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PSI

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Wet storage pool under loss of cooling conditions

10th EMUG meeting, Zagreb, Croatia, 2018

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Content

Motivation

Stop of export of nuclear spent fuel in 2006 by Swiss law

Reprocessing not longer possible

Storage of spent fuel assemblies at site or in intermediate storage facility

→ **Construction of wet storage pool**

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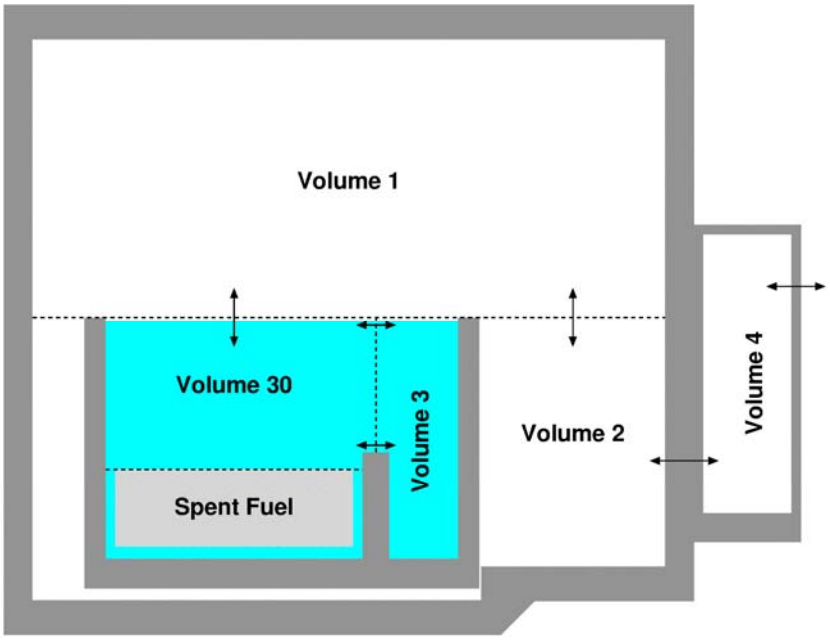
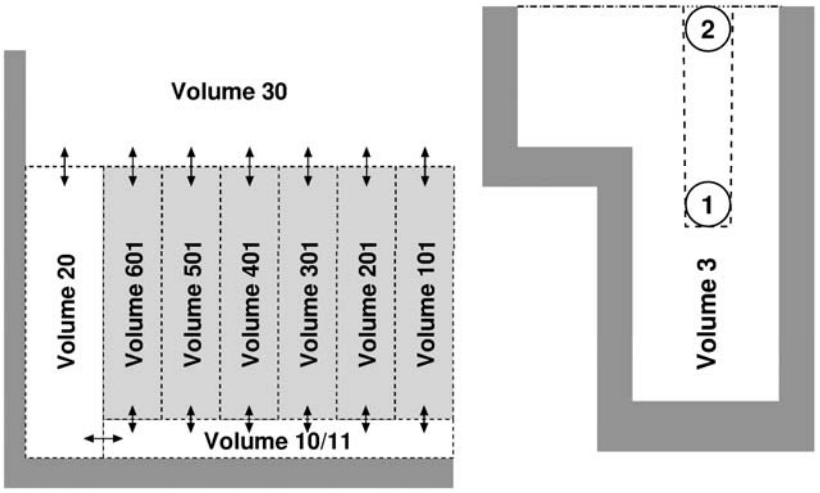
Content

1. Motivation
2. Modeling
3. Results
4. Summary

Modeling I





All safety systems have failed

Control volume model for building and wet storage pool

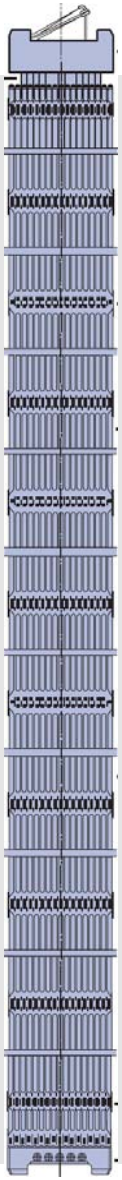
Transfer pool is connected to WSP by (removed) steel seperator

Flow pathes between control volumes

Carefull connection to outside boundary conditions

Checking for instabilities of calculation

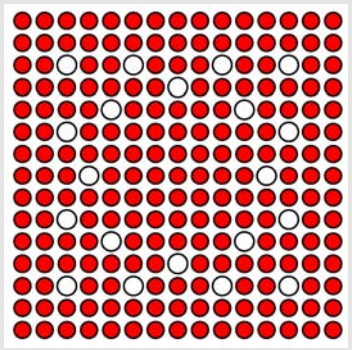
Modeling II

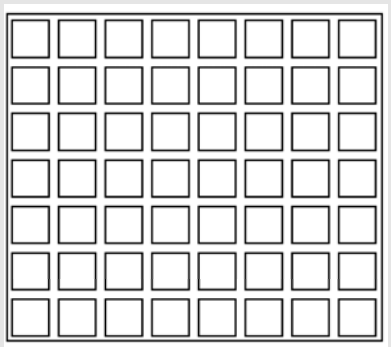


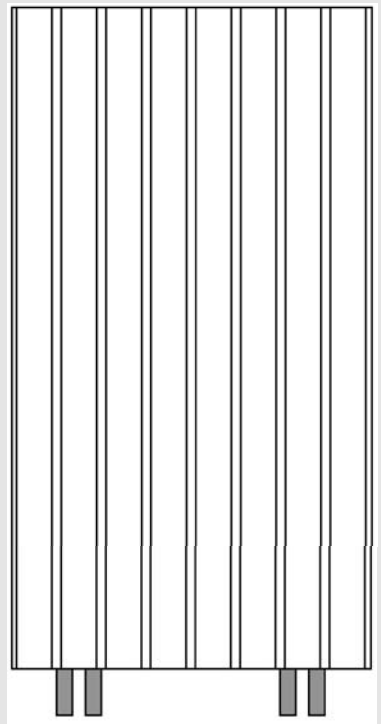
Fuel is modeled as 15x15-20 fuel assemblies without CRP

Each spent fuel rack contains 7x8 FA's

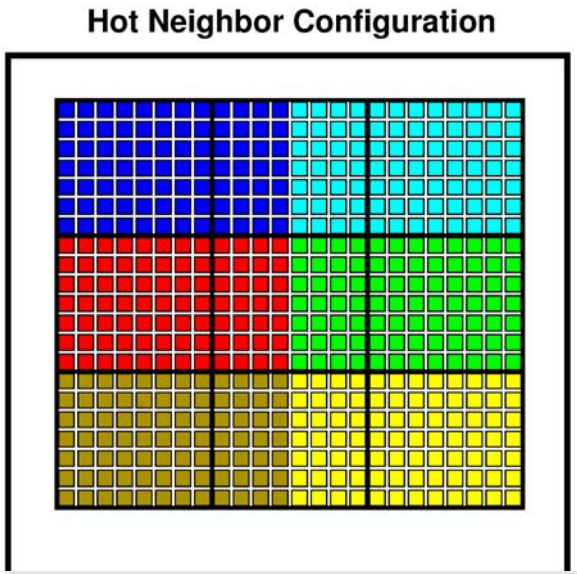
The FA's are separated by borated steel walls and stored in clean water

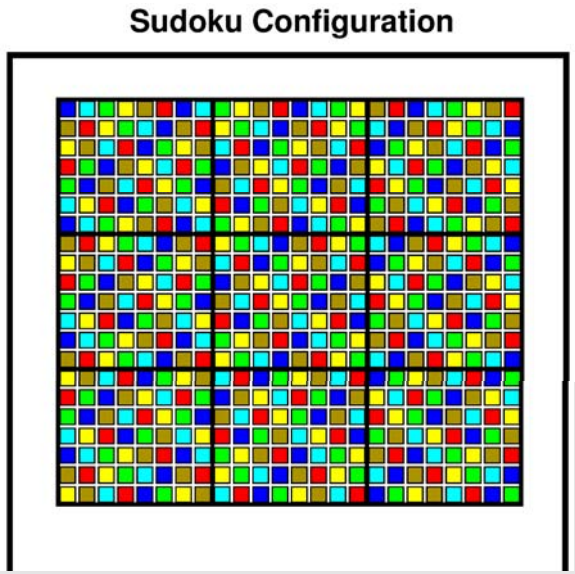




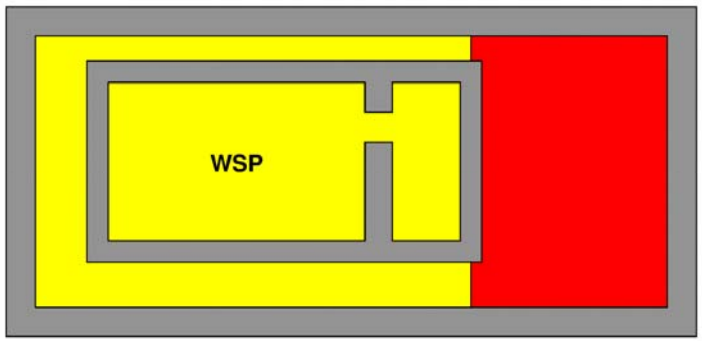


Modeling III





The storage configuration was either a hot neighbor (left) or a cold neighbor storage (right)



The condensed water is flowing back to the pool (yellow area) or into the lower building (red area)

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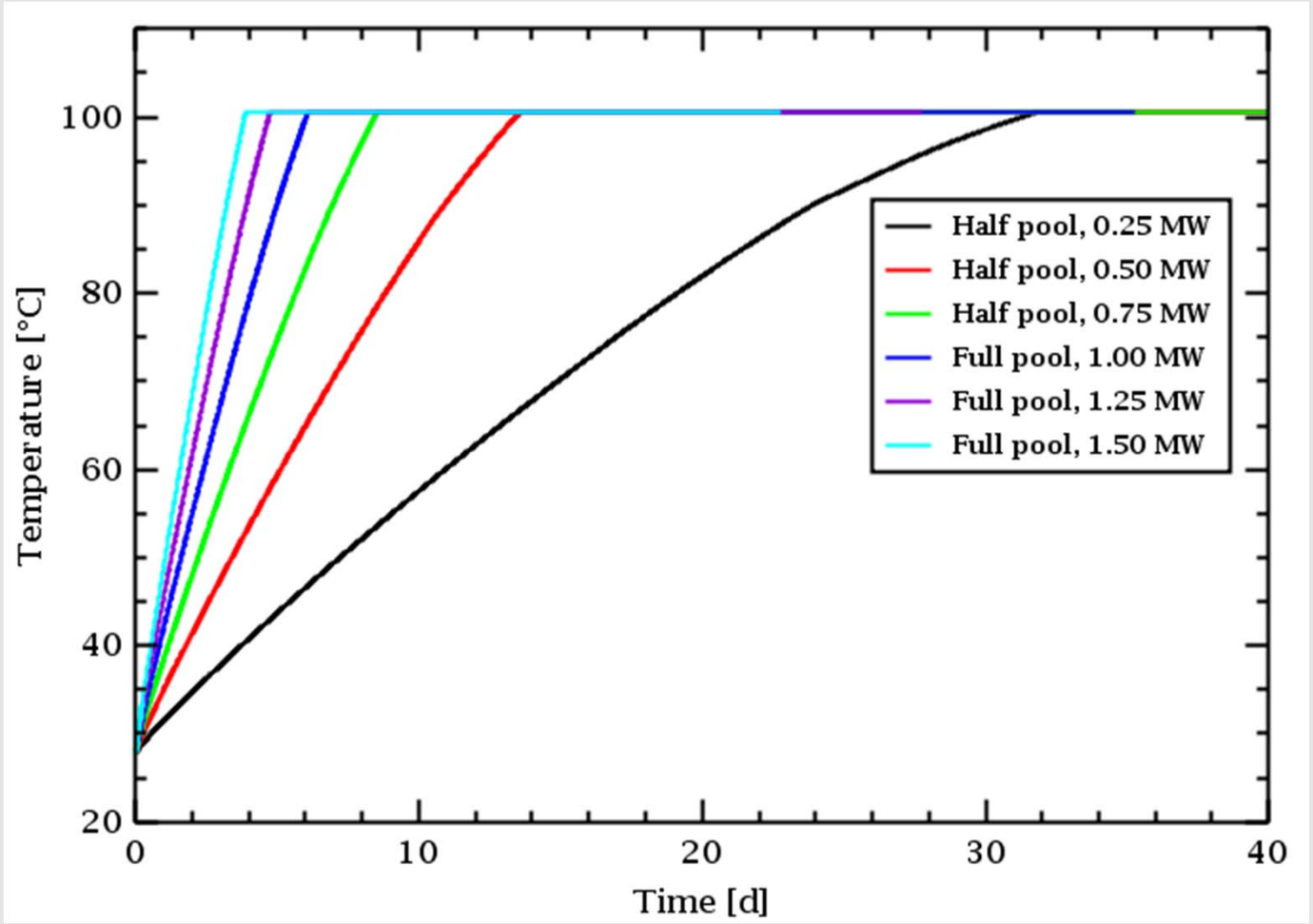
Boundary conditions

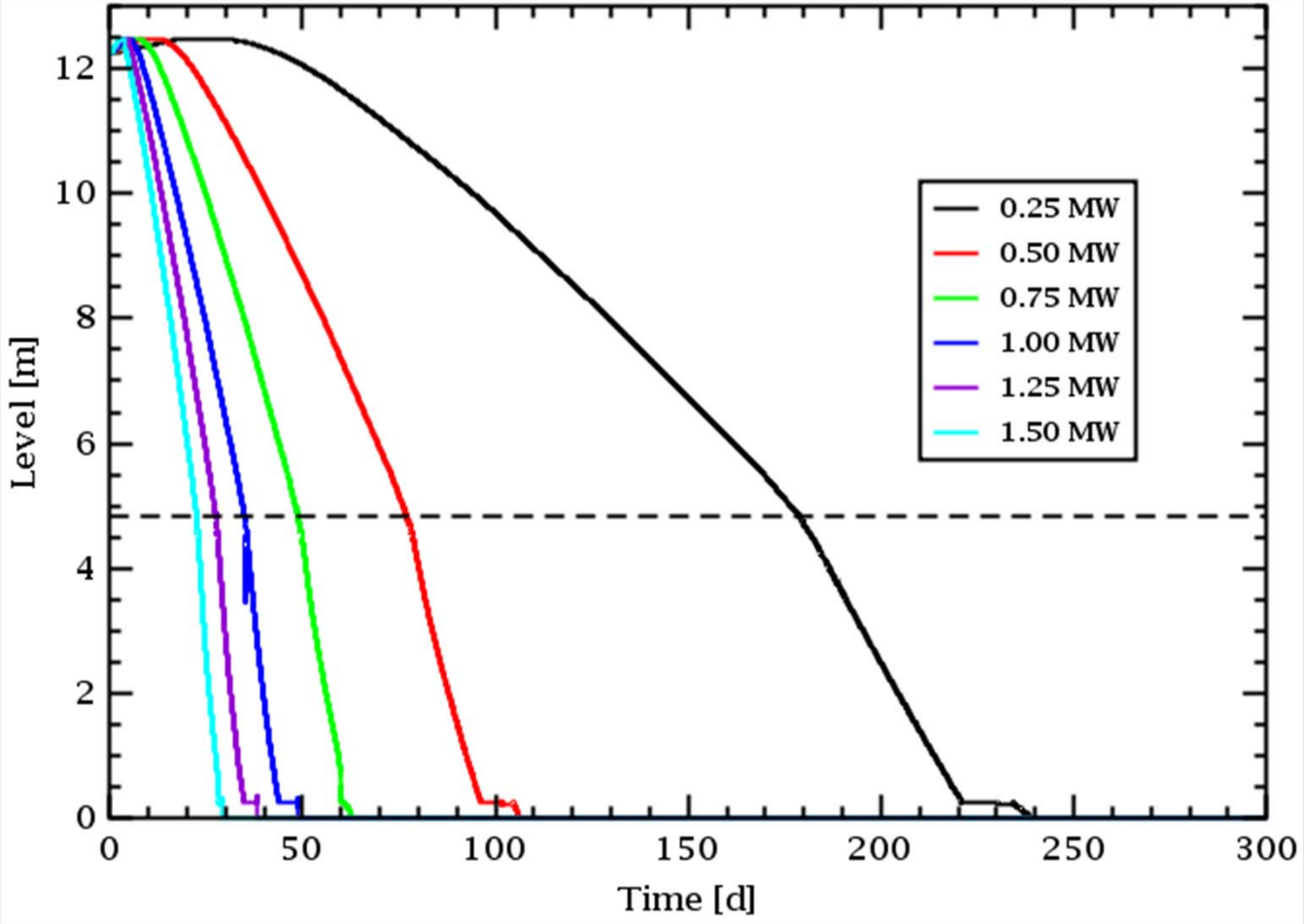
Heat load	250 kW	500 kW	750 kW	1000 kW	1250 kW	1500 kW
FA's	504	504	504	1008	1008	1008
Config.	cold/hot	cold/hot	cold/hot	cold/hot	cold/hot	cold/hot
Temp.	Summer /Winter	Summer	Summer	Summer	Summer	Summer
Oxidation Model	PSI / SNL	PSI / SNL	PSI / SNL	PSI / SNL	PSI / SNL	PSI / SNL

Six different fuel groups with six different heat loads are defined

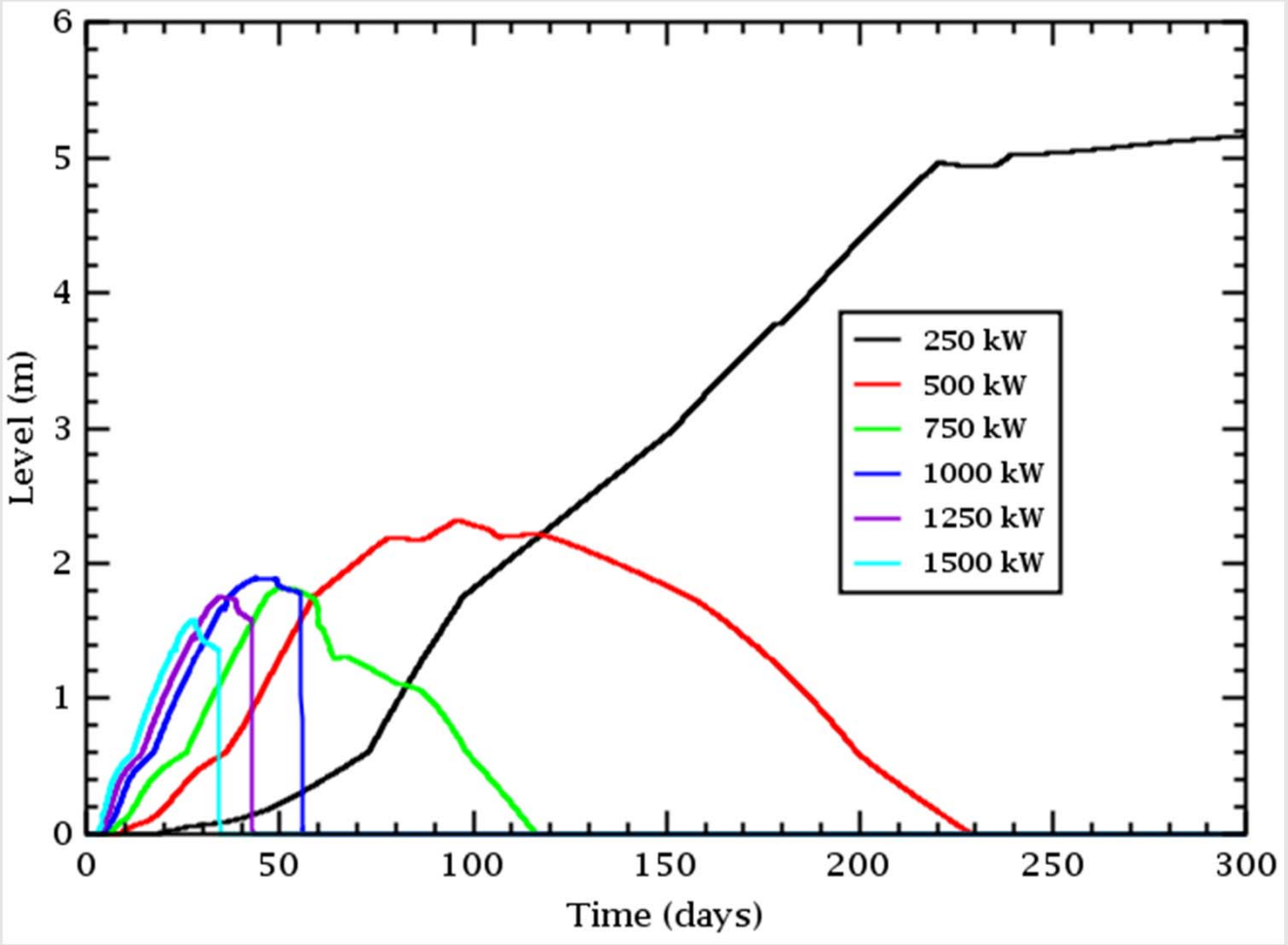
Temperature increase of pool water



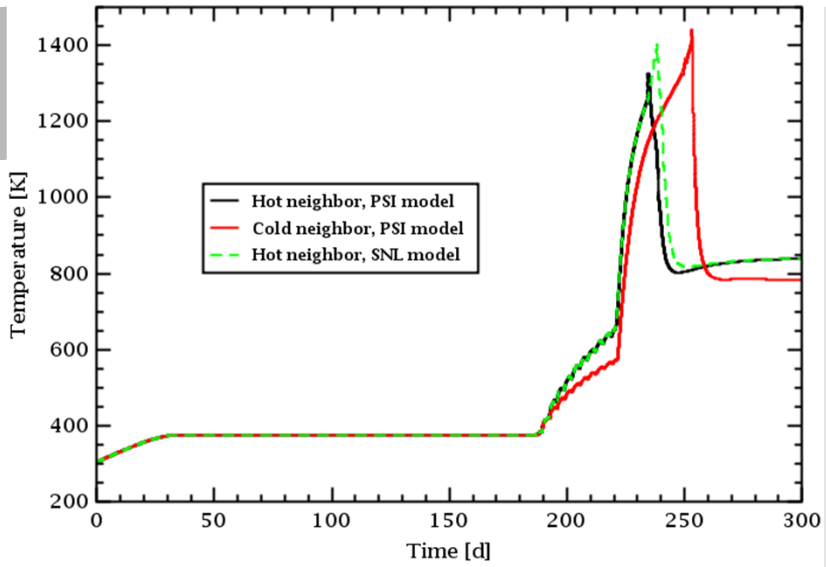
Pool water level

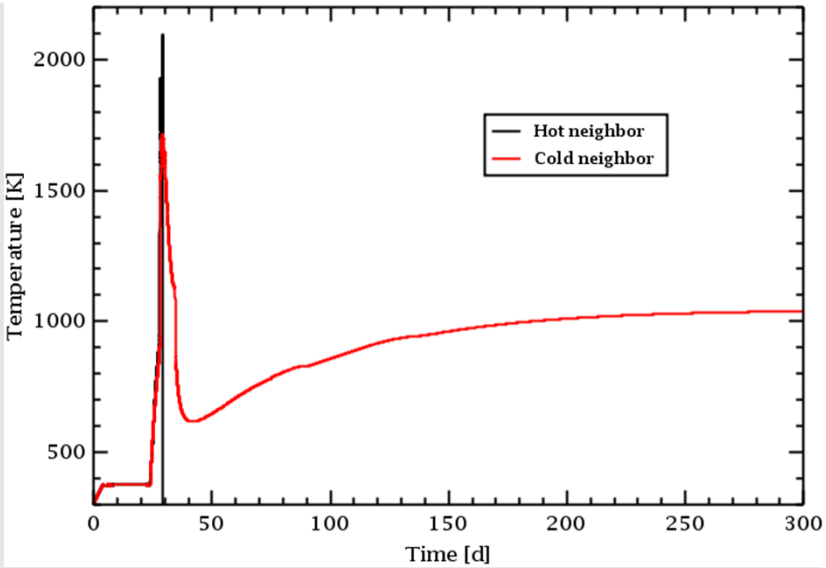


Water level in wet storage building



Peak cladding temperatures



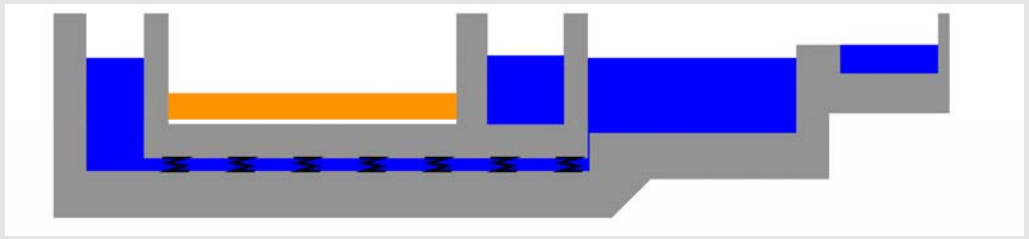


The cases with 250 kW (left) and 1500 kW (right) show strongly differences in the timing of the heat up and also in the temperatures reached in the different calculations

The 250 kW calculation did not reach temperatures for failure of the steel liner while in the 1500 kW calculation the core-concrete-interaction was started after melting of the liner.

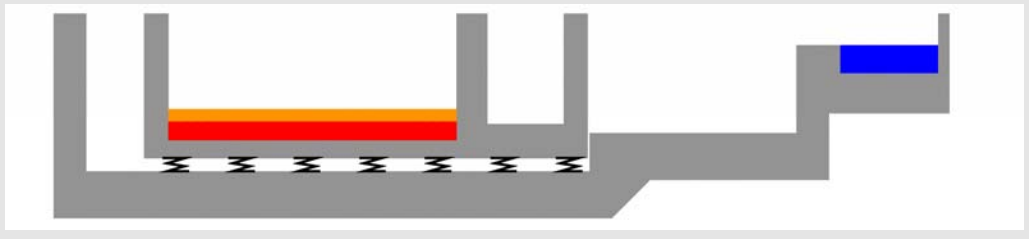
End state after 300 days accident time

250 kW



500 kW

750 kW

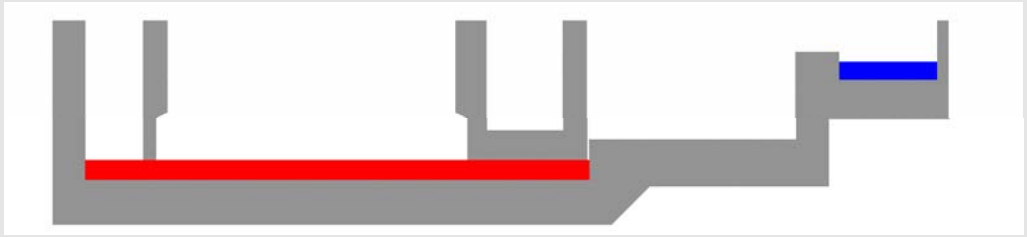


End state after 300 days accident time

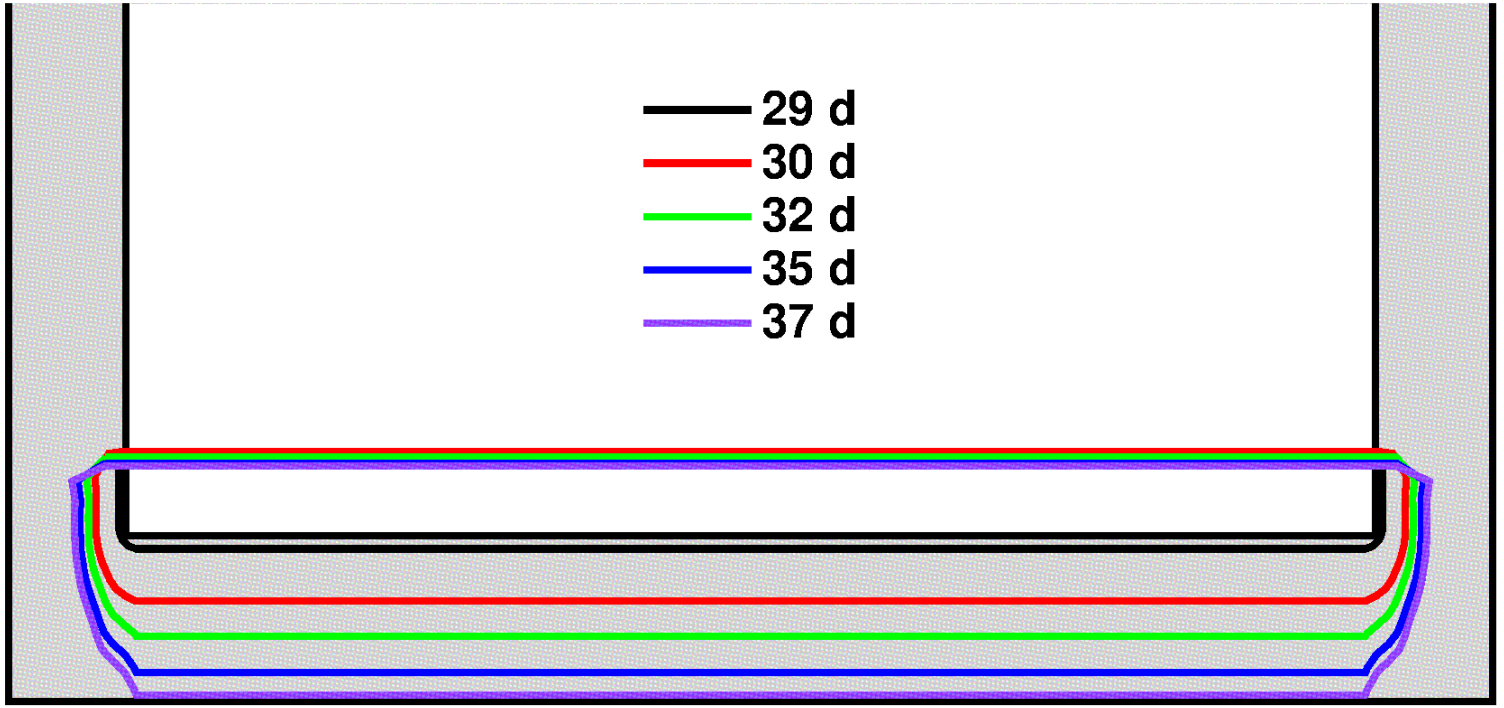
1000 kW

1250 kW

1500 kW

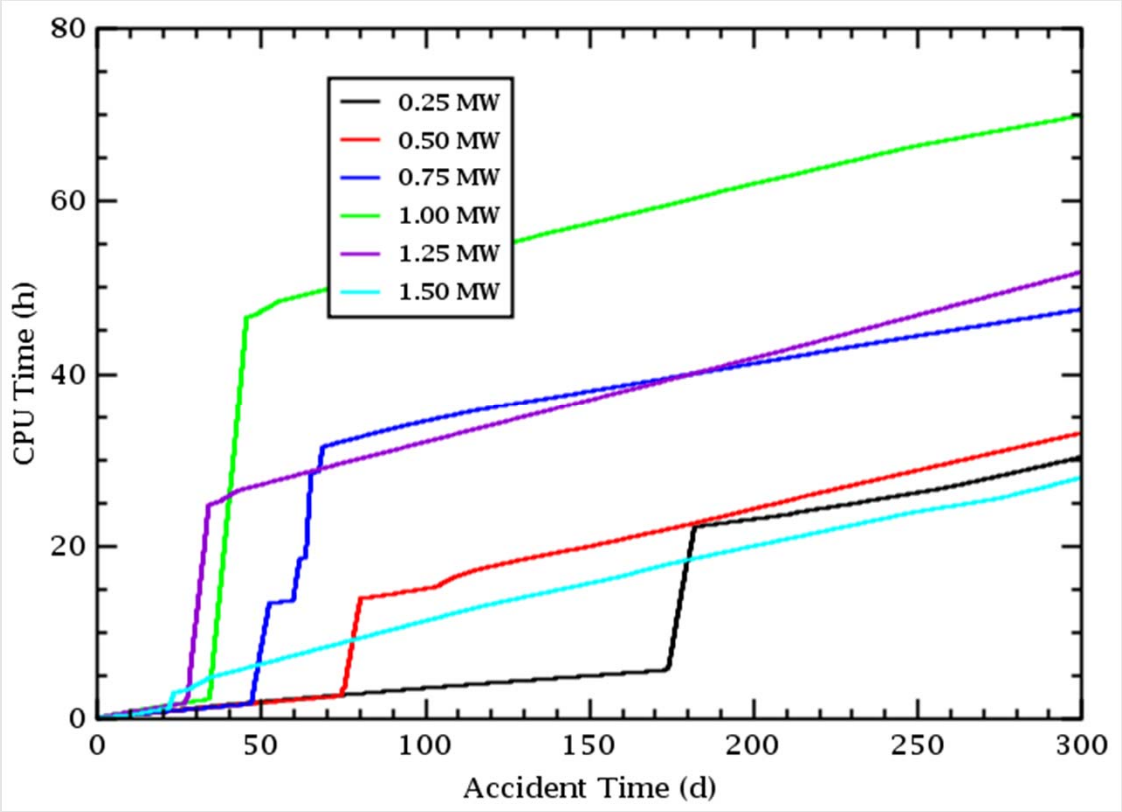


Erosion history of WSP for 1500 kW case



The erosion of the concrete in the case with highest heat load needs about one week to fail the bottom of the wet storage pool.

CPU time consumption of WSP calculations



The time step is selected up to 10 seconds.

Cladding degradation and relocation reduces strongly the preset value.

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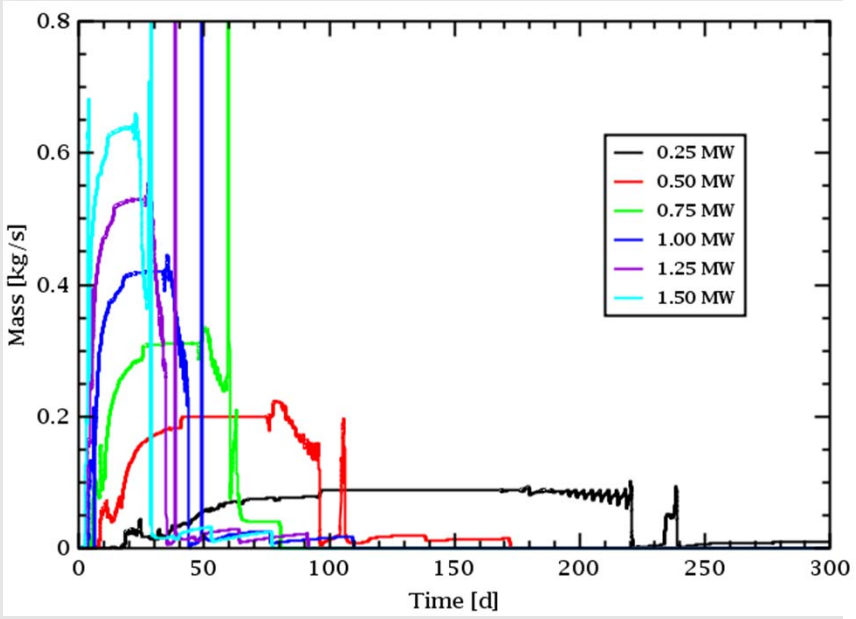
Summary

The accident progression of a loss of cooling accident in the wet storage pool is rather slow, so that in each case enough time is available for accident management measures.

Even with the highest heat load of 1500 kW more than 24 days are passing before the fuel starts to heat up to more than boiling temperature.

Less than 0.7 kg/s cooling water is enough to keep the water level constant in the pool. This amount can be easily delivered by a simple fire water pump.



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Summary

Power/Event	Onset of Boiling	7 m	Water loss at boil down	Water at top of rack	Top of active fuel
0.25 MW	31.8 d	145 d	0.092 kg/s	178 d	186 d
0.50 MW	13.5 d	62 d	0.20 kg/s	76 d	80 d
0.75 MW	8.5 d	39 d	0.32 kg/s	49 d	51 d
1.00 MW	6.1 d	28 d	0.42 kg/s	35 d	36 d
1.25 MW	4.7 d	21.9 d	0.53 kg/s	27.4 d	28.4 d
1.50 MW	3.8 d	17.9 d	0.64 kg/s	22.4 d	23.3 d

This table shows clearly that a wet storage pool for nuclear spent fuel assemblies is a safe storage possiblity with long reaction times for prevention measures in case of a loss of cooling accident.
Dry storage of spent fuel assemblies may have a higher risk due to the enhanced flow resistence in fuel bundles and therefore lower convective heat loss. Peak cladding temperatures should not exceed 400°C.

Questions?