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Realistic High Burnup UO2 Fuel Response to a LOCA in a PWR

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ABSTRACT

Design basis large break LOCA analyses for PWRs in the US typically conclude that the limiting results are obtained when the fuel is in its first cycle of irradiation. With increasing irradiation, the power production from the fuel will naturally decrease as a result of depletion of the fissionable isotopes. An analysis was performed to compare the response of fresh and high burnup fuel in the same core to a large break LOCA. The analysis used realistic computer codes, but included the typical licensing requirements for a design basis analysis (limiting single failure, etc.). The fresh fuel analysis used a non-parametric statistical method based on order statistics, and was performed consistent with methods considered acceptable by the USNRC. 59 cases with approximately 40 uncertainty parameters randomly sampled in each were performed. The most limiting case resulted in a peak cladding temperature of 1082°C (1980°F). According to order statistics theory, this case can be considered to capture a fraction of at least 95% of the PCT uncertainty distribution at 95% confidence.

The high burnup fuel analysis repeated the same 59 cases, but each reflected realistic changes to the fuel that occur with burnup. These included reduced linear heat rates, degradation of the thermal conductivity of the fuel, increased rod internal pressures, and decay heat contributors. The linear heat rate reductions assumed in the analysis were representative of values typically seen in current core reload designs. The effects of fuel thermal conductivity degradation were estimated using the FRAPCON-3 models. The most limiting case resulted in a PCT of 859°C (1579°F). These results indicate that oxidation in high burnup UO2 fuel is expected to be very low in a large break LOCA, provided that the fresh fuel satisfies the acceptance criteria of 10 CFR 50.46.