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Research Centre of Metal Structures

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Effect of Eurocode 1 Annex E factors to the gas temperatures in car park fires

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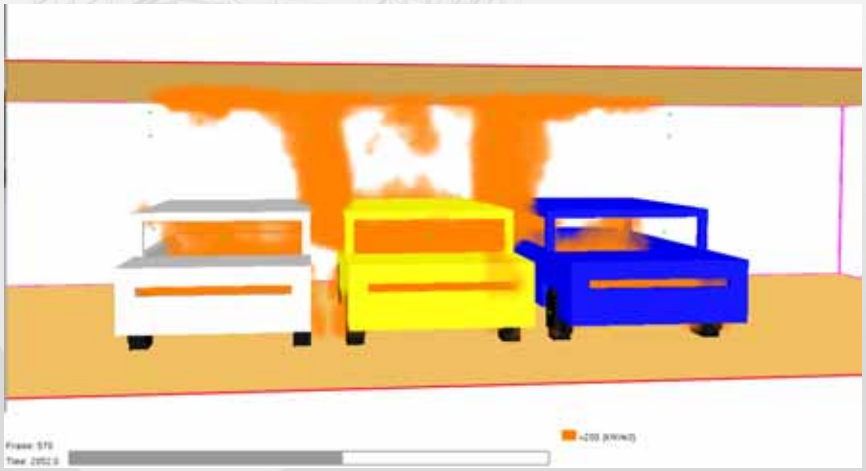
Idea: Eurocode SFS-EN 1991-1-2 includes informative Annex E, which allows a fire designer to reduce design value of the fire load in certain factor, if a compartment are installed a fire suppression system. We are studying with Fire Dynamics Simulator software how similar temperature results Eurocode factors and real sprinklers produce at the hot gas layer level in car park fires.



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Calculation of the design value of the fire load density, Annex E

(3) The design value of the fire load $q_{f,d}$ is defined as:

$$q_{f,d} = q_{f,k} \cdot m \cdot \delta_{q1} \cdot \delta_{q2} \cdot \delta_n \quad [MJ/m^2] \quad (E.1)$$

where

m is the combustion factor (see E.3)

δ_{q1} is a factor taking into account the fire activation risk due to the size of the compartment (see Table E.1)

δ_{q2} is a factor taking into account the fire activation risk due to the type of occupancy (see Table E.1)

$\delta_n = \prod_{i=1}^{10} \delta_{ni}$ is a factor taking into account the different active fire fighting measures I (sprinkler, detection, automatic alarm transmission, firemen …). These active measures are generally imposed for life safety reason (see Table E.2 and clauses (4) and (5)).

$q_{f,k}$ is the characteristic fire load density per unit floor area [MJ/m^2] (see f.i. Table E.4)

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Table E.2 Factors δ_{ni}

δ_{ni} Function of Active Fire Fighting Measures									
Automatic Fire Suppression			Automatic Fire Detection			Manual Fire Suppression				
Automativ water Extinquishing system	Independent Water Supplies 0 | 1 | 2		Automatic fire Detection & Alarm		Automatic Alarm Transmission to Fire Brigade	Work Fire Brigade	Off Site Fire Brigade	Safe Access Routes	Fire Fighting Devices	Smoke Exhaust System
			by Heat	by Smoke						
δ_{n1}	δ_{n2}		δ_{n3}	δ_{n4}	δ_{n5}	δ_{n6}	δ_{n7}	δ_{n8}	δ_{n9}	δ_{n10}
0,61	1,0	0,87 | 0,7	0,87 or 0,73		0,87	0,61 or 0.78		0,9 or 1 or 1,5	1,0 or1,5	1,0 or1,5

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FDS simulation model (1/2)

- Dimensions, heat release rates and source codes of the simulation are based on literature mentioned below.

Standard SFS-EN 1991-1-2, Eurocode 1: Actions on structures – Part 1-2: General actions – Actions on structures exposed to fire, 1(1+102)p.

Shleich J-B, Modern Fire Engineering, Fire Design of Car Parks, Arcelor Profil, Luxembourg Research Centre. (Internet publication), 2010.

Hietaniemi, J., 2007, Palon voimakkuuden kuvaaminen toiminnallisessa paloteknisessä suunnittelussa, Internet julkaisu,http://proxnet.vtt.fi/fise/simon/Fise/opetusmateriaali/mitoituspalot/MITOITUSPALOT_15052007.pdf

Heinisuo M., Outinen J., Cost IFER, Proposal for standardization of performance based design fires in buildings, Version 1, 30.10.2011

Hietaniemi J., Mikkola E., Design Fires for Fire Safety Engineering, VTT Working Papers 139, VTT, 2010

Mc Grattan, K., et al.: Fire Dynamics Simulator, Technical reference guide. National Institute of Standards and Technology, Version 5.5, 2010, USA

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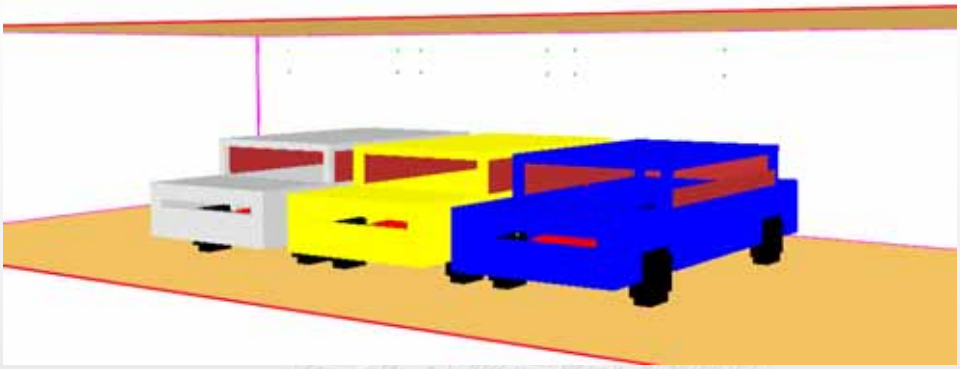
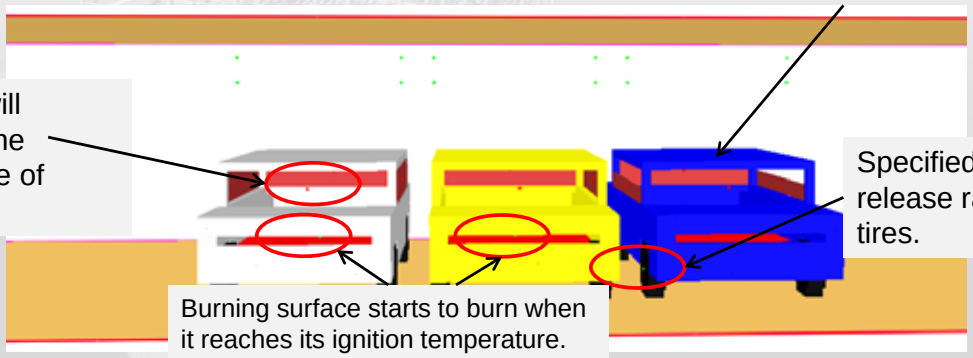
FDS simulation model (2/2)



- Mesh 100mm, Resolution factor 25
- Open car park, height of 3m

Car body does not ignite but material properties were determined.



Windows will shatter at the temperature of 250˚C.

Specified heat release rates for tires.

Burning surface starts to burn when it reaches its ignition temperature. (approximately at 720s and 1440s)

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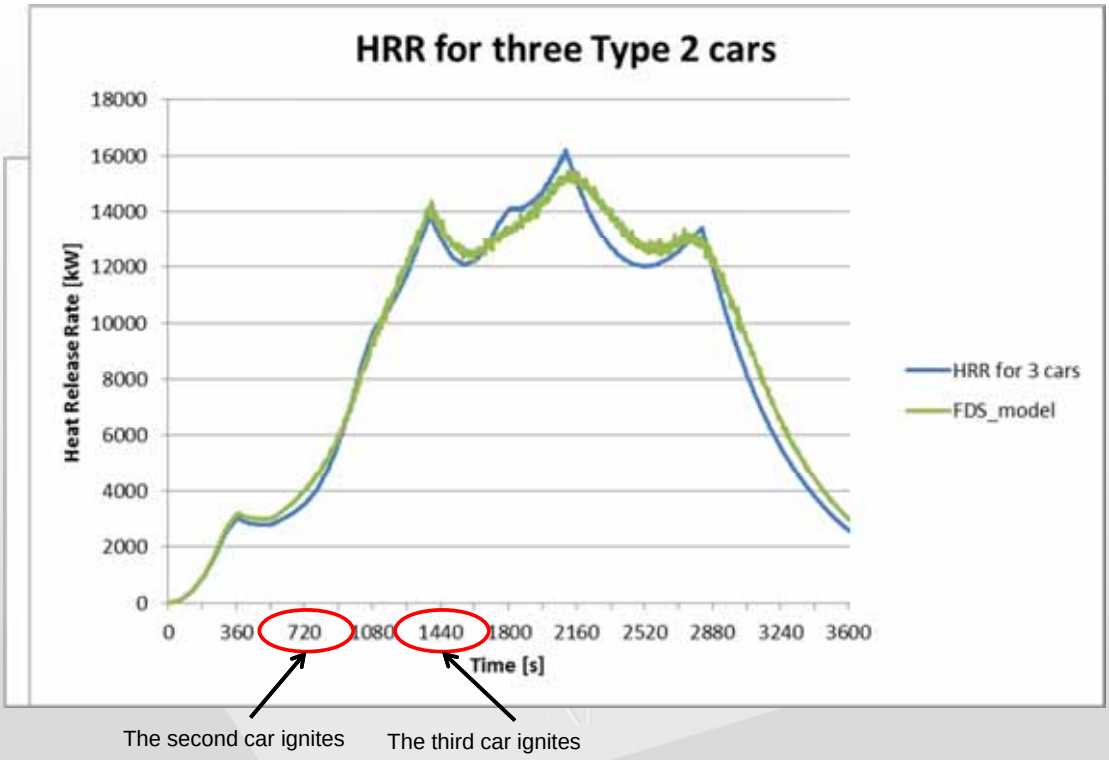

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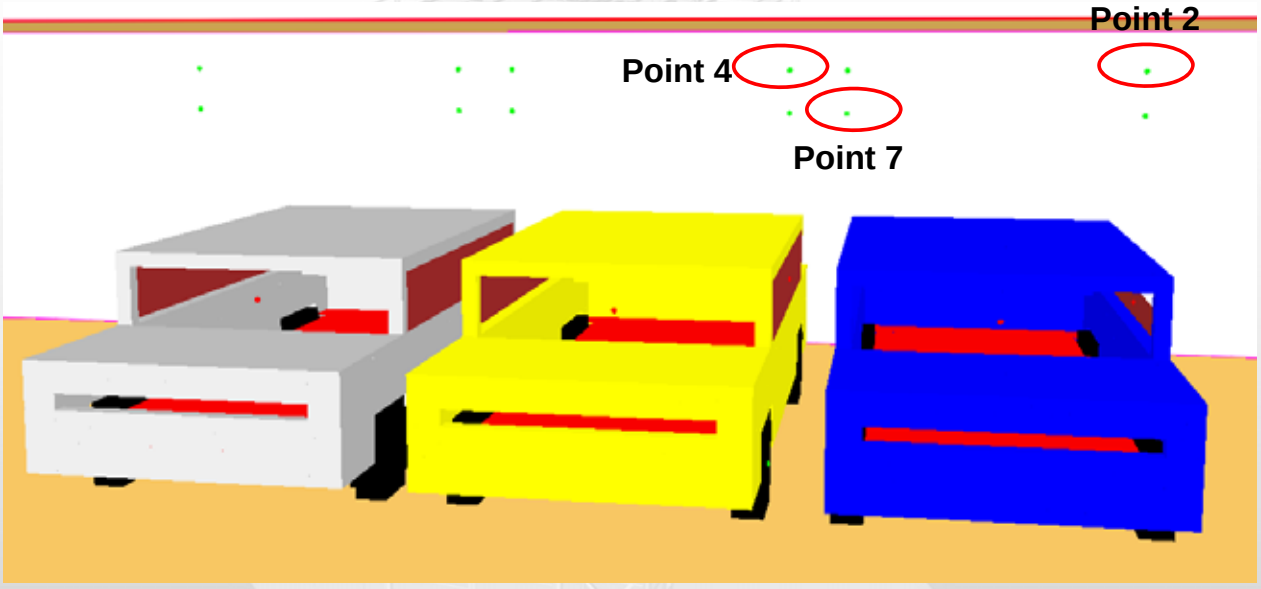
Example measurement points



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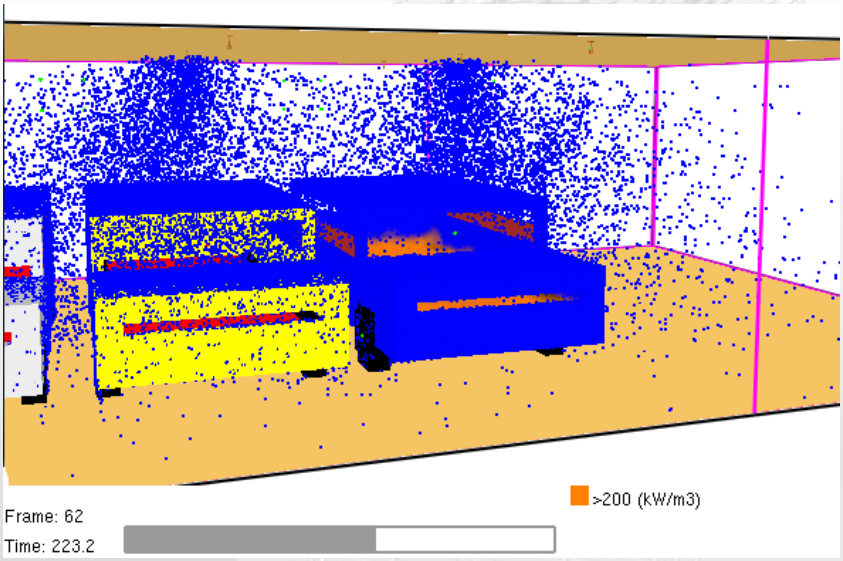
Sprinklers



Activated sprinkler:

- Cools upper layer temperatures and prewets car body parts.
- Prevents fire spreading to the other cars.
- Does not suppress fire of the first car.

- The sprinkler system was designed with OH2 classification, 5mm/min and 9m2 per sprinkler head
- 9 sprinklers, position upright, K5.6

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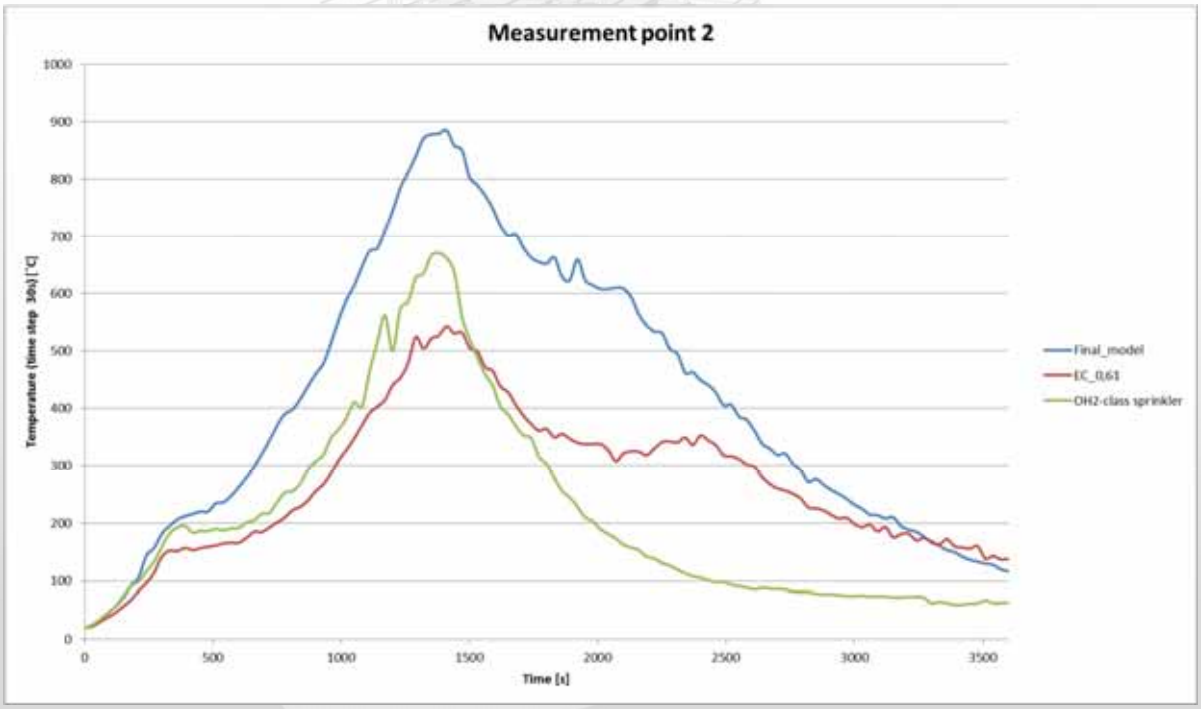
Results:



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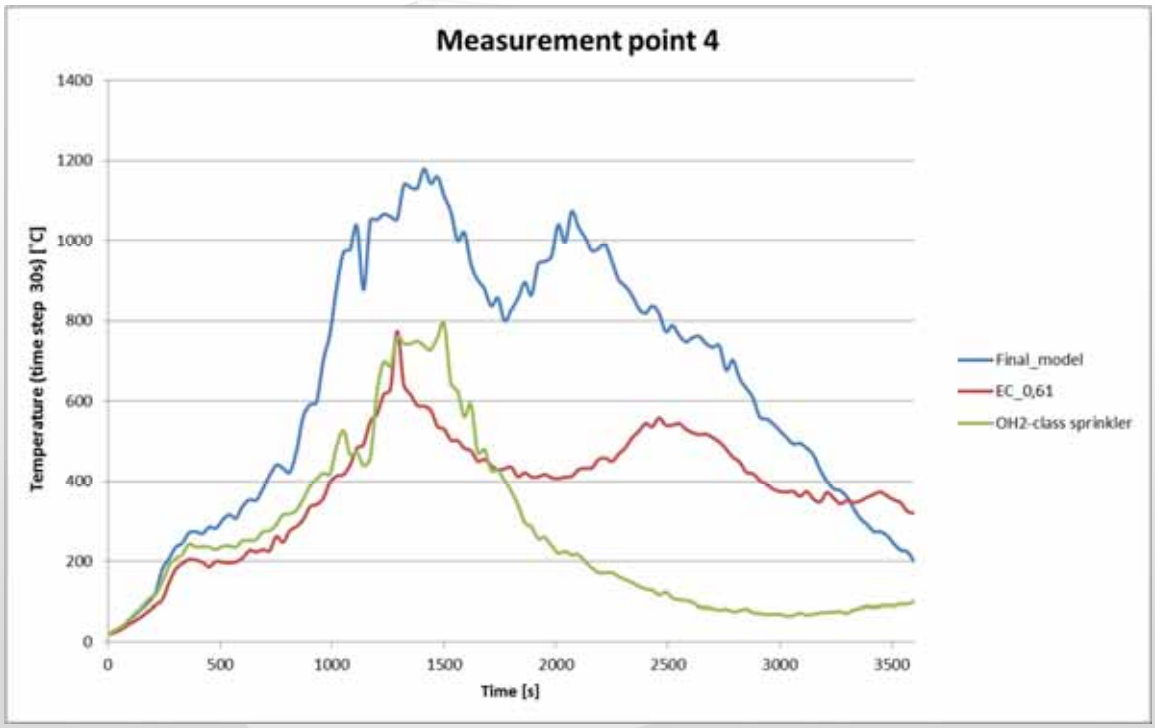

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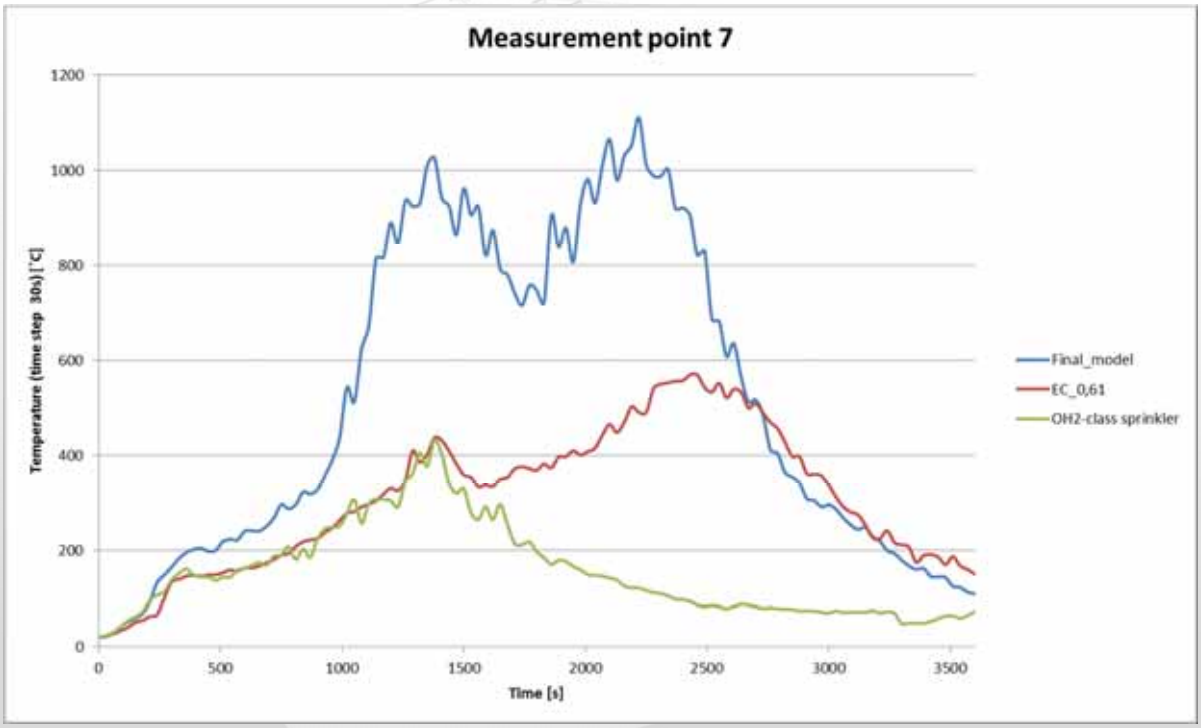

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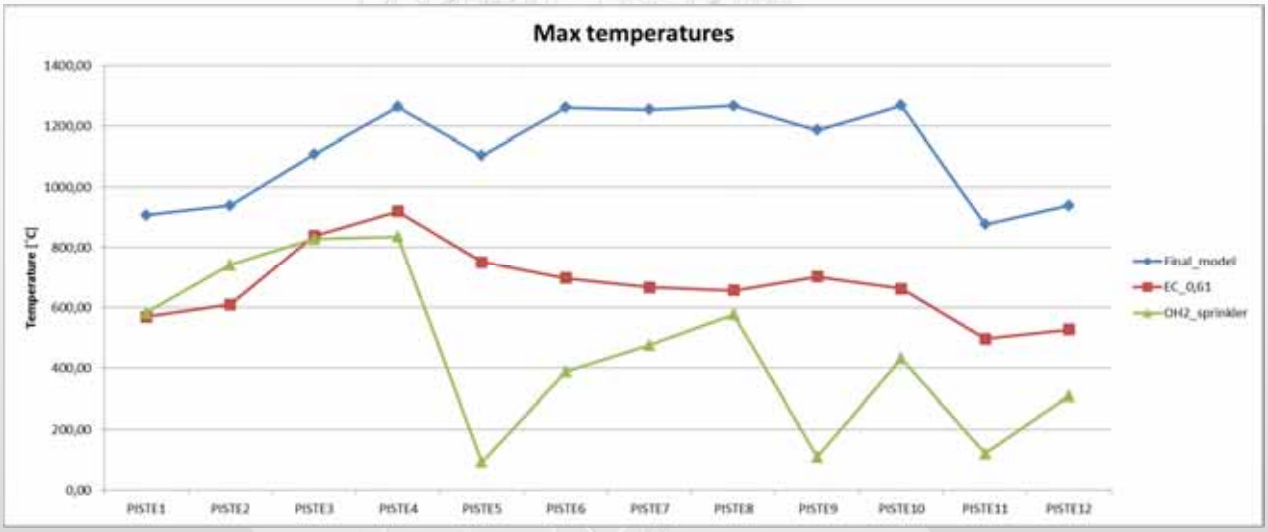

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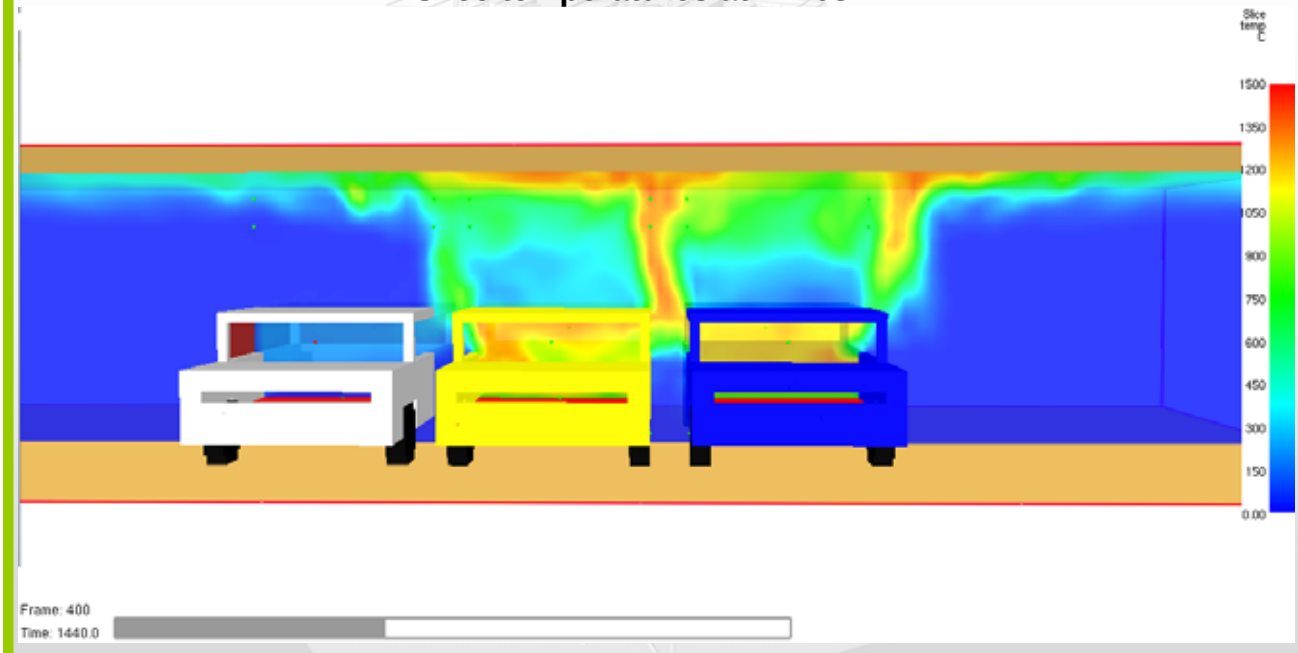
Slice temperatures at 1440s



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Conclusions

- Temperatures are quite high (over 1200˚C) at the ceiling level, because flames don't penetrate car body. Therefore flames from two cars penetrate through the shattered windows and create very hot and high fire plume to the roof.
- The hot gas layer temperatures decrease when real sprinklers are installed or HRRPUA (Heat Release of Unit Area) values are reduced with Eurocode factors. Maximum temperatures are still quite high (over 800˚C) in some test points.
- Sprinklers prevented fire from spreading one car to another, unlike every car ignited in EC_0,61 model with slightly longer time delay than in basic model.
- EC_0,61 and OH-2_class_sprinkler curves produce quite similar temperature results during the first twenty minutes.
- There are some problems with ignition temperatures in a present simulation model. The model is still in develop stage.