

Apros® Nuclear - Success stories

Loviisa case 1: Modelling and Analysis of Loviisa maximum power fuel assemblies

Fuel assembly update to second generation fuel has a significant effect on loss of coolant accidents and in fuel handling accidents.

Fuel assemblies were updated to second generation fuel and the new fuel is currently in use at Loviisa Nuclear Power Plant (NPP). Maximum power of the fuel assembly has a significant effect on loss of coolant accidents and in fuel handling accidents. New second generation fuel assemblies were updated to Loviisa **Apros®** model and large break loss of coolant accident (LBLOCA) was analyzed. Partly with this LBLOCA analysis it was shown that the new fuel is acceptable to use in Loviisa 1&2.

New fuel - rods have higher maximum power

According to technical specification of the new fuel, rods have higher maximum power. This means that also the fuel assembly maximum power is higher. Taking safety margin into account maximum power of the new fuel assembly used in analysis was 19,1% higher than the previous power used in analysis. Reactor core was divided into seven flow channels and for 12 maximum power assemblies one more channel was created. Fuel assemblies and rods have also other limitations like maximum linear power. This was taken into account by adjusting axial power distribution of the rods. Also the heat conductance of the gap in function of fuel burn-up was updated to the model.

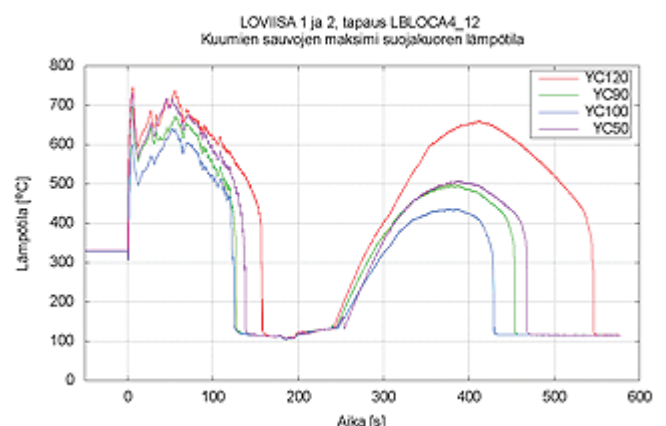
Earlier analysis has shown that Loviisa behaves just like any other PWR during LBLOCA. Accident can be divided into two phases: blow-down and refill. Both phases has the temperature peak of the fuel cladding. After refill the fuel is cooled down and there is no boiling crisis present. When the new maximum power fuel was used, a new third temperature peak of the fuel cladding was discovered.

Third fuel cladding temperature peak occurs because the primary circuit pressure rises and causes the collapsed water levels to decrease in the core. This happens in combination of the pressurized emergency core cooling tanks discharge above the reactor core and the high steam generation rate of the reactor core.

These circumstances leads to fulfilling of the loop seals in hot legs of the primary circuit (exceptional feature of VVER-440 design) which significantly decreases steam flow from above the core. Limited steam flow is the reason for pressure rise causing the decrease of the collapsed water level in the core.

The analysis shows the flexibility and adjustability of Apros® simulation tool

Third cladding temperature peak was lower than the first one and the second one. Maximum cladding temperature was below 800°C and the result were acceptable. Second generation fuel is in use at Loviisa 1&2. Without a good simulation model this task would have been practically impossible considering the complexity of the phenomena and demanding requirements. This analysis also showed the flexibility and adjustability of the simulation tool **Apros®** in very complex two-phase flow circumstances.



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