

## Introduction

The standard ISO 10077-2:2017<sup>1</sup> allows 2 methods for simulating the heat transfer in air cavities:

1. The single equivalent thermal conductivity method.  
In BISCO the **EQUIMAT** type uses this method.  
The standard Annex I contains the validation examples.
2. The radiosity method.  
In BISCO the **TRANSMAT** type (requiring the RADCON module) uses this method.  
The standard Annexes G and H contain the validation examples.

The examples are calculated using the program BISCO version 12 and compared to the standard figures.

## Summary of results for Annex I examples (examples of window frames)

Table 1 contains the two-dimensional conductance  $L^{2D}$  and the frame thermal transmittance  $U$  or the linear thermal transmittance  $\Psi$  for the examples of Annex I. The simulations were done using the single equivalent thermal conductivity method, using EQUIMAT for cavities. The validation criterion (maximum deviation of 3% on the  $L^{2D}$ -value) is fulfilled for all examples.

**Table 1 – Results for Annex I examples (window frames)**

Example	I.1	I.2	I.3	I.4	I.5	I.6	I.7	I.8	I.9		I.10
$L^{2D}_{REF}$ [W/mK]	0.550	0.263	0.424	0.346	0.408	0.659	0.285	0.181	0.207		0.481
$L^{2D}_{BSC}$ [W/mK]	0.553	0.261	0.418	0.345	0.399	0.662	0.284	0.180	0.207		0.480
$\Delta L^{2D}_{BSC-REF}$ [%]	0.5	-0.8	-1.4	-0.3	-2.2	0.5	-0.4	-0.6	0.0		-0.2
$U_{REF}$ [W/m <sup>2</sup> K]	3.22	1.44	2.07	1.36	2.08	4.67	1.31	1.05	3.64	$\Psi_{REF}$ [W/mK]	0.08
$U_{BSC}$ [W/m <sup>2</sup> K]	3.24	1.43	2.02	1.35	1.99	4.70	1.27	1.01	3.63	$\Psi_{BSC}$ [W/mK]	0.08
$\Delta U^{2D}_{BSC-REF}$ [%]	0.6	-0.7	-2.4	-0.7	-4.2	0.6	-2.3	-3.8	-0.3	$\Delta \Psi_{BSC-REF}$ [%]	-2.4
Number of nodes [-]	83837	163105	95733	101027	111295	65951	63555	250896	51145		100940
BISCO data file	<a href="#">ZZ_case_I01_EQ.bsc</a>	<a href="#">ZZ_case_I02_EQ.bsc</a>	<a href="#">ZZ_case_I03_EQ.bsc</a>	<a href="#">ZZ_case_I04_EQ.bsc</a>	<a href="#">ZZ_case_I05_EQ.bsc</a>	<a href="#">ZZ_case_I06_EQ.bsc</a>	<a href="#">ZZ_case_I07_EQ.bsc</a>	<a href="#">ZZ_case_I08_EQ.bsc</a>	<a href="#">ZZ_case_I09_EQ.bsc</a>		<a href="#">ZZ_case_I10_EQ.bsc</a>

## Summary of results for Annex H examples (examples of window frames)

Table 2 contains the two-dimensional conductance  $L^{2D}$  and the frame thermal transmittance  $U$  or the linear thermal transmittance  $\Psi$  for the examples of Annex H. The simulations were done using the radiosity method, using TRANSMAT for non-ventilated cavities and using BC\_SIMPL

<sup>1</sup> EN ISO 10077-2:2017 *Thermal performance of windows, doors and shutters – Calculation of thermal transmittance – Part 2: Numerical method for frames*

( $h = 3.33 \text{ W/m}^2\text{K}$ ) for slightly ventilated cavities. The validation criterion (maximum deviation of 3% on the  $L^{2D}$ -value) is fulfilled for all examples.

**Table 2 – Results for Annex H examples (window frames)**

Example	H.1	H.2	H.3	H.4	H.5	H.6	H.7	H.8	H.9	H.10		H.11
$L^{2D}_{REF} [\text{W/mK}]$	0.539	0.508	0.252	0.400	0.344	0.407	0.637	0.281	0.188	0.208		0.478
$L^{2D}_{BSC} [\text{W/mK}]$	0.537	0.505	0.252	0.399	0.344	0.406	0.630	0.282	0.187	0.208		0.478
$\Delta L^{2D}_{BSC-REF} [\%]$	-0.4	-0.6	0.0	-0.3	0.0	-0.2	-1.1	0.4	-0.5	0.0		0.0
$U_{REF} [\text{W/m}^2\text{K}]$	3.11	2.83	1.35	1.86	1.34	2.07	4.44	1.23	1.06	3.64	$\psi_{REF} [\text{W/mK}]$	0.08
$U_{BSC} [\text{W/m}^2\text{K}]$	3.10	2.81	1.35	1.85	1.34	2.07	4.37	1.24	1.06	3.65	$\psi_{BSC} [\text{W/mK}]$	0.08
$\Delta U^{2D}_{BSC-REF} [\%]$	-0.3	-0.7	0.0	-0.5	0.0	0.0	-1.6	0.8	0.0	0.3	$\Delta\psi_{BSC-REF} [\%]$	0.0
Number of nodes [-]	86044	86214	164979	99596	101528	107244	67524	65158	102818	52865		100868
BISCO data file	<a href="#">77_case_H01_TM.bsc</a>	<a href="#">77_case_H02_TM.bsc</a>	<a href="#">77_case_H03_TM.bsc</a>	<a href="#">77_case_H04_TM.bsc</a>	<a href="#">77_case_H05_TM.bsc</a>	<a href="#">77_case_H06_TM.bsc</a>	<a href="#">77_case_H07_TM.bsc</a>	<a href="#">77_case_H08_TM.bsc</a>	<a href="#">77_case_H09_TM.bsc</a>	<a href="#">77_case_H10_TM.bsc</a>		<a href="#">77_case_H11_TM.bsc</a>

### Summary of results for Annex G examples

Table 3 contains the analytical and BISCO results for the 4 variants of example G.1.

Table 4 contains the analytical and BISCO results for the example G.2.

Figure 1 contains the analytical and BISCO results for the example G.3 (the grid temperatures obtained by BISCO rounded to 1 decimal are identical to the analytical ones).

Table 5 contains the BISCO results for the example G.4.

The validation criteria of the standard are fulfilled in all cases.

**Table 3 – Results for G.1 example (concentric cylinders)**

Variant	Radiation heat flow [W/m]		BISCO data file
	Analytical	BISCO	
A	44.12	44.10	<a href="#">77_case_G1A.bsc</a>
B	5.15	5.15	<a href="#">77_case_G1B.bsc</a>
C	8.29	8.29	<a href="#">77_case_G1C.bsc</a>
D	3.42	3.42	<a href="#">77_case_G1D.bsc</a>

**Table 4 – Results for G.2 example (vacuum within a square cavity)**

Surface	Temperature [°C]		BISCO data file
	Analytical	BISCO	
$S_{i1}$	4.67	4.67	<a href="#">77_case_G2.bsc</a>
$S_{i2}$	7.25	7.25	
$S_{i3}$	9.18	9.18	
$S_{i4}$	13.89	13.89	

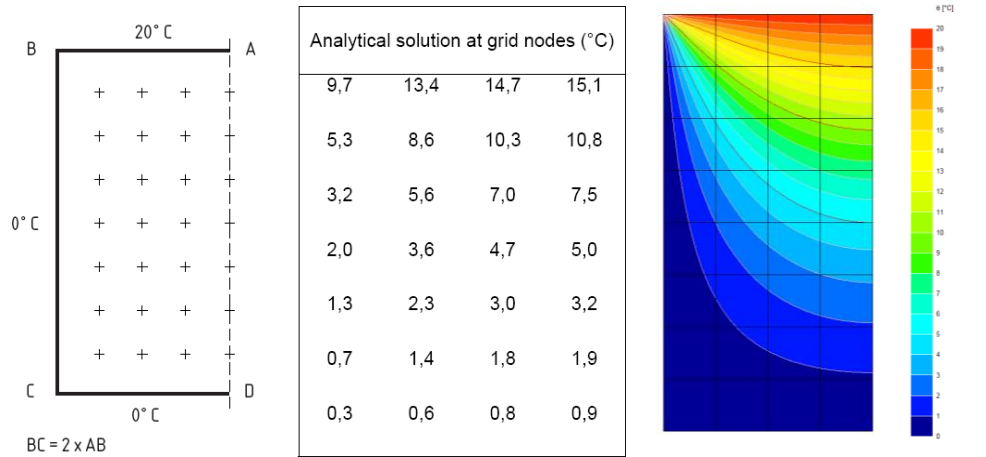


Figure 1. Data and results for G.3 example (half square column with specified temperatures)  
[77\\_case\\_G3.bsc](#).

Table 5 – Results for G.4 example (air cavity)

Cavity equivalent conduction direction	21.72 ° (21.8 °C)	BISCO data file
Cavity equivalent conductivity	0.048 W/mK (0.048 W/Mk)	<a href="#">77_case_G4.bsc</a>
Total heat flow	0.8277 W/K (0.826 W/K)	

## APPENDIX

The validation of BISCO V9, V10 and V11 according to previous versions of the standard were presented in the documents:

- PPB\_BISCO\_V9\_validation\_EN\_ISO\_10077\_2.pdf
- PPB\_BISCO\_V10\_round\_robin\_ISO\_WD\_10077\_2(2011).pdf
- PPB\_BISCO\_V11\_validation\_EN\_ISO\_10077\_2\_2016.pdf