Discussion by PT.

From all countries who made a comment in the NDP database:

- 16 countries accepted the Recommended value (RV) of 200 and 240 K for EN 1992-1-2, 17 countries for EN 1994-1-2 and 15 countries for EN 1995-1-2.
- 2 countries made a comment and recommended values that are more severe than the RV.
  - DNK: "*140, 180*"
  - SWE: "*180, 220*"
- 1 country made a comment that is less severe than the RV.
  - FIN: "*No values are given for the average temperature rise and for the maximum temperature rise during the cooling phase of fire. The requirements for separation function EI is only based on a standard fire and on temperature limits set by it.*"

Work performed by PT

Some numerical thermal analyses have been performed on concrete slabs/walls subjected to a parametric fire in order to see whether the value of 200 K that is recommended for the average temperature rise during the decay phase is more severe or less severe than the value of 140 K that is imposed during the heating phase.

The analyses have been performed for a uniaxial conductive heat transfer through the slabs with the software SAFIR® using concrete with a specific mass of 2300 kg/m³, moisture content of 46 L/m³ and thermal conductivity average between the upper and the lower limit. Initial temperature was 20°C.

In a first step, the thicknesses of 52, 80, 101 and 117 mm have been determined as the necessary thickness for the insulating criteria I of 140 K for the rise of average temperature being obtained after respectively 30, 60, 60 and 120 minutes in a standard fire (the maximum temperature rise is the same as the average temperature rise in a numerical analysis). In other words, these slabs would satisfy the criteria I30, I60, I90 or I120 under standard fire curve. It has to be noted that the thicknesses determined here are close to the values that are recommended in Table 5.3 of EN 1992-1-2 for non load-bearing walls, which seems to comfort the results of the numerical analyses.

Table 5.3: Minimum wall thickness of non load-bearing walls (partitions)

Standard fire resistance	Minimum wall thickness (mm)
1	2
EI 30	60
EI 60	80
EI 90	100
EI 120	120
EI 180	150
EI 240	175

In a second step, these slabs have been subjected to the parametric fire of Annex A of EN 1991-1-2 on one side and 20°C ambient temperature on the other side. The value of the parameter Γ was equal to

1 which ensures that the heating phase was very similar to the standard fire curve. For each slab, the duration of the heating phase (DHP) was equal to 30, 60, 90 or 120 minutes depending on the thickness and a cooling phase followed thereafter with a slope of the linear descending branch in the cooling phase determined according to Annex A. The coefficients of convection of 25 and 4 W/m²K used in the first step were changed to 35 and 4 W/mK according to clause 3.3.1.1 (3) of EN 1991-1-2. Figure 1 shows the 4 different parametric curves that have been applied, one to each thickness.

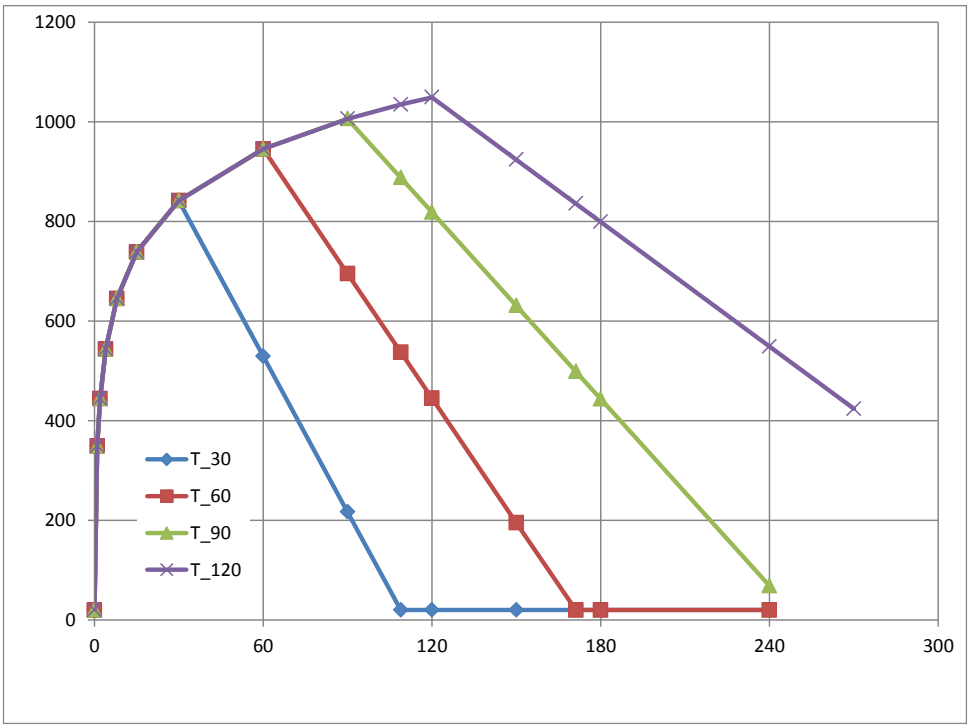

Figure 1 : four different parametric fire curves

Figure 2, Figure 3, Figure 4 and Figure 5 show the evolution of the temperature on the unexposed side for the four slabs.

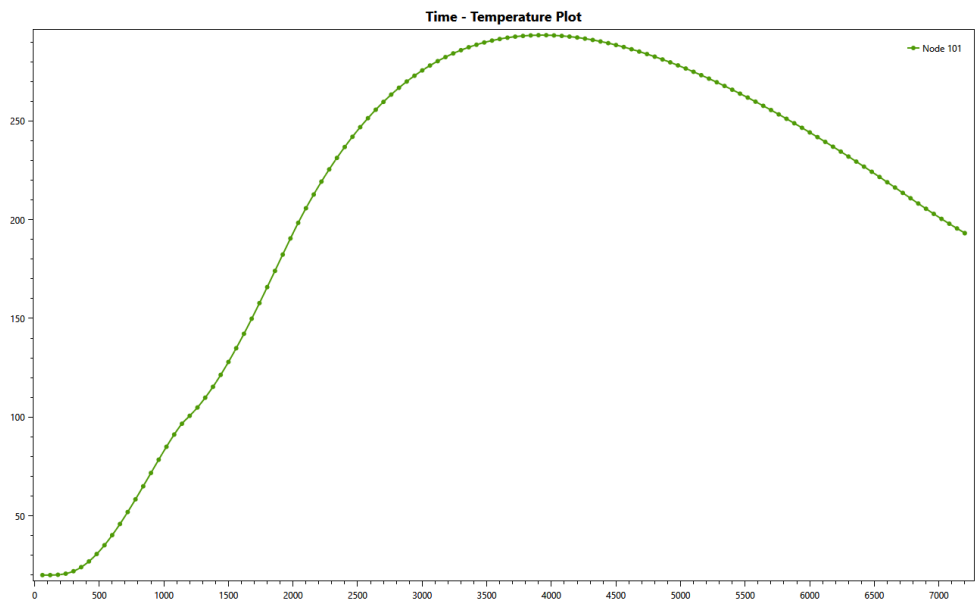

Figure 2: DHP = 30 minutes

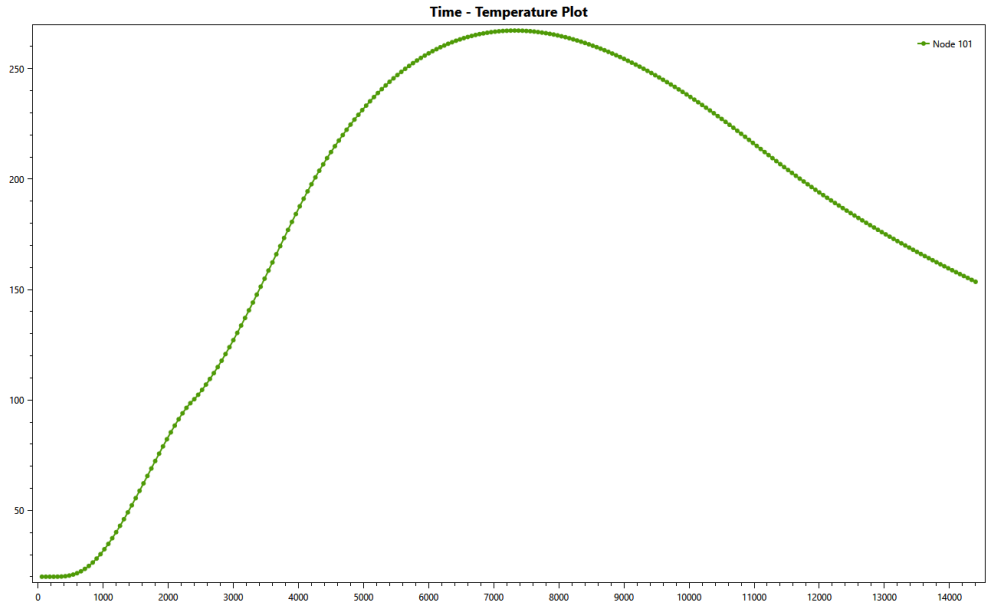

Figure 3: DHP = 60 minutes

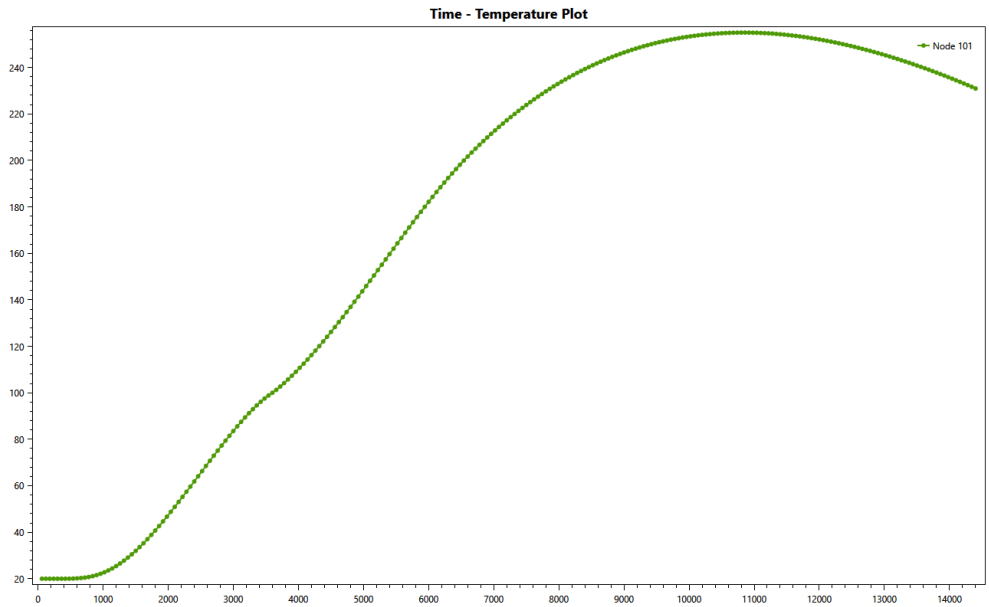

Figure 4: DHP = 90 minutes

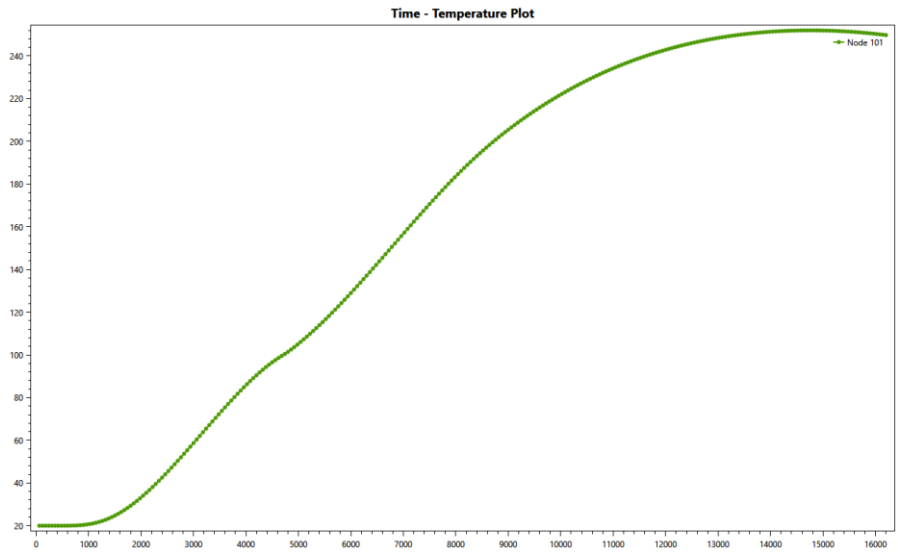

Figure 5: DHP = 120 minutes

The maximum value of the temperature on the unexposed side of the slab was recorded during the cooling phase. This value was respectively 293°C, 267°C, 255°C and 252°C whereas, according to the RV, only 220°C was allowed.

It is thus observed that these slabs that would satisfy the requirement of average temperature increase for a standard fire exposure would not satisfy the requirement during the cooling phase for the parametric fire having the same heating phase being now followed by a cooling phase.

In other words, the requirements of 200 K as a maximum increase of the average temperature during the cooling phase is more severe than the requirement of 140 K as a maximum increase of the average temperature during the heating phase.

In order to fulfill this requirement of 200 K during the cooling phase, the thickness of the slabs should be increased from 52 to 75 mm for a heating phase of 30 minutes, from 80 to 100 mm for a heating phase of 60 minutes, from 101 to 120 mm for a heating phase of 90 minutes and from 117 to 138 mm for a heating phase of 120 minutes.

Alternatively, if the thickness of the slabs is kept equal to the value that satisfies the requirement under the standard fire (i.e. 52, 80, 101 and 117 mm), the duration of the heating phase that allows not to exceed an increase of 200 K during the decay phase is only 12,5 minutes instead of 30 minutes for the thinnest slab, 35 minutes instead of 60 minutes for the 80 mm slab, 61 minutes instead of 90 minutes for the 101 mm slab and 85 instead of 120 minutes for the thickest slab. Figure 6 shows the 4 parametric fire curve that fulfill the criteria of 200 K as a maximum temperature increase during the decay phase. The curves on this Figure have to be compared to the heating part of the respective curves in Figure 1.

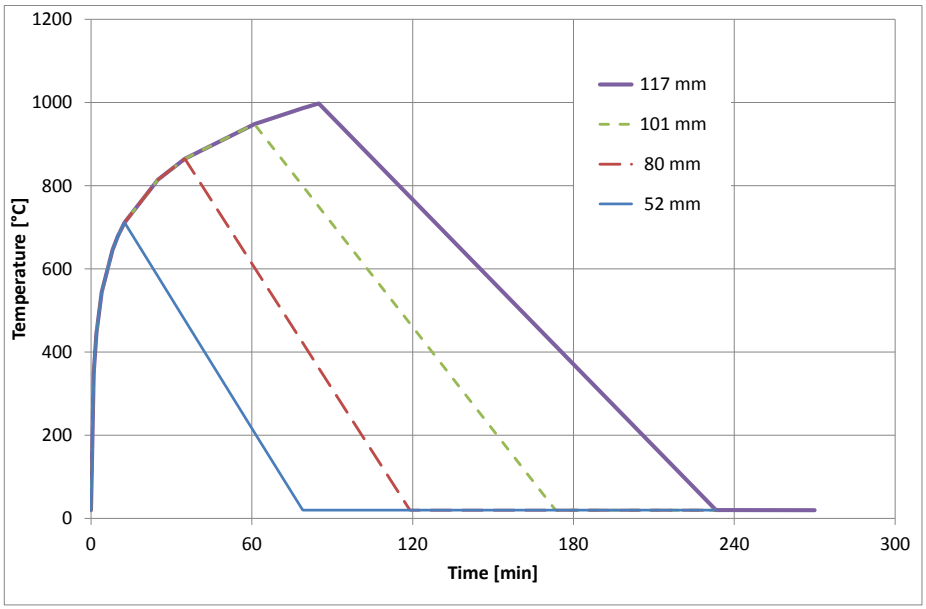

Figure 6: four curves that fulfil the 200 K criteria

Figure 7 shows four fire curves which are acceptable for an 80 mm thick slab.

The curve labelled "I = 60 minutes" is the standard fire curve that leads to an average temperature increase of 140 K after 60 minutes, that means that a rating I60 is achieved in a prescriptive environment.

The curve labelled 'FIN" is the parametric curve based on the standard fire curve that has been completed by a decreasing phase. This curve is acceptable if the comment of FIN is considered and no limit is given for the average temperature increase during the cooling phase. In that case, the average temperature increase will reach 247 K.

The curve labelled "R.V." is the parametric fire curve with a DHP of 35 minutes that leads to an average temperature increase of 200 K during the cooling phase. This is the fire curve that is acceptable for the 80 mm thick slab if the Recommended Value is adopted.

The curve labelled "DNK" is the parametric fire curve with a DHP of 17 minutes that leads to an average temperature increase of 140 K during the cooling phase. This curve is acceptable if the comment of DNK is considered and the average temperature increase is limited to 140 K during the cooling phase as during the heating phase.

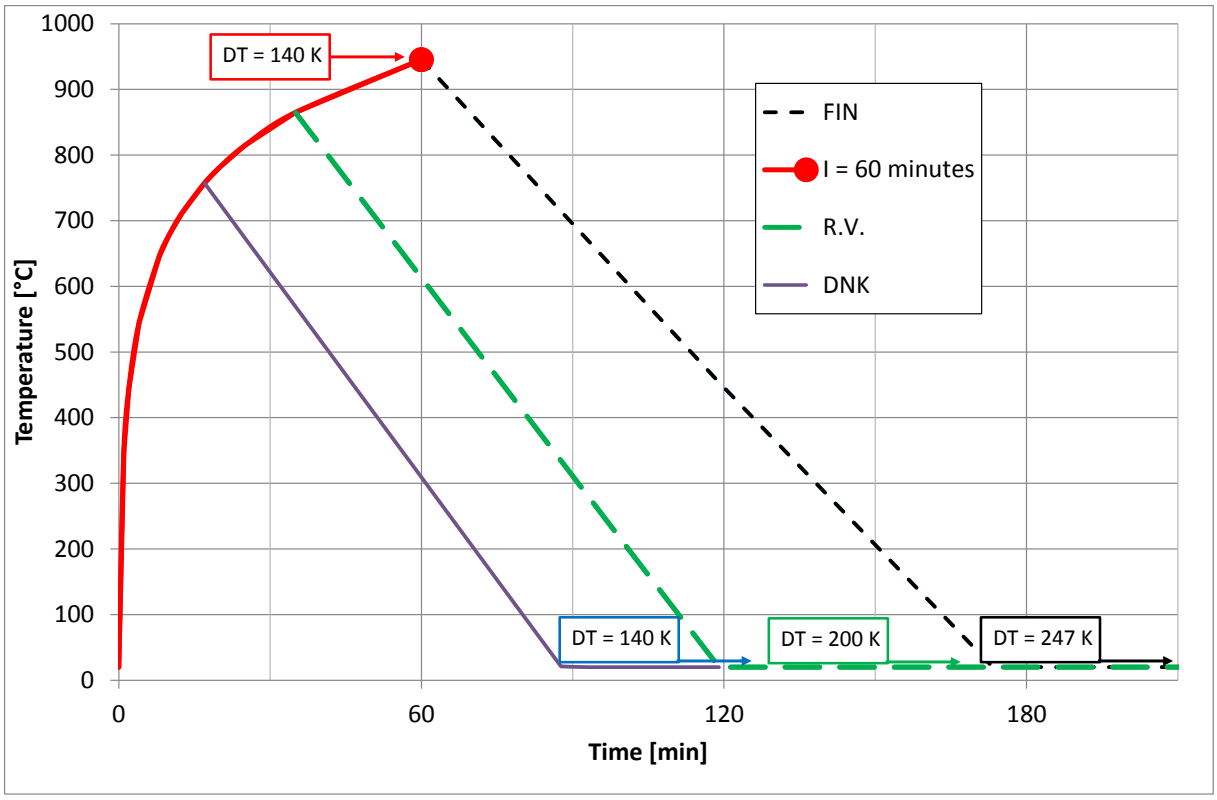

Figure 7: four "acceptable" fire curves

It thus does not seem necessary, from these examples on concrete walls/slabs, to propose values that are more severe than the RV.

On the other hand, giving no limit at all for the temperatures on the unexposed side during the decay phase, as proposed by FIN, would allow, for example, for a solid timber slab to completely burn through after the time of maximum temperature in the fire while being still declared appropriate when designed according to a parametric fire, which seems to be somehow extreme.

As a conclusion, it is proposed to delete this NDP and to make the recommended values of 200 K and 240 K mandatory.