physibel

THERMAL TRANSMITTANCE OF DOORS
2D METHOD AND 3D VALIDATION

1. Introduction

The thermal transmittance of windows and doors is typically derived from 2D numerical simulations neglecting 3D effects. The present document elaborates on the validity of this assumption. First, the 2D method according to EN ISO 10077 is used to calculate the thermal transmittance of the door with BISCO. Next, the door is simulated in 3D with the program TRISCO. To conclude, comparison between the 2D methods and the 3D method is made.

2. Door data

elevation.dwg

Figure 1 shows the front view and the relevant sections of the door.

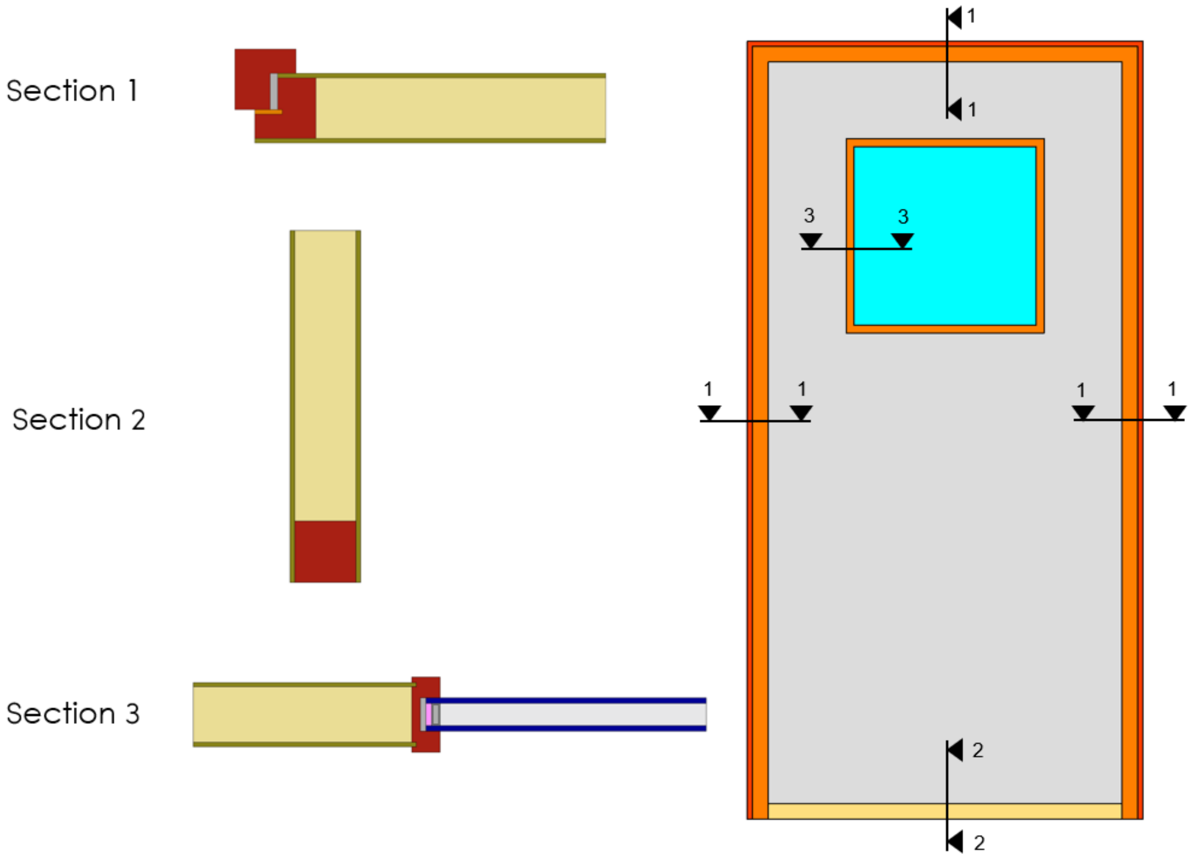


Figure 1. Front view and relevant sections of the door

- **The material thermal conductivities** are the following:

- hardwood (door and window frame)	0.180 W/mK
- PU insulation (door insulation)	0.022 W/mK
- hard cover (door finishing)	0.500 W/mK
- EPDM	0.25 W/mK
- glass	1.00 W/mK
- aluminium (glazing edge)	160 W/mK
- polysulfide (glazing edge)	0.400 W/mK
- glazing cavity (equivalent U_g = 1.2 W/m²K)	0.024 W/mK

- **The equivalent thermal conductivities of the cavities** are calculated according to EN ISO 10077-2.
- **The boundary conditions** are according to EN ISO 10077-2:
  - Outdoors: temperature 0 °C, surface heat transfer coefficient 25 W/m2K
  - Indoors: temperature 20 °C, surface heat transfer coefficient 7.7 W/m2K, reduced surface heat transfer coefficient in corners 5 W/m2K.

3. 2D method in BISCO

3.1. Section 1

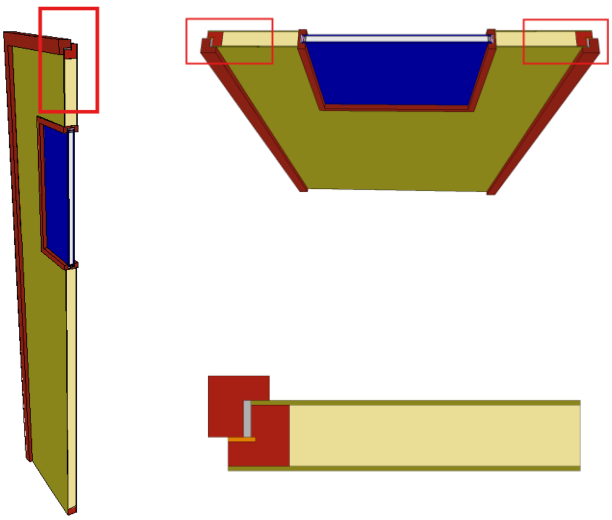


Figure 2. Section 1

In accordance with EN ISO 10077-2, the calculation of the linear transmittance ψ_1 needs 2 numerical simulations:

- Simulation 1: Section 1 is replaced by an insulation panel with λ=0.035 W/mK in order to derive the thermal transmittance of the frame U_{f1}.

- Simulation 2: Section 1 with the real panel in order to derive the linear transmittance ψ_1.

section_left_panel.bsc section_left.bsc

Results: U_{f1} = 2.525 W/m².K, ψ_1 =0.003 W/mK, U_p = 0.5 W/m².K

3.2. Section 2:

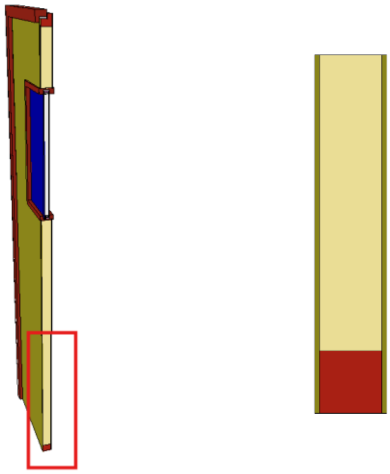
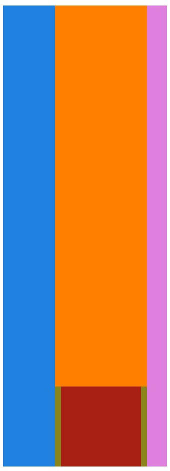
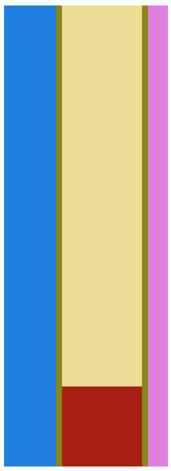


Figure 3. Section 2

Similar as the Section 1, the same procedure was applied to Section 2 to obtain U_{f2}, ψ_2.





section_down_panel.bsc section_down.bsc

Results: U_{f2} = 2.522 W/m².K, ψ_2 =0.004 W/mK.

3.3. Section 3

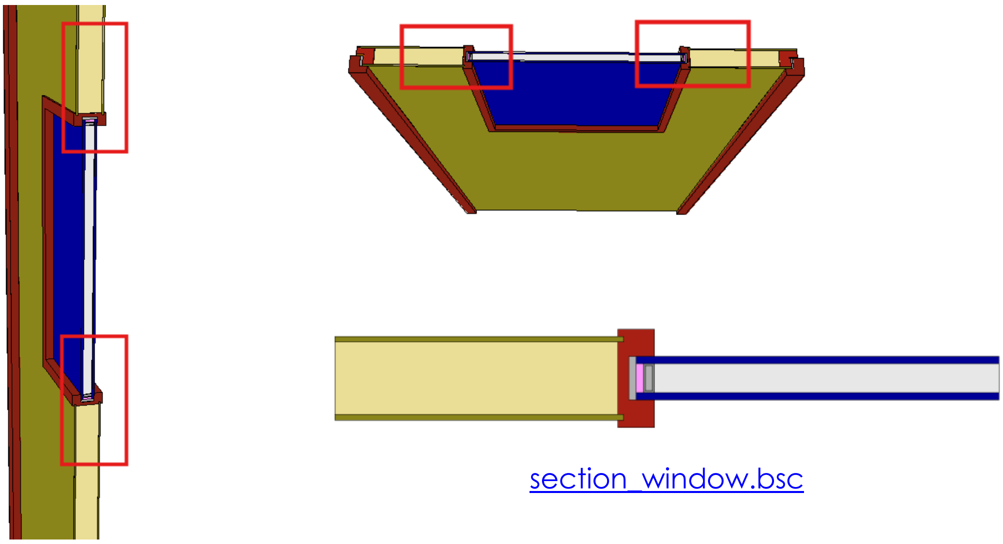


Figure 4. Section 3

According to EN ISO 10077-1, the linear thermal transmittance of the frame (Ψ_3) is the combined thermal effect of panel, frame, glass and spacer.

With the U_p = 0.5 W/m².K, U_g= 1.2 W/m².K applied with their corresponding lengths, the resulting linear thermal transmittance is: $\Psi_3 =$ 0.134(W/mK).

3.4. Door U-value calculation

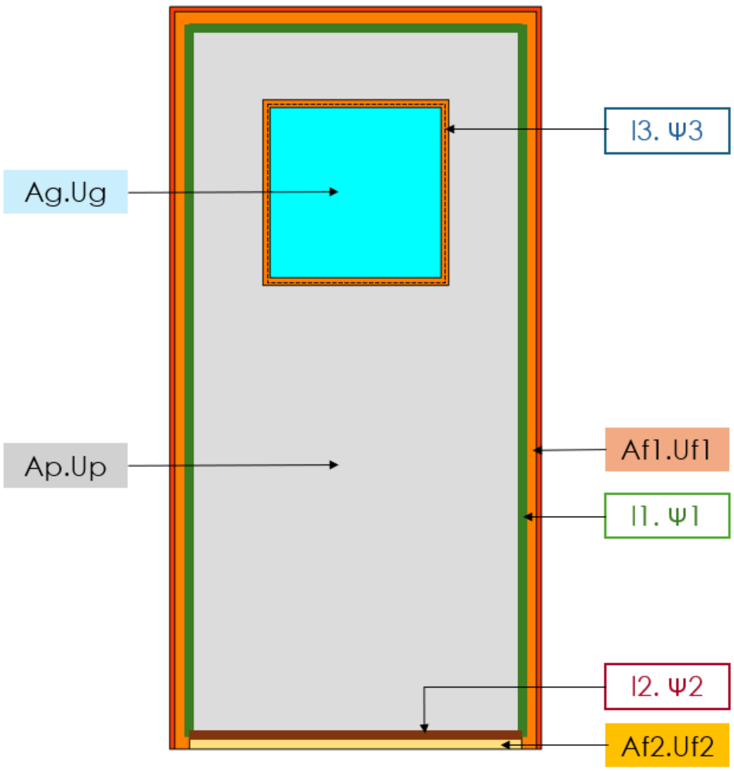


Figure 5. Schematic illustration of door U-value calculation

According to EN ISO 10077-1, if the door consists of frame, glazing and opaque panels, the formula below shall be used:

$$Udoor = \frac{\text{Af1}.\text{Uf1} + \text{Af2}.\text{Uf2} + \text{Ap}.\text{Up} + \text{Ag}.\text{Ug} + \Psi 1.\text{l1} + \Psi 2.\text{l2} + \Psi 3.\text{l3}}{\sum \text{A}}$$

Section 1	Af1 (m2)		Uf1 (W/m2.K)	
		0.259		2.525
	l1 (m)		Ψ1 (W/mK)	
		4.711		0.003
	Ap (m2)		Up (W/m2.K)	
		1.474		0.5
Section 2	Af2 (m2)		Uf2 (W/m2.K)	
		0.036		2.522
	l2 (m)		Ψ2 (W/mK)	
		0.894		0.004
Section 3	l3 (m)		Ψ3 (W/mK)	
		1.92		0.134
	Ag (m2)		Ug (W/m2.K)	
		0.2304		1.2
	Udoor			**1.017**

Result: U_{door} = 1.017 W/m^2.K

4. 3D steady state thermal simulation

door_3D.trc

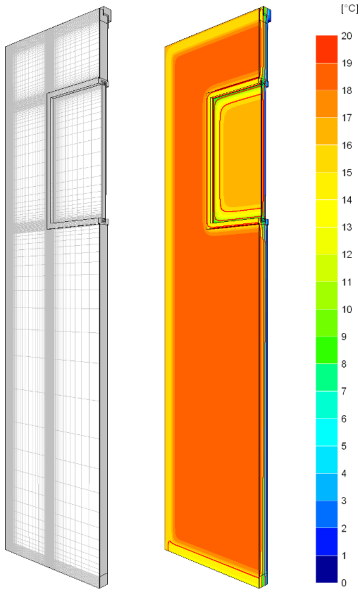


Figure 6. 3D thermal simulation: calculation grid (left) and isotherms (right).

Figure 6 shows the calculation grid (814171 nodes) used in the 3D steady state thermal situation and the isotherms for half the door. From the heat loss through the complete door (40.52 W) the thermal transmittance can be derived.

$$U_{door} = \frac{Q_{3D}}{\Delta\theta_{ie}\, S_{door}} \quad = \quad \mathbf{1.013} \quad \mathbf{W/m^2K}$$

with	U_{door}	door thermal transmittance	[W/m²K]			
	Q_{3D}	thermal heat loss through the door	[W]	=	40.52	W
	$\Delta\theta_{ie}$	temperature difference	[K]	=	20	K
	S_{door}	door surface	[m²]	=	2 m²	

5. Discussion

The 2D method results in a thermal transmittance that is comparable to the 3D value (0.4% difference).