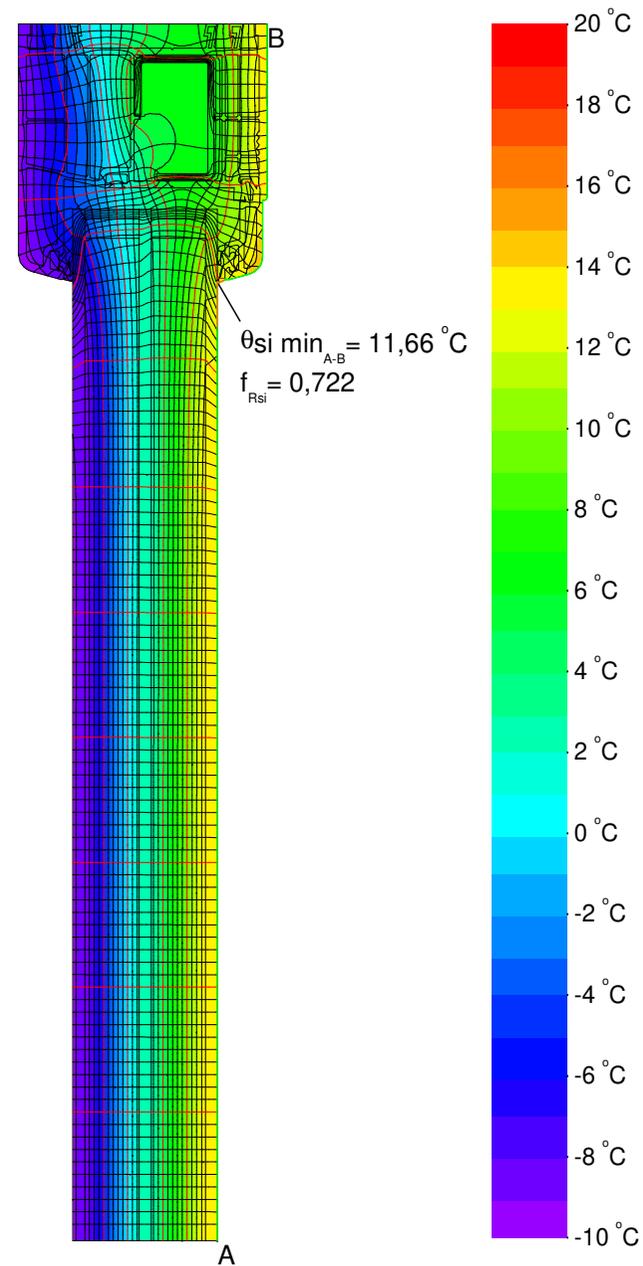
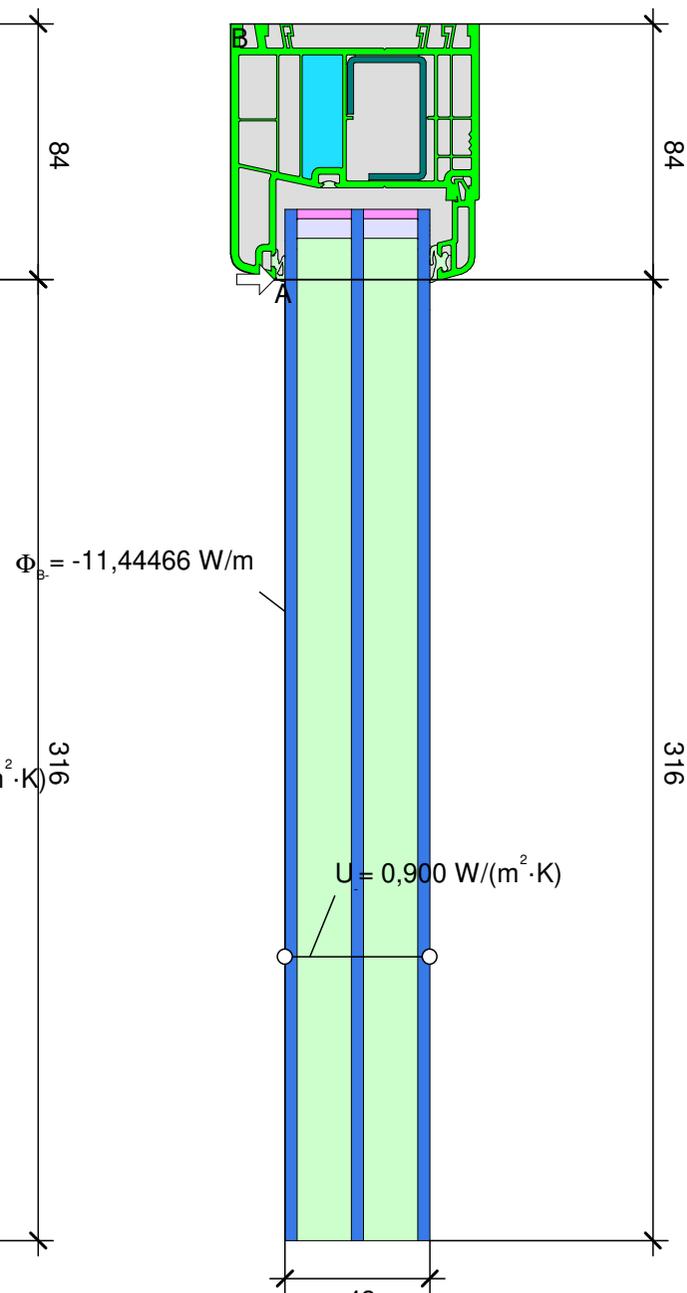
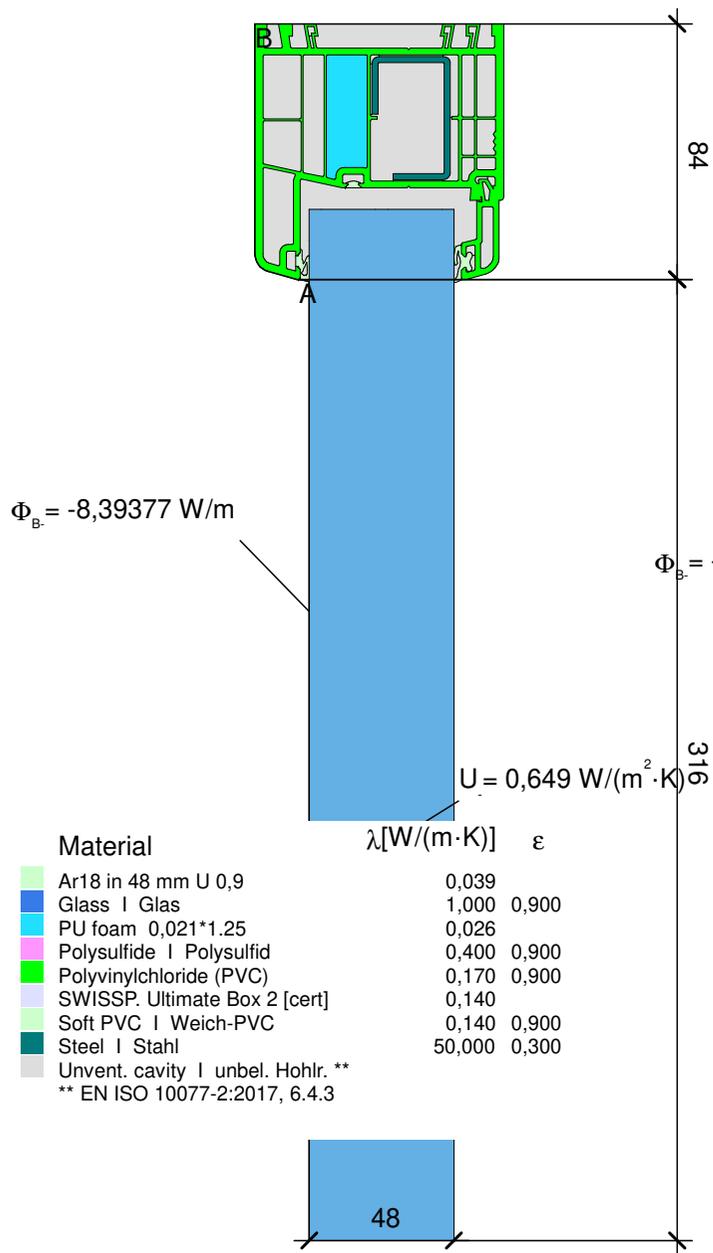




$$U_{f,AB} = \frac{\Phi}{\Delta T} - \frac{U_p \cdot b_p}{b_f} = \frac{8,432}{30,000} - \frac{0,649 \cdot 0,330}{0,070} = 0,957 \text{ W}/(\text{m}^2 \cdot \text{K})$$

$$\psi_{A-E-C} = \frac{\Phi}{\Delta T} - U_1 \cdot b_1 - U_2 \cdot b_2 = \frac{11,601}{30,000} - 0,900 \cdot 0,330 - 0,957 \cdot 0,070 = 0,023 \text{ W}/(\text{m}^2 \cdot \text{K})$$





Material	$\lambda$ [W/(m·K)]	$\epsilon$
Ar18 in 48 mm U 0,9	0,039	
Glass   Glas	1,000	0,900
PU foam 0,021*1.25	0,026	
Polysulfide   Polysulfid	0,400	0,900
Polyvinylchloride (PVC)	0,170	0,900
SWISSP. Ultimate Box 2 [cert]	0,140	
Soft PVC   Weich-PVC	0,140	0,900
Steel   Stahl	50,000	0,300
Unvent. cavity   unbel. Hohlr. **		

\*\* EN ISO 10077-2:2017, 6.4.3

$$U_{f,AB} = \frac{\Phi}{\Delta T} - \frac{U_p \cdot b_p}{b_f} = \frac{8,394}{30,000} - \frac{0,649 \cdot 0,316}{0,084} = 0,890 \text{ W}/(\text{m}^2 \cdot \text{K})$$

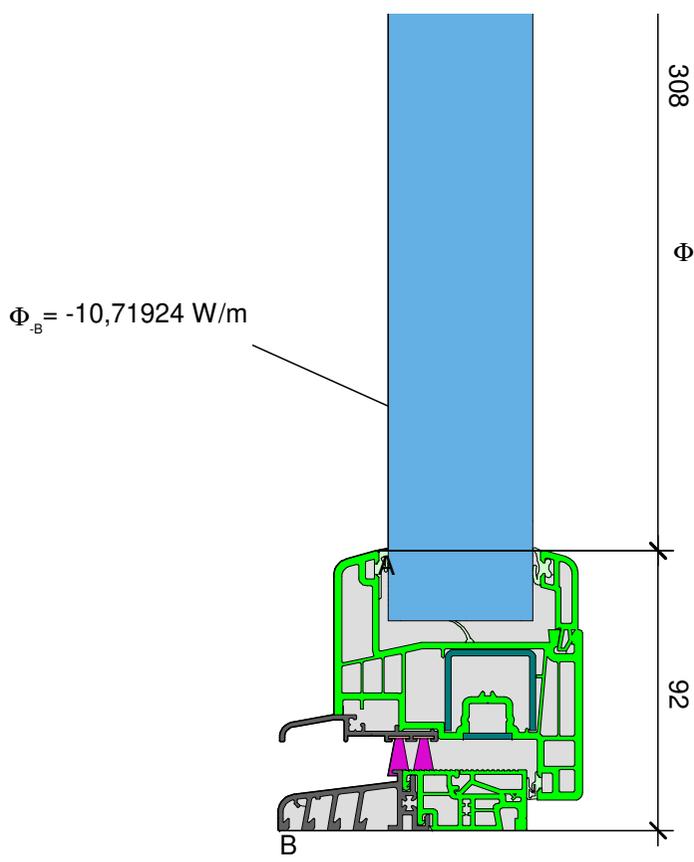
$$U_{f,AB} = \frac{\Phi}{\Delta T} - \frac{U_g \cdot b_g}{b_f} - \frac{U_i \cdot b_i}{b_f} = \frac{11,445}{30,000} - \frac{0,900 \cdot 0,316}{0,084} - \frac{0,890 \cdot 0,084}{0,084} = 0,022 \text{ W}/(\text{m}^2 \cdot \text{K})$$



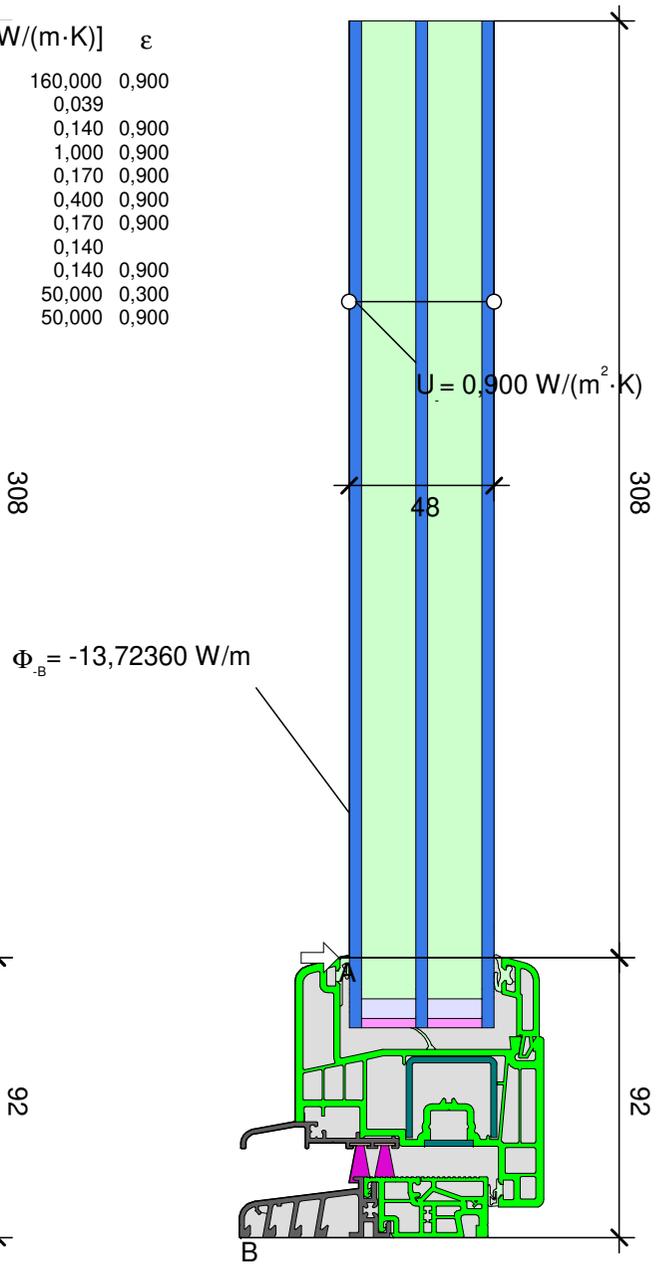
48

Material	$\lambda$ [W/(m·K)]	$\epsilon$
Aluminum   Aluminium 10456	160,000	0,900
Ar18 in 48 mm U 0,9	0,039	
Bürstendichtung (polyesterbeschichtetes Mohair)	0,140	0,900
Glass   Glas	1,000	0,900
Hart-Polyvinylchlorid (PVC)	0,170	0,900
Polysulfide   Polysulfid	0,400	0,900
Polyvinylchloride (PVC)	0,170	0,900
SWISSP. Ultimate Box 2 [cert]	0,140	
Soft PVC   Weich-PVC	0,140	0,900
Steel   Stahl	50,000	0,300
Steel   Stahl	50,000	0,900
Unvent. cavity   unbel. Hohlr. **		

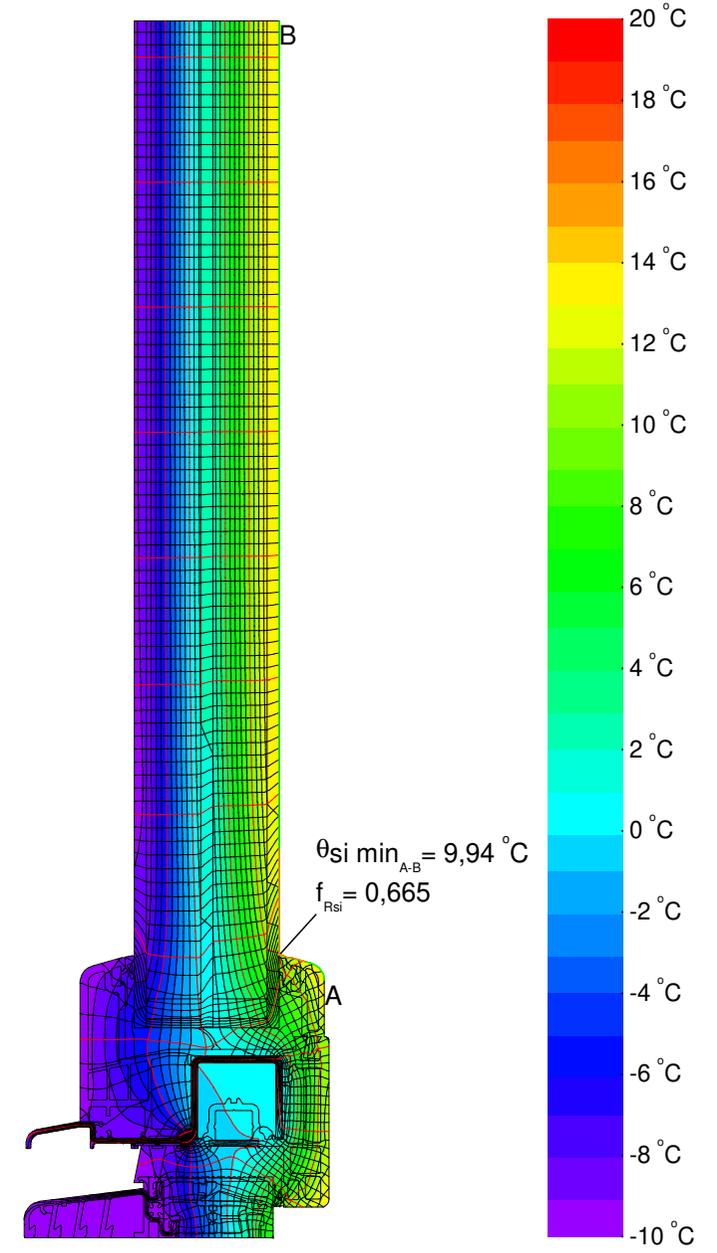
\*\* EN ISO 10077-2:2017, 6.4.3

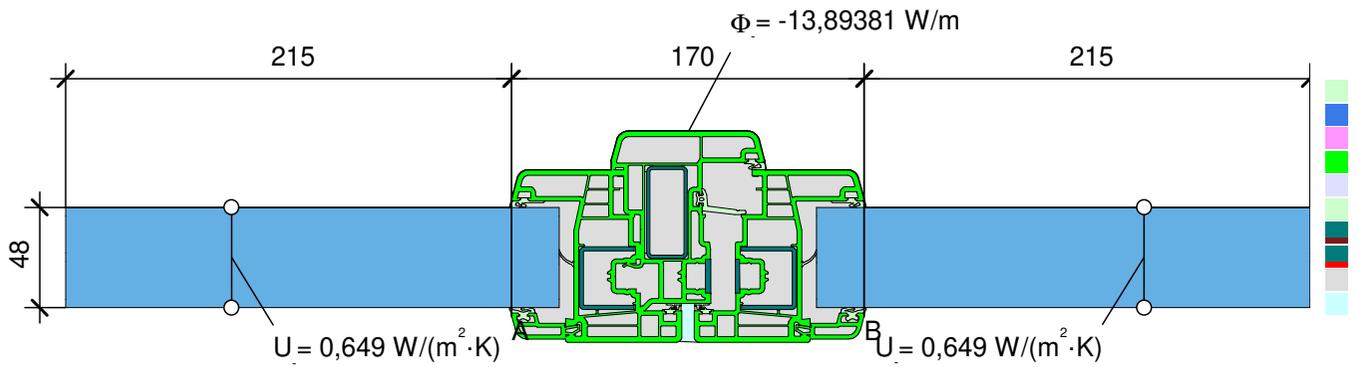


$$U_{fA,B} = \frac{\frac{\Phi}{\Delta T} - U_p \cdot b_p}{b_f} = \frac{\frac{10,719}{30,000} - 0,649 \cdot 0,308}{0,092} = 1,712 \text{ W/(m}^2 \cdot \text{K)}$$



$$\psi_A = \frac{\Phi}{\Delta T} - U_g \cdot b_g - U_f \cdot b_f = \frac{13,724}{30,000} - 0,900 \cdot 0,308 - 1,712 \cdot 0,092 = 0,023 \text{ W/(m} \cdot \text{K)}$$

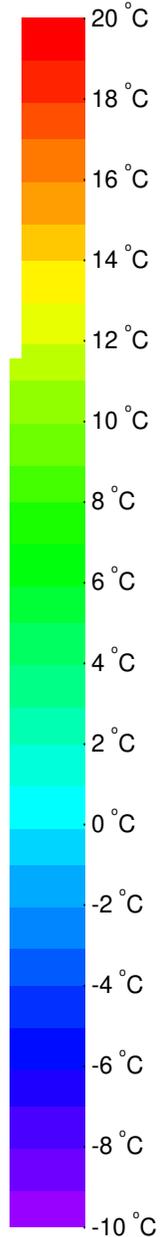




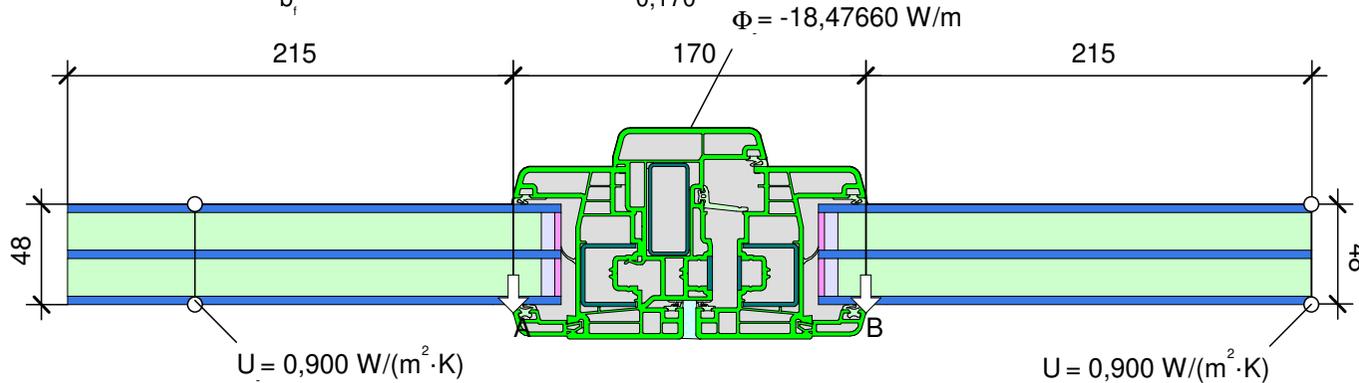
**Material**

- Ar18 in 48 mm U 0,9
- Glass I Glas
- Polysulfide I Polysulfid
- Polyvinylchloride (PVC)
- SWISSP. Ultimate Box 2 [cert]
- Soft PVC I Weich-PVC
- Steel I Stahl
- Steel I Stahl
- Unvent. cavity I unbel. Hohlr. \*\*
- slightly vent. cav. I leicht bel. Hohlr. \*\*

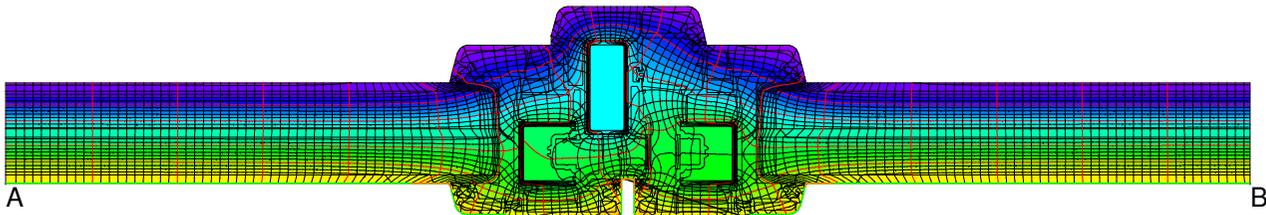
$\lambda$ [W/(m·K)]	$\epsilon$
0,039	
1,000	0,900
0,400	0,900
0,170	0,900
0,140	
0,140	0,900
50,000	0,900
50,000	0,300



$$U_{f,A,B} = \frac{\frac{\Phi}{\Delta T} - U_{p1} \cdot b_{p1} - U_{p2} \cdot b_{p2}}{b_f} = \frac{\frac{13,894}{30,000} - 0,649 \cdot 0,215 - 0,649 \cdot 0,215}{0,170} = 1,083 \text{ W/(m}^2 \cdot \text{K)}$$

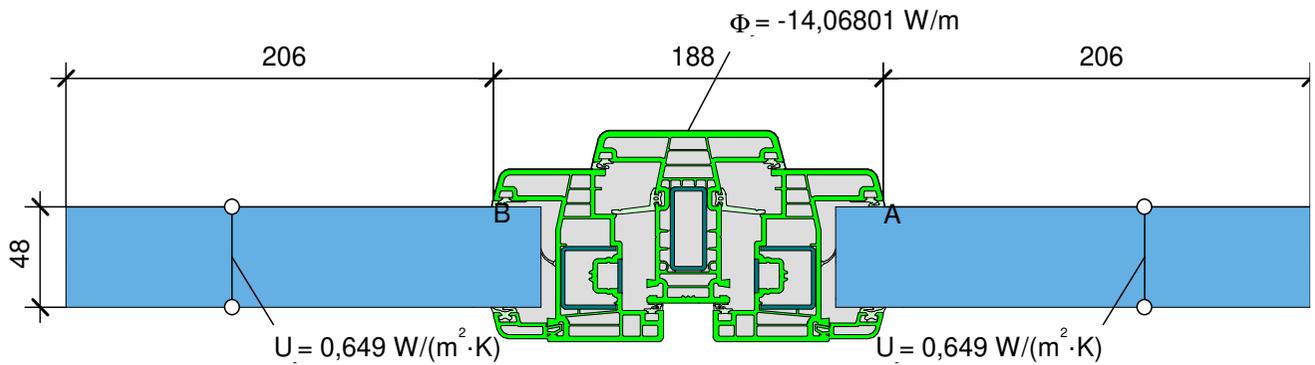


$$\Psi_{A,B} = \frac{\frac{\Phi}{\Delta T} - U_{g1} \cdot b_{g1} - U_f \cdot b_f - U_{g2} \cdot b_{g2}}{2} = \frac{\frac{18,477}{30,000} - 0,900 \cdot 0,215 - 1,083 \cdot 0,170 - 0,900 \cdot 0,215}{2} = 0,022 \text{ W/(m} \cdot \text{K)}$$



$\theta_{si \min_{A-B}} = 9,51 \text{ }^\circ\text{C}$   
 $f_{Rsi} = 0,650$



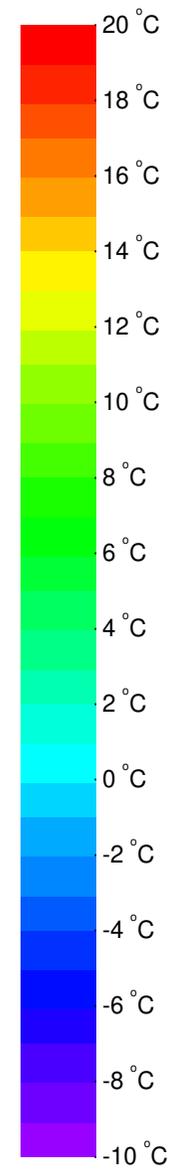


**Material**

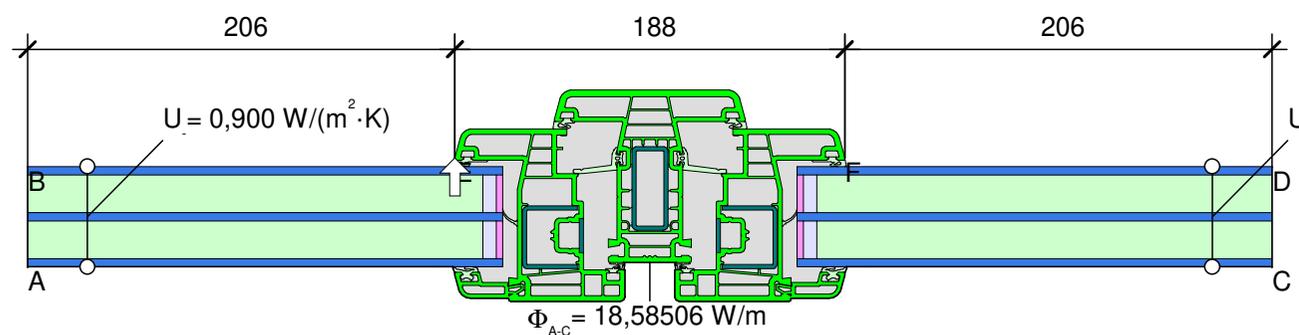
Ar18 in 48 mm U 0,9	0,039	
Glass   Glas	1,000	0,900
Polysulfide   Polysulfid	0,400	0,900
Polyvinylchloride (PVC)	0,170	0,900
SWISSP. Ultimate Box 2 [cert]	0,140	
Soft PVC   Weich-PVC	0,140	0,900
Soft PVC   Weich-PVC	0,140	0,900
Steel   Stahl	50,000	0,900
Steel   Stahl	50,000	0,300
Unvent. cavity   unbel. Hohlr.	**	**

\*\* EN ISO 10077-2:2017, 6.4.3

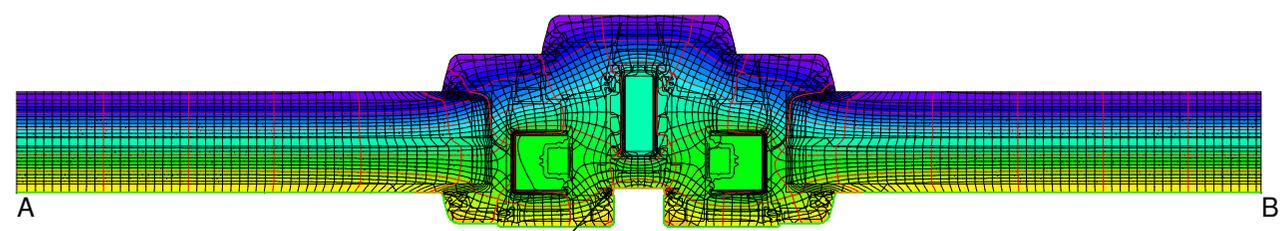
$\lambda$ [W/(m·K)]	$\epsilon$
0,039	
1,000	0,900
0,400	0,900
0,170	0,900
0,140	
0,140	0,900
0,140	0,900
50,000	0,900
50,000	0,300



$$U_{f,A,B} = \frac{\frac{\Phi}{\Delta T} - U_{p1} \cdot b_{p1} - U_{p2} \cdot b_{p2}}{b_f} = \frac{\frac{14,068}{30,000} - 0,649 \cdot 0,206 - 0,649 \cdot 0,206}{0,188} = 1,073 \text{ W/(m}^2 \cdot \text{K)}$$

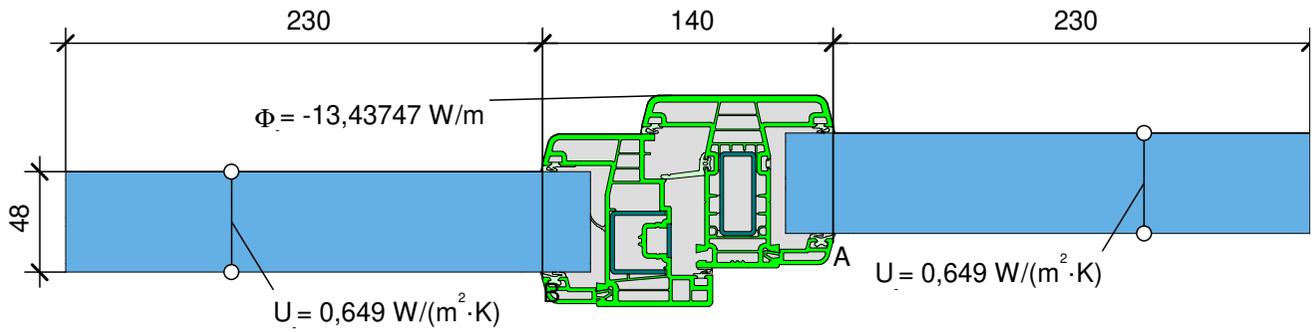


$$\Psi_{A-E,C,\dots} = \frac{\Phi}{\Delta T} - U_1 \cdot b_1 - U_2 \cdot b_2 - U_3 \cdot b_3 = \frac{18,585}{30,000} - 0,900 \cdot 0,206 - 1,073 \cdot 0,188 - 0,900 \cdot 0,206 = 0,047 \text{ W/(m} \cdot \text{K)}$$



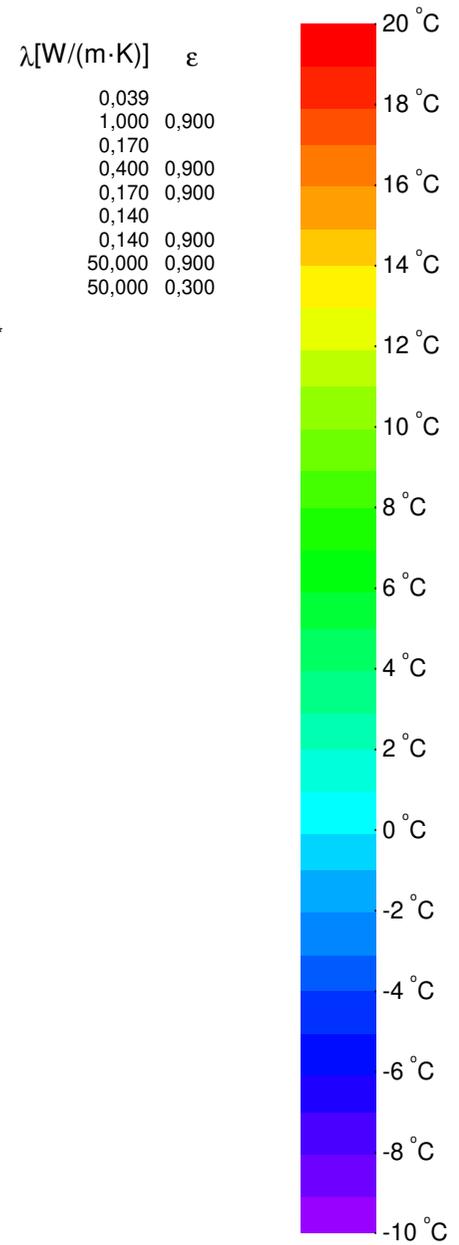
$\theta_{si \min}_{A-B} = 10,52 \text{ } ^\circ\text{C}$   
 $f_{Rsi} = 0,684$



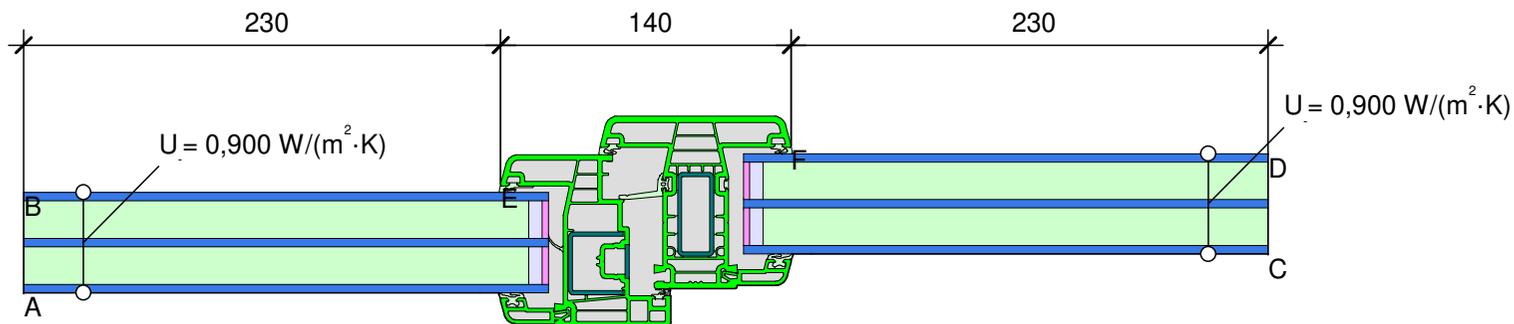


Material	$\lambda$ [W/(m·K)]	$\epsilon$
Ar18 in 48 mm U 0,9	0,039	
Glass   Glas	1,000	0,900
Hart-Polyvinylchlorid (PVC)	0,170	
Polysulfide   Polysulfid	0,400	0,900
Polyvinylchloride (PVC)	0,170	0,900
SWISSP. Ultimate Box 2 [cert]	0,140	
Soft PVC   Weich-PVC	0,140	0,900
Steel   Stahl	50,000	0,900
Steel   Stahl	50,000	0,300
Unbelüftete Hohlräume **		
Unvent. cavity   unbel. Hohlr.		

\*\* EN ISO 10077-2:2017, 6.4.3

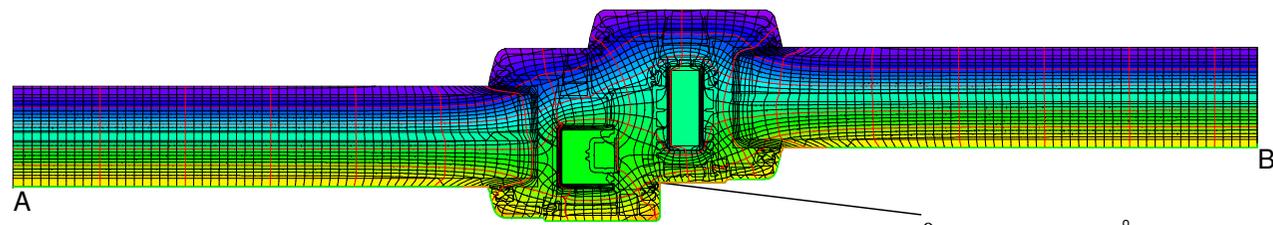


$$U_{fA,B} = \frac{\frac{\Phi}{\Delta T} - U_{p1} \cdot b_{p1} - U_{p2} \cdot b_{p2}}{b_f} = \frac{\frac{13,437}{30,000} - 0,649 \cdot 0,230 - 0,649 \cdot 0,230}{0,140} = 1,068 \text{ W/(m}^2 \cdot \text{K)}$$



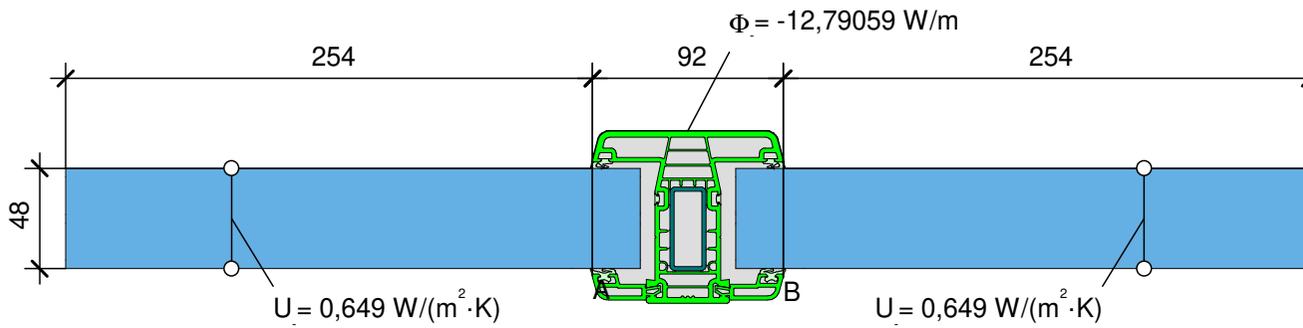
$$\psi_{A-E,C} = \frac{\Phi}{\Delta T} - U_1 \cdot b_1 - U_2 \cdot b_2 - U_3 \cdot b_3 = \frac{18,273}{30,000} - 0,900 \cdot 0,230 - \dots - 0,140 - 0,900 \cdot 0,230 = \text{Nicht definiert}$$

$\Phi_{A-C} = 18,27292 \text{ W/m}$



$\theta_{si \text{ min}}_{A-B} = 10,75 \text{ }^\circ\text{C}$   
 $f_{Rsi} = 0,692$

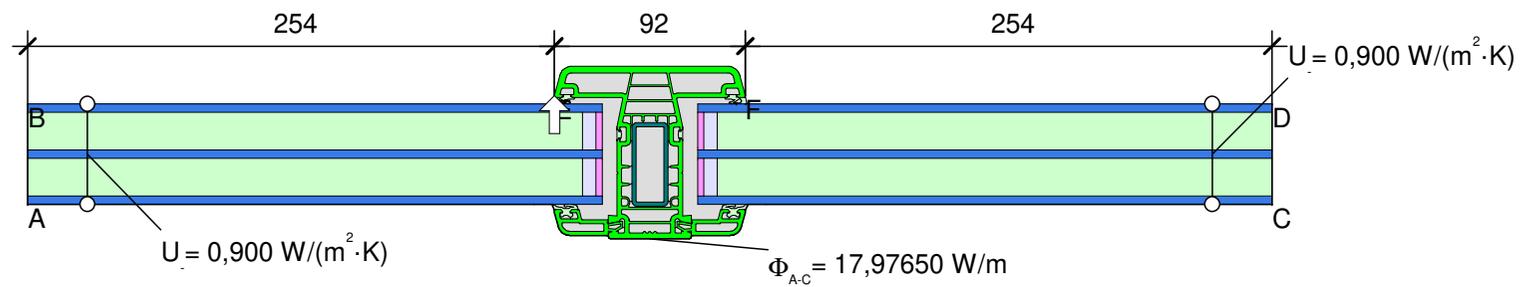




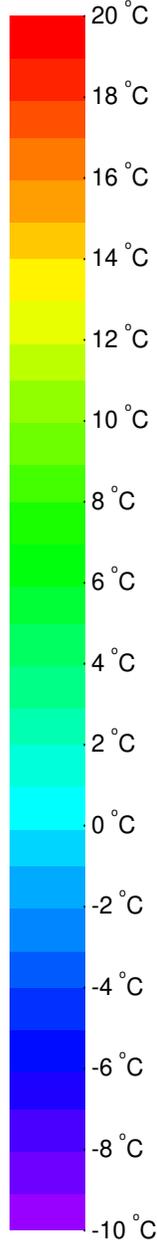
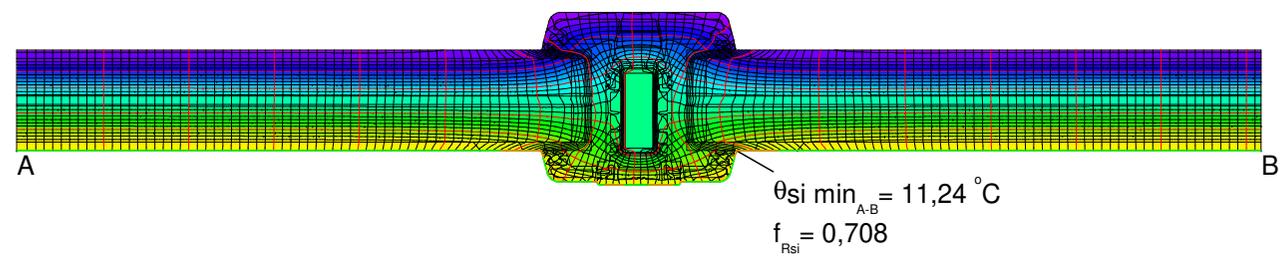
Material	$\lambda$ [W/(m·K)]	$\epsilon$
Ar18 in 48 mm U 0,9	0,039	
Glass   Glas	1,000	0,900
Hart-Polyvinylchlorid (PVC)	0,170	
Polysulfide   Polysulfid	0,400	0,900
Polyvinylchloride (PVC)	0,170	0,900
SWISSP. Ultimate Box 2 [cert]	0,140	
Soft PVC   Weich-PVC	0,140	0,900
Steel   Stahl	50,000	0,300
Unvent. cavity   unbel. Hohlr. **		

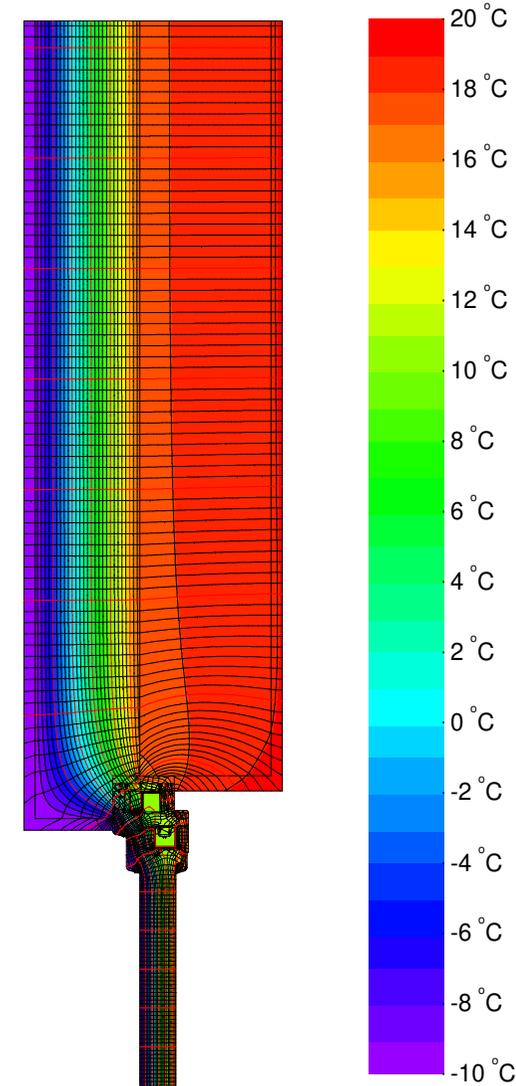
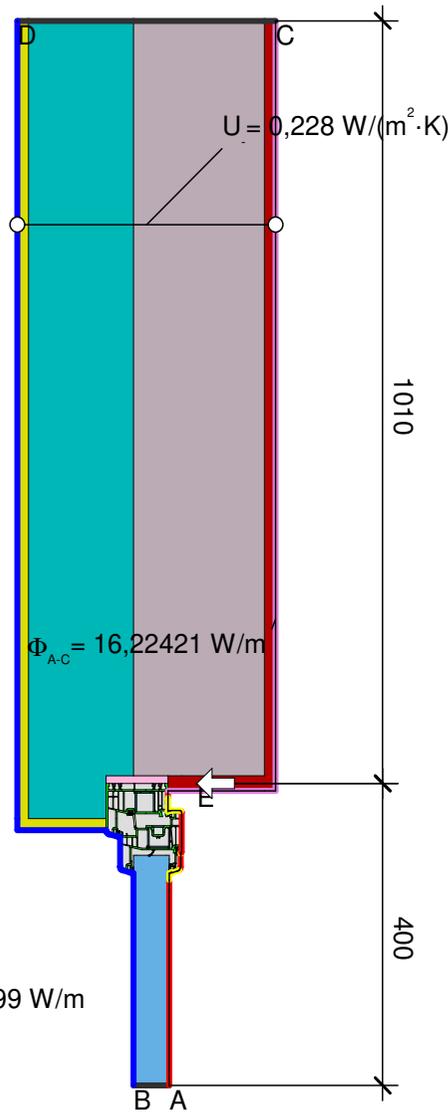
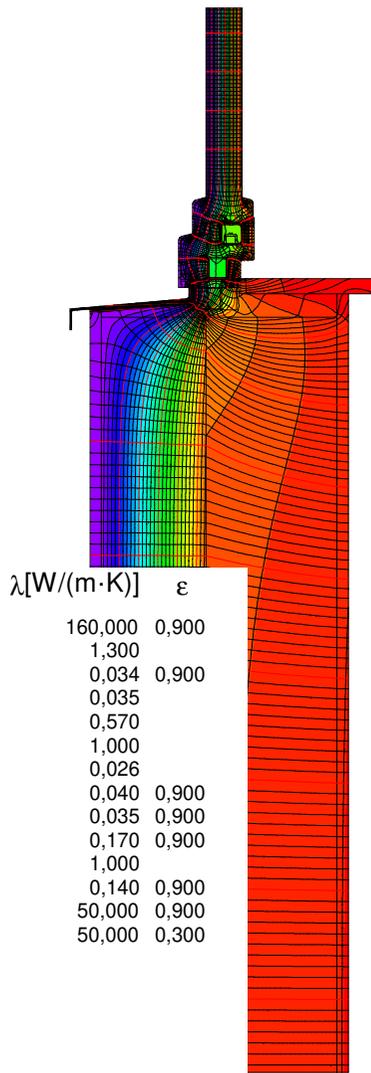
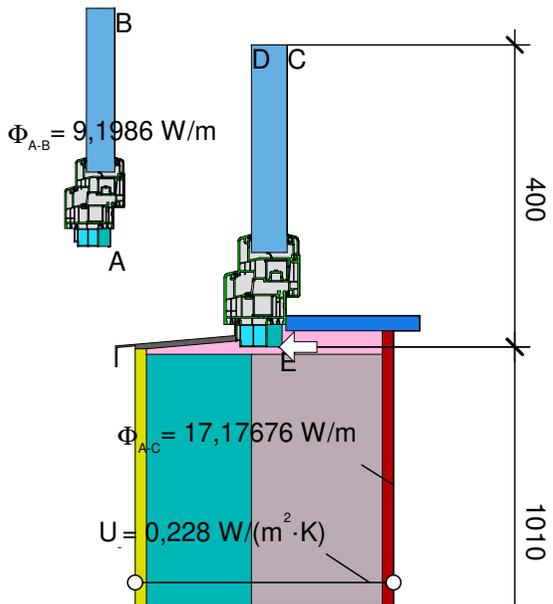
\*\* EN ISO 10077-2:2017, 6.4.3

$$U_{f,A,B} = \frac{\frac{\Phi}{\Delta T} - U_{p1} \cdot b_{p1} - U_{p2} \cdot b_{p2}}{b_f} = \frac{\frac{12,791}{30,000} - 0,649 \cdot 0,254 - 0,649 \cdot 0,254}{0,092} = 1,052 \text{ W/(m}^2 \cdot \text{K)}$$



$$\psi_{A-E-C,*} = \frac{\Phi}{\Delta T} - U_1 \cdot b_1 - U_2 \cdot b_2 - U_3 \cdot b_3 = \frac{17,977}{30,000} - 0,900 \cdot 0,254 - 1,052 \cdot 0,092 - 0,900 \cdot 0,254 = 0,045 \text{ W/(m} \cdot \text{K)}$$



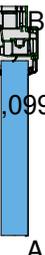


- Material**
- Aluminum | Aluminium 10456
  - Artificial stone | Kunststein 10456
  - Insulation | Wärmedämmung 034
  - Insulation | Wärmedämmung 035
  - Interior plaster | Gipsputz 10456
  - Lime-cement plaster | Kalkzementputz ISO 10456
  - PU foam 0,021\*1.25
  - PU in-situ foam | PU-Ortschaum 040
  - Panel | Maske
  - Polyvinylchloride (PVC)
  - Sand-lime stone | Kalksandstein 1745
  - Soft PVC | Weich-PVC
  - Steel | Stahl
  - Steel | Stahl
  - Unbelüftete Hohlräume \*\*
  - Unvent. cavity | unbel. Hohlr. \*\*
  - slightly vent. cav. | leicht bel. Hohlr. \*\*
- \*\* EN ISO 10077-2:2017, 6.4.3

$\lambda [\text{W/(m}\cdot\text{K)}]$	$\epsilon$
160,000	0,900
1,300	
0,034	0,900
0,035	
0,570	
1,000	
0,026	
0,040	0,900
0,035	0,900
0,170	0,900
1,000	
0,140	0,900
50,000	0,900
50,000	0,300

$$\psi_{A-E,C,*} = \frac{\Phi}{\Delta T} - U_1 \cdot b_1 - \frac{\Phi_2}{\Delta T} = \frac{17,177}{30,000} - 0,228 \cdot 1,010 - \frac{9,199}{30,000} = 0,036 \text{ W/(m}\cdot\text{K)}$$

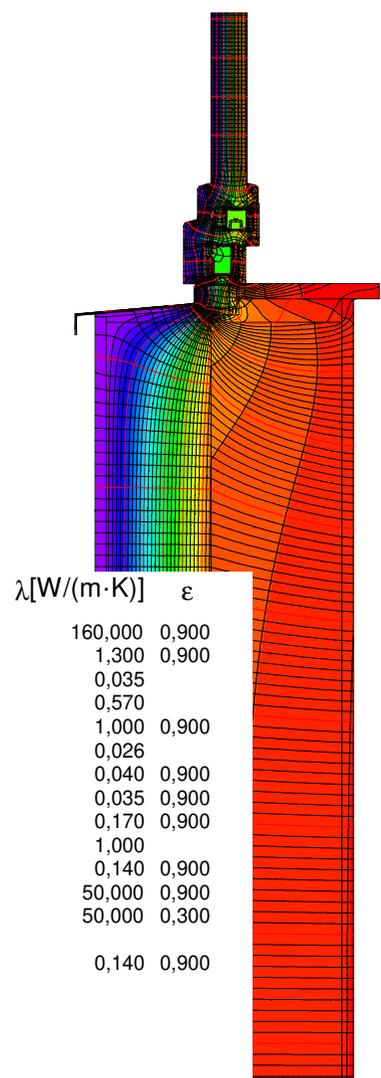
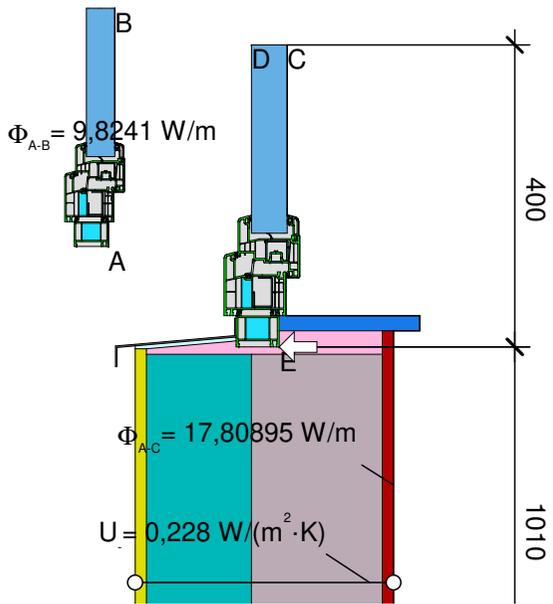
$$\psi_{A-E,C,*} = \frac{\Phi}{\Delta T} - \frac{\Phi_1}{\Delta T} - U_2 \cdot b_2 = \frac{16,224}{30,000} - \frac{9,100}{30,000} - 0,228 \cdot 1,010 = 0,007 \text{ W/(m}\cdot\text{K)}$$



A

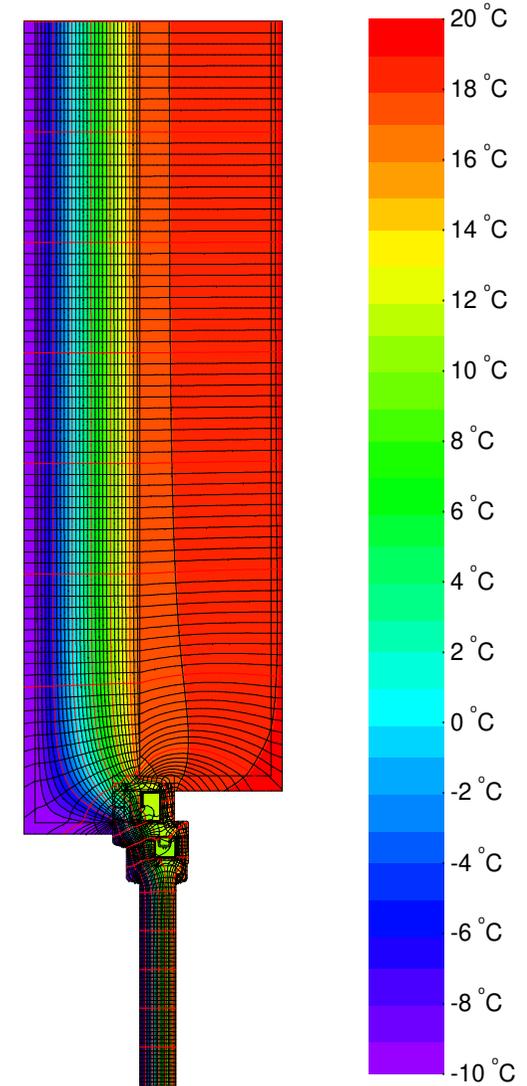
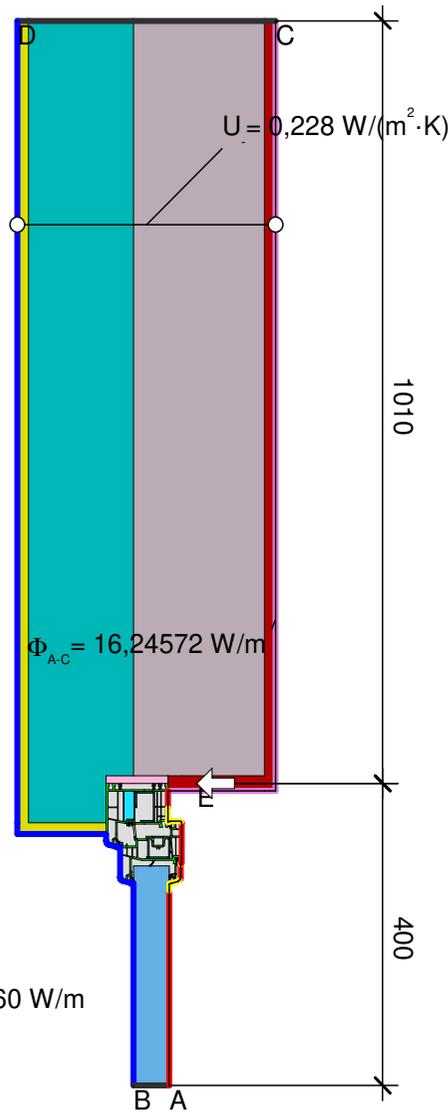
Randbedingung	$q [\text{W/m}^2]$	$\theta [^\circ\text{C}]$	$R [(\text{m}^2 \cdot \text{K})/\text{W}]$	$\epsilon$
Adiabatic   Adiat	0,000			
Exterior   Außen		-10,000	0,040	
Interior   Innen		20,000	0,130	
Interior, frame, normal		20,000	0,130	
Interior, frame, reduced		20,000	0,200	
e 0,3 Cavity in metal				0,300
e 0,9 Cavity   Hohlraum				0,900





Material	$\lambda [\text{W/(m}\cdot\text{K)}]$	$\epsilon$
Aluminum   Aluminium 10456	160,000	0,900
Artificial stone   Kunststein 10456	1,300	0,900
Insulation   Wärmedämmung 035	0,035	
Interior plaster   Gipsputz 10456	0,570	
Lime-cement plaster   Kalkzementputz ISO 10456	1,000	0,900
PU foam 0,021*1.25	0,026	
PU in-situ foam   PU-Ortschaum 040	0,040	0,900
Panel   Maske	0,035	0,900
Polyvinylchloride (PVC)	0,170	0,900
Sand-lime stone   Kalksandstein 1745	1,000	
Soft PVC   Weich-PVC	0,140	0,900
Steel   Stahl	50,000	0,900
Steel   Stahl	50,000	0,300
Unvent. cavity   unbel. Hohlr. **		
Weich-Polyvinylchlorit (PVC-P)	0,140	0,900
slightly vent. cav.   leicht bel. Hohlr. **		

- Aluminum | Aluminium 10456
  - Artificial stone | Kunststein 10456
  - Insulation | Wärmedämmung 035
  - Interior plaster | Gipsputz 10456
  - Lime-cement plaster | Kalkzementputz ISO 10456
  - PU foam 0,021\*1.25
  - PU in-situ foam | PU-Ortschaum 040
  - Panel | Maske
  - Polyvinylchloride (PVC)
  - Sand-lime stone | Kalksandstein 1745
  - Soft PVC | Weich-PVC
  - Steel | Stahl
  - Steel | Stahl
  - Unvent. cavity | unbel. Hohlr. \*\*
  - Weich-Polyvinylchlorit (PVC-P)
  - slightly vent. cav. | leicht bel. Hohlr. \*\*
- \*\* EN ISO 10077-2:2017, 6.4.3

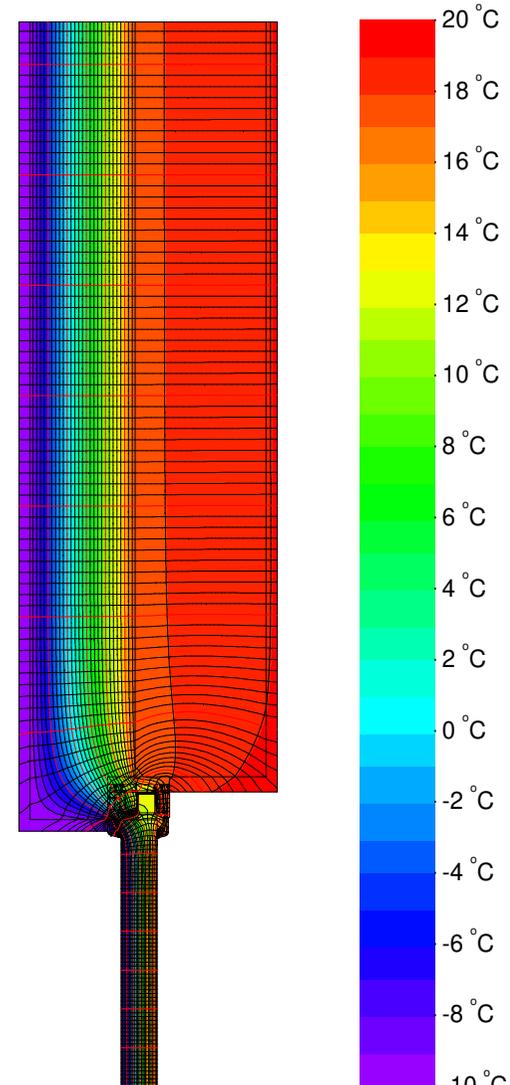
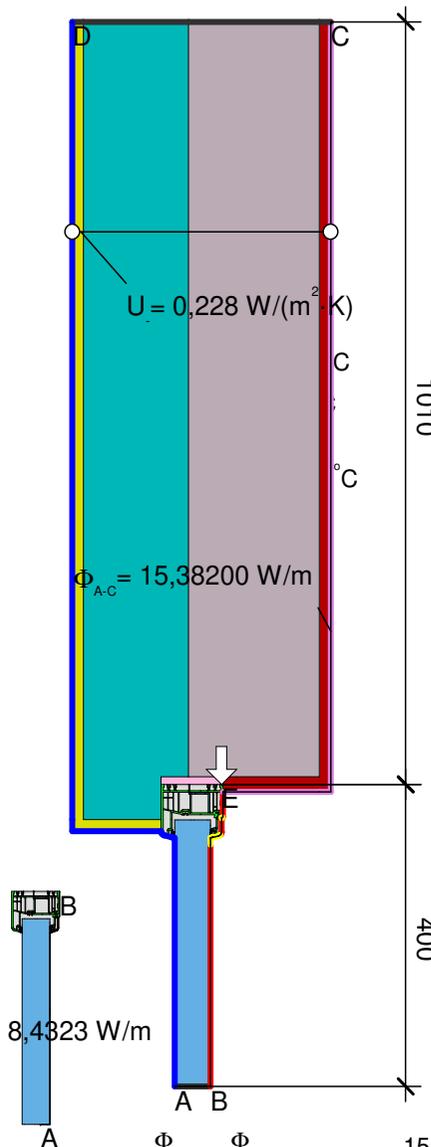
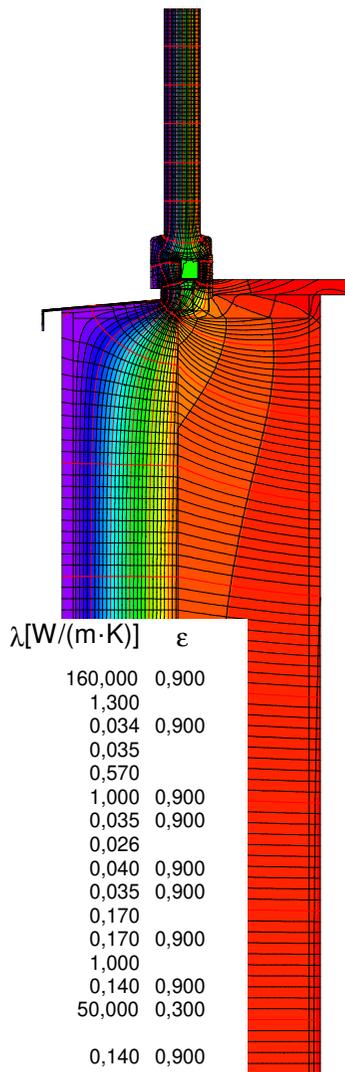
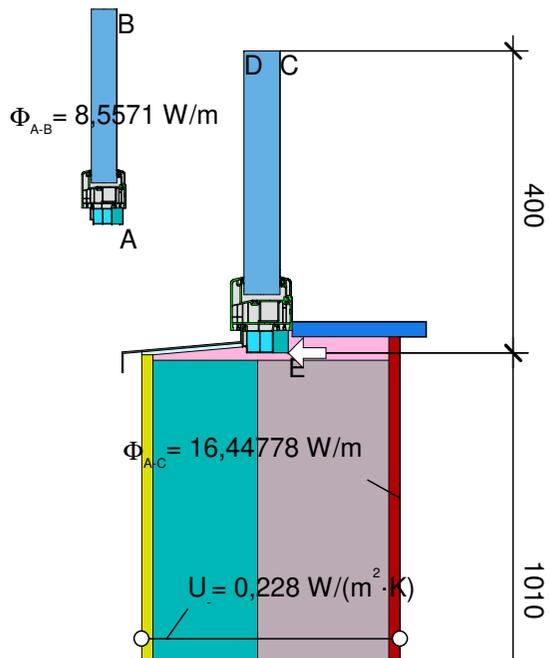


$$\psi_{A-E,C,*} = \frac{\Phi}{\Delta T} - U_1 \cdot b_1 - \frac{\Phi_2}{\Delta T} = \frac{17,809}{30,000} - 0,228 \cdot 1,010 - \frac{9,824}{30,000} = 0,036 \text{ W/(m}\cdot\text{K)}$$

$$\psi_{A-E,C,*} = \frac{\Phi}{\Delta T} - \frac{\Phi_1}{\Delta T} - U_2 \cdot b_2 = \frac{16,246}{30,000} - \frac{9,096}{30,000} - 0,228 \cdot 1,010 = 0,008 \text{ W/(m}\cdot\text{K)}$$

Randbedingung	$q [\text{W/m}^2]$	$\theta [^\circ\text{C}]$	$R [(\text{m}^2 \cdot \text{K})/\text{W}]$	$\epsilon$
Adiabatic   Adiat	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   Hohlraum				0,900





Material	$\lambda$ [W/(m·K)]	$\epsilon$
Aluminum   Aluminium 10456	160,000	0,900
Artificial stone   Kunststein 10456	1,300	
Insulation   Wärmedämmung 034 (1)	0,034	0,900
Insulation   Wärmedämmung 035	0,035	
Interior plaster   Gipsputz 10456	0,570	
Lime-cement plaster   Kalkzementputz ISO 10456	1,000	0,900
Maske	0,035	0,900
PU foam 0,021*1.25	0,026	
PU in-situ foam   PU-Ortschaum 040	0,040	0,900
Panel   Maske	0,035	0,900
Polyvinylchloride (PVC)	0,170	
Polyvinylchloride (PVC)	0,170	0,900
Sand-lime stone   Kalksandstein 1745	1,000	
Soft PVC   Weich-PVC	0,140	0,900
Steel   Stahl	50,000	0,300
Unvent. cavity   unbel. Hohlr. **		
Weich-Polyvinylchlorit (PVC-P)	0,140	0,900
slightly vent. cav.   leicht bel. Hohlr. **		

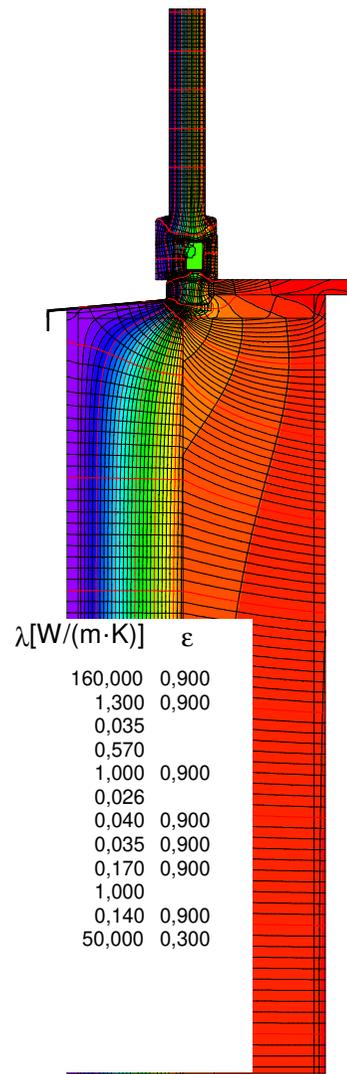
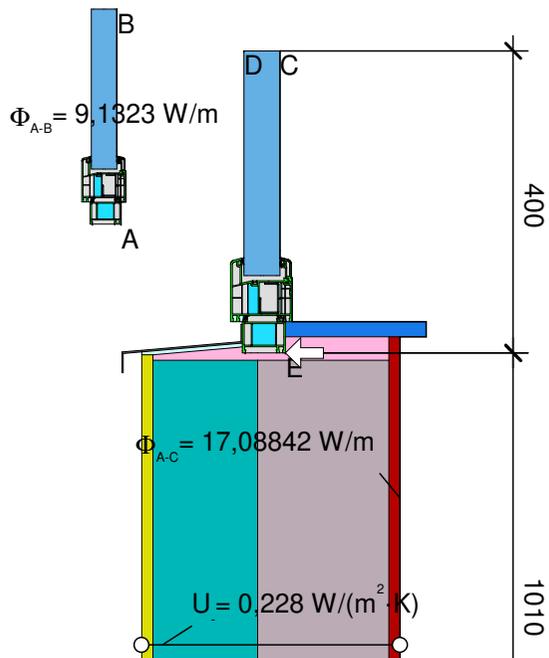
\*\* EN ISO 10077-2:2017, 6.4.3

$$\Psi_{A-E-C,*} = \frac{\Phi}{\Delta T} - \frac{\Phi_1}{\Delta T} - U_2 \cdot b_2 = \frac{15,382}{30,000} - \frac{8,432}{30,000} - 0,228 \cdot 1,010 = -0,001 \text{ W/(m} \cdot \text{K)}$$

$$\Psi_{A-E-C,*} = \frac{\Phi}{\Delta T} - U_1 \cdot b_1 - \frac{\Phi_2}{\Delta T} = \frac{16,448}{30,000} - 0,228 \cdot 1,010 - \frac{8,557}{30,000} = 0,033 \text{ W/(m} \cdot \text{K)}$$

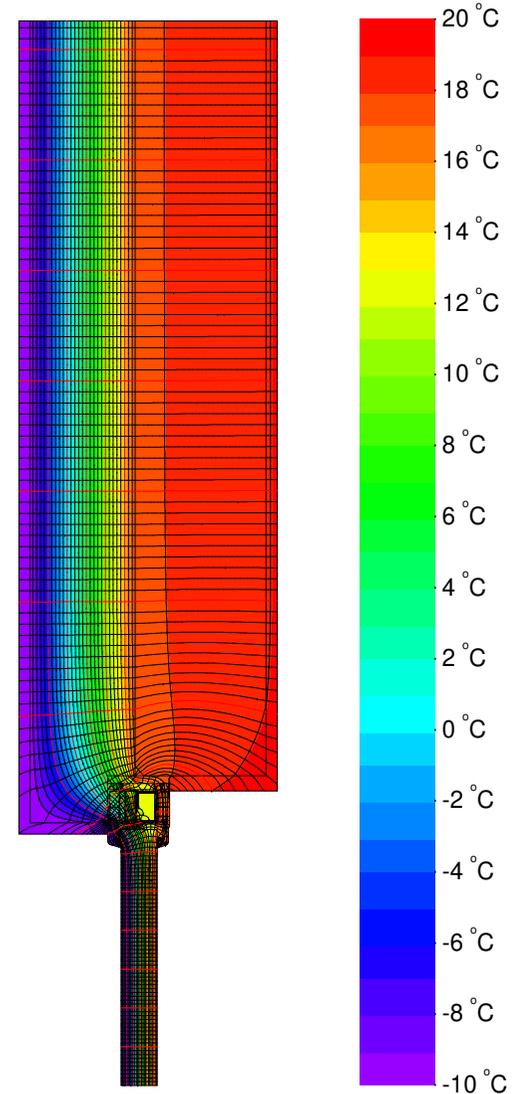
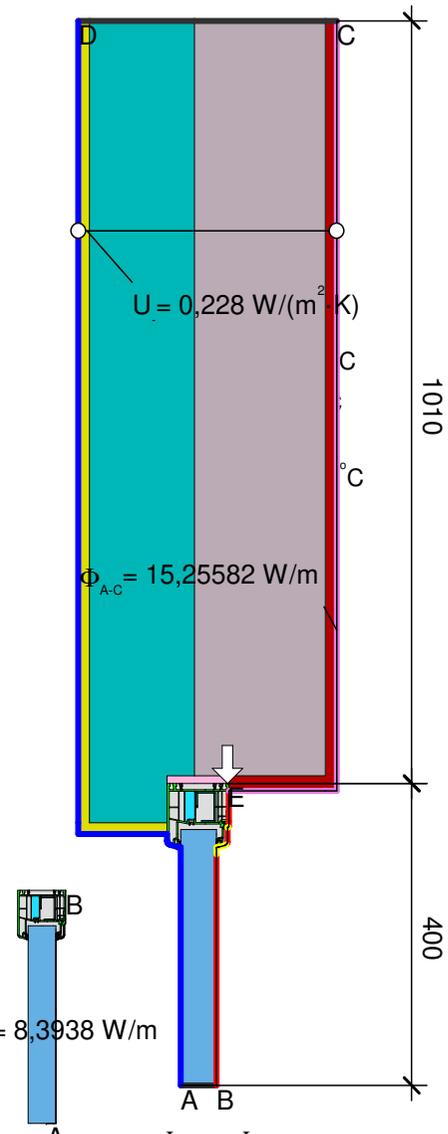
Randbedingung	$q$ [W/m <sup>2</sup> ]	$\theta$ [°C]	$R$ [(m <sup>2</sup> ·K)/W]	$\epsilon$
Adiabatic   Adiat	0,000			
Exterior   Außen		-10,000	0,040	
Interior   Innen		20,000	0,130	
Interior, frame, normal		20,000	0,130	
Interior, frame, reduced		20,000	0,200	
e 0,3 Cavity in metal				0,300
e 0,9 Cavity   Hohlraum				0,900





Material	$\lambda [\text{W}/(\text{m} \cdot \text{K})]$	$\epsilon$
Aluminum I Aluminium 10456	160,000	0,900
Artificial stone I Kunststein 10456	1,300	0,900
Insulation I Wärmedämmung 035	0,035	
Interior plaster I Gipsputz 10456	0,570	
Lime-cement plaster   Kalkzementputz ISO 10456	1,000	0,900
PU foam 0,021*1.25	0,026	
PU in-situ foam I PU-Ortschaum 040	0,040	0,900
Panel I Maske	0,035	0,900
Polyvinylchloride (PVC)	0,170	0,900
Sand-lime stone I Kalksandstein 1745	1,000	
Soft PVC I Weich-PVC	0,140	0,900
Steel I Stahl	50,000	0,300
Unvent. cavity I unbel. Hohlr. **		
slightly vent. cav. I leicht bel. Hohlr. **		

- Material**
- Aluminum I Aluminium 10456
  - Artificial stone I Kunststein 10456
  - Insulation I Wärmedämmung 035
  - Interior plaster I Gipsputz 10456
  - Lime-cement plaster | Kalkzementputz ISO 10456
  - PU foam 0,021\*1.25
  - PU in-situ foam I PU-Ortschaum 040
  - Panel I Maske
  - Polyvinylchloride (PVC)
  - Sand-lime stone I Kalksandstein 1745
  - Soft PVC I Weich-PVC
  - Steel I Stahl
  - Unvent. cavity I unbel. Hohlr. \*\*
  - slightly vent. cav. I leicht bel. Hohlr. \*\*
- \*\* EN ISO 10077-2:2017, 6.4.3

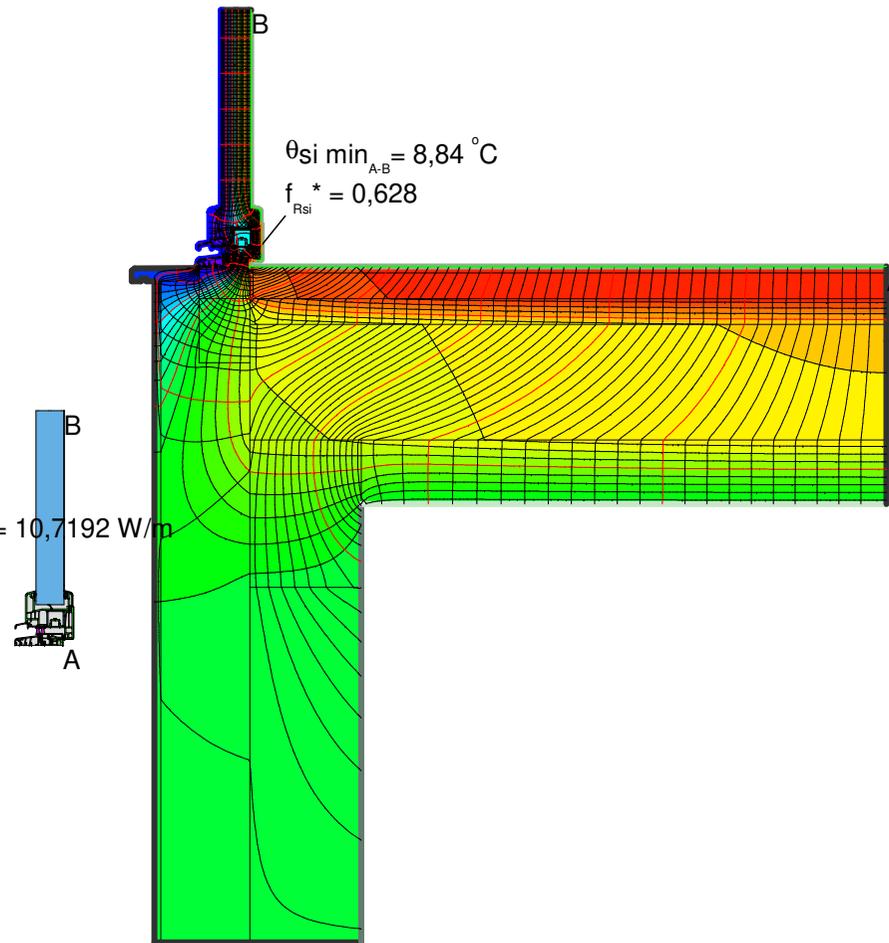
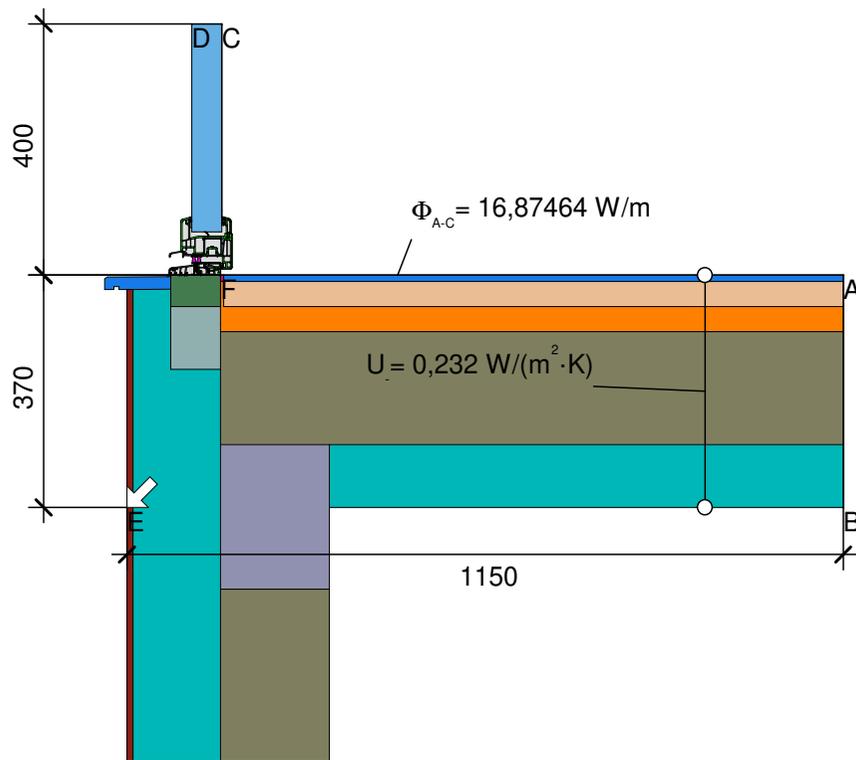


$$\psi_{A-E,C,*} = \frac{\Phi}{\Delta T} - U_1 \cdot b_1 - \frac{\Phi_2}{\Delta T} = \frac{17,088}{30,000} - 0,228 \cdot 1,010 - \frac{9,132}{30,000} = 0,035 \text{ W}/(\text{m} \cdot \text{K})$$

$$\psi_{A-E,C,*} = \frac{\Phi}{\Delta T} - \frac{\Phi_1}{\Delta T} - U_2 \cdot b_2 = \frac{15,256}{30,000} - \frac{8,394}{30,000} - 0,228 \cdot 1,010 = -0,002 \text{ W}/(\text{m} \cdot \text{K})$$

Randbedingung	$q [\text{W}/\text{m}^2]$	$\theta [^\circ\text{C}]$	$R [(\text{m}^2 \cdot \text{K})/\text{W}]$	$\epsilon$
Adiabatic   Adiat	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 0,3 Cavity in metal				0,300
e 0,9 Cavity I Hohlraum				0,900





**Material**

Material	$\lambda[\text{W}/(\text{m}\cdot\text{K})]$	$\epsilon$
Aluminum   Aluminium 10456	160,000	0,900
Artificial stone   Kunststein 10456	1,300	
Bürstendichtung (polyesterbeschichtetes Mohair)	0,140	0,900
Cement screed   Zement-Estrich 4108	1,400	
Concrete, 1% Steel   Beton, 1% Stahl 10456	2,300	
Gas concrete   Porenbeton 750 4108	0,240	
Hart-Polyvinylchlorid (PVC)	0,170	0,900
Insulation   Dämmstoff 040	0,040	0,900
Insulation   Wärmedämmung 035	0,035	
Insulation   Wärmedämmung 040	0,040	
Organic compound plaster   Kunstharzputz 4108-4	0,700	
Panel   Maske	0,035	0,900
Polyvinylchloride (PVC)	0,170	0,900
Silicone   Silikon	0,350	
Soft PVC   Weich-PVC	0,140	0,900
Spruce, Fir   Fichte, Tanne	0,110	
Steel   Stahl	50,000	0,300
Steel   Stahl	50,000	0,900
Unvent. cavity   unbel. Hohlr. **		

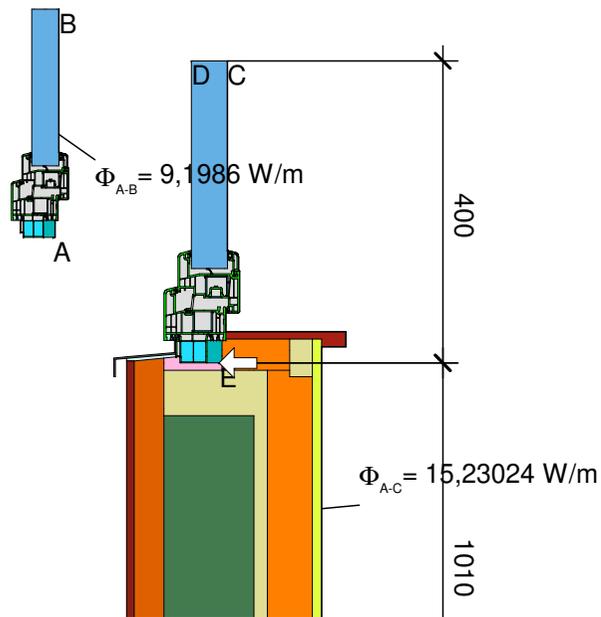
\*\* EN ISO 10077-2:2017, 6.4.3

**Randbedingung**

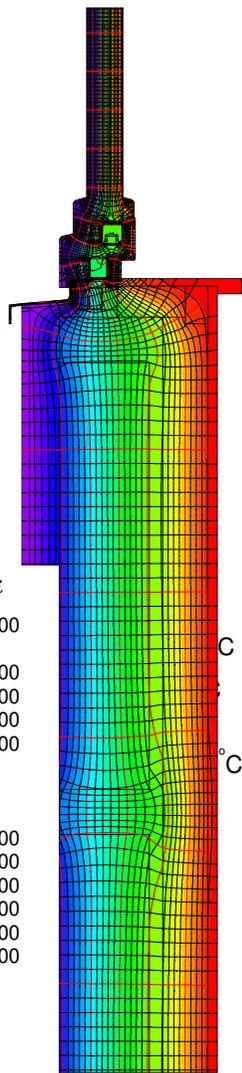
Randbedingung	$q[\text{W}/\text{m}^2]$	$\theta[\text{ }^\circ\text{C}]$	$R[(\text{m}^2 \cdot \text{K})/\text{W}]$	$\epsilon$
Adiabatic   Adiabatt	0,000			
Exterior   Außen	-10,000		0,040	
Int. unheated down   Innen unbeheizt abwärts	5,000		0,170	
Int. unheated   Innen unbeheizt	5,000		0,130	
e 0,3 Cavity in metal				0,300
e 0,9 Cavity   Hohlraum				0,900
fRsi: Interior   Innen	20,000		0,250	

$$\Psi_{A-E-C,*} = \frac{\Phi - U_1 \cdot b_1 \cdot \Delta T_1 - U_2 \cdot b_2 \cdot \Delta T_2 - \Phi_3}{\Delta T} = \frac{16,875 - 0,232 \cdot 1,150 \cdot 15,000 - 0,228 \cdot 0,370 \cdot 30,000 - 10,719}{30,000} = -0,013 \text{ W}/(\text{m}\cdot\text{K})$$

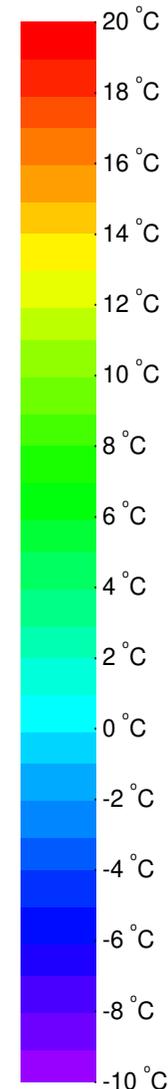
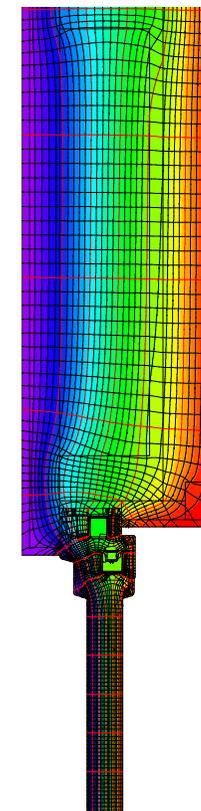
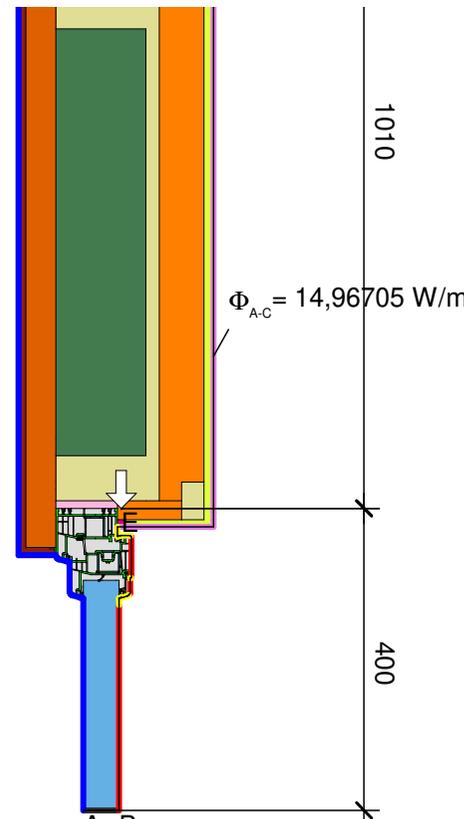




Material	$\lambda$ [W/(m·K)]	$\epsilon$
Aluminum   Aluminium 10456	160,000	0,900
Gipskartonplatten 900 kg/m3 10456	0,250	
Holzweichfaserplatte	0,050	0,900
Insulation   Wärmedämmung 034	0,034	0,900
Insulation   Wärmedämmung 040	0,040	0,900
Kunstharzputz 4108-4	0,700	0,900
Nutzholz 500 kg/m3, auch OSB 10456	0,130	
Nutzholz 700 kg/m3 10456	0,180	
PU foam 0,021*1.25	0,026	
PUR-Ortschaum WLG 040	0,040	0,900
Panel   Maske	0,035	0,900
Polyvinylchloride (PVC)	0,170	0,900
Soft PVC   Weich-PVC	0,140	0,900
Steel   Stahl	50,000	0,900
Steel   Stahl	50,000	0,300
Unbelüftete Hohlräume **		
Unvent. cavity   unbel. Hohlr.		
Wärmedämmung 040	0,040	
Zellulose 040	0,040	
slightly vent. cav.   leicht bel. Hohlr. **		
** EN ISO 10077-2:2017, 6.4.3		



Randbedingung	$q$ [W/m <sup>2</sup> ]	$\theta$ [°C]	$R$ [(m <sup>2</sup> ·K)/W]	$\epsilon$
Adiabatic   Adiat	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 0,3 Cavity in metal				0,300
e 0,9 Cavity   Hohlraum				0,900



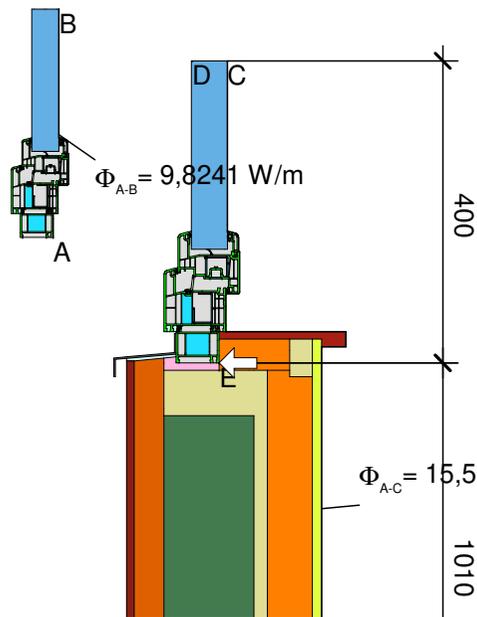
$$\psi_{A-E-C,*} = \frac{\Phi}{\Delta T} - U_1 \cdot b_1 - \frac{\Phi_2}{\Delta T} = \frac{15,230}{30,000} - 0,189 \cdot 1,010 - \frac{9,199}{30,000} = 0,011 \text{ W}/(\text{m} \cdot \text{K})$$

$$\psi_{A-E-C,*} = \frac{\Phi}{\Delta T} - \frac{\Phi_1}{\Delta T} - U_2 \cdot b_2 = \frac{14,967}{30,000} - \frac{9,100}{30,000} - 0,189 \cdot 1,010 = 0,005 \text{ W}/(\text{m} \cdot \text{K})$$

$$U_{eq A-B} = \frac{\Phi}{\Delta T \cdot b} = \frac{3,903}{30,000 \cdot 0,690} = 0,189 \text{ W}/(\text{m}^2 \cdot \text{K})$$

$$\Phi_{A-B} = 3,90321 \text{ W/m}$$



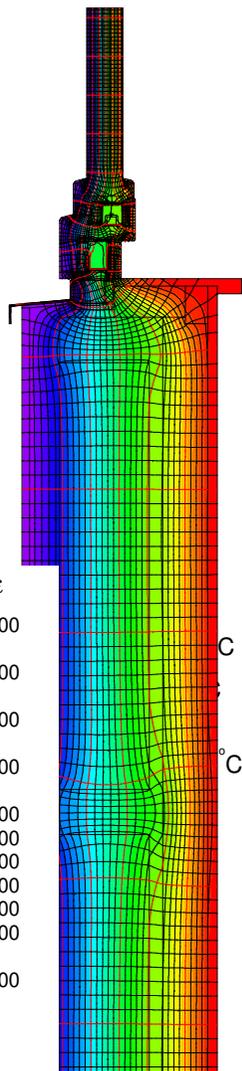


Material	$\lambda$ [W/(m·K)]	$\epsilon$
Aluminum   Aluminium 10456	160,000	0,900
Gipskartonplatten 900 kg/m <sup>3</sup> 10456	0,250	
Holzweichfaserplatte	0,050	0,900
Insulation   Wärmedämmung 040	0,040	
Kunstharzputz 4108-4	0,700	0,900
Nutzholz 500 kg/m <sup>3</sup> , auch OSB 10456	0,130	
Nutzholz 700 kg/m <sup>3</sup> 10456	0,180	0,900
PU foam 0,021*1.25	0,026	
PUR-Ortschaum WLG 040	0,040	0,900
Panel   Maske	0,035	0,900
Polyvinylchloride (PVC)	0,170	0,900
Soft PVC   Weich-PVC	0,140	0,900
Steel   Stahl	50,000	0,900
Steel   Stahl	50,000	0,300
Unvent. cavity   unbel. Hohlr. **		
Weich-Polyvinylchlorit (PVC-P)	0,140	0,900
Wärmedämmung 040	0,040	
Zellulose 040	0,040	
slightly vent. cav.   leicht bel. Hohlr. **		

Material

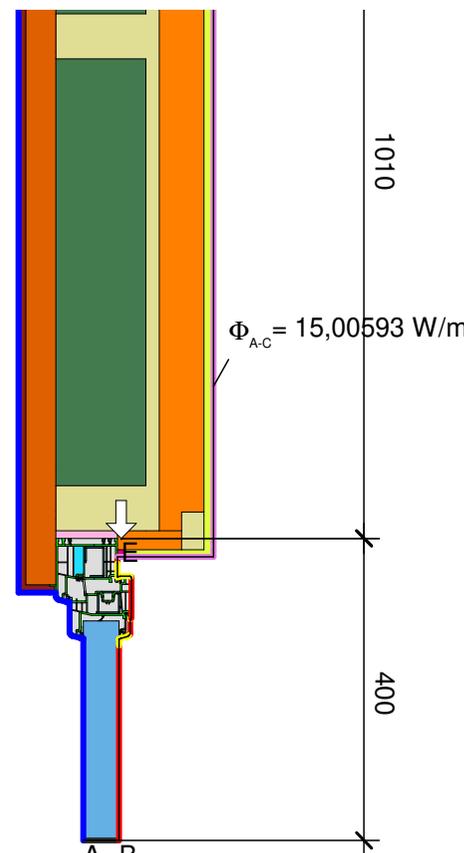
- Aluminum | Aluminium 10456
- Gipskartonplatten 900 kg/m<sup>3</sup> 10456
- Holzweichfaserplatte
- Insulation | Wärmedämmung 040
- Kunstharzputz 4108-4
- Nutzholz 500 kg/m<sup>3</sup>, auch OSB 10456
- Nutzholz 700 kg/m<sup>3</sup> 10456
- PU foam 0,021\*1.25
- PUR-Ortschaum WLG 040
- Panel | Maske
- Polyvinylchloride (PVC)
- Soft PVC | Weich-PVC
- Steel | Stahl
- Steel | Stahl
- Unvent. cavity | unbel. Hohlr. \*\*
- Weich-Polyvinylchlorit (PVC-P)
- Wärmedämmung 040
- Zellulose 040
- slightly vent. cav. | leicht bel. Hohlr. \*\*

\*\* EN ISO 10077-2:2017, 6.4.3

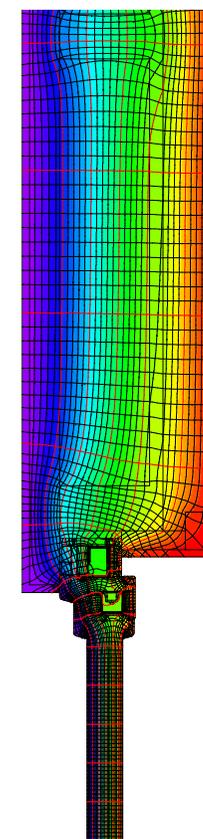


$\Phi_{A-B} = 9,0960 \text{ W/m}$

Randbedingung	$q$ [W/m <sup>2</sup> ]	$\theta$ [°C]	$R$ [(m <sup>2</sup> ·K)/W]	$\epsilon$
Adiabatic   Adiatat	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   Hohlräum				0,900



$\Phi_{A-C} = 15,00593 \text{ W/m}$

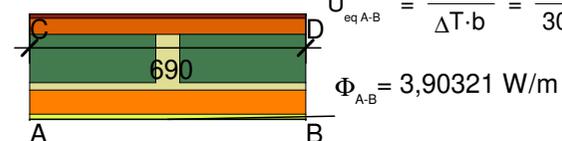


$\Phi_{A-B} = 9,0960 \text{ W/m}$

$$\Psi_{A-E-C,*} = \frac{\Phi}{\Delta T} - \frac{\Phi_1}{\Delta T} - U_2 \cdot b_2 = \frac{15,006}{30,000} - \frac{9,096}{30,000} - 0,189 \cdot 1,010 = 0,007 \text{ W}/(\text{m} \cdot \text{K})$$

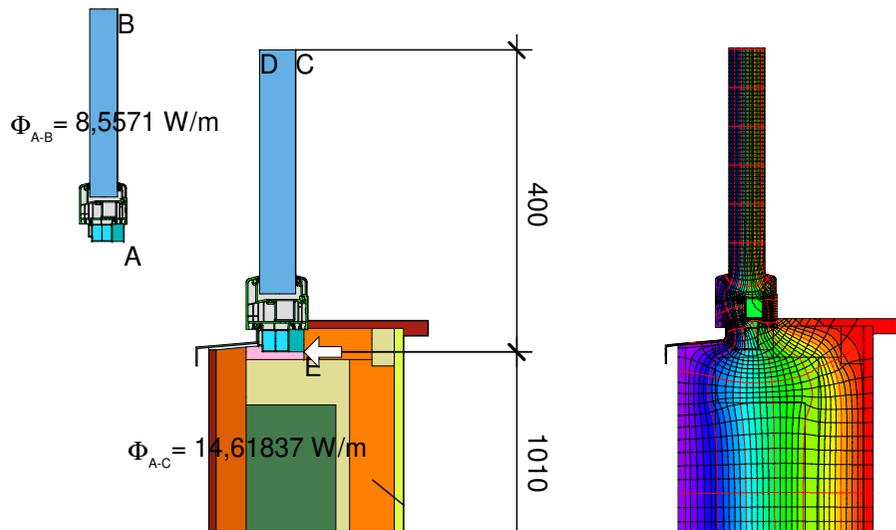
$$\Psi_{A-E-C,*} = \frac{\Phi}{\Delta T} - U_1 \cdot b_1 - \frac{\Phi_2}{\Delta T} = \frac{15,568}{30,000} - 0,189 \cdot 1,010 - \frac{9,824}{30,000} = 0,001 \text{ W}/(\text{m} \cdot \text{K})$$

$$U_{eq A-B} = \frac{\Phi}{\Delta T \cdot b} = \frac{3,903}{30,000 \cdot 0,690} = 0,189 \text{ W}/(\text{m}^2 \cdot \text{K})$$



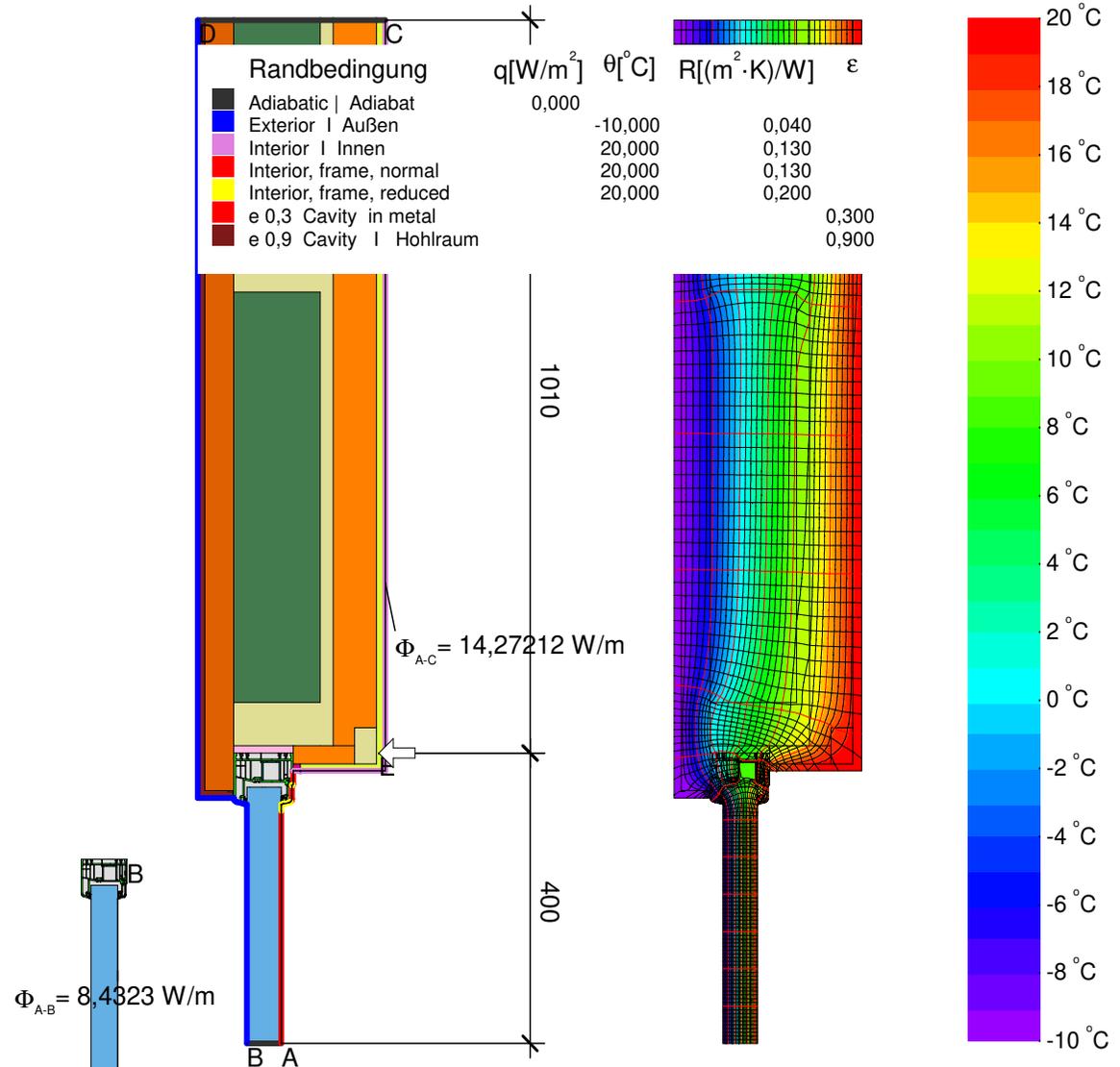
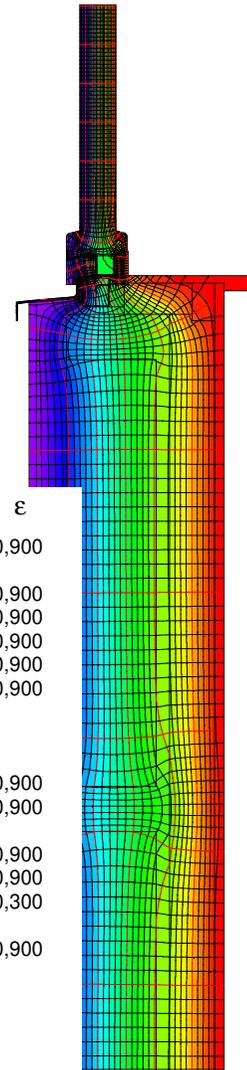
$\Phi_{A-B} = 3,90321 \text{ W/m}$





Material	λ[W/(m·K)]	ε
Aluminum I Aluminium 10456	160,000	0,900
Gipskartonplatten 900 kg/m3 10456	0,250	
Holzweichfaserplatte	0,050	0,900
Insulation I Wärmedämmung 034 (1)	0,034	0,900
Insulation I Wärmedämmung 040	0,040	0,900
Kunstharzputz 4108-4	0,700	0,900
Maske	0,035	0,900
Nutzholz 500 kg/m3, auch OSB 10456	0,130	
Nutzholz 700 kg/m3 10456	0,180	
PU foam 0,021*1.25	0,026	
PUR-Ortschaum WLG 040	0,040	0,900
Panel I Maske	0,035	0,900
Polyvinylchloride (PVC)	0,170	
Polyvinylchloride (PVC)	0,170	0,900
Soft PVC I Weich-PVC	0,140	0,900
Steel I Stahl	50,000	0,300
Unvent. cavity I unbel. Hohlr. **		
Weich-Polyvinylchlorit (PVC-P)	0,140	0,900
Wärmedämmung 040	0,040	
Zellulose 040	0,040	
slightly vent. cav. I leicht bel. Hohlr. **		

\*\* EN ISO 10077-2:2017, 6.4.3



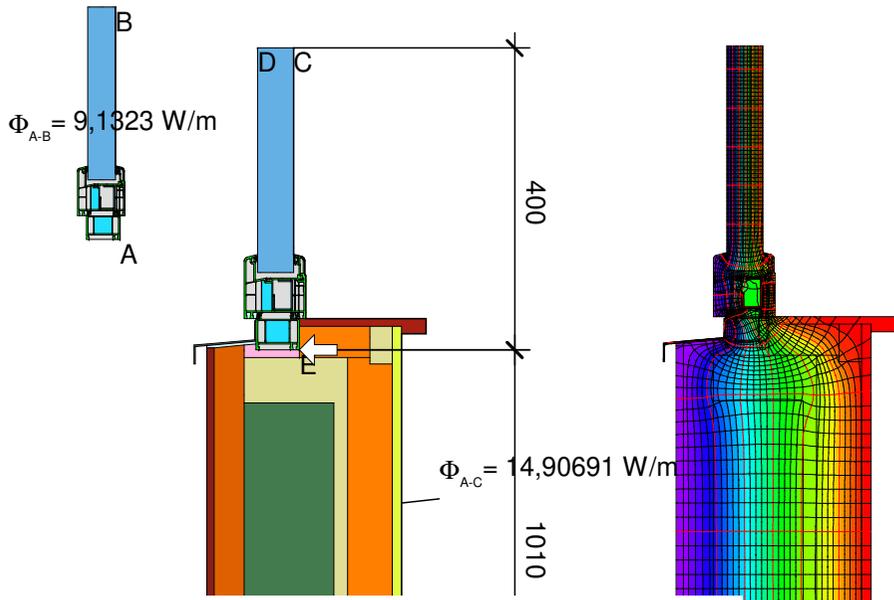
$$\psi_{A-E,C,*} = \frac{\Phi}{\Delta T} - \frac{\Phi_1}{\Delta T} - U_2 \cdot b_2 = \frac{14,272}{30,000} - \frac{8,432}{30,000} - 0,189 \cdot 1,010 = 0,004 \text{ W}/(\text{m} \cdot \text{K})$$

$$\psi_{A-E,C,*} = \frac{\Phi}{\Delta T} - U_1 \cdot b_1 - \frac{\Phi_2}{\Delta T} = \frac{14,618}{30,000} - 0,189 \cdot 1,010 - \frac{8,557}{30,000} = 0,012 \text{ W}/(\text{m} \cdot \text{K})$$

$$U_{\text{eq } A-B} = \frac{\Phi}{\Delta T \cdot b} = \frac{3,903}{30,000 \cdot 0,690} = 0,189 \text{ W}/(\text{m}^2 \cdot \text{K})$$

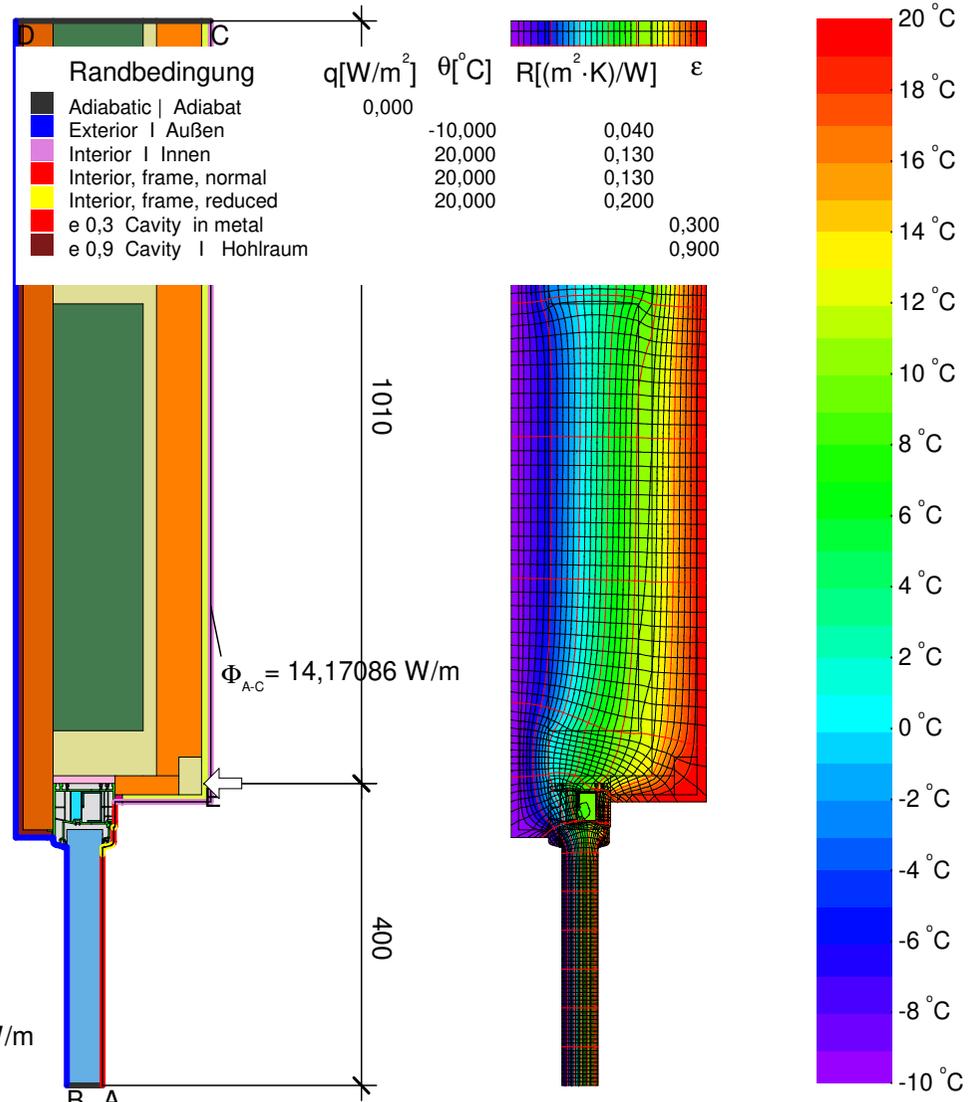
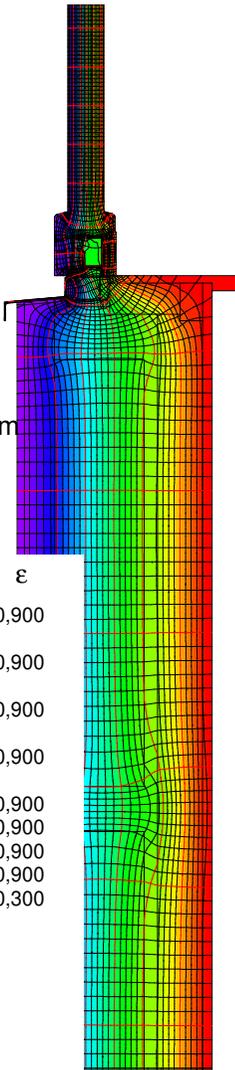
Φ<sub>A-B</sub> = 3,90321 W/m





Material	λ[W/(m·K)]	ε
Aluminum   Aluminium 10456	160,000	0,900
Gipskartonplatten 900 kg/m3 10456	0,250	
Holzweichfaserplatte	0,050	0,900
Insulation   Wärmedämmung 040	0,040	
Kunstharzputz 4108-4	0,700	0,900
Nutzholz 500 kg/m3, auch OSB 10456	0,130	
Nutzholz 700 kg/m3 10456	0,180	0,900
PU foam 0,021*1.25	0,026	
PUR-Ortschaum WLG 040	0,040	0,900
Panel   Maske	0,035	0,900
Polyvinylchloride (PVC)	0,170	0,900
Soft PVC   Weich-PVC	0,140	0,900
Steel   Stahl	50,000	0,300
Unvent. cavity   unbel. Hohlr. **	0,040	
Wärmedämmung 040	0,040	
Zellulose 040	0,040	
slightly vent. cav.   leicht bel. Hohlr. **		

\*\* EN ISO 10077-2:2017, 6.4.3



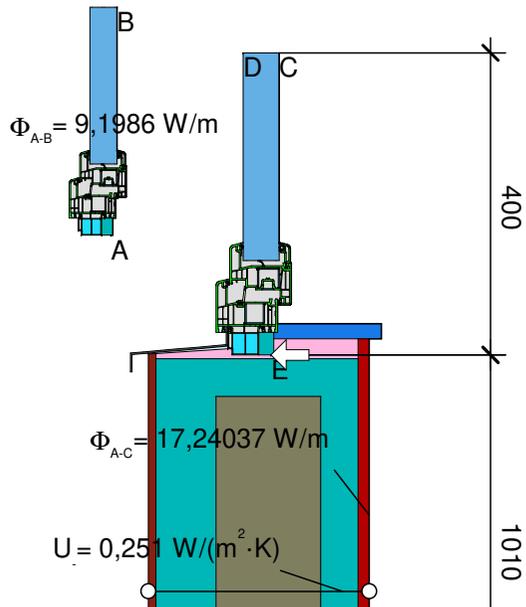
$$\psi_{A-E-C,*} = \frac{\Phi}{\Delta T} - U_1 \cdot b_1 - \frac{\Phi_2}{\Delta T} = \frac{14,907}{30,000} - 0,189 \cdot 1,010 - \frac{9,132}{30,000} = 0,002 \text{ W}/(\text{m} \cdot \text{K})$$

$$\psi_{A-E-C,*} = \frac{\Phi}{\Delta T} - \frac{\Phi_1}{\Delta T} - U_2 \cdot b_2 = \frac{14,171}{30,000} - \frac{8,394}{30,000} - 0,189 \cdot 1,010 = 0,002 \text{ W}/(\text{m} \cdot \text{K})$$

$$U_{\text{eq A-B}} = \frac{\Phi}{\Delta T \cdot b} = \frac{3,903}{30,000 \cdot 0,690} = 0,189 \text{ W}/(\text{m}^2 \cdot \text{K})$$

$$\Phi_{A-B} = 3,90321 \text{ W/m}$$



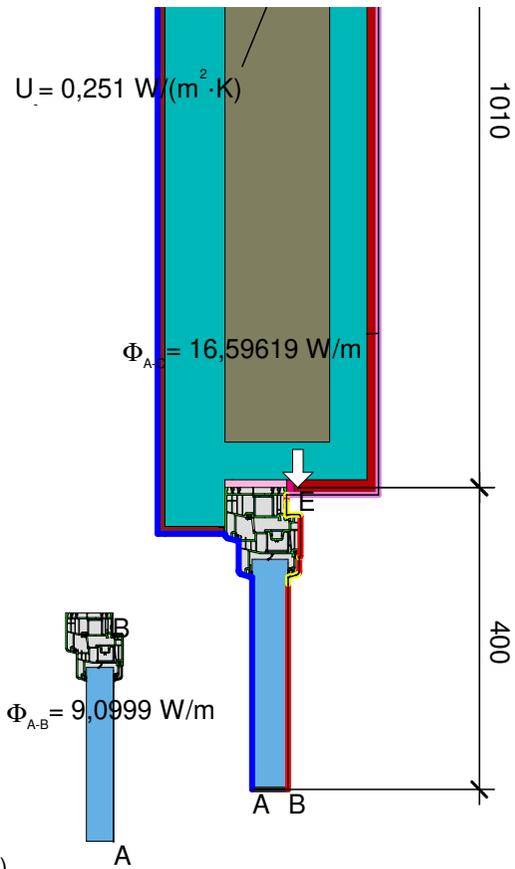


Material	$\lambda$ [W/(m·K)]	$\epsilon$
Aluminum I Aluminium 10456	160,000	0,900
Beton armiert (mit 1% Stahl) 10456	2,300	
EPS, Mineralwolle 035	0,035	
Gipsputz 1300 kg/m3 10456	0,570	
Insulation I Wärmedämmung 034	0,034	0,900
Kunstharzputz 4108-4	0,700	0,900
Kunststein 10456	1,300	0,900
PU foam 0,021*1.25	0,026	
PUR-Ortschaum WLG 040	0,040	0,900
Panel I Maske	0,035	0,900
Polyvinylchloride (PVC)	0,170	0,900
Soft PVC I Weich-PVC	0,140	0,900
Steel I Stahl	50,000	0,900
Steel I Stahl	50,000	0,300
Unbelüftete Hohlräume **		
Unvent. cavity I unbel. Hohlr. **		
slightly vent. cav. I leicht bel. Hohlr. **		

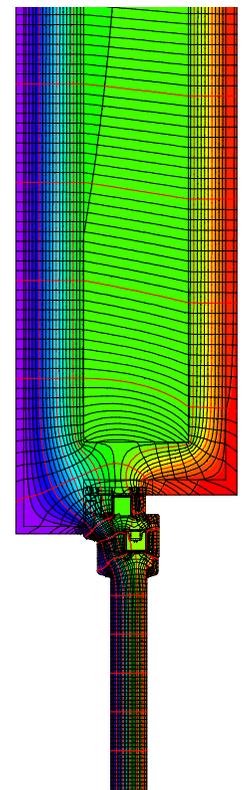
- Aluminum I Aluminium 10456
  - Beton armiert (mit 1% Stahl) 10456
  - EPS, Mineralwolle 035
  - Gipsputz 1300 kg/m3 10456
  - Insulation I Wärmedämmung 034
  - Kunstharzputz 4108-4
  - Kunststein 10456
  - PU foam 0,021\*1.25
  - PUR-Ortschaum WLG 040
  - Panel I Maske
  - Polyvinylchloride (PVC)
  - Soft PVC I Weich-PVC
  - Steel I Stahl
  - Steel I Stahl
  - Unbelüftete Hohlräume \*\*
  - Unvent. cavity I unbel. Hohlr. \*\*
  - slightly vent. cav. I leicht bel. Hohlr. \*\*
- \*\* EN ISO 10077-2:2017, 6.4.3

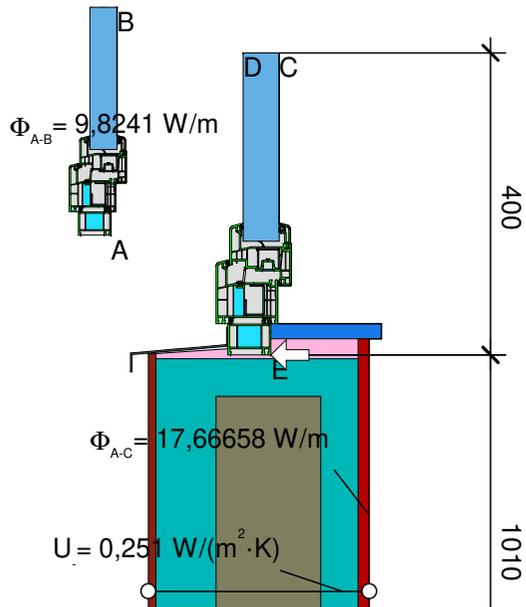
$$\psi_{A-E-C,*} = \frac{\Phi}{\Delta T} - U_1 \cdot b_1 - \frac{\Phi_2}{\Delta T} = \frac{17,240}{30,000} - 0,251 \cdot 1,010 - \frac{9,199}{30,000} = 0,015 \text{ W/(m·K)}$$

Randbedingung	$q$ [W/m <sup>2</sup> ]	$\theta$ [°C]	$R$ [(m <sup>2</sup> ·K)/W]	$\epsilon$
Adiabatic	0,000			
Adiabatic   Adiat	0,000			
Exterior I Außen		-10,000	0,040	
Interior I Innen		20,000	0,130	
Interior, frame, normal		20,000	0,130	
Interior, frame, reduced		20,000	0,200	
e 0,3 Cavity in metal				0,300
e 0,9 Cavity I Hohlraum				0,900



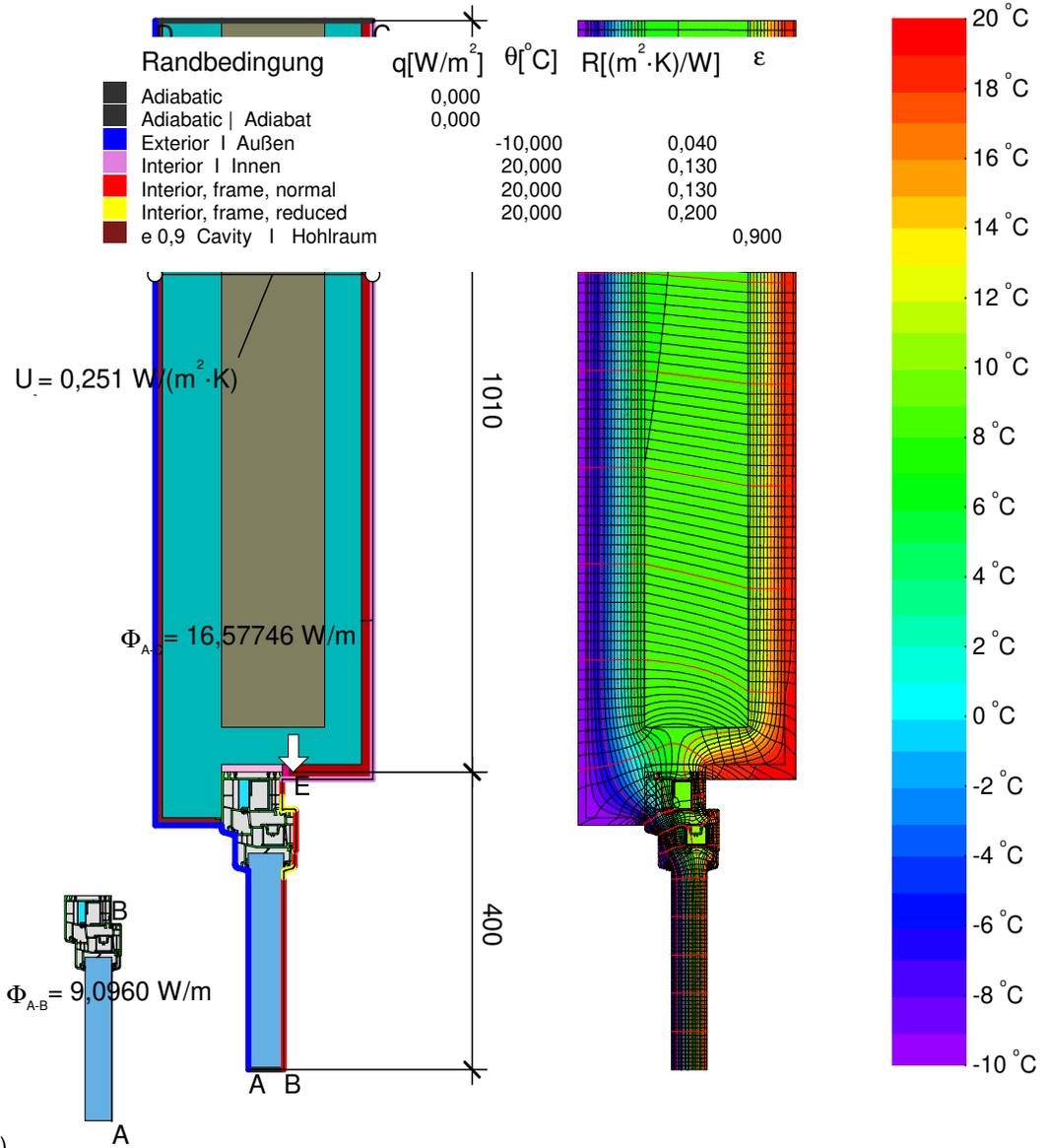
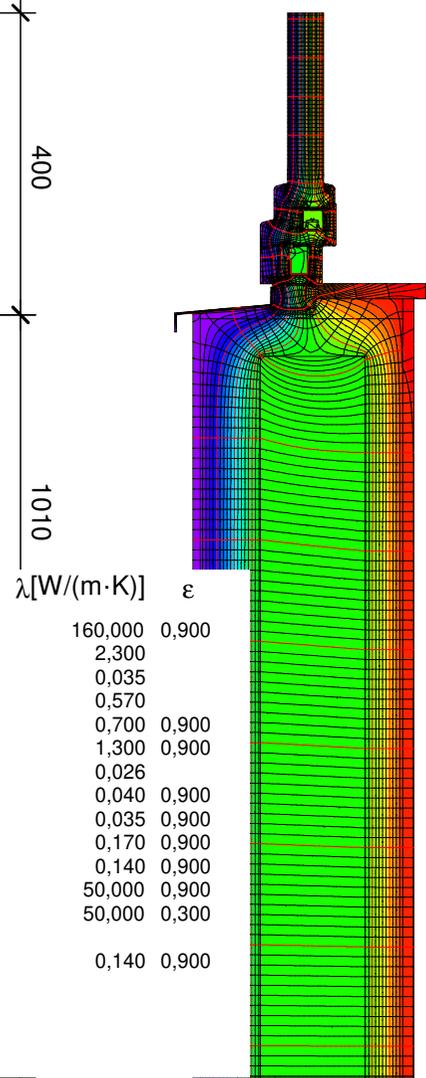
$$\psi_{A-E-C,*} = \frac{\Phi}{\Delta T} - \frac{\Phi_1}{\Delta T} - U_2 \cdot b_2 = \frac{16,596}{30,000} - \frac{9,100}{30,000} - 0,251 \cdot 1,010 = -0,004 \text{ W/(m·K)}$$





Material	$\lambda$ [W/(m·K)]	$\epsilon$
Aluminum I Aluminium 10456	160,000	0,900
Beton armiert (mit 1% Stahl) 10456	2,300	
EPS, Mineralwolle 035	0,035	
Gipsputz 1300 kg/m3 10456	0,570	
Kunstharzputz 4108-4	0,700	0,900
Kunststein 10456	1,300	0,900
PU foam 0,021*1.25	0,026	
PUR-Ortschaum WLG 040	0,040	0,900
Panel I Maske	0,035	0,900
Polyvinylchloride (PVC)	0,170	0,900
Soft PVC I Weich-PVC	0,140	0,900
Steel I Stahl	50,000	0,900
Steel I Stahl	50,000	0,300
Unvent. cavity I unbel. Hohlr. **		
Weich-Polyvinylchlorit (PVC-P)	0,140	0,900
slightly vent. cav. I leicht bel. Hohlr. **		

\*\* EN ISO 10077-2:2017, 6.4.3

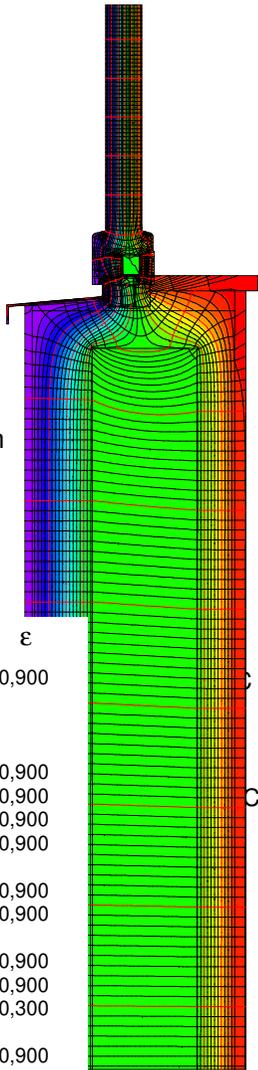
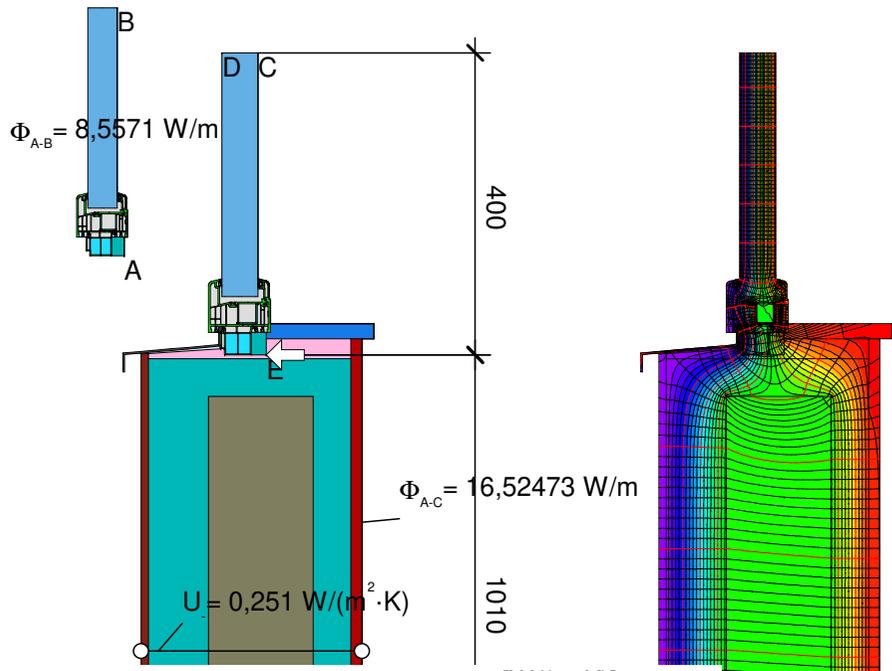


Randbedingung	$q$ [W/m <sup>2</sup> ]	$\theta$ [°C]	$R$ [(m <sup>2</sup> ·K)/W]	$\epsilon$
Adiabatic	0,000			
Adiabatic   Adiat	0,000			
Exterior I Außen		-10,000	0,040	
Interior I Innen		20,000	0,130	
Interior, frame, normal		20,000	0,130	
Interior, frame, reduced		20,000	0,200	
e 0,9 Cavity I Hohlraum				0,900

$$\psi_{A-E,C,*} = \frac{\Phi}{\Delta T} - U_1 \cdot b_1 - \frac{\Phi_2}{\Delta T} = \frac{17,667}{30,000} - 0,251 \cdot 1,010 - \frac{9,824}{30,000} = 0,008 \text{ W}/(\text{m} \cdot \text{K})$$

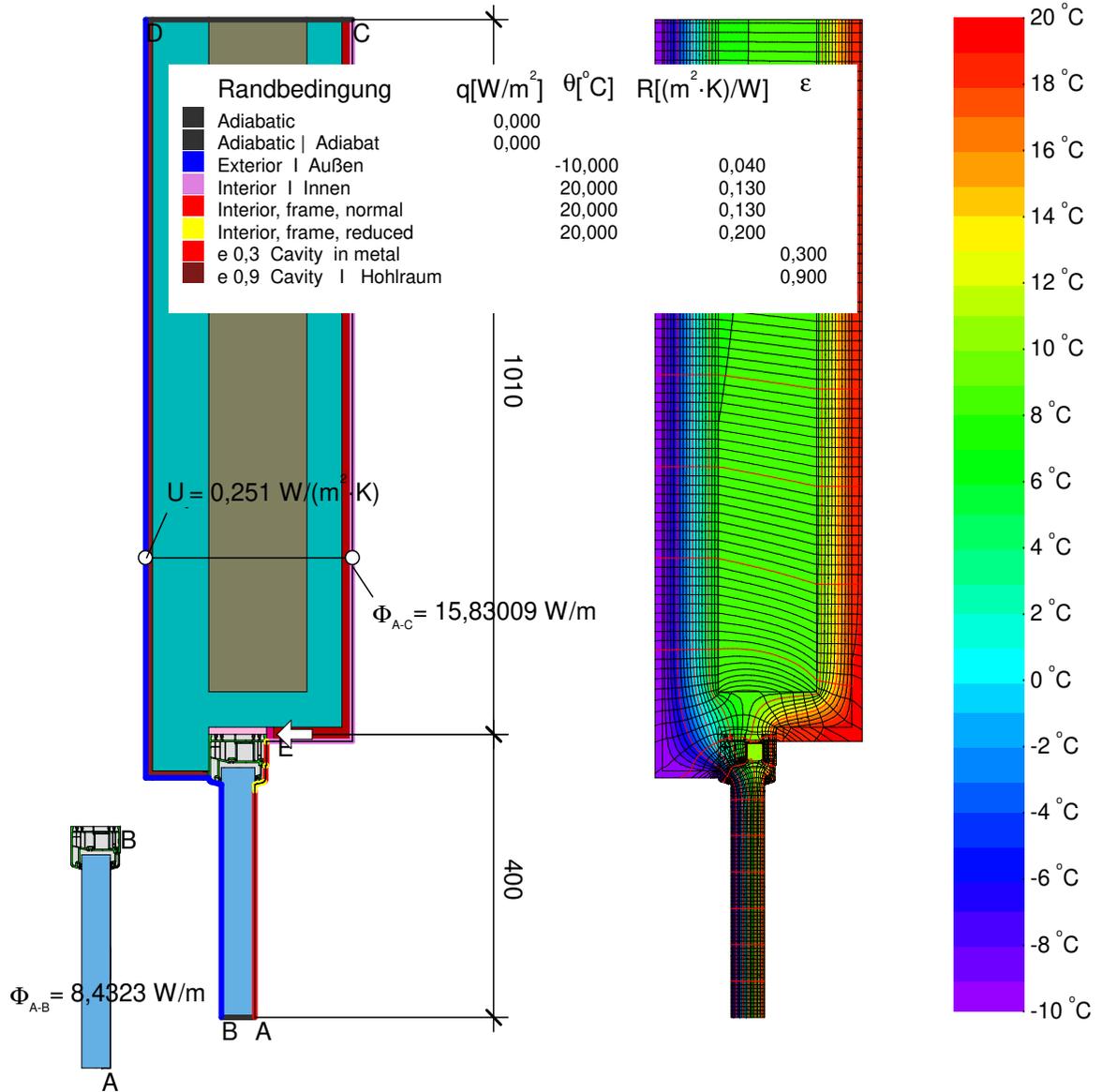
$$\psi_{A-E,C,*} = \frac{\Phi}{\Delta T} - \frac{\Phi_1}{\Delta T} - U_2 \cdot b_2 = \frac{16,577}{30,000} - \frac{9,096}{30,000} - 0,251 \cdot 1,010 = -0,004 \text{ W}/(\text{m} \cdot \text{K})$$





Material	$\lambda$ [W/(m·K)]	$\epsilon$
Aluminum I Aluminium 10456	160,000	0,900
Beton armiert (mit 1% Stahl) 10456	2,300	
EPS, Mineralwolle 035	0,035	
Gipsputz 1300 kg/m3 10456	0,570	
Insulation I Wärmedämmung 034 (1)	0,034	0,900
Kunstharzputz 4108-4	0,700	0,900
Kunststein 10456	1,300	0,900
Maske	0,035	0,900
PU foam 0,021*1.25	0,026	
PUR-Ortschaum WLG 040	0,040	0,900
Panel I Maske	0,035	0,900
Polyvinylchloride (PVC)	0,170	
Polyvinylchloride (PVC)	0,170	0,900
Soft PVC I Weich-PVC	0,140	0,900
Steel I Stahl	50,000	0,300
Unvent. cavity I unbel. Hohlr. **		
Weich-Polyvinylchlorit (PVC-P)	0,140	0,900
slightly vent. cav. I leicht bel. Hohlr. **		

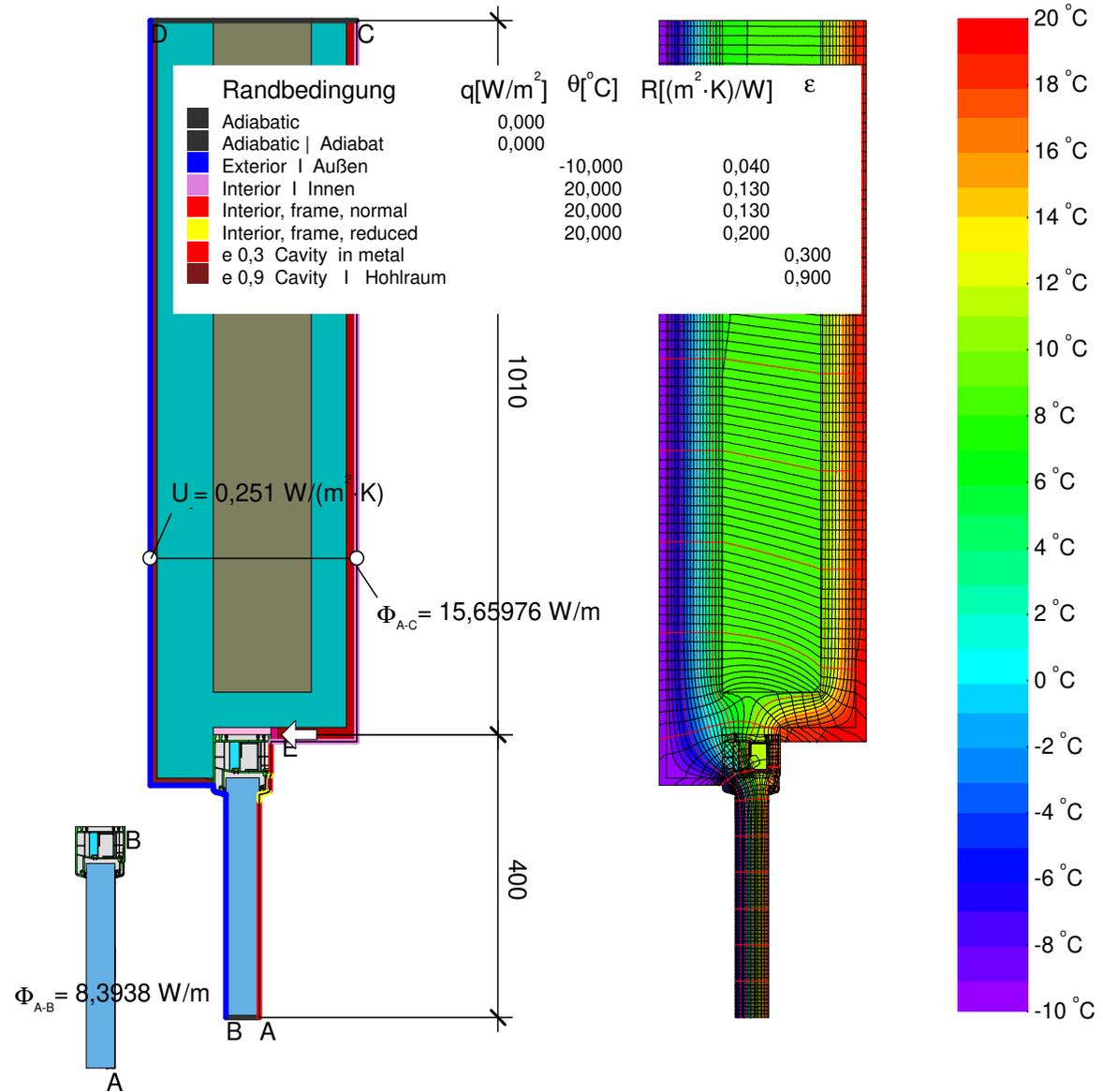
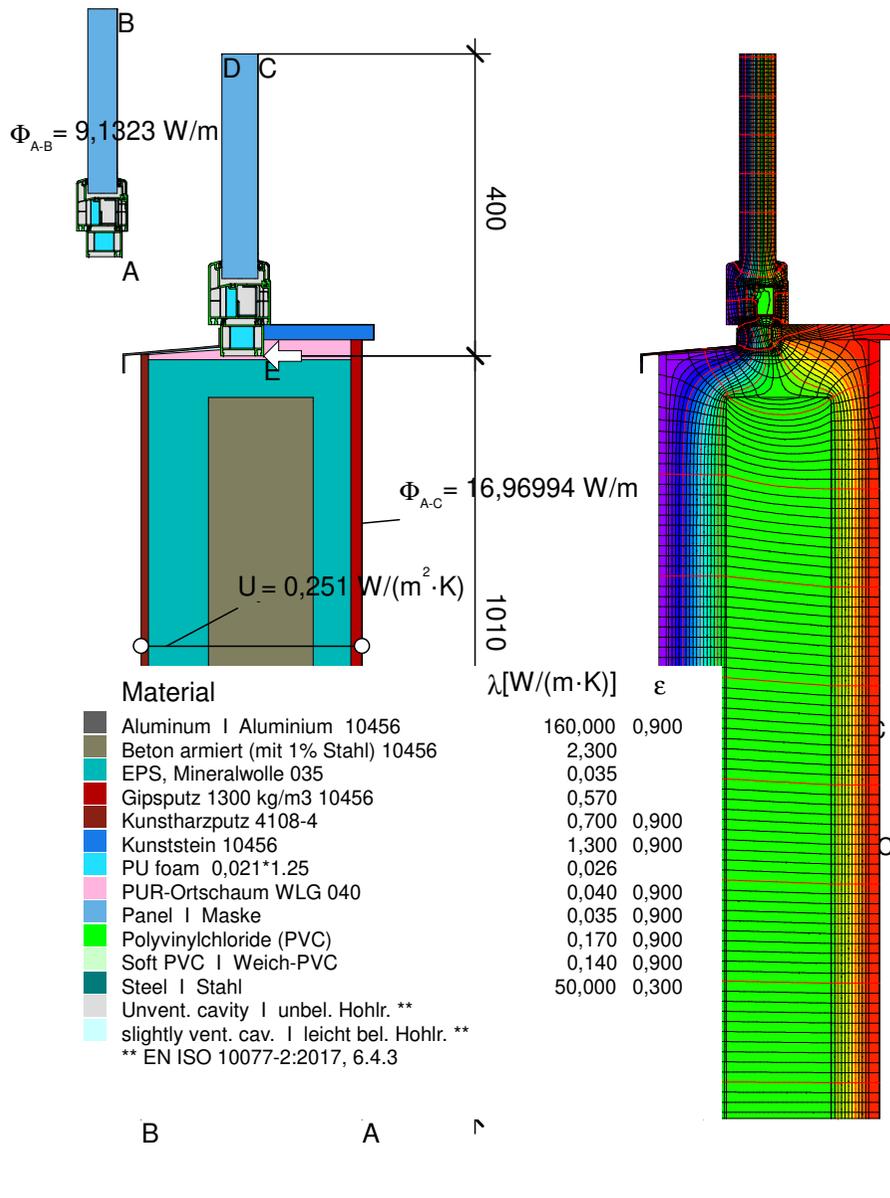
\*\* EN ISO 10077-2:2017, 6.4.3



$$\Psi_{A-E,C,*} = \frac{\Phi}{\Delta T} - \frac{\Phi_1}{\Delta T} - U_2 \cdot b_2 = \frac{15,830}{30,000} - \frac{8,432}{30,000} - 0,251 \cdot 1,010 = -0,007 \text{ W}/(\text{m} \cdot \text{K})$$

$$\Psi_{A-E,C,*} = \frac{\Phi}{\Delta T} - U_1 \cdot b_1 - \frac{\Phi_2}{\Delta T} = \frac{16,525}{30,000} - 0,251 \cdot 1,010 - \frac{8,557}{30,000} = 0,012 \text{ W}/(\text{m} \cdot \text{K})$$





$$\psi_{A-E,C,*} = \frac{\Phi}{\Delta T} - U_1 \cdot b_1 - \frac{\Phi_2}{\Delta T} = \frac{16,970}{30,000} - 0,251 \cdot 1,010 - \frac{9,132}{30,000} = 0,008 \text{ W}/(\text{m} \cdot \text{K})$$

$$\psi_{A-E,C,*} = \frac{\Phi}{\Delta T} - \frac{\Phi_1}{\Delta T} - U_2 \cdot b_2 = \frac{15,660}{30,000} - \frac{8,394}{30,000} - 0,251 \cdot 1,010 = -0,011 \text{ W}/(\text{m} \cdot \text{K})$$

