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## PKL Experiments on Loss of Residual Heat Removal under Shutdown Conditions in PWRs

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When a PWR is shutdown for refueling, the main coolant inventory is reduced so that the level is at mid-loop elevation. For spatial replacement of water, nitrogen is injected into the primary. At so-called mid loop operation, removal of the decay heat from the core is maintained by the residual heat removal system (RHRS), which under these conditions represents the heat sink. Loss of RHRS under shutdown conditions has occurred several times worldwide and still plays an important role in risk studies for PWRS.

The experimental investigation on loss RHRS is one mayor topic in the current PKL test program which is included in an international project set up by the OECD.

PKL is an integral test facility simulating a typical western-type 1300 MW PWR and is used to investigate the thermal hydraulic system behavior of PWRs under accident situations. It replicates the entire primary system and most of the secondary system of the reference plant with elevations scaled 1:1 and diameters reduced by a factor of 12 (volume and power scaling factor 1:145). PKL is equipped with 4 primary loops which are symmetrically arranged around the reactor pressure vessel. PKL is also equipped with all relevant engineered safety and operational systems on the primary and secondary side. With its total of around 1300 measuring points, the PKL facility is well instrumented, which permits detailed analysis and interpretation of the phenomena observed in the tests. The test on loss of RHRS have been performed with borated water and special measurement techniques for the determination of the boron concentration (online measurements).

The PKL tests demonstrate that, as long as the primary circuit is closed, a failure of the residual heat removal system can be compensated by one or more steam generators, which remain filled with water on the secondary side and stay ready for use during refueling and other outages. The temperature and pressure increase on the primary side following the failure of the RHRS is limited and equilibrium conditions become established. The heat transfer to the steam generators is in the reflux-condenser mode. The tests however also showed that accumulations of large condensate inventories (with low boron concentration) can occur in the cold leg piping during mid-loop operation after loss of the RHRS.

The proposed paper will include an overview on the activities within the current PKL/OECD project and will focus on experimental results dealing with loss of residual heat removal during mid-loop operation.