Report - Certified Passive House Component I Informe - Componente Passivhaus Certificado

Passive House Institute

Recommended for | Recomendado para

Warm, temperate climate | Clima cálido - templado

Window system
Sistema de ventana
2111ws04

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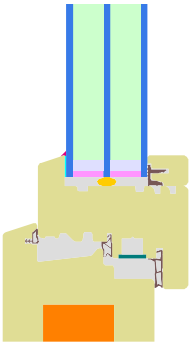
Product | Producto:	**EnergyTEK 89**
Client | Fabricante:	**CARPINTEK MOBDESIGN S.L.**
Spacer | Intercalario:	**SWISSPACER Ultimate**
Date | Fecha:	**25.07.2023**
Author | Autor:	**M. Arch. Soraya Lopez**



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 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.

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.

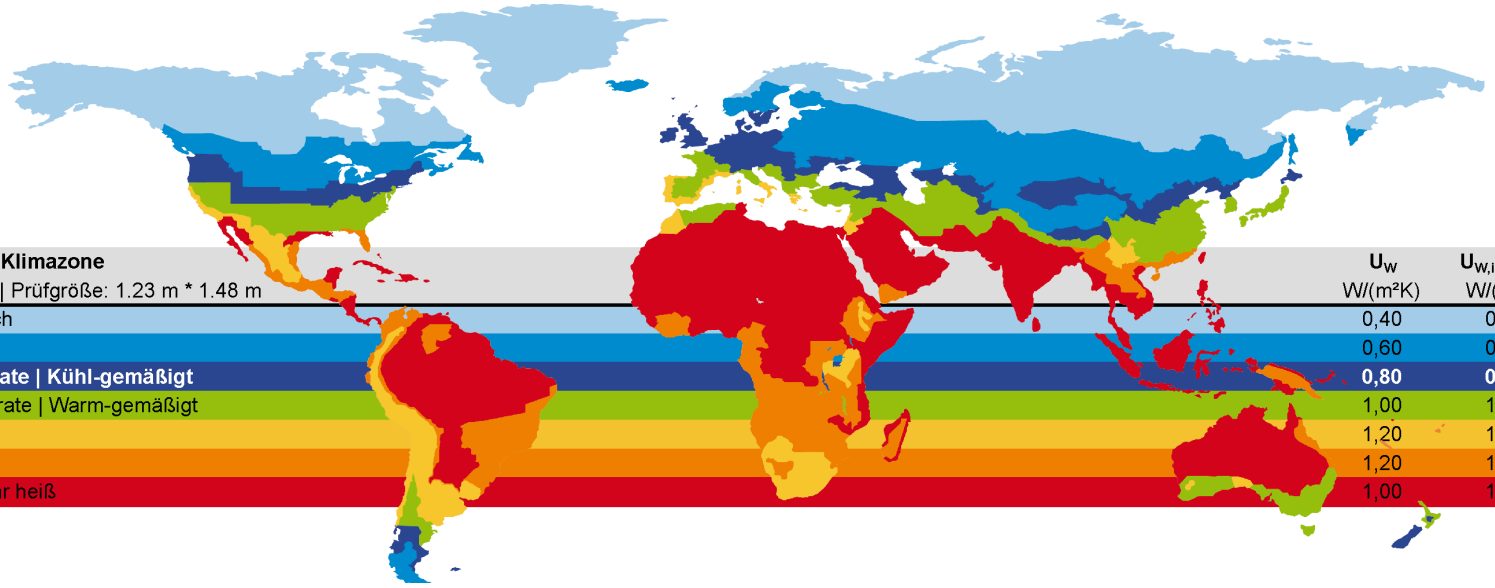
The below stated requirements for awarding the label "Certified Passive House Component" have been set by the Passive House Institute (PHI).

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 ventana empleada (valor U de la ventana) UW 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 UW, instalado, que se comprobó a modo de ejemplo en el marco de la certificación.

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”.



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)	$f_{Rsi=0,25\ m²K/W}$ -
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 8 of Infomind was used. For the used **boundary conditions**, please have a look at following drawings and tables.

Las ventanas se clasifican en clases de eficiencia en función de la trasmitancia térmica de su parte opaca. Esta clasificación incluye la influencia de valor-U del marco, anchura del marco, valor-Ψ del borde del vidrio y distancia del borde del vidrio.

El balance entre pérdidas y ganancias térmica es relevante para los edificios Passivhaus. Puesto que las ganancias solares dependen del lugar, resulta útil cuantificar las pérdidas en función de otros factores de la ventana y hacer un balance que no considera las ganancias solares. Esto es lo que determina Ψ_{opak}.

El cálculo de los valores térmicos específicos de los marcos se ha realizado siguiendo las normas ISO 10077-1:2010 y ISO 10077-2:2012. La conductividad térmica se ha tomado de las normas pertinentes, las autorizaciones de las autoridades constructivas o se ha determinado según los procedimientos de la norma ISO 10077-2:2012 Parte 5.1 En el caso del acristalamiento, los modelos con una partición tienen 40 cm de altura, y los modelos de dos particiones 60 cm de altura.

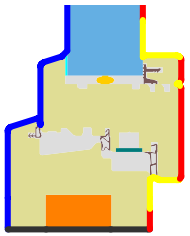
Los espaciadores se modelaron siguiendo los supuestos del grupo de trabajo “Warm Edge” de la asociación de vidrio plano (Bundesverband Flachglas) de Alemania.

Los coeficientes por puente térmico se han calculado a modo de ejemplo para sistemas constructivos habituales. Estos valores solo pueden utilizarse en situaciones de instalación idénticas a la hora de realizar el cálculo del balance energético. Los modelos de instalación tienen 1,41 m de altura; la altura del vidrio y del marco es de 40 cm. La hueco 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 de contorno utilizadas.

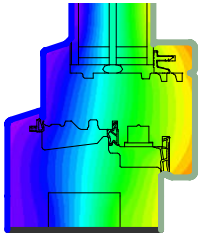
$$\Psi_{opak} = \Psi_{g} + \frac{U_{f} \cdot A_{f}}{l_{g}}$$

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	θ[°C]	R[(m²·K)/W]	ε
Adiabatic | Adiabat			
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	θ[°C]	R[(m²·K)/W]	ε
Adiabatic | Adiabat			
Exterior | Außen	-10.000	0.040	
e 0,9 Cavity I Hohlraum			0.900
fRsi: Interior | Innen	20.000	0.250	



CARPINTEK MOBDESIGN S.L.

EnergyTEK 89

Spacer | Intercalario:
SWISSPACER Ultimate

Frame values | Frame values

		OB Bottom / Inferior	OH Top / Superior	OJ Side / Lateral	FB Bottom fixed / Inferior fijo	FH Top fixed / Superior fijo	FJ Side fixed / Lateral fijo	OT Thres-hold / Umbral	DL Side door / Puerta lateral	FM Flying mullion / Montante móvil	M2 Mullion / Montante	M1 Mullion / Montante	M0 Mullion fixed / Montante fijo	CO Corner / Esquina	T2 Transom / Trave-saño	T1 Transom / Trave-saño	T0 Transom fixed / Trave-saño fijo
Temperaturefactor Factor de temp.	$f_{Rsi=0,25m^2k/W}$	0.70	0.70	0.70	0.69	0.69	0.69			0.69		0.69	0.69			0.69	0.69
Frame width Ancho del marco	b_f [mm]	110	110	110	70	70	70			132		141	100			141	100
U-value frame Valor-U marco	**Uf** [W/(m²K)]	1.02	1.02	1.02	0.94	0.94	0.94			1.11		1.10	1.06			1.10	1.06
Ψ-glass edge Ψ borde del vidrio	**Ψg** [W/(mK)]	0.026	0.026	0.026	0.026	0.026	0.026			0.026		0.026	0.027			0.026	0.027
U-value window Valor-U ventana	Uw [W/(m²K)] @Ug= 0.9 W/(m²K)	**1.000**															
Ψ_{opaque}	Ψ_{opaque} W/(mK)	**0.149**															
Passive House effiziency class Clasificación de eficiencia Passive House		**phB**															

Installation | Installation

EIFS | SATE U-Wall = 0.227 W/(m²K)

$\Psi_{install}$ [W/(mK)]	0.015	0.005	0.005	0.014	0.002	0.002			
$U_{W,\ installed}$ [W/(m²K)]	1.02			1.01					

Lightwight timber construction | Entramado ligero de madera U-Wall = 0.254 W/(m²K)

$\Psi_{install}$ [W/(mK)]	0.024	0.011	0.011	0.023	0.008	0.008		
$U_{W,\ installed}$ [W/(m²K)]	1.04			1.03				

Formwork blocks | Bloques de hormigón U-Wall = 0 W/(m²K)

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

Ventilated facade | Fachada ventilada U-Wall = 0.229 W/(m²K)

$\Psi_{install}$ [W/(mK)]	0.016	0.003	0.003	0.014	-0.002	-0.002		
$U_{W,\ installed}$ [W/(m²K)]	1.02			1.01				

Cavity wall | Muro con cámara U-Wall = 0 W/(m²K)

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

Contact person | Persona de contacto

CARPINTEK MOBDESIGN S.L., Juan Mato
+34 691 328 058 juan.mato@carpintek.es

Description

Timber window system with frames made of pinewood density up to 500 kg/m³(lambda 0.13 W/(mK)). The main structure is insulated with EPS (Donpol 0.034 W/(mK)). Glazing rebate insulated with a jute cord (0.065 W/(mK)).
Pane thickness: 48 mm (4/18/4/18/4), rebate depth: 13 mm.

Descripción

Sistema de ventana con carpintería de madera de pino, densidad hasta 500 kg/m³ (lambda 0,13 W/(mK)). El marco fijo de la carpintería está aislado con EPS (producto Donpol 0,034 W/(mK)). El galce del acristalamiento está aislado con un cordón de yute (0,065 W/(mK)).
Espesor del acristalamiento 48 mm (4/18/4/18/4), Altura de junquillo: 13 mm.

Calculation | Cálculo

Passivhaus Institut Darmstadt 25.07.2023

Passive House Institute

frame values | Rahmenwerte

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EnergyTEK 89

Spacer | Intercalario:
SWISSPACER Ultimate

		V1 bo Bottom	V1 to Top	V1 s Side	V1 bof Bottom fixed	V1 tof Top fixed	V1 sf Side fixed
		Inferior	Superior	Lateral	Inferior fijo	Superior fijo	Lateral fijo
							
Temperaturefactor Factor de temp.	$f_{Rsi=0,25m^2k/W}$						
Frame width Ancho del marco	b_f [mm]						
U-value frame Valor-U marco	**Uf** [W/(m²K)]						
Ψ-glass edge Ψ borde del vidrio	**Ψg** [W/(mK)]						
U-value window Valor-U ventana	Uw [W/(m²K)] @Ug= 0.9 W/(m²K)						
Ψ_{opaque}	Ψ_{opaque} W/(mK)						
Passive House effiziency class Clasificación de eficiencia Passive House							

EIFS | SATE U-Wall = 0.227 W/(m²K)

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

Lightwight timber construction | Entramado ligero de madera U-Wall = 0.254 W/(m²K)

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

Formwork blocks | Bloques de hormigón U-Wall = 0 W/(m²K)

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

Ventilated facade | Fachada ventilada U-Wall = 0.229 W/(m²K)

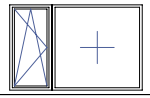
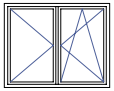
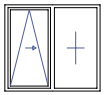
	$\Psi_{install}$ [W/(mK)]						
	$U_{W,\ installed}$ [W/(m²K)]						

Cavity wall | Muro con cámara U-Wall = 0 W/(m²K)

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

Classification according to EN 14351-1, carried out by elabora

Clasificación según EN 14351-1, realizada por elabora

Window-type Tipo de ventana Dimension Dimensiones	Reference number Número de referencia	Resistance to wind Resistencia al EN 12210	Water tightness Estanqueidad al agua EN 12208	Air tightness Luftdichtheit EN 12207 Q100
 2500 * 900 mm	Obra: 21349-21 Muestra 935	C5	E1200	4 0,15 m³/hm
 3290 * 2372 mm				
 1650 * 1472 mm				
 1642 * 2372 mm				
 1642 * 2372 mm				
Criterion achieved			Criterion not achieved	

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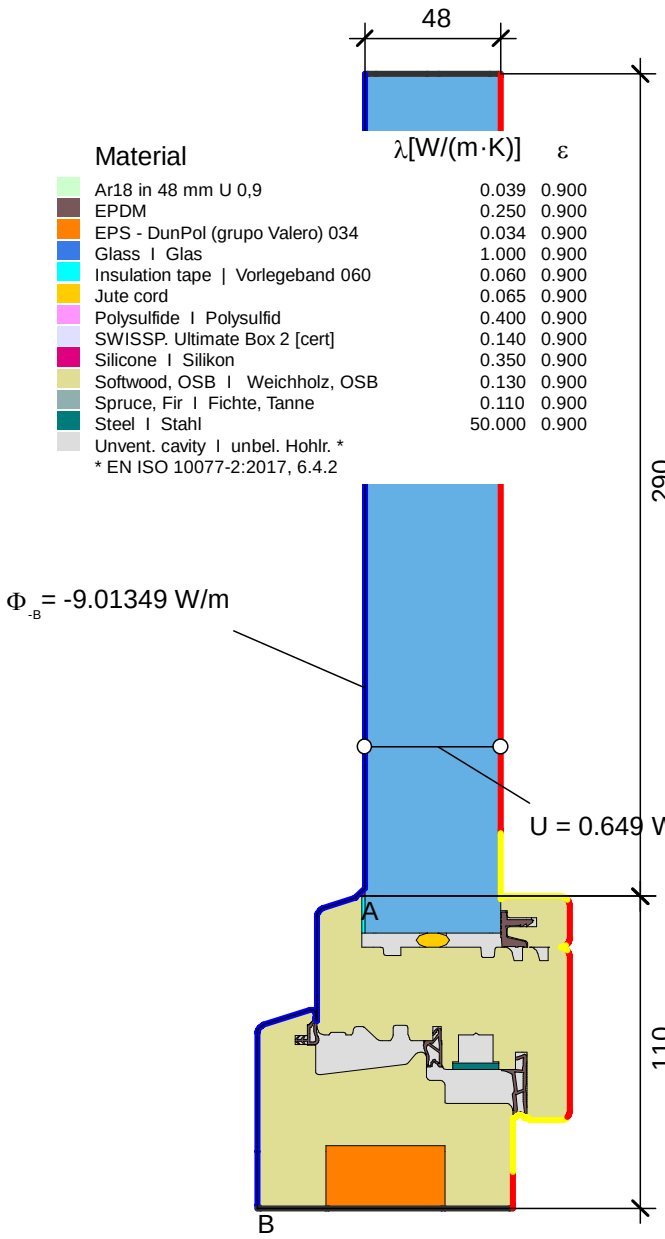
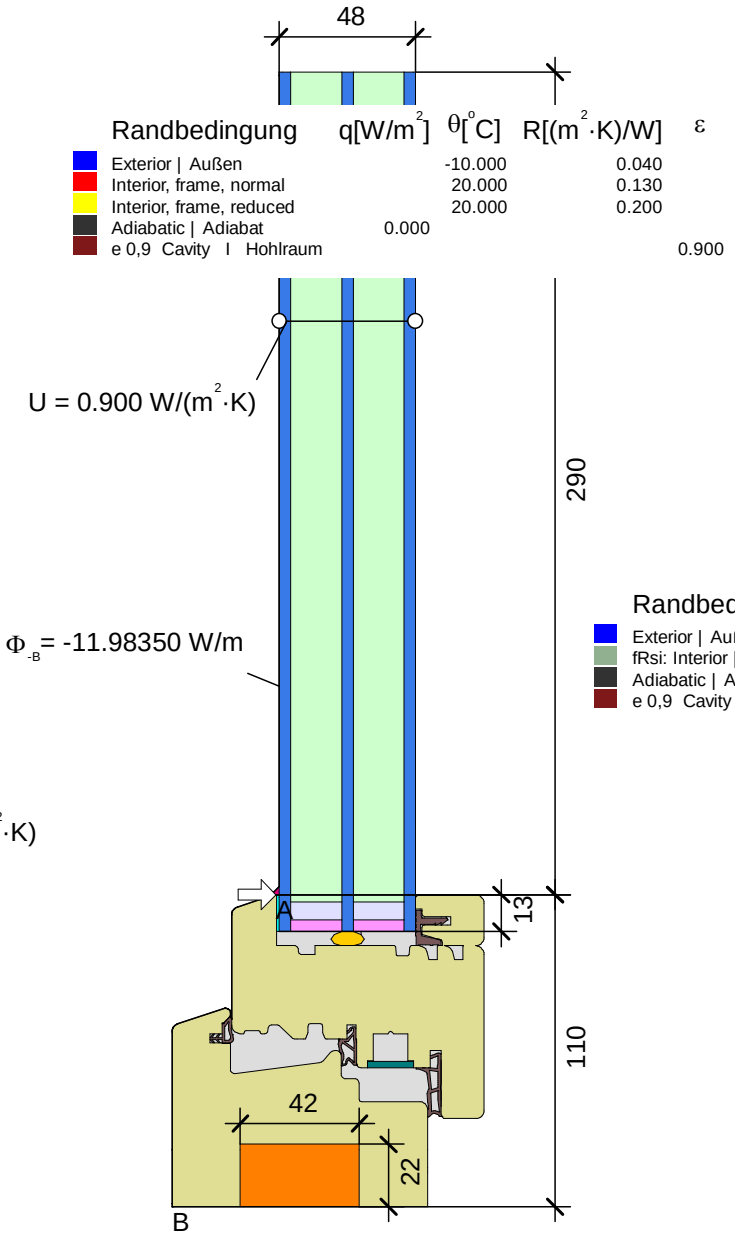
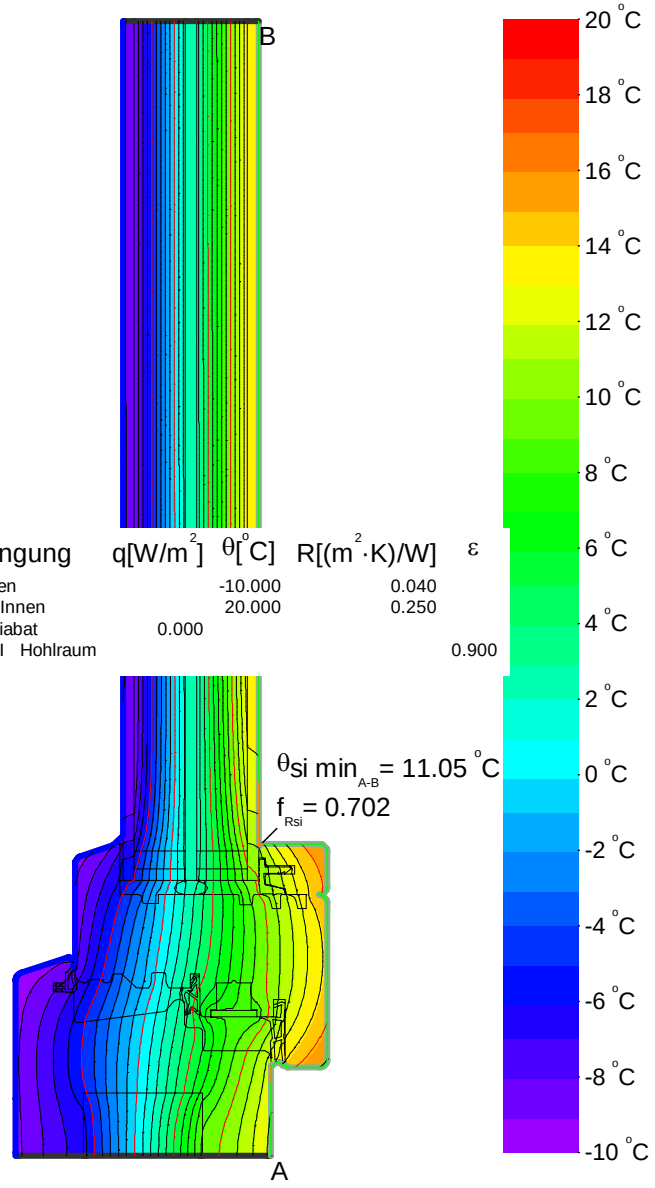
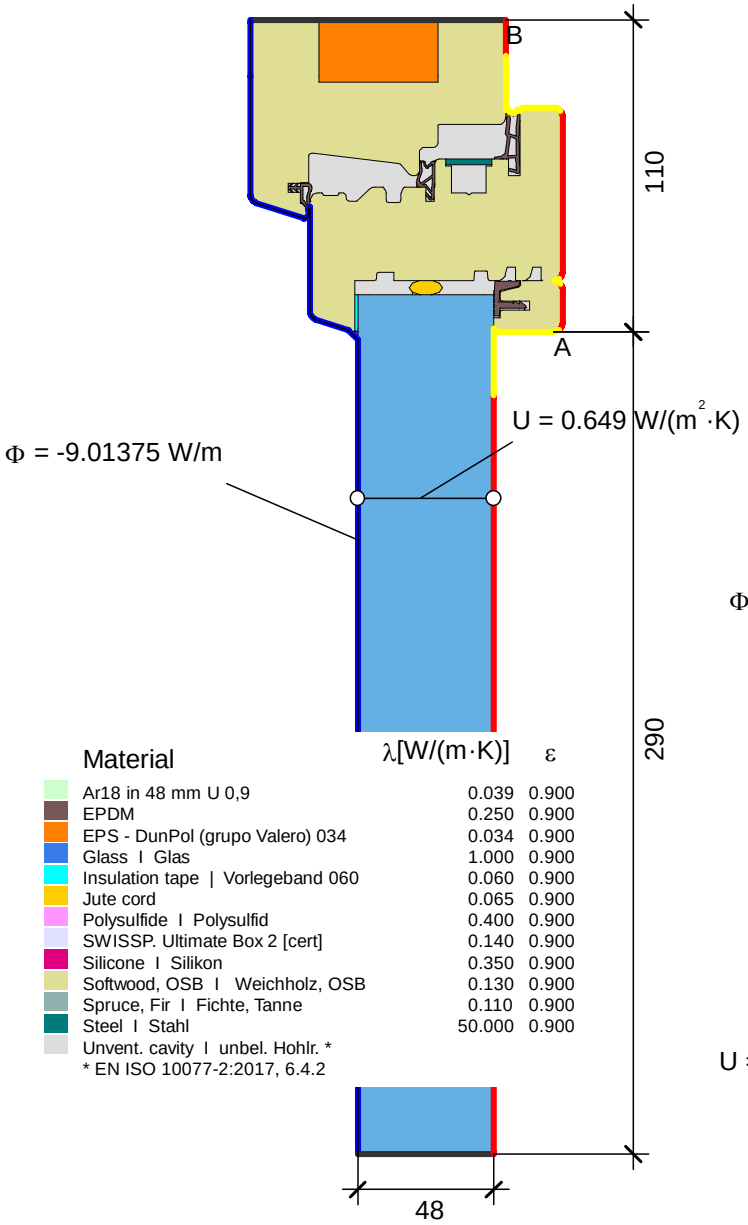






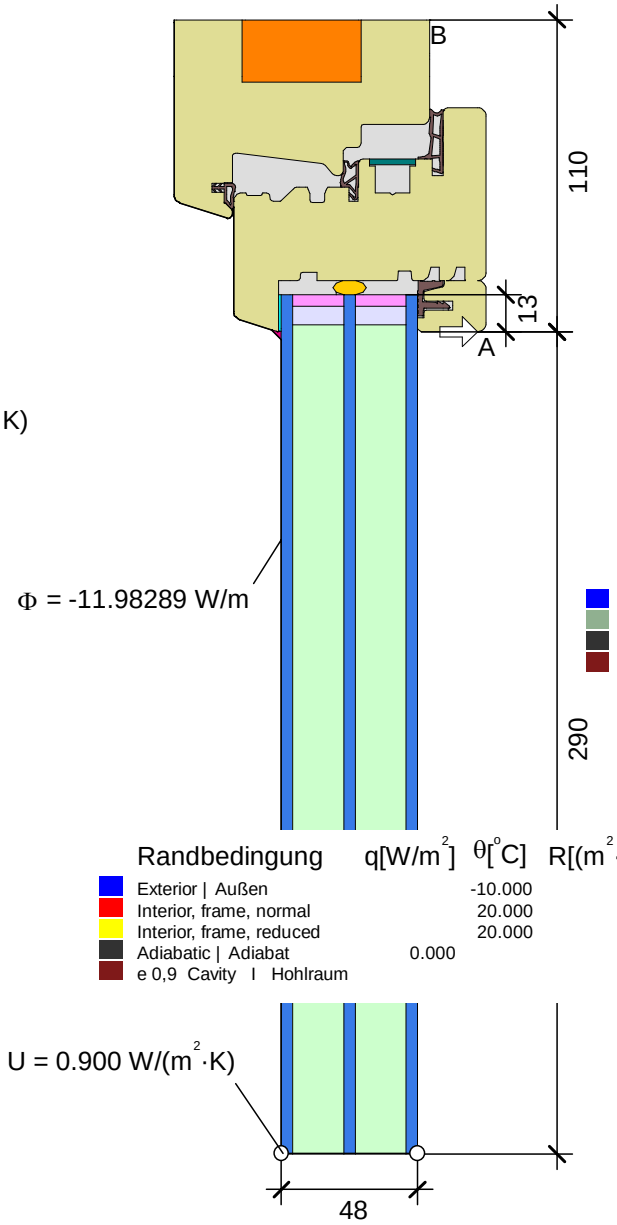
$$U_{f\,A,B} = \frac{\frac{\Phi}{\Delta T} - U_p \cdot b_p}{b_f} = \frac{\frac{9.013}{30.000} - 0.649 \cdot 0.290}{0.110} = 1.021\ \text{W/(m}^2\cdot\text{K)}$$

$$\psi_{ed\,A} = \frac{\Phi}{\Delta T} - U_g \cdot b_g - U_f \cdot b_f = \frac{11.984}{30.000} - 0.900 \cdot 0.290 - 1.021 \cdot 0.110 = 0.026\ \text{W/(m·K)}$$

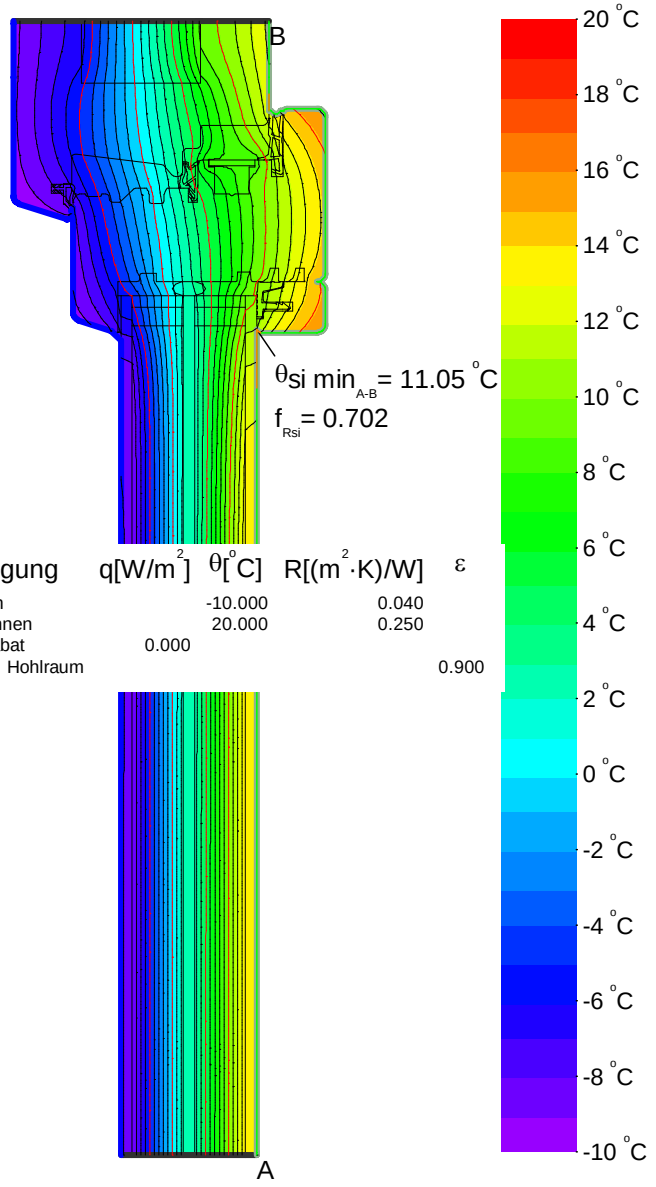


Material	λ[W/(m·K)]	ε
Ar18 in 48 mm U 0,9	0.039	0.900
EPDM	0.250	0.900
EPS - DunPol (grupo Valero) 034	0.034	0.900
Glass I Glas	1.000	0.900
Insulation tape | Vorlegeband 060	0.060	0.900
Jute cord	0.065	0.900
Polysulfide I Polysulfid	0.400	0.900
SWISSP. Ultimate Box 2 [cert]	0.140	0.900
Silicone I Silikon	0.350	0.900
Softwood, OSB I Weichholz, OSB	0.130	0.900
Spruce, Fir I Fichte, Tanne	0.110	0.900
Steel I Stahl	50.000	0.900
Unvent. cavity I unbel. Hohlr. *		

* EN ISO 10077-2:2017, 6.4.2



Randbedingung	q[W/m²]	θ[°C]	R[(m²·K)/W]	ε
Exterior | Außen		-10.000	0.040	
Interior, frame, normal		20.000	0.130	
Interior, frame, reduced		20.000	0.200	
Adiabatic | Adiabat	0.000			
e 0,9 Cavity I Hohlraum				0.900



Randbedingung	q[W/m²]	θ[°C]	R[(m²·K)/W]	ε
Exterior | Außen		-10.000	0.040	
fRsi: Interior | Innen		20.000	0.250	
Adiabatic | Adiabat	0.000			
e 0,9 Cavity I Hohlraum				0.900

$$U_{f\,A,B} = \frac{\frac{\Phi}{\Delta T} - U_p \cdot b_p}{b_f} = \frac{\frac{9.014}{30.000} - 0.649 \cdot 0.290}{0.110} = 1.021\ W/(m^2 \cdot K)$$

$$\psi_{ed\,A} = \frac{\Phi}{\Delta T} - U_g \cdot b_g - U_f \cdot b_f = \frac{11.983}{30.000} - 0.900 \cdot 0.290 - 1.021 \cdot 0.110 = 0.026\ W/(m \cdot K)$$

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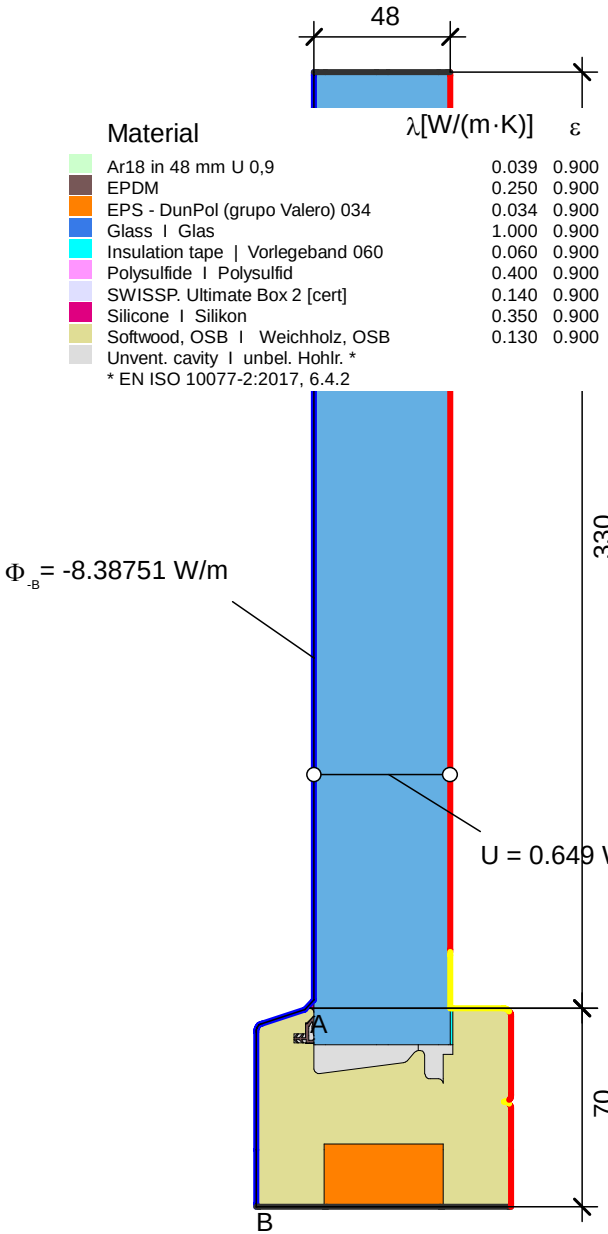
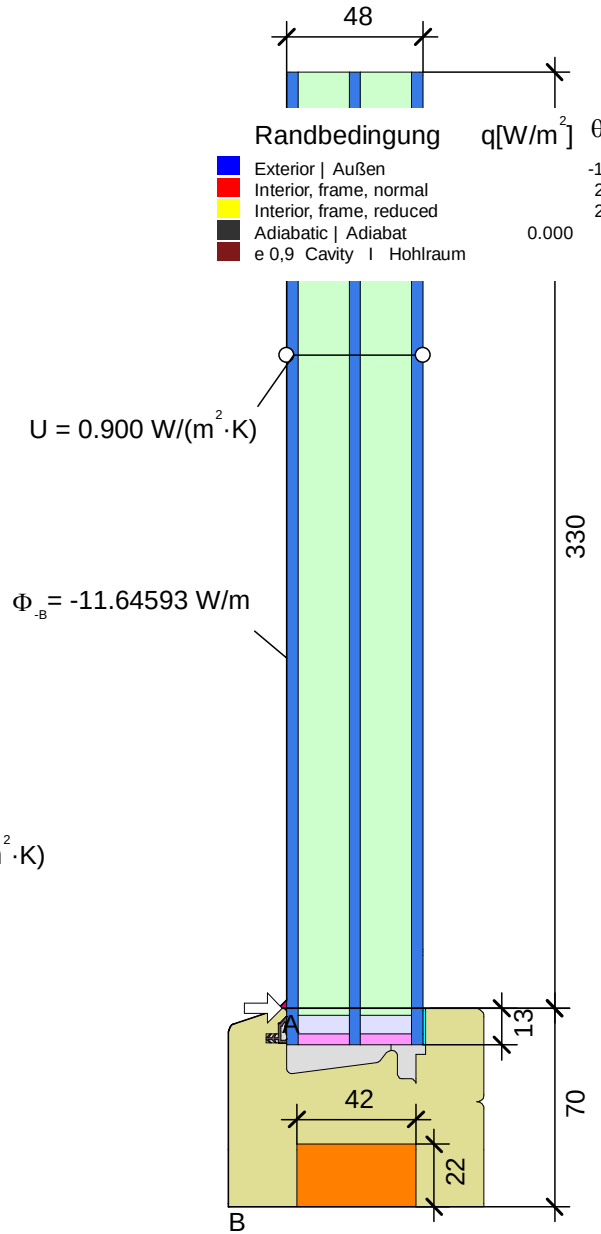
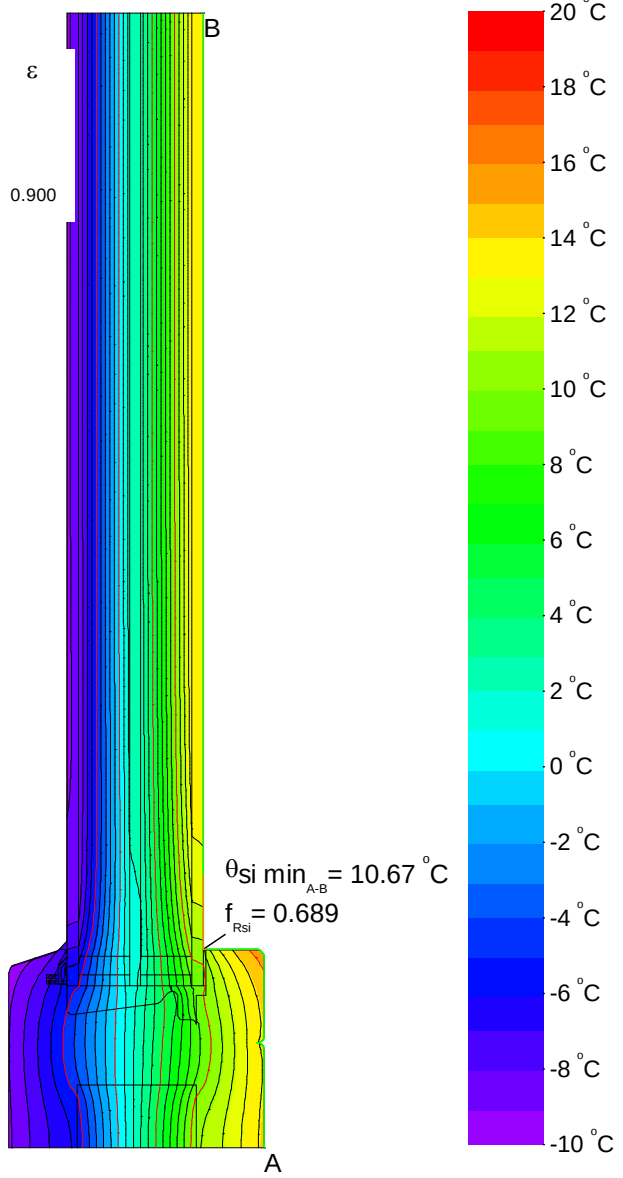
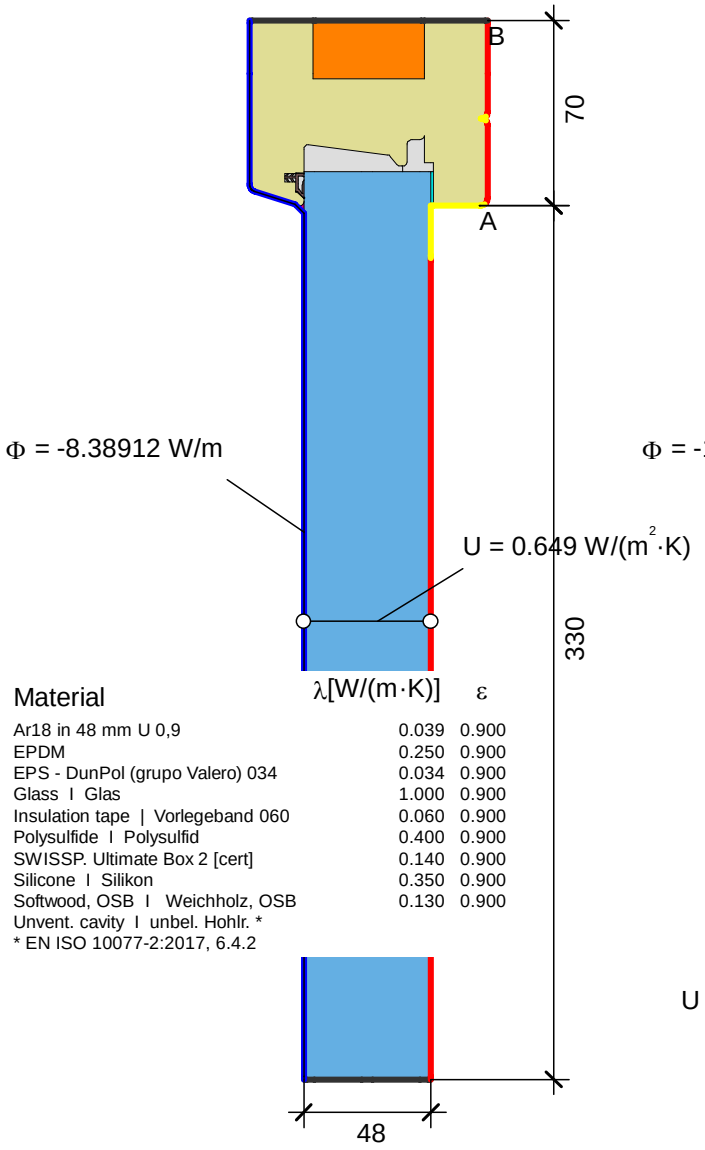


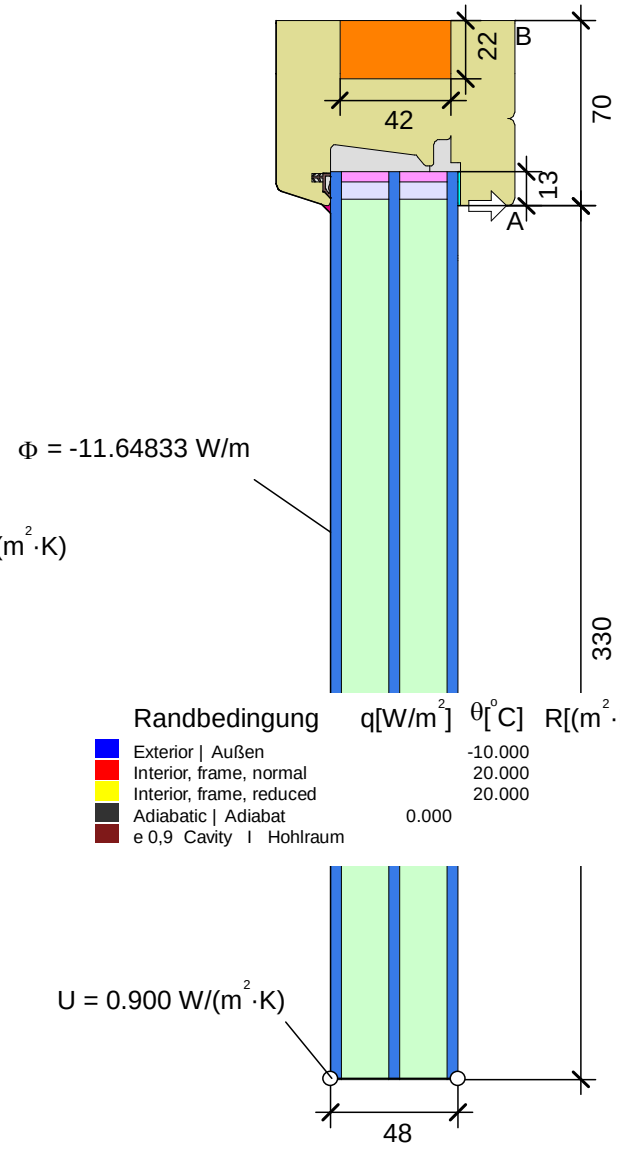


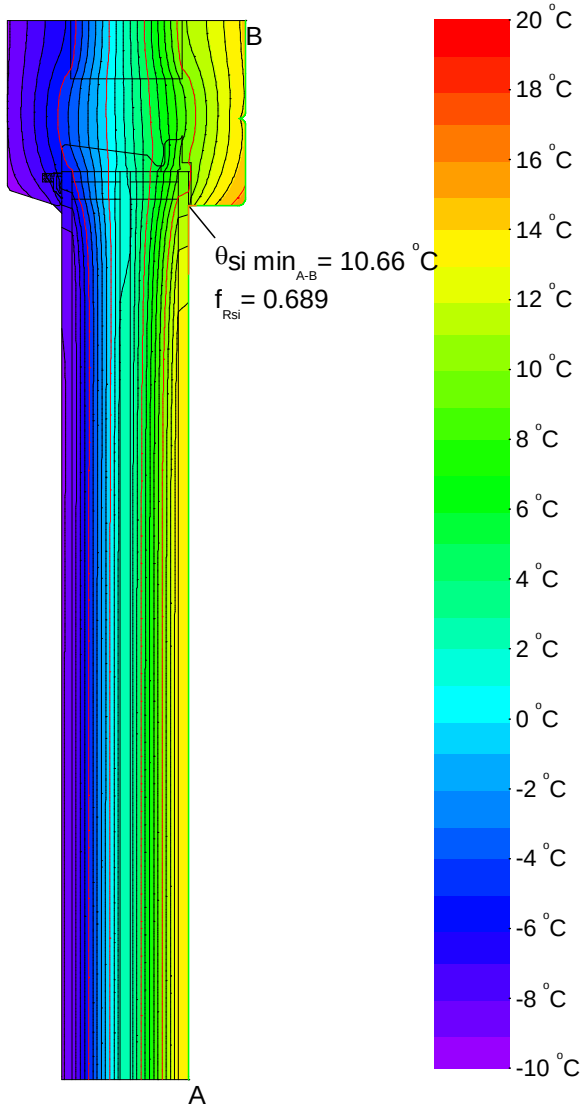


$$U_{f\,A,B} = \frac{\frac{\Phi}{\Delta T} - U_p \cdot b_p}{b_f} = \frac{\frac{8.388}{30.000} - 0.649 \cdot 0.330}{0.070} = 0.936\ W/(m^2 \cdot K)$$

$$\psi_{ed\,A} = \frac{\Phi}{\Delta T} - U_g \cdot b_g - U_f \cdot b_f = \frac{11.646}{30.000} - 0.900 \cdot 0.330 - 0.936 \cdot 0.070 = 0.026\ W/(m \cdot K)$$







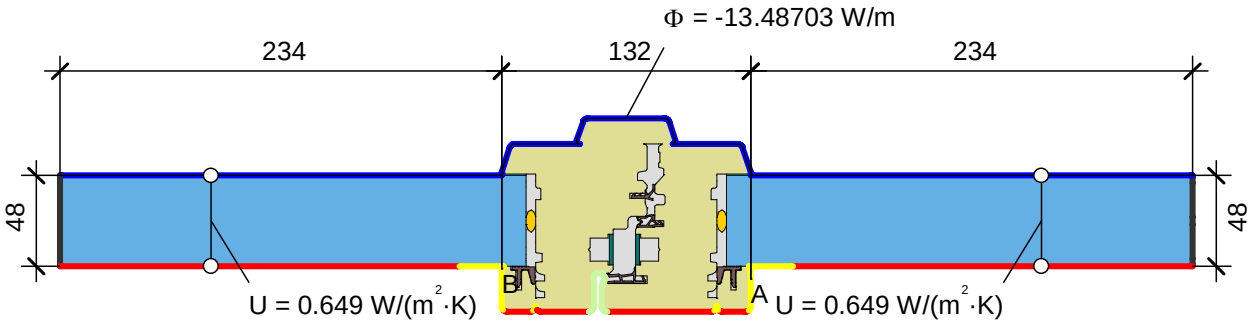
Material	λ[W/(m·K)]	ε
Ar18 in 48 mm U 0,9	0.039	0.900
EPDM	0.250	0.900
EPS - DunPol (grupo Valero) 034	0.034	0.900
Glass I Glas	1.000	0.900
Insulation tape | Vorlegeband 060	0.060	0.900
Polysulfide I Polysulfid	0.400	0.900
SWISSP. Ultimate Box 2 [cert]	0.140	0.900
Silicone I Silikon	0.350	0.900
Softwood, OSB I Weichholz, OSB	0.130	0.900
Unvent. cavity I unbel. Hohlr. *		

* EN ISO 10077-2:2017, 6.4.2

Randbedingung	q[W/m²]	θ[°C]	R[(m²·K)/W]	ε
Exterior | Außen		-10.000	0.040	
Interior, frame, normal		20.000	0.130	
Interior, frame, reduced		20.000	0.200	
Adiabatic | Adiabat	0.000			
e 0,9 Cavity I Hohlraum				0.900

$$U_{f\,A,B} = \frac{\frac{\Phi}{\Delta T} - U_p \cdot b_p}{b_f} = \frac{\frac{8.389}{30.000} - 0.649 \cdot 0.330}{0.070} = 0.936\ \mathrm{W/(m^2 \cdot K)}$$

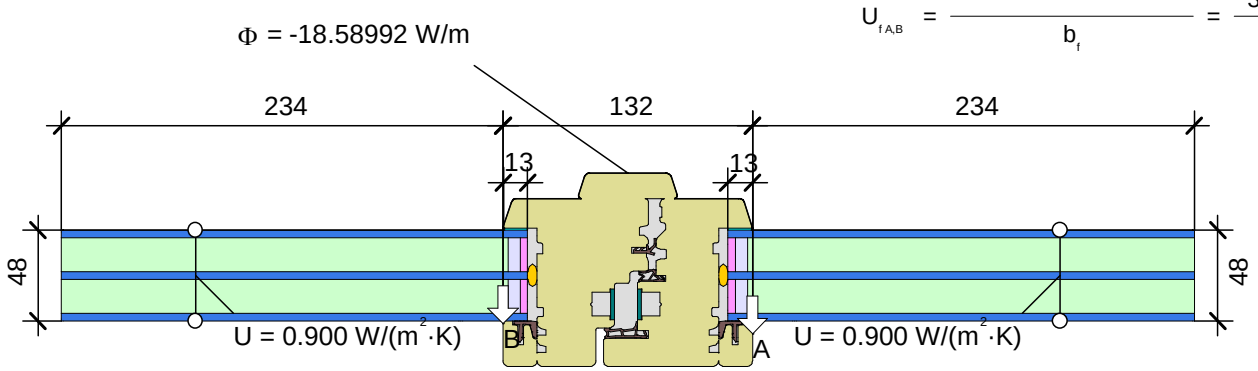
$$\psi_{ed\,A} = \frac{\Phi}{\Delta T} - U_g \cdot b_g - U_f \cdot b_f = \frac{11.648}{30.000} - 0.900 \cdot 0.330 - 0.936 \cdot 0.070 = 0.026\ \mathrm{W/(m \cdot K)}$$



Material	λ[W/(m·K)]	ε
Ar18 in 48 mm U 0,9	0.039	0.900
EPDM	0.250	0.900
Glass I Glas	1.000	0.900
Insulation tape | Vorlegeband 060	0.060	0.900
Jute cord	0.065	0.900
Polysulfide I Polysulfid	0.400	0.900
SWISSP. Ultimate Box 2 [cert]	0.140	0.900
Softwood, OSB I Weichholz, OSB	0.130	0.900
Steel I Stahl	50.000	0.900
Unvent. cavity I unbel. Hohlr. *		

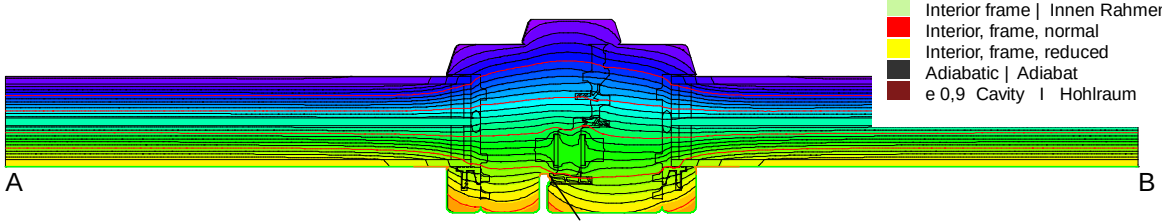
* EN ISO 10077-2:2017, 6.4.2

$$U_{f\,A,B} = \frac{\frac{\Phi}{\Delta T} - U_{p1}\cdot b_{p1} - U_{p2}\cdot b_{p2}}{b_f} = \frac{\frac{13.487}{30.000} - 0.649\cdot 0.234 - 0.649\cdot 0.234}{0.132} = 1.105\ \mathrm{W/(m^2\cdot K)}$$



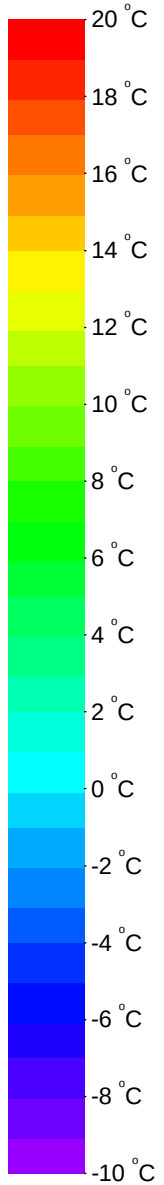
$$\psi_{ed\,A,B} = \frac{\frac{\Phi}{\Delta T} - U_{g1}\cdot b_{g1} - U_f\cdot b_f - U_{g2}\cdot b_{g2}}{2} = \frac{\frac{18.590}{30.000} - 0.900\cdot 0.234 - 1.105\cdot 0.132 - 0.900\cdot 0.234}{2} = 0.026\ \mathrm{W/(m\cdot K)}$$

Randbedingung	q[W/m²]	θ[°C]	R[(m²·K)/W]	ε
Exterior | Außen		-10.000	0.040	
Interior frame | Innen Rahmen, Leicht belüftete Hohlräume		20.000	0.300	
Interior, frame, normal		20.000	0.130	
Interior, frame, reduced		20.000	0.200	
Adiabatic | Adiabat	0.000			
e 0,9 Cavity I Hohlraum				0.900



$\theta_{si\,min_{A-B}} = 10.73\ ^{\circ}C$

$f_{Rsi} = 0.691$



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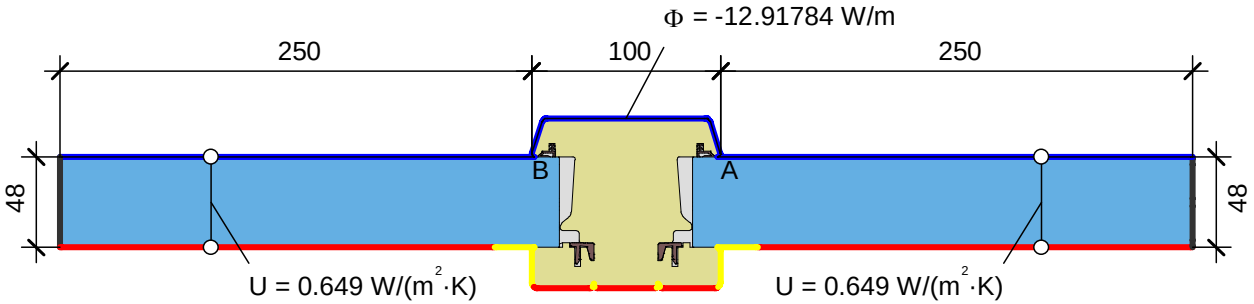
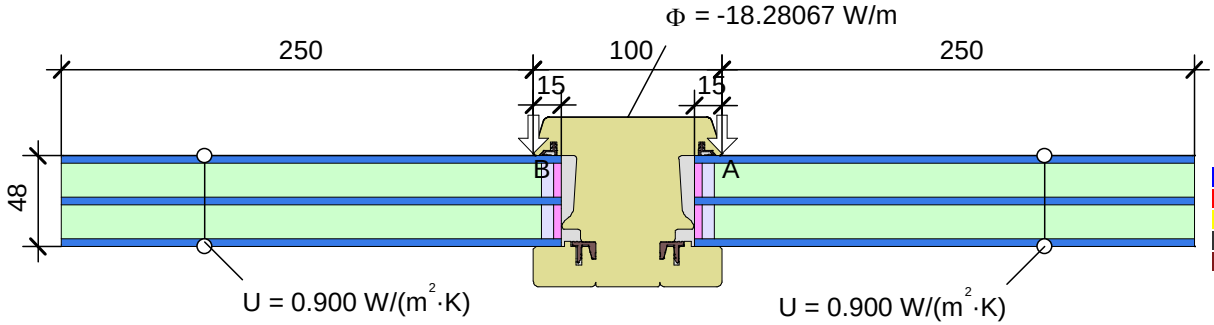


Material	λ[W/(m·K)]	ε
Ar18 in 48 mm U 0,9	0.039	0.900
EPDM	0.250	0.900
Glass I Glas	1.000	0.900
Polysulfide I Polysulfid	0.400	0.900
SWISSP. Ultimate Box 2 [cert]	0.140	0.900
Softwood, OSB I Weichholz, OSB	0.130	0.900
Unvent. cavity I unbel. Hohlr. *		

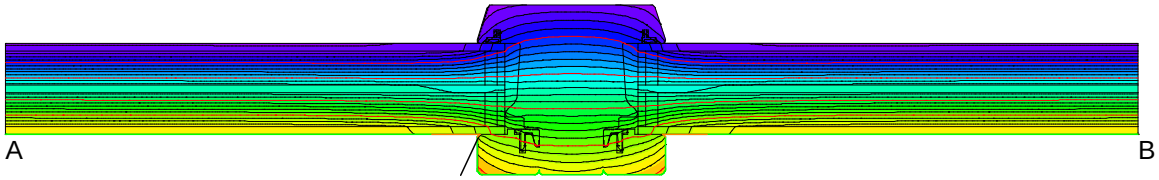
* EN ISO 10077-2:2017, 6.4.2

$$U_{f\,A,B} = \frac{\frac{\Phi}{\Delta T} - U_{p1}\cdot b_{p1} - U_{p2}\cdot b_{p2}}{b_f} = \frac{\frac{12.918}{30.000} - 0.649\cdot 0.250 - 0.649\cdot 0.250}{0.100} = 1.062\ \text{W/(m}^2\cdot\text{K)}$$



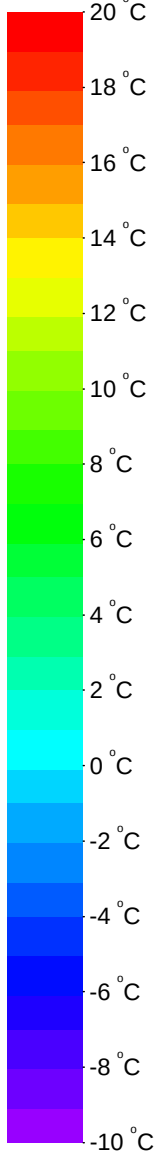
Randbedingung	q[W/m²]	θ[°C]	R[(m²·K)/W]	ε
Exterior | Außen		-10.000	0.040	
Interior, frame, normal		20.000	0.130	
Interior, frame, reduced		20.000	0.200	
Adiabatic | Adiabat	0.000			
e 0,9 Cavity I Hohlraum				0.900

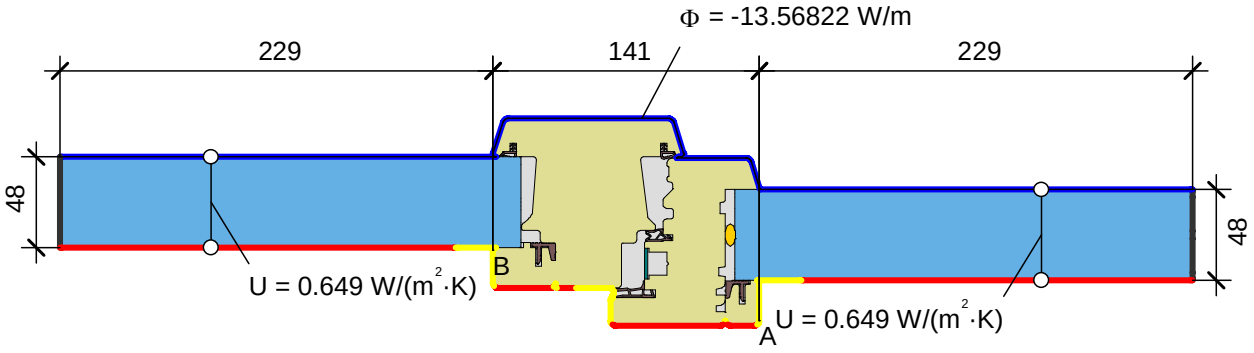
$$\psi_{ed\,A,B} = \frac{\frac{\Phi}{\Delta T} - U_{g1}\cdot b_{g1} - U_f\cdot b_f - U_{g2}\cdot b_{g2}}{2} = \frac{\frac{18.281}{30.000} - 0.900\cdot 0.250 - 1.062\cdot 0.100 - 0.900\cdot 0.250}{2} = 0.027\ \text{W/(m·K)}$$



$\theta_{si\,min_{A-B}} = 10.82\ ^{\circ}C$

$f_{Rsi} = 0.694$

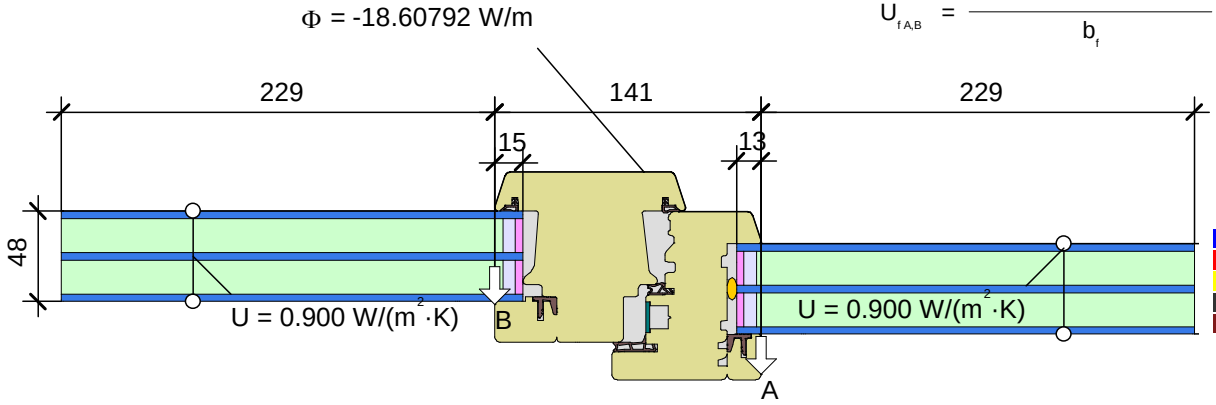




Material	λ[W/(m·K)]	ε
Ar18 in 48 mm U 0,9	0.039	0.900
EPDM	0.250	0.900
Glass I Glas	1.000	0.900
Jute cord	0.065	0.900
Polysulfide I Polysulfid	0.400	0.900
SWISSP. Ultimate Box 2 [cert]	0.140	0.900
Silicone I Silikon	0.350	0.900
Softwood, OSB I Weichholz, OSB	0.130	0.900
Steel I Stahl	50.000	0.900
Unvent. cavity I unbel. Hohlr. *		

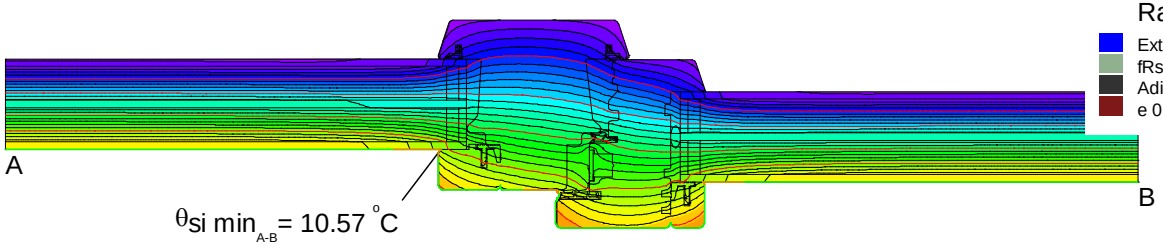
* EN ISO 10077-2:2017, 6.4.2

$$U_{f\,A,B} = \frac{\frac{\Phi}{\Delta T} - U_{p1}\cdot b_{p1} - U_{p2}\cdot b_{p2}}{b_f} = \frac{\frac{13.568}{30.000} - 0.649\cdot 0.229 - 0.649\cdot 0.229}{0.141} = 1.095\ \mathrm{W/(m^2\cdot K)}$$

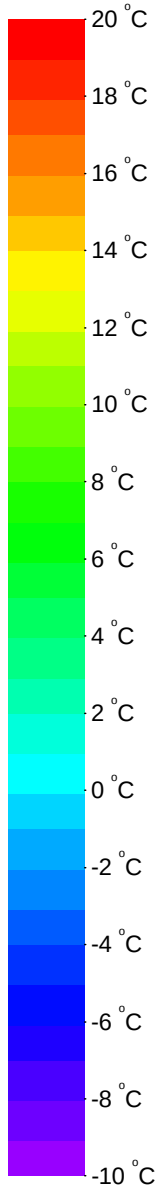


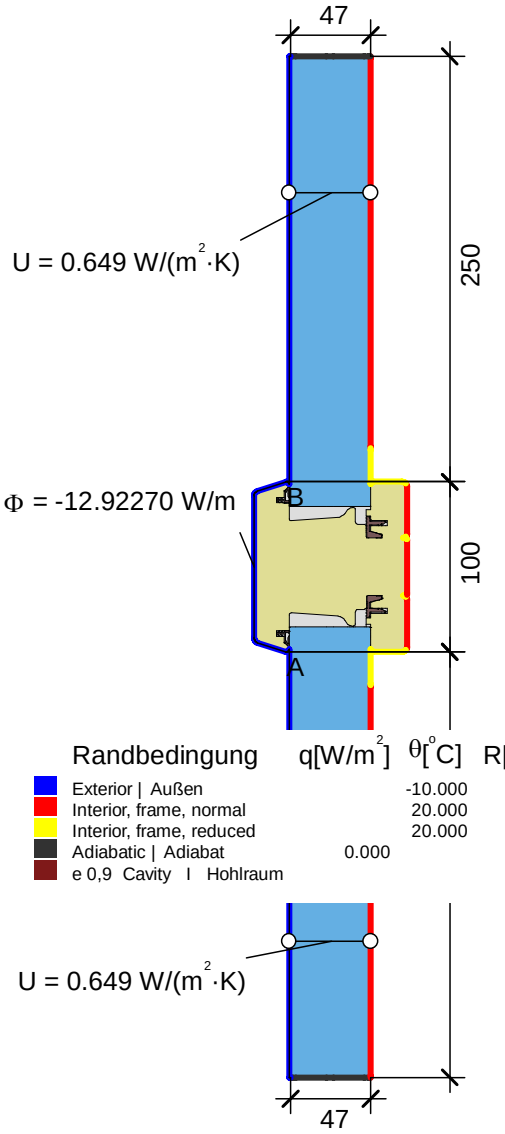
Randbedingung	q[W/m²]	θ[°C]	R[(m²·K)/W]	ε
Exterior | Außen		-10.000	0.040	
Interior, frame, normal		20.000	0.130	
Interior, frame, reduced		20.000	0.200	
Adiabatic | Adiabat	0.000			
e 0,9 Cavity I Hohlraum				0.900

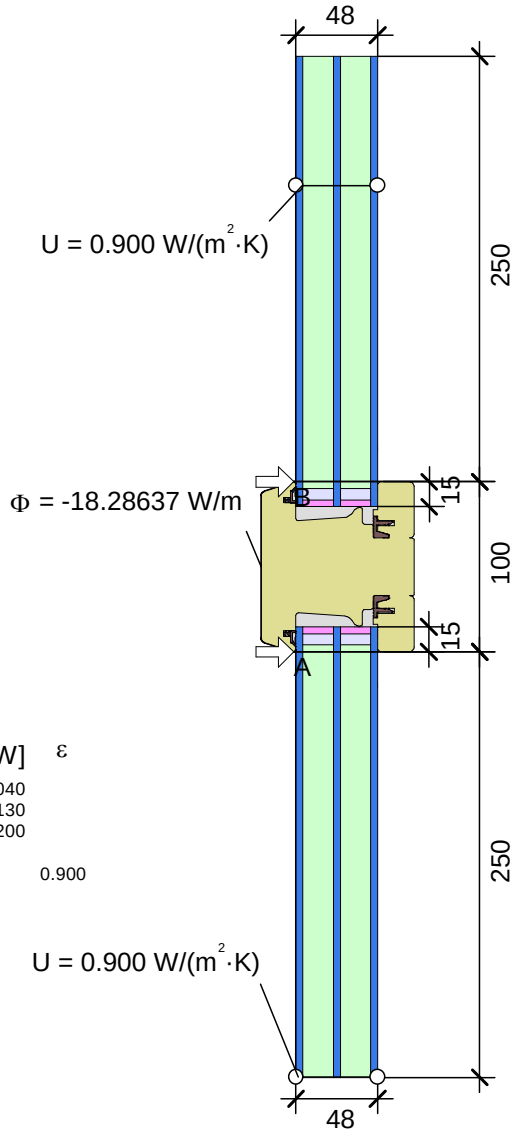
$$\psi_{ed\,A,B} = \frac{\frac{\Phi}{\Delta T} - U_{g1}\cdot b_{g1} - U_f\cdot b_f - U_{g2}\cdot b_{g2}}{2} = \frac{\frac{18.608}{30.000} - 0.900\cdot 0.229 - 1.095\cdot 0.141 - 0.900\cdot 0.229}{2} = 0.026\ \mathrm{W/(m\cdot K)}$$

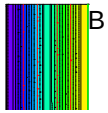


Randbedingung	q[W/m²]	θ[°C]	R[(m²·K)/W]	ε
Exterior | Außen		-10.000	0.040	
fRsi: Interior | Innen		20.000	0.250	
Adiabatic | Adiabat	0.000			
e 0,9 Cavity I Hohlraum				0.900





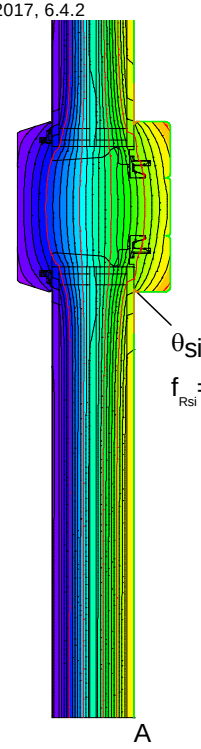


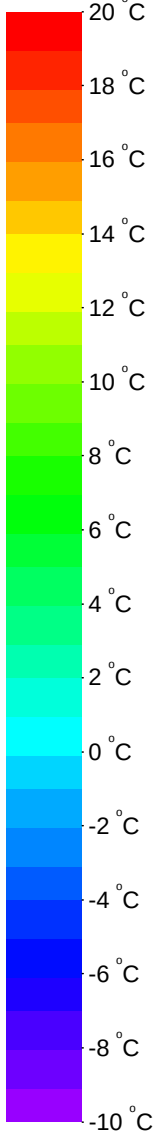


Material

	λ[W/(m·K)]	ε
Ar18 in 48 mm U 0,9	0.039	0.900
EPDM	0.250	0.900
Glass I Glas	1.000	0.900
Polysulfide I Polysulfid	0.400	0.900
SWISSP. Ultimate Box 2 [cert]	0.140	0.900
Softwood, OSB I Weichholz, OSB	0.130	0.900
Unvent. cavity I unbel. Hohlr. *		

* EN ISO 10077-2:2017, 6.4.2

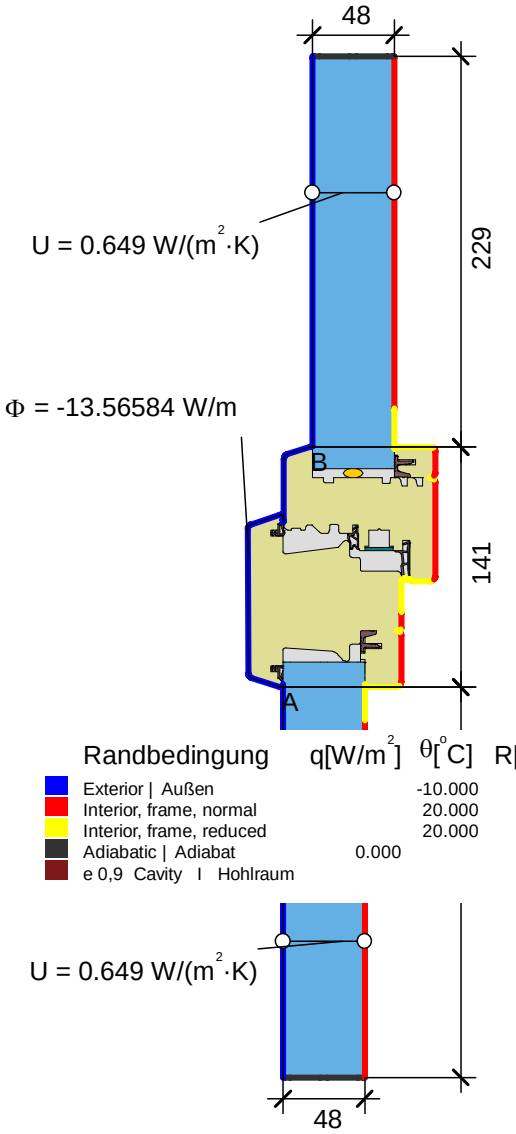


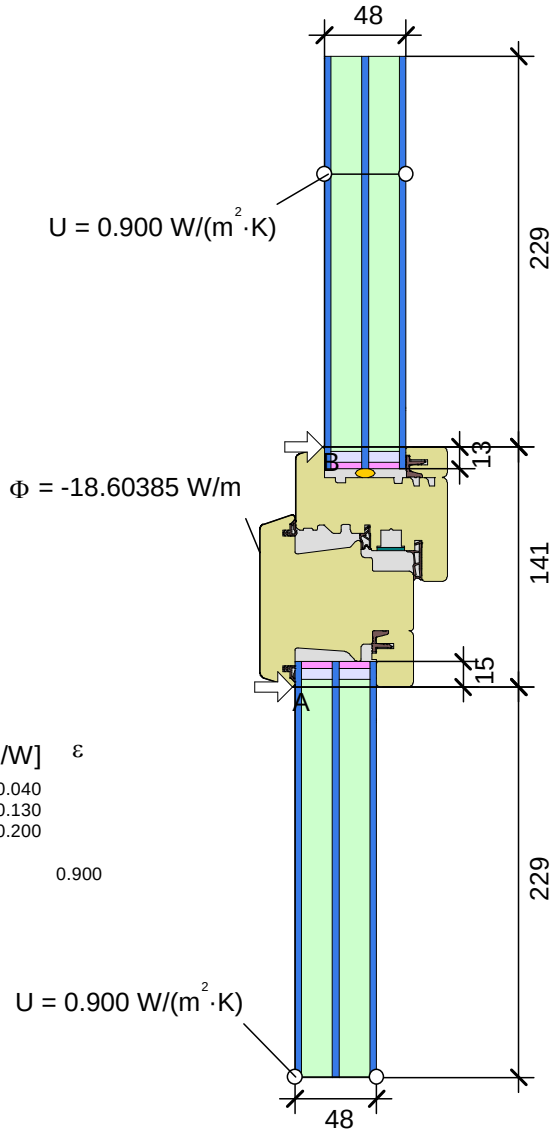


Randbedingung	q[W/m²]	θ[°C]	R[(m²·K)/W]	ε
Exterior | Außen		-10.000	0.040	
Interior, frame, normal		20.000	0.130	
Interior, frame, reduced		20.000	0.200	
Adiabatic | Adiabat	0.000			
e 0,9 Cavity I Hohlraum				0.900

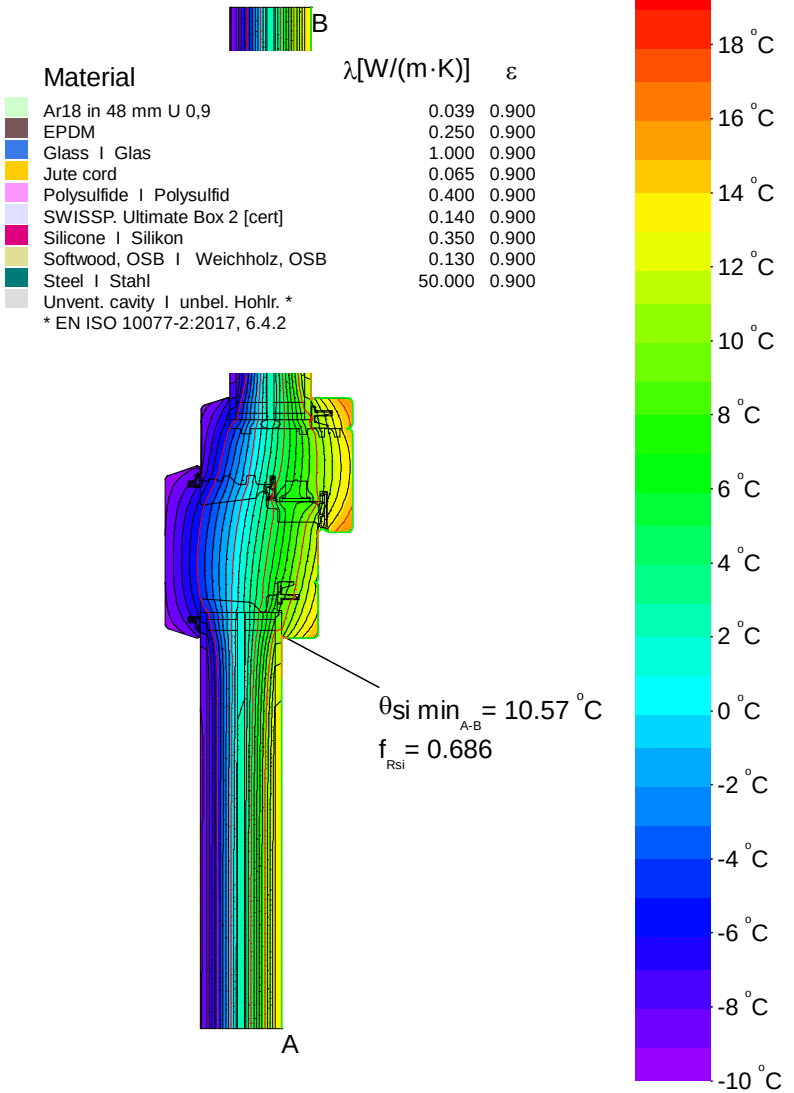
$$U_{f\,A,B} = \frac{\frac{\Phi}{\Delta T} - U_{p1}\cdot b_{p1} - U_{p2}\cdot b_{p2}}{b_f} = \frac{\frac{12.923}{30.000} - 0.649\cdot 0.250 - 0.649\cdot 0.250}{0.100} = 1.064\ W/(m^2\cdot K)$$

$$\psi_{ed\,A,B} = \frac{\frac{\Phi}{\Delta T} - U_{g1}\cdot b_{g1} - U_f\cdot b_f - U_{g2}\cdot b_{g2}}{2} = \frac{\frac{18.286}{30.000} - 0.900\cdot 0.250 - 1.064\cdot 0.100 - 0.900\cdot 0.250}{2} = 0.027\ W/(m\cdot K)$$





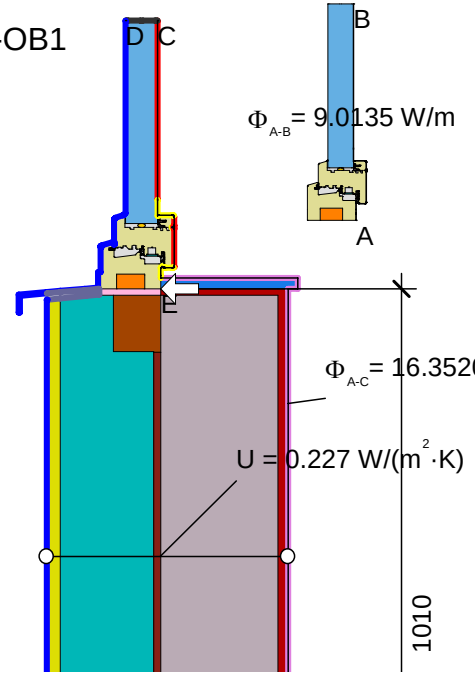
Randbedingung	q[W/m²]	θ[°C]	R[(m²·K)/W]	ε
Exterior | Außen		-10.000	0.040	
Interior, frame, normal		20.000	0.130	
Interior, frame, reduced		20.000	0.200	
Adiabatic | Adiabat	0.000			
e 0,9 Cavity I Hohlraum				0.900

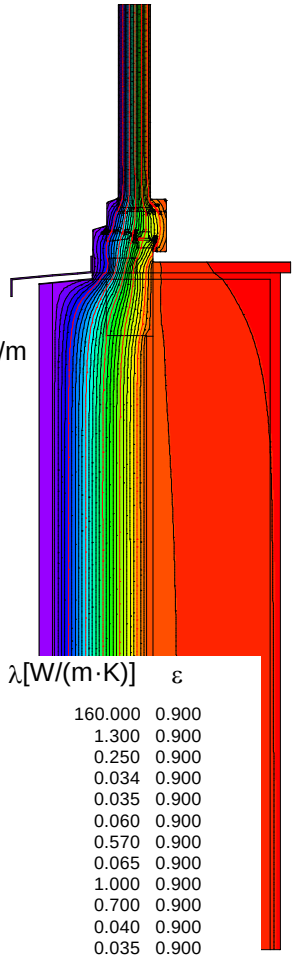


$$U_{f\,A,B} = \frac{\frac{\Phi}{\Delta T} - U_{p1}\cdot b_{p1} - U_{p2}\cdot b_{p2}}{b_f} = \frac{\frac{13.566}{30.000} - 0.649\cdot 0.229 - 0.649\cdot 0.229}{0.141} = 1.095\ W/(m^2\cdot K)$$

$$\psi_{ed\,A,B} = \frac{\frac{\Phi}{\Delta T} - U_{g1}\cdot b_{g1} - U_f\cdot b_f - U_{g2}\cdot b_{g2}}{2} = \frac{\frac{18.604}{30.000} - 0.900\cdot 0.229 - 1.095\cdot 0.141 - 0.900\cdot 0.229}{2} = 0.026\ W/(m\cdot K)$$

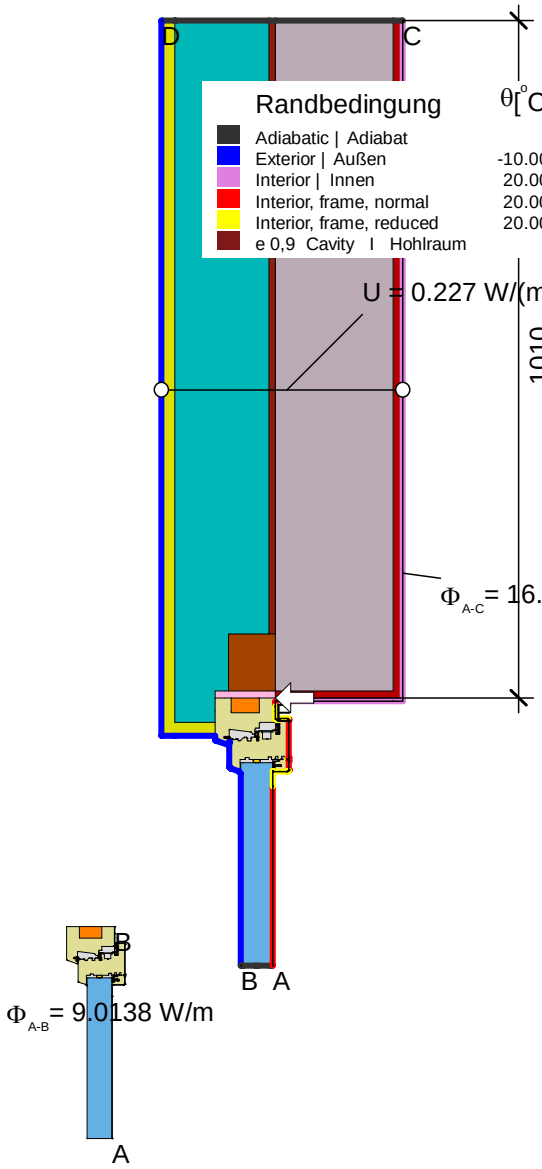
EW1-OB1



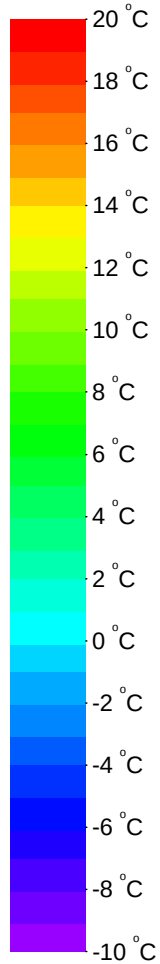


Material	λ[W/(m·K)]	ε
Aluminum I Aluminium 10456	160.000	0.900
Artificial stone I Kunststein 10456	1.300	0.900
EPDM	0.250	0.900
EPS - DunPol (grupo Valero) 034	0.034	0.900
Insulation I Wärmedämmung 035	0.035	0.900
Insulation tape | Vorlegeband 060	0.060	0.900
Interior plaster I Gipsputz 10456	0.570	0.900
Jute cord	0.065	0.900
Mörtel, Zement, Sand	1.000	0.900
Organic compound plaster I Kunstharzputz 4108-4	0.700	0.900
PU in-situ foam I PU-Ortschaum 040	0.040	0.900
Panel I Maske	0.035	0.900
Rigid EPS-foam incl. screws | Fester EPS-Schaum inkl. Schrauben	0.045	0.900
Sand-lime stone I Kalksandstein 1745	1.000	0.900
Silicone I Silikon	0.350	0.900
Softwood, OSB I Weichholz, OSB	0.130	0.900
Spruce, Fir I Fichte, Tanne	0.110	0.900
Steel I Stahl	50.000	0.900
Unvent. cavity I unbel. Hohlr. *		

* EN ISO 10077-2:2017, 6.4.2



Randbedingung	θ[°C]	R[(m²·K)/W]	ε
Adiabatic | Adiabat			
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

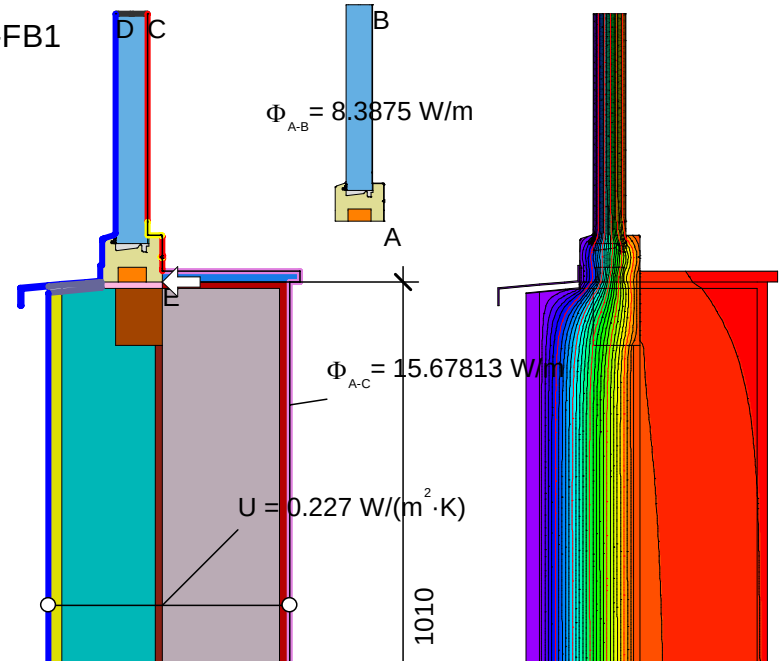


EW1-OH1

$$\psi_{A\text{-}E\text{-}C,*} = \frac{\Phi}{\Delta T} - U_1 \cdot b_1 - \frac{\Phi_2}{\Delta T} = \frac{16.352}{30.000} - 0.227 \cdot 1.010 - \frac{9.013}{30.000} = 0.015\ \text{W/(m·K)}$$

$$\psi_{A\text{-}E\text{-}C,*} = \frac{\Phi}{\Delta T} - \frac{\Phi_1}{\Delta T} - U_2 \cdot b_2 = \frac{16.027}{30.000} - \frac{9.014}{30.000} - 0.227 \cdot 1.010 = 0.005\ \text{W/(m·K)}$$

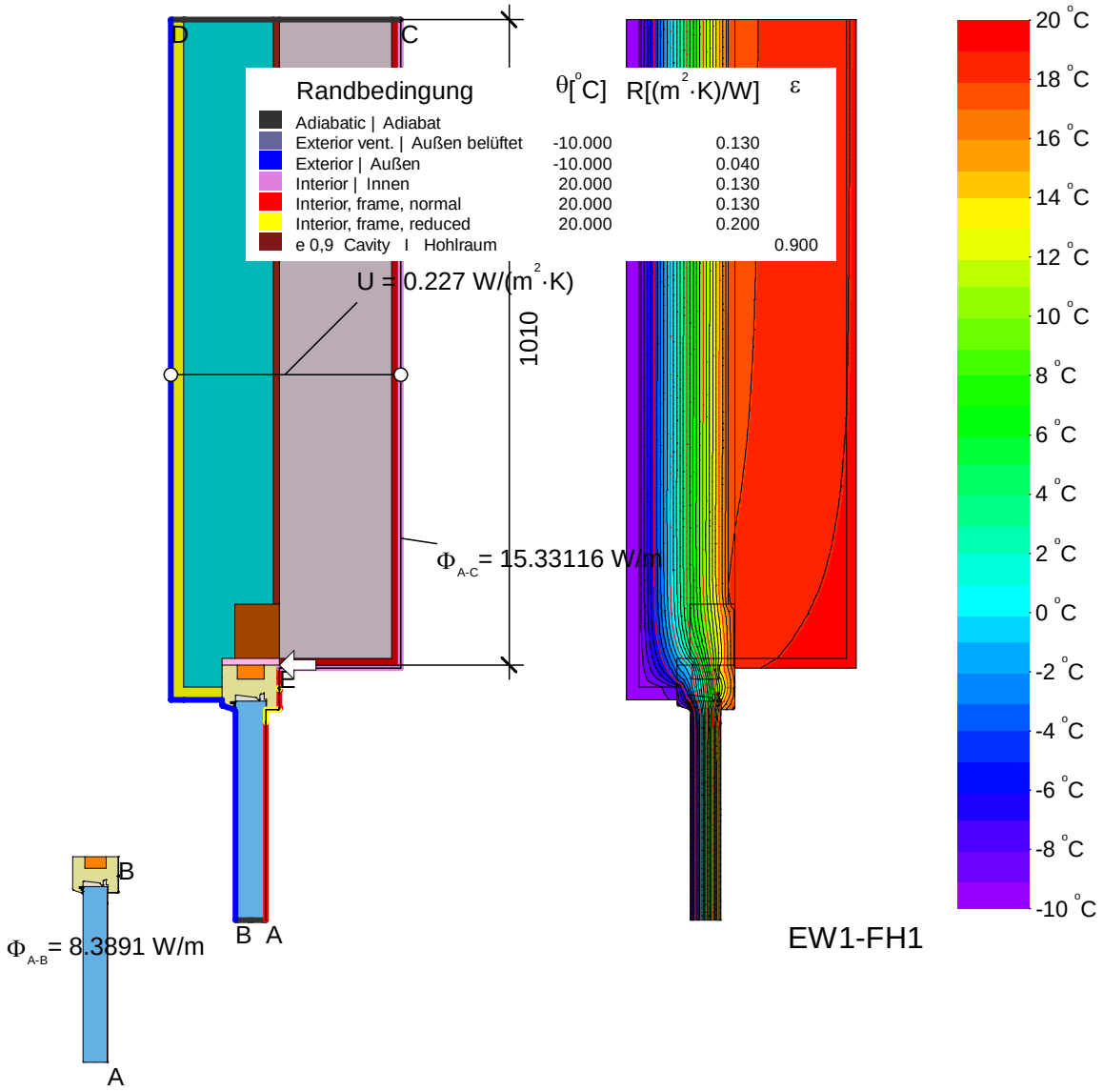
EW1-FB1



Material

	λ[W/(m·K)]	ε
Aluminum I Aluminium 10456	160.000	0.900
Artificial stone I Kunststein 10456	1.300	0.900
EPDM	0.250	0.900
EPS - DunPol (grupo Valero) 034	0.034	0.900
Insulation I Wärmedämmung 035	0.035	0.900
Insulation tape | Vorlegeband 060	0.060	0.900
Interior plaster I Gipsputz 10456	0.570	0.900
Mörtel, Zement, Sand	1.000	0.900
Organic compound plaster I Kunstharzputz 4108-4	0.700	0.900
PU in-situ foam I PU-Ortschaum 040	0.040	0.900
Panel I Maske	0.035	0.900
Rigid EPS-foam incl. screws | Fester EPS-Schaum inkl. Schrauben	0.045	0.900
Sand-lime stone I Kalksandstein 1745	1.000	0.900
Silicone I Silikon	0.350	0.900
Softwood, OSB I Weichholz, OSB	0.130	0.900
Unvent. cavity I unbel. Hohlr. *		

* EN ISO 10077-2:2017, 6.4.2



EW1-FH1

$$\psi_{A\text{-}E\text{-}C,\,*} = \frac{\Phi}{\Delta T} - U_1 \cdot b_1 - \frac{\Phi_2}{\Delta T} = \frac{15.678}{30.000} - 0.227 \cdot 1.010 - \frac{8.388}{30.000} = 0.014\ \text{W/(m·K)}$$

$$\psi_{A\text{-}E\text{-}C,\,*} = \frac{\Phi}{\Delta T} - \frac{\Phi_1}{\Delta T} - U_2 \cdot b_2 = \frac{15.331}{30.000} - \frac{8.389}{30.000} - 0.227 \cdot 1.010 = 0.002\ \text{W/(m·K)}$$

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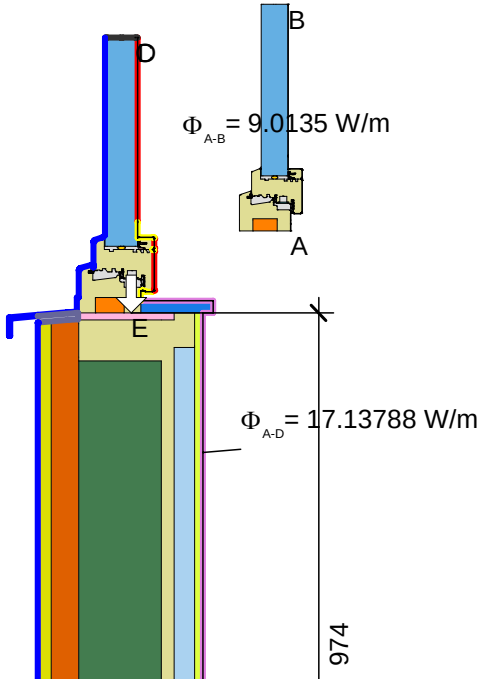
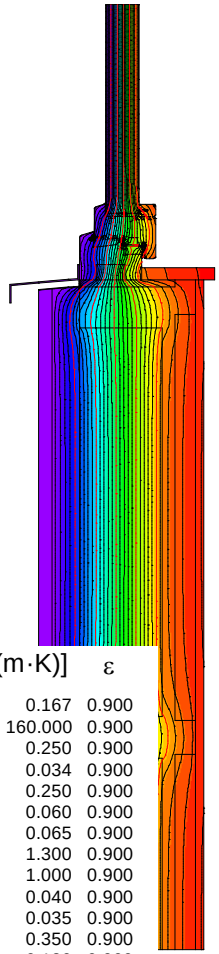
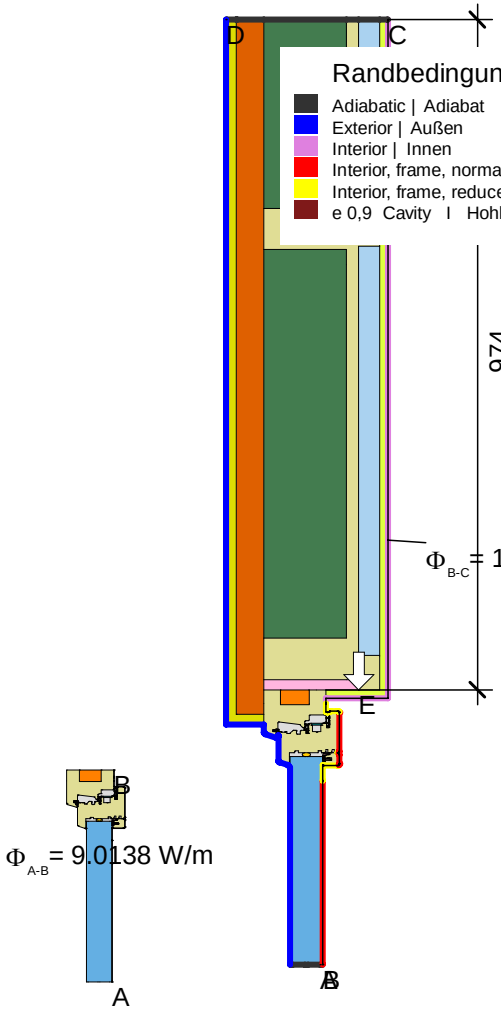
EW2-OB1

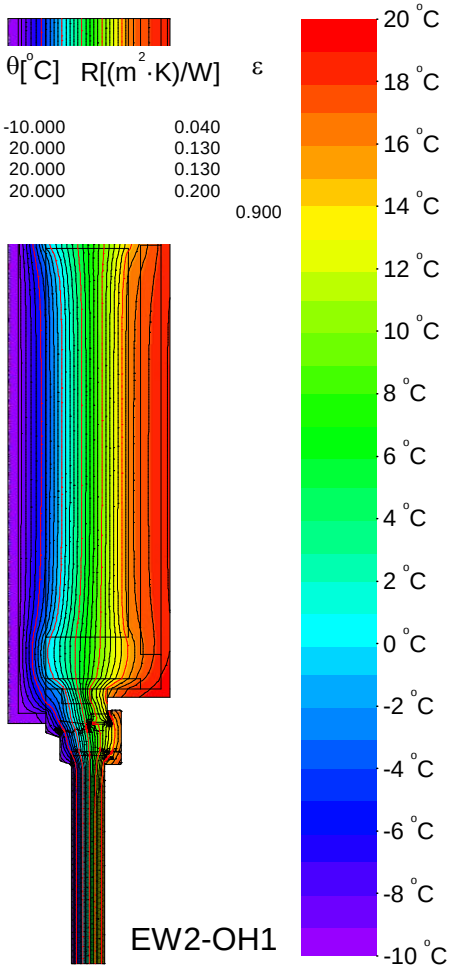




Material	λ[W/(m·K)]	ε
Airgap, static, horizontal | Luftschicht, ruhend, horizontal, 30 mm	0.167	0.900
Aluminum I Aluminium 10456	160.000	0.900
EPDM	0.250	0.900
EPS - DunPol (grupo Valero) 034	0.034	0.900
Gipskartonplatten 900 kg/m3 10456	0.250	0.900
Insulation tape | Vorlegeband 060	0.060	0.900
Jute cord	0.065	0.900
Kunststein 10456	1.300	0.900
Mörtel, Zement, Sand	1.000	0.900
PU in-situ foam I PU-Ortschaum 040	0.040	0.900
Panel I Maske	0.035	0.900
Silicone I Silikon	0.350	0.900
Softwood, OSB I Weichholz, OSB	0.130	0.900
Spruce, Fir I Fichte, Tanne	0.110	0.900
Steel I Stahl	50.000	0.900
Unvent. cavity I unbel. Hohlr. *		
Wood fiber board | Holzfaserplatte 050	0.050	0.900
Zellulose 040	0.040	0.900

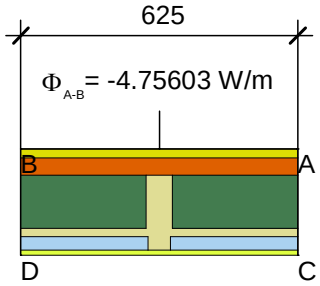
* EN ISO 10077-2:2017, 6.4.2





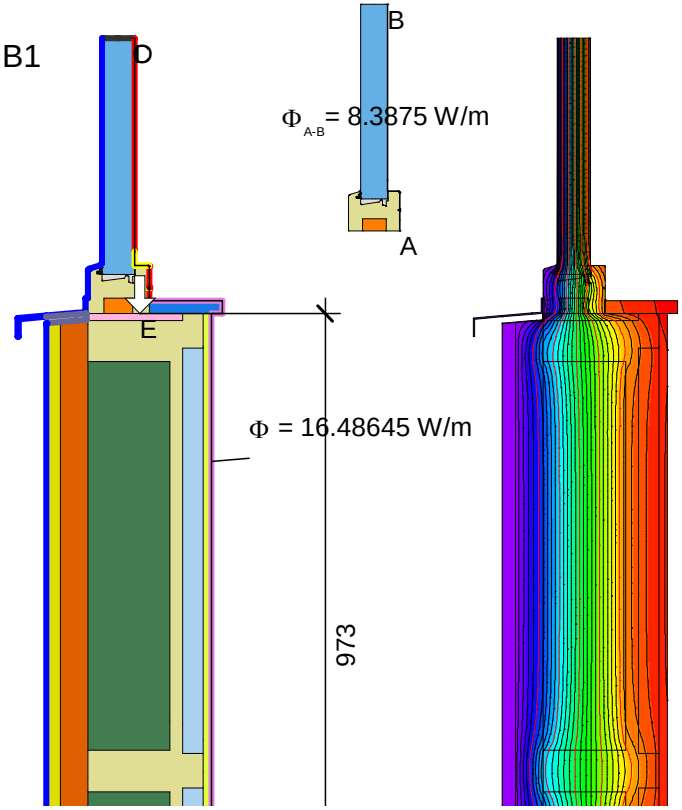
$$\psi_{A\text{-}E\text{-}C,*} = \frac{\Phi}{\Delta T} - \frac{\Phi_1}{\Delta T} - U_2 \cdot b_2 = \frac{16.749}{30.000} - \frac{9.014}{30.000} - 0.254 \cdot 0.974 = 0.011 \text{ W/(m·K)}$$

$$\psi_{A\text{-}E\text{-}C,*} = \frac{\Phi}{\Delta T} - U_1 \cdot b_1 - \frac{\Phi_2}{\Delta T} = \frac{17.138}{30.000} - 0.254 \cdot 0.974 - \frac{9.013}{30.000} = 0.024 \text{ W/(m·K)}$$



$$U_{eq\ A\text{-}B} = \frac{\Phi}{\Delta T \cdot b} = \frac{4.756}{30.000 \cdot 0.625} = 0.254 \text{ W/(m}^2\text{·K)}$$

EW2-FB1



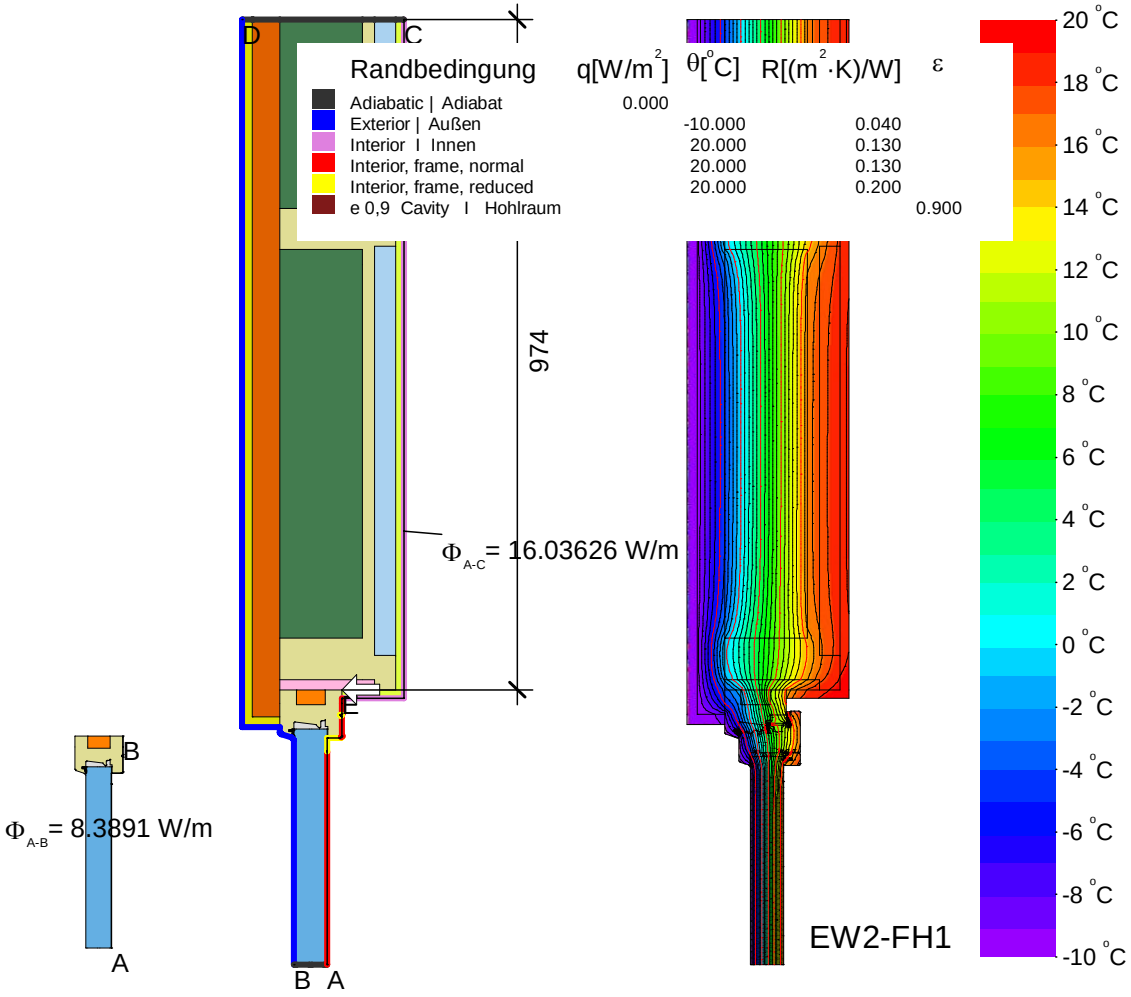
Material

	λ[W/(m·K)]	ε
Airgap, static, horizontal | Luftschicht, ruhend, horizontal, 30 mm	0.167	0.900
Aluminum I Aluminium 10456	160.000	0.900
EPDM	0.250	0.900
EPS - DunPol (grupo Valero) 034	0.034	0.900
Gipskartonplatten 900 kg/m3 10456	0.250	0.900
Insulation tape | Vorlegeband 060	0.060	0.900
Kunststein 10456	1.300	0.900
Mörtel, Zement, Sand	1.000	0.900
PU in-situ foam I PU-Ortschaum 040	0.040	0.900
Panel I Maske	0.035	0.900
Silicone I Silikon	0.350	0.900
Softwood, OSB I Weichholz, OSB	0.130	0.900
Wood fiber board | Holzfaserplatte 050	0.050	0.900
Zellulose 040	0.040	0.900
Unvent. cavity I unbel. Hohlr. *		

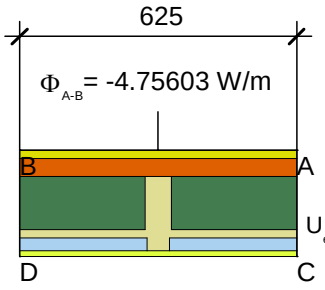
* EN ISO 10077-2:2017, 6.4.2

$$\psi_{A\text{-}E\text{-}C,*} = \frac{\Phi}{\Delta T} - U_1 \cdot b_1 - \frac{\Phi_2}{\Delta T} = \frac{16.468}{30.000} - 0.254 \cdot 0.973 - \frac{8.388}{30.000} = 0.023\ \text{W/(m·K)}$$

EW2-FH1

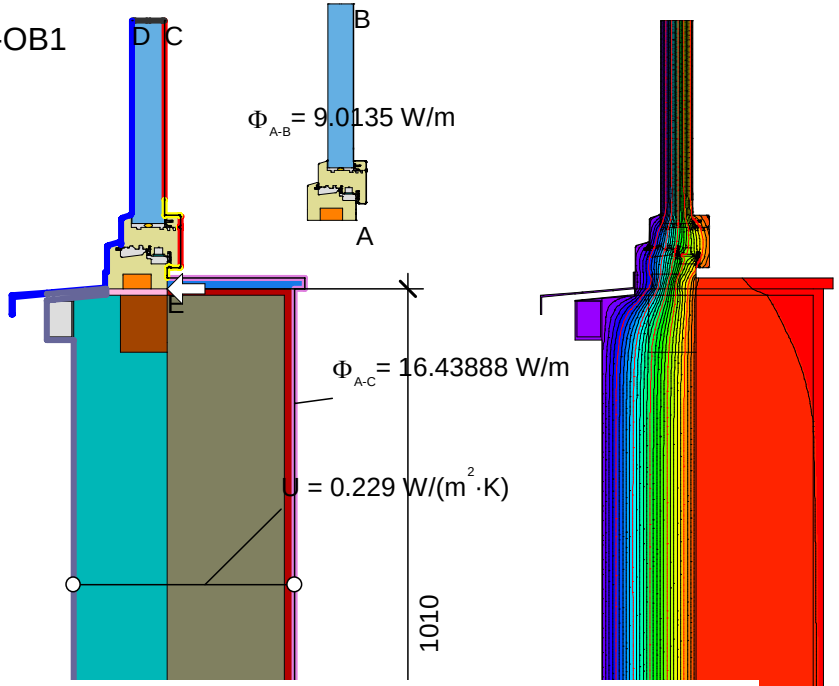


$$\psi_{A\text{-}E\text{-}C,*} = \frac{\Phi}{\Delta T} - U_1 \cdot b_1 - \frac{\Phi_2}{\Delta T} = \frac{16.036}{30.000} - 0.254 \cdot 0.974 - \frac{8.389}{30.000} = 0.008\ \text{W/(m·K)}$$



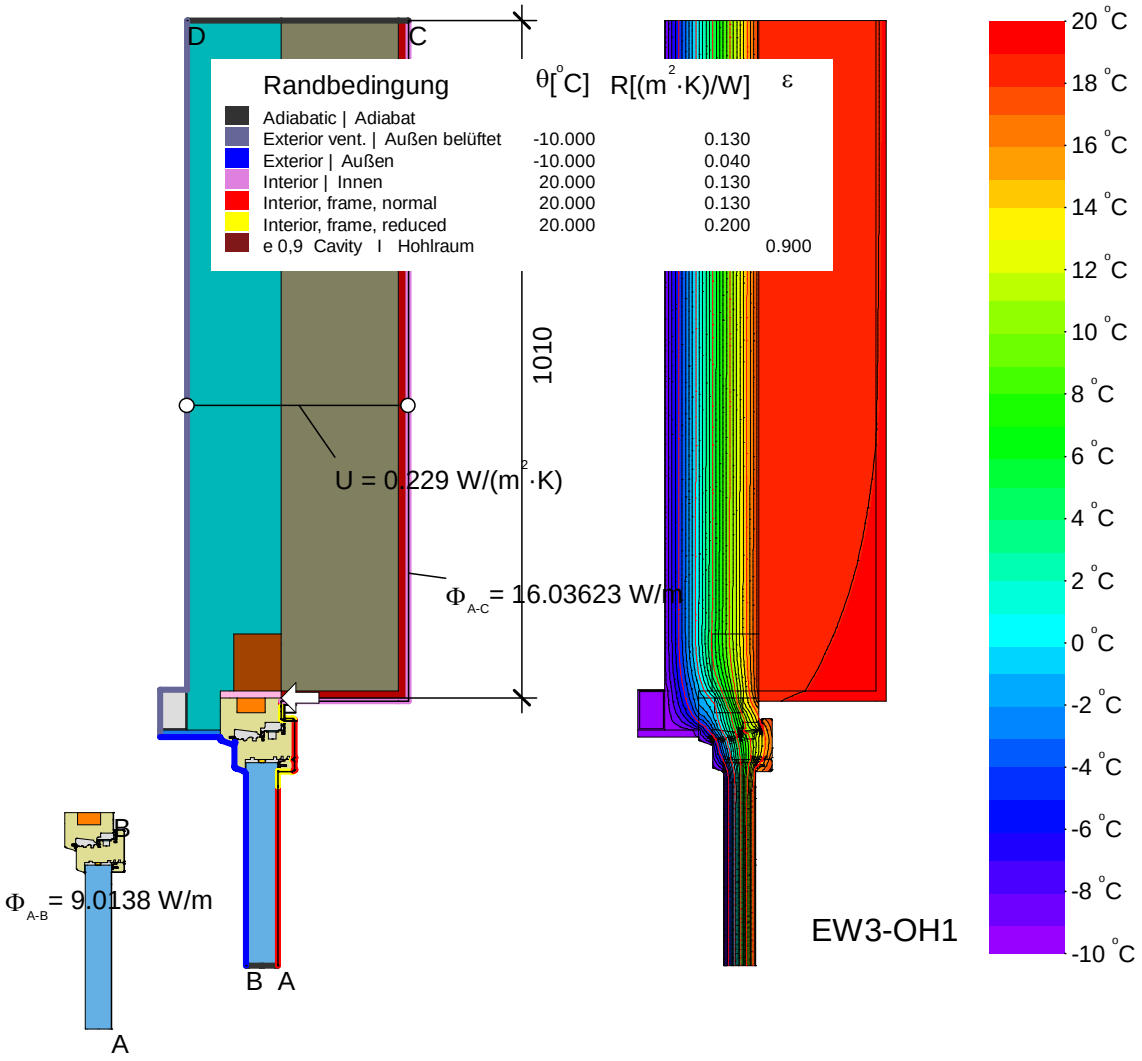
$$U_{eq\ A\text{-}B} = \frac{\Phi}{\Delta T \cdot b} = \frac{4.756}{30.000 \cdot 0.625} = 0.254\ \text{W/(m²·K)}$$

EW3-OB1



Material	λ[W/(m·K)]	ε
Aluminum I Aluminium 10456	160.000	0.900
Artificial stone I Kunststein 10456	1.300	0.900
Concrete, 1% Steel I Beton, 1% Stahl 10456	2.300	0.900
EPDM	0.250	0.900
EPS - DunPol (grupo Valero) 034	0.034	0.900
Insulation I Wärmedämmung 035	0.035	0.900
Insulation tape I Vorlegeband 060	0.060	0.900
Interior plaster I Gipsputz 10456	0.570	0.900
Jute cord	0.065	0.900
PU in-situ foam I PU-Ortschaum 040	0.040	0.900
Panel I Maske	0.035	0.900
Rigid EPS-foam incl. screws | Fester EPS-Schaum inkl. Schrauben	0.045	0.900
Silicone I Silikon	0.350	0.900
Softwood, OSB I Weichholz, OSB	0.130	0.900
Spruce, Fir I Fichte, Tanne	0.110	0.900
Steel I Stahl	50.000	0.900
Unvent. cavity I unbel. Hohlr. *		

* EN ISO 10077-2:2017, 6.4.2

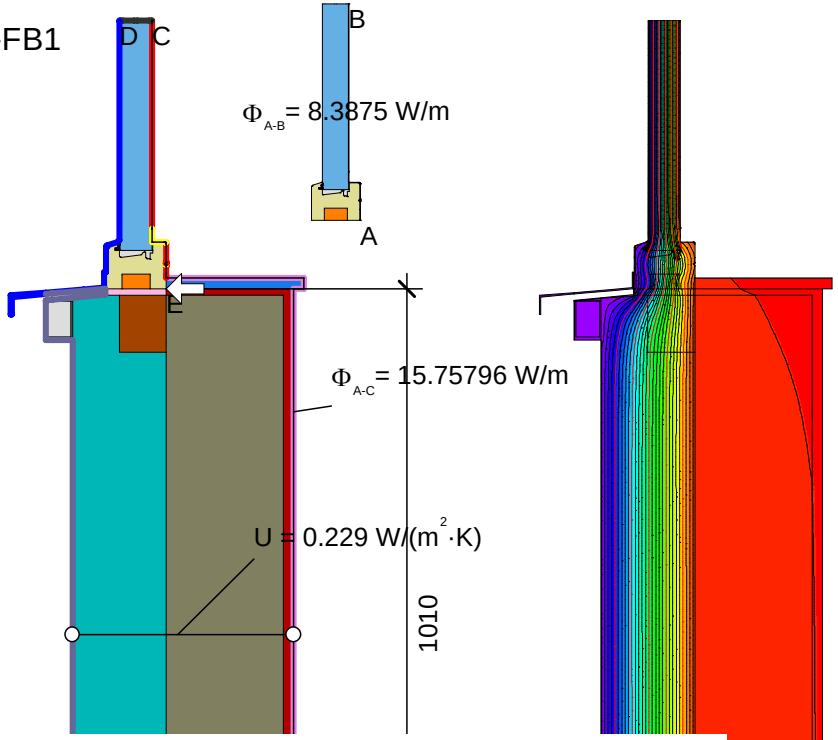


EW3-OH1

$$\psi_{A\text{-}E\text{-}C,*} = \frac{\Phi}{\Delta T} - U_1 \cdot b_1 - \frac{\Phi_2}{\Delta T} = \frac{16.439}{30.000} - 0.229 \cdot 1.010 - \frac{9.013}{30.000} = 0.016 \text{ W/(m·K)}$$

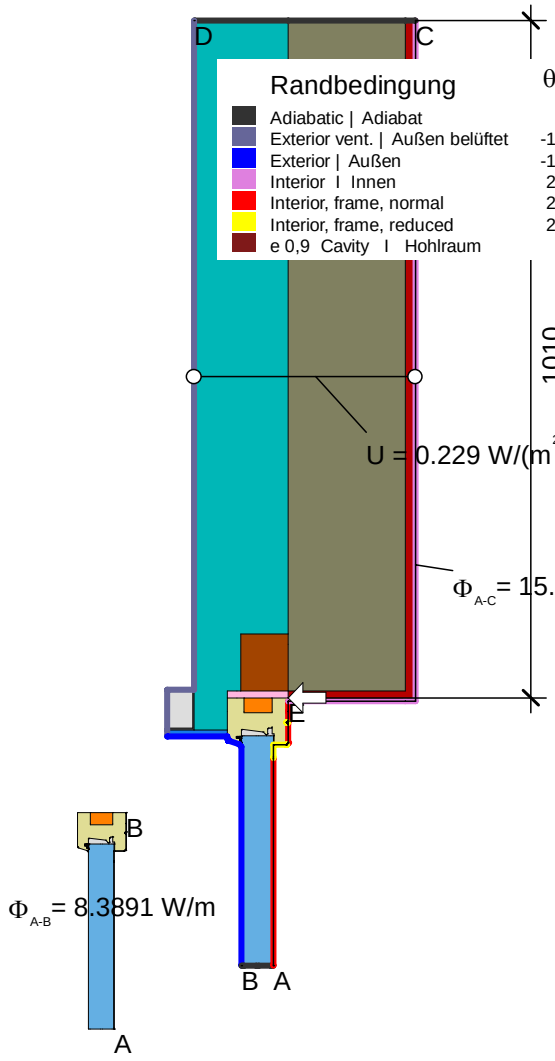
$$\psi_{A\text{-}E\text{-}C,*} = \frac{\Phi}{\Delta T} - \frac{\Phi_1}{\Delta T} - U_2 \cdot b_2 = \frac{16.036}{30.000} - \frac{9.014}{30.000} - 0.229 \cdot 1.010 = 0.003 \text{ W/(m·K)}$$

EW3-FB1

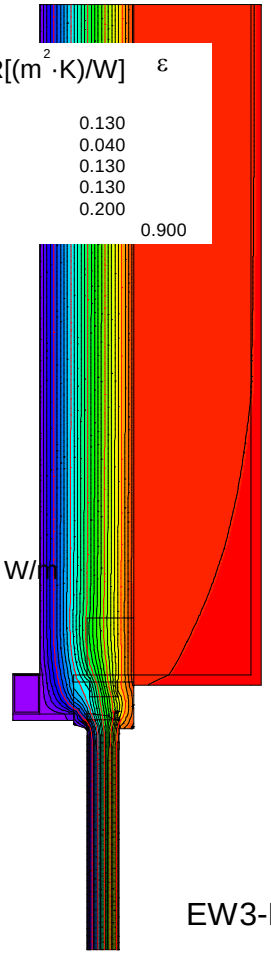


Material	λ[W/(m·K)]	ε
Aluminum I Aluminium 10456	160.000	0.900
Artificial stone I Kunststein 10456	1.300	0.900
Concrete, 1% Steel I Beton, 1% Stahl 10456	2.300	0.900
EPDM	0.250	0.900
EPS - DunPol (grupo Valero) 034	0.034	0.900
Insulation I Wärmedämmung 035	0.035	0.900
Insulation tape | Vorlegeband 060	0.060	0.900
Interior plaster I Gipsputz 10456	0.570	0.900
PU in-situ foam I PU-Ortschaum 040	0.040	0.900
Panel I Maske	0.035	0.900
Rigid EPS-foam incl. screws | Fester EPS-Schaum inkl. Schrauben	0.045	0.900
Silicone I Silikon	0.350	0.900
Softwood, OSB I Weichholz, OSB	0.130	0.900
Unvent. cavity I unbel. Hohlr. *		

* EN ISO 10077-2:2017, 6.4.2



Randbedingung	θ[°C]	R[(m²·K)/W]	ε
Adiabatic | Adiabat			
Exterior vent. | Außen belüftet	-10.000	0.130	
Exterior | 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	



EW3-FH1

$$\psi_{A\text{-}E\text{-}C,*} = \frac{\Phi}{\Delta T} - U_1 \cdot b_1 - \frac{\Phi_2}{\Delta T} = \frac{15.758}{30.000} - 0.229 \cdot 1.010 - \frac{8.388}{30.000} = 0.014 \text{ W/(m·K)}$$

$$\psi_{A\text{-}E\text{-}C,*} = \frac{\Phi}{\Delta T} - \frac{\Phi_1}{\Delta T} - U_2 \cdot b_2 = \frac{15.287}{30.000} - \frac{8.389}{30.000} - 0.229 \cdot 1.010 = -0.002 \text{ W/(m·K)}$$

Passive House Institute