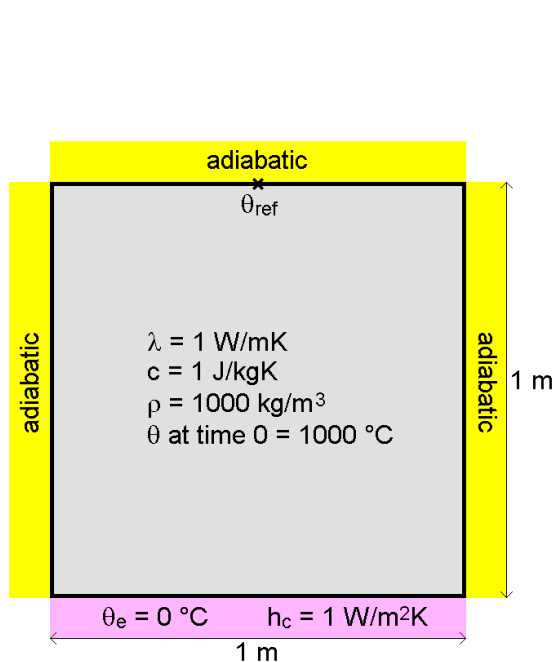


Introduction

The document DIN EN 1991-1-2/NA¹ (2015-09) annex CC contains test reference cases for validating transient simulation programs in case of fire exposed structures. The cases are simulated using the programs BISTRA and VOLTRA and the results are within the requested tolerances for each case.

Case 1

BISTRA data [CC4_1\CC4_1.bst](#)
VOLTRA data [CC4_1\CC4_1.vtr](#)



BISTRA data file [CC4_1\CC4_1.bst](#)

time [s]	θ _{ref} [°C]	θ _{sim} [°C]	θ _{sim} -θ _{ref} [°C]	100*(θ _{sim} -θ _{ref})/θ _{ref} [%]
0	1000	1000	0,0	0,0
60	999,3	999,4	0,1	0,0
300	891,8	893,3	1,5	0,2
600	717,7	719	1,3	0,2
900	574,9	575,9	1,0	0,2
1200	460,4	461,3	0,9	0,2
1500	368,7	369,4	0,7	0,2
1800	295,3	295,8	0,5	0,2
			< 5 K	< 1 %

VOLTRA data file [CC4_1\CC4_1.vtr](#)

time [s]	θ _{ref} [°C]	θ _{sim} [°C]	θ _{sim} -θ _{ref} [°C]	100*(θ _{sim} -θ _{ref})/θ _{ref} [%]
0	1000	1000	0,0	0,0
60	999,3	999,4	0,1	0,0
300	891,8	893,3	1,5	0,2
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900	574,9	575,9	1,0	0,2
1200	460,4	461,3	0,9	0,2
1500	368,7	369,4	0,7	0,2
1800	295,3	295,8	0,5	0,2
			< 5 K	< 1 %

Figure 1. Case 1 data.

Table 1. Case 1 results

Figure 1 shows the data for case 1.

Points of interest in the BISTRA & VOLTRA DATA are the following.

- The problem is 1D, i.e. the width of the object has no importance. A width of 0.02 m only is used in BISTRA, resulting in a faster calculation.
- BISTRA uses a triangular grid. The triangulation size is 0.001 m.
- VOLTRA uses a rectangular grid. The grid size is 0.001 m.
- The time step used is 5 seconds.

¹ DIN EN 1991-1-2/NA:2015:09 Nationaler Anhang – National festgelegte Parameter – Eurocode 1: Einwirkungen auf Tragwerke – Teil 1-2: Allgemeine Einwirkungen - Brandeinwirkungen auf Tragwerke

For the non-adiabatic boundary, the boundary condition type BC_SKY (radiation and convection) is used. By applying a surface emissivity $\varepsilon = 0$, no radiation and only convection is considered. Table 1 shows the results for case 1. The results are within the requested tolerances.

Case 2

BISTRA data [CC4 2\CC4 2.bst](#)
VOLTRA data [CC4 2\CC4 2 .vtr](#)

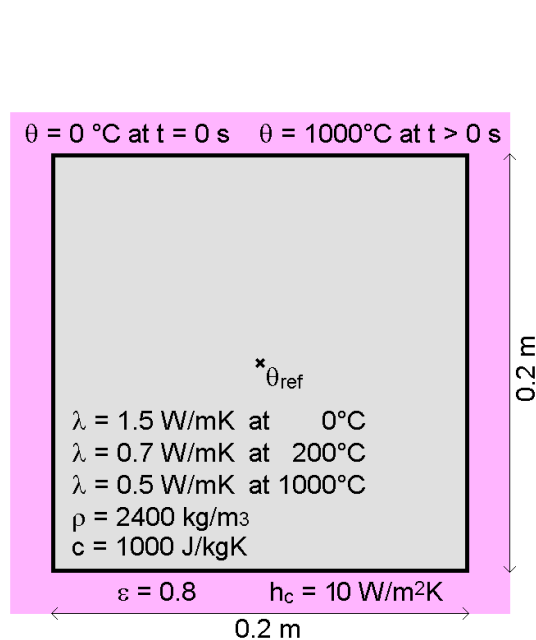


Figure 2. Case 2 data.

BISTRA data file [CC4 2\CC4 2.bst](#)

time [min]	θ_{ref} [°C]	θ_{sim} [°C]	$\theta_{sim}-\theta_{ref}$ [°C]	$100*(\theta_{sim}-\theta_{ref})/\theta_{ref}$ [%]
30	36,9	34,3	-2,6	-7,0
60	137,4	134,7	-2,7	-2,0
90	244,6	243,8	-0,8	-0,3
120	361,1	364,3	3,2	0,9
150	466,2	470,9	4,7	1,0
180	554,8	560,7	5,9	1,1

$< 5 \text{ K}$ $< 3 \%$
 $t \leq 60 \text{ min}$ $t > 60 \text{ min}$

VOLTRA data file [CC4 2\CC4 2 .vtr](#)

time [min]	θ_{ref} [°C]	θ_{sim} [°C]	$\theta_{sim}-\theta_{ref}$ [°C]	$100*(\theta_{sim}-\theta_{ref})/\theta_{ref}$ [%]
30	36,9	34,3	-2,6	-7,0
60	137,4	134,7	-2,7	-2,0
90	244,6	243,8	-0,8	-0,3
120	361,1	364,3	3,2	0,9
150	466,2	470,9	4,7	1,0
180	554,8	560,7	5,9	1,1

$< 5 \text{ K}$ $< 3 \%$
 $t \leq 60 \text{ min}$ $t > 60 \text{ min}$

Table 2. Case 2 results

Figure 2 shows the data for case 2.

Points of interest in the BISTRA & VOLTRA DATA are the following.

- Because of symmetry it is sufficient to consider a quarter of the square object.
- BISTRA uses a triangular grid. The triangulation size used is 0.0005 m.
- VOLTRA uses a rectangular grid. The grid size used is 0.0005 m.
- The time step used is 10 seconds.

Table 2 shows the results for case 2.

The results are within the requested tolerances.

Case 3

BISTRA data [CC4 3\CC4 3.bst](#)
VOLTRA data [CC4 3\CC4 3 .vtr](#)

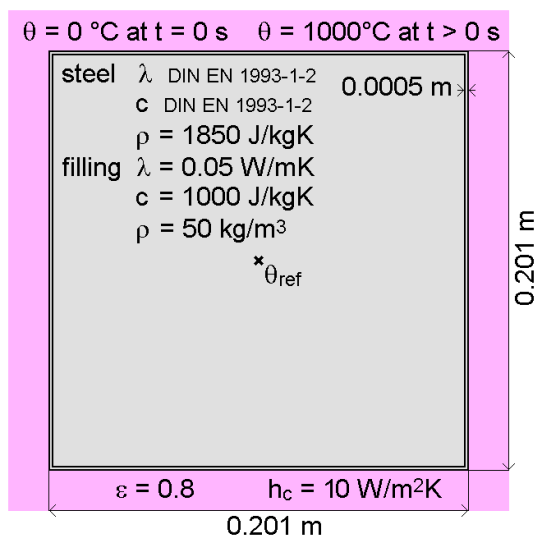
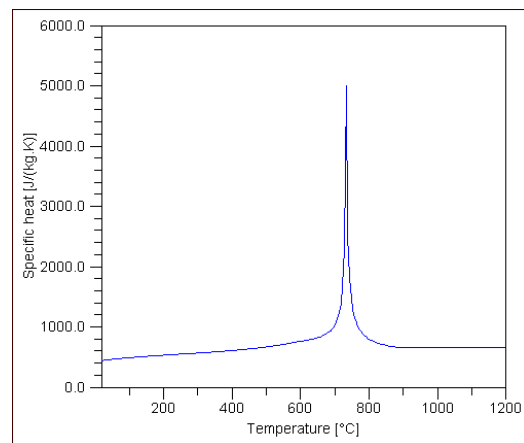
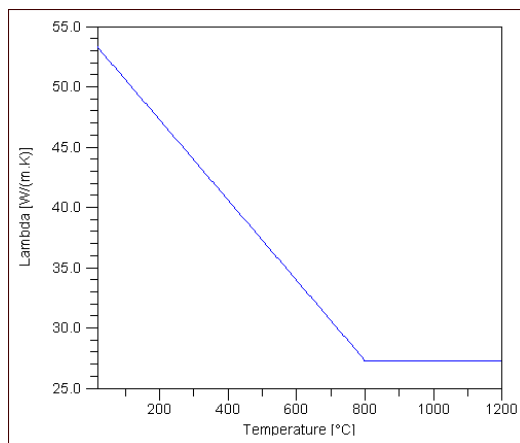


Figure 3. Case 3 data.

BISTRA data file [CC4 3\CC4 3.bst](#)

t [min]	θ_{ref} [°C]	θ_{sim} [°C]	$\theta_{\text{sim}} - \theta_{\text{ref}}$ [°C]	$100 \cdot (\theta_{\text{sim}} - \theta_{\text{ref}}) / \theta_{\text{ref}}$ [%]
30	340,5	337,8	-2,7	-0,8
60	717,1	721,5	4,4	0,6
90	881,6	885,1	3,5	0,4
120	950,6	952,6	2,0	0,2
150	979,3	980,5	1,2	0,1
180	991,7	991,9	0,2	0,0
			< 5 K	< 1 %

VOLTRA data file [CC4 3\CC4 3.vtr](#)

t [min]	θ_{ref} [°C]	θ_{sim} [°C]	$\theta_{\text{sim}} - \theta_{\text{ref}}$ [°C]	$100 \cdot (\theta_{\text{sim}} - \theta_{\text{ref}}) / \theta_{\text{ref}}$ [%]
30	340,5	337,8	-2,7	-0,8
60	717,1	721,5	4,4	0,6
90	881,6	885,1	3,5	0,4
120	950,6	952,6	2,0	0,2
150	979,3	980,5	1,2	0,1
180	991,7	991,9	0,2	0,0
			< 5 K	< 1 %

Table 3. Case 3 results

Figure 3 shows the data for case 3.

Points of interest in the BISTRA & VOLTRA DATA are the following.

- Because of symmetry it is sufficient to consider a quarter of the square object.
- BISTRA uses a triangular grid with a triangulation size of 0.001 m.
- VOLTRA uses a rectangular grid with a grid size of 0.001 m.
- The time step used is 10 seconds.

Table 3 shows the results for case 3.

The results are within the requested tolerances.