THERMAL TRANSMITTANCE OF A WINDOW ACCORDING TO EN ISO 10077

1. Introduction

The calculation of the thermal transmittance of a window according to EN ISO 10077 is applied for a window containing 2 different frame sections simulated using the program BISCO.

2. Case study data

BISCO data frame_A_glazing.bsc, frame_B_glazing.bsc

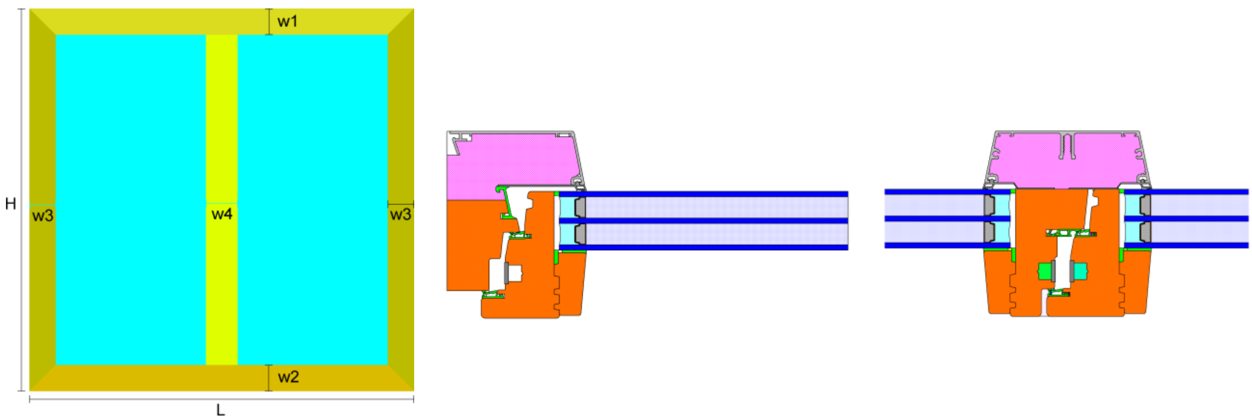


Figure 1. Window front view (left),
frame section 1,2 and 3 (centre) = frame A, frame section 4 (right) = frame B.

A window (Figure 1) with 2 different frame sections and with a triple glazing (central U-value 0.6 W/m^{2}K) is used as an example. The BISCO data files mentioned above contain all data (material thermal conductivities, cavity equivalent thermal conductivities, boundary conditions) to perform a 2-dimensional thermal simulation according to EN ISO 10077-2.
For section A the heat loss is 5.08 W/m.
For section B the heat loss is 8.96 W/m.
These 2D heat losses obtained need to be post-processed using some 'book-keeping' rules in order to obtain the thermal transmittance of the total 3D window. Several post-processing rules exists: e.g. EN ISO 10077, NFRC-rules, and other alternative logical post-processing rules.
In this document the post-processing rules from EN ISO 10077 are discussed.

Note: for a comparison between different post-processor methods we refer to the Knowledge Base document 'THERMAL TRANSMITTANCE OF A WINDOW - COMPARISON OF EN 10077, NFRC AND OTHER RULES'

3. EN ISO 10077 method

BISCO data frame_A_insulation.bsc, frame_B_insulation.bsc
frame_A_glazing.bsc, frame_B_glazing.bsc

The EN ISO 10077 method uses the following formula to calculate the thermal transmittance of the window.

$$U_w = \frac{U_g S_g + \sum_i U_{fi} S_{fi} + \sum_i \Psi_{gi} L_{gi}}{S_w} \tag{1}$$

U_w	[W/m²K]	thermal transmittance of the window
S_w	[m²]	surface of the window
U_g	[W/m²K]	thermal transmittance of the central glazing
S_g	[m²]	surface of the glazing
U_{fi}	[W/m²K]	thermal transmittance of the frame i
S_{fi}	[m²]	surface of frame i
ψ_{gi}	[W/mK]	linear thermal transmittance of the glazing spacer in frame i
L_{gi}	[m]	length of the glazing spacer in frame i

EN ISO 10077 requires another numerical simulation to derive the thermal transmittance of the window frame U_f. In this simulation an insulation panel replaces the glazing. In this way the thermal transmittance of the frame is independent on the glazing edge spacer. The simulation results are shown in Figure 2 – Figure 5.

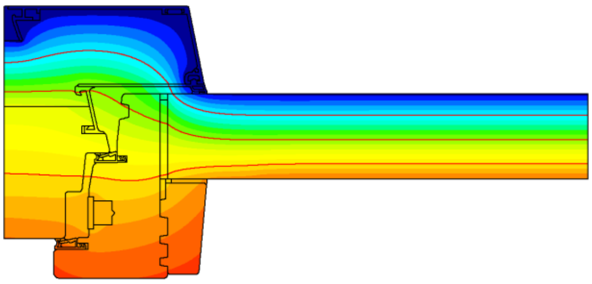


Figure 2. Frame A with panel: isotherms

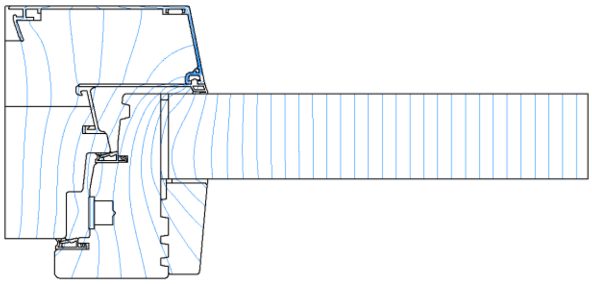


Figure 3. Frame A with panel: heat flow lines

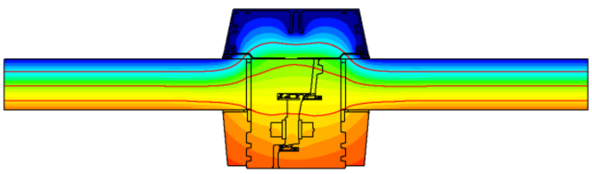


Figure 4. Frame B with panel: isotherms

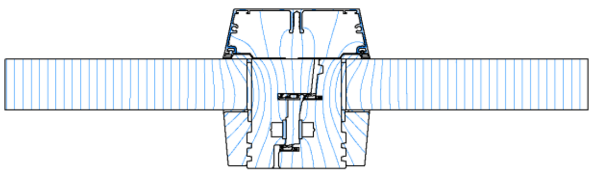


Figure 5. Frame B with panel: heat flow lines

The thermal transmittance of the frame can be calculated using the formula

$$U_f = \frac{\frac{Q_{2D}}{\Delta\theta_{ie}} - U_p w_p}{w_f} \qquad U_{fA} = 0.642\ \mathrm{W/m^2K} \qquad U_{fB} = 0.717\ \mathrm{W/m^2K} \tag{2}$$

U_f	[W/m²K]	thermal transmittance of the frame
Q_{2D}	[W/mK]	simulated total heat loss through the frame and the panel
$\Delta\theta_{ie}$	[K]	assumed temperature difference between indoors and outdoors
U_p	[W/m²K]	thermal transmittance of the insulation panel
w_p	[m]	width of the insulation panel
w_f	[m]	width of the frame

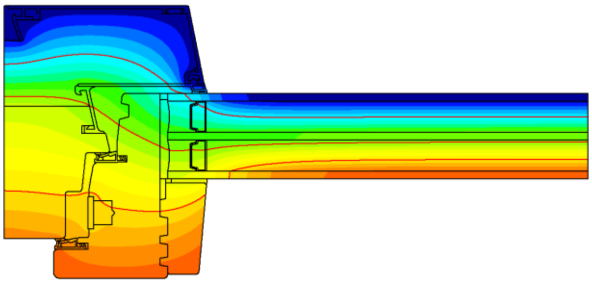


Figure 6. Frame A with glazing: isotherms

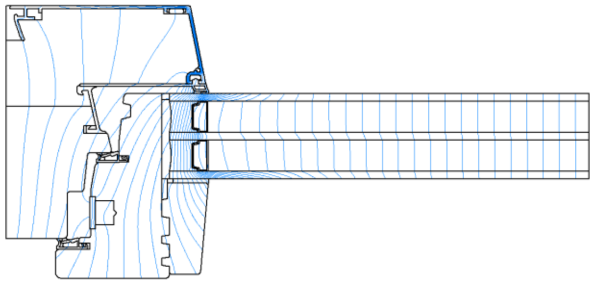


Figure 7. Frame A with glazing: heat flow lines

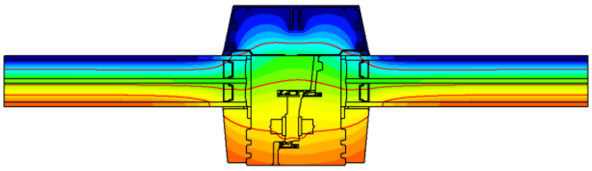


Figure 8. Frame B with glazing: isotherms

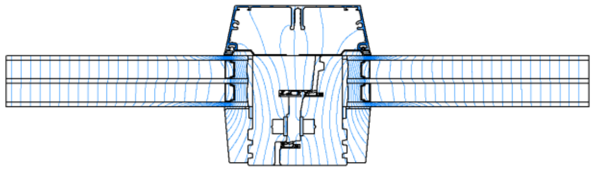


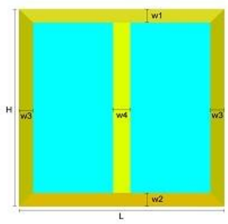
Figure 9. Frame B with glazing: heat flow lines

Now the linear thermal transmittance of the glazing edge can be derived from the simulation of the frame with the glazing. The simulation results are shown in Figure 6 – Figure 9.
The linear transmittance of the spacer is derived using the formula:

$$\psi_g = \frac{Q_{2D}}{\Delta\theta_{ie}} - U_f w_f - U_g w_g \qquad \psi_{gA} = 0.0700 \text{ W/mK} \qquad \psi_{gB} = 0.0655 \text{ W/mK} \tag{3}$$

ψ_g	[W/mK]	linear transmittance of the glazing spacer
Q_{2D}	[W/mK]	simulated total heat loss through the frame and glazing
$\Delta\theta_{ie}$	[K]	assumed temperature difference between indoors and outdoors
U_f	[W/m²K]	thermal transmittance of the frame (obtained above)
w_f	[m]	width of the frame
U_g	[W/m²K]	thermal transmittance of the central glazing (U_g = 0.6 W/m²K)
w_g	[m]	width of the glazing

Now the window thermal transmittance U_w can be derived (Table 1).



$$U_w = \frac{U_g S_g + \sum_i U_{fi} S_{fi} + \sum_i \Psi_{gi} L_{gi}}{S_w}$$

			frame 1	frame 2	frame 3	frame 4	frame 1	frame 2	frame 3	frame 4	glazing	glazing edge 1	glazing edge 2	glazing edge 3	glazing edge 4	total window
	L [m]	H [m]	w_1 [m]	w_2 [m]	w_3 [m]	w_4 [m]	U_{f1} [W/m²K]	U_{f2} [W/m²K]	U_{f3} [W/m²K]	U_{f4} [W/m²K]	U_g [W/m²K]	Ψ_{g1} [W/mK]	Ψ_{g2} [W/mK]	Ψ_{g3} [W/mK]	Ψ_{g4} [W/mK]	U_w [W/m2K]
window 1	1.000	1.000	0.1028	0.1028	0.1028	0.1246	0.642	0.642	0.642	0.717	0.600	0.0700	0.0700	0.0700	0.0655	0.936
							S_{f1} [m²]	S_{f2} [m²]	S_{f3} [m²]	S_{f4} [m²]	S_g [m²]	L_{g1} [m]	L_{g2} [m]	L_{g3} [m]	L_{g4} [m]	S_w [m²]
							0.092	0.092	0.184	0.099	0.532	0.670	0.670	1.589	1.589	1.000
window 2	1.500	1.500	0.1028	0.1028	0.1028	0.1246	0.642	0.642	0.642	0.717	0.600	0.0700	0.0700	0.0700	0.0655	0.848
							S_{f1} [m²]	S_{f2} [m²]	S_{f3} [m²]	S_{f4} [m²]	S_g [m²]	L_{g1} [m]	L_{g2} [m]	L_{g3} [m]	L_{g4} [m]	S_w [m²]
							0.144	0.144	0.287	0.161	1.514	1.170	1.170	2.589	2.589	2.250
window 3	2.000	2.000	0.1028	0.1028	0.1028	0.1246	0.642	0.642	0.642	0.717	0.600	0.0700	0.0700	0.0700	0.0655	0.795
							S_{f1} [m²]	S_{f2} [m²]	S_{f3} [m²]	S_{f4} [m²]	S_g [m²]	L_{g1} [m]	L_{g2} [m]	L_{g3} [m]	L_{g4} [m]	S_w [m²]
							0.195	0.195	0.390	0.224	2.996	1.670	1.670	3.589	3.589	4.000

Table 1. Derivation of the window thermal transmittance U_w
U-window_EN.xlsx

The thermal transmittance U_w of 3 windows with different length (L) and height (H) is derived:
- L = 1 m   H = 1 m   **U_w = 0.936 W/m²K.**
- L = 1.5 m   H = 1.5 m   **U_w = 0.848 W/m²K.**
- L = 2 m   H = 2 m   **U_w = 0.795 W/m²K.**