SIEMENS

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PWR Assembly Liftoff Calculations

Siemens Power Corporation has identified errors in the calculational approach it uses to evaluate the potential for PWR fuel assembly liftoff. An internal condition report (CR 8050) was written to track the evaluation of the errors. The errors identified were: (1) the calculation did not account for the lack of an RCCA in controlled assemblies under operating conditions, (2) the calculation did not account for the effect of momentum changes in the flow, (3) the flow velocity used in the calculation did not account for the temperature increase in the core at operating conditions.

An evaluation of these errors for reporting per 10 CFR 21 has been performed. It was concluded that the impact of the errors was not significant, no defect exists, and the errors are not reportable per 10 CFR 21.

An evaluation of all PWRs for which SPC supplies fuel indicated that the SPC criterion for fuel assembly liftoff would be satisfied for all except two reactors. The impact of not satisfying the criterion was determined to be insignificant from a safety standpoint. Even though SPC has concluded that the errors are not required to be reported per 10 CFR 21, we have decided to provide this letter for information.

The SPC criterion for PWR fuel assembly liftoff is given in EMF-92-116(P)(A), "Generic Mechanical Design Criteria for PWR Fuel Designs," February 1999. The criterion is:

"SPC requires that the assembly not levitate from hydraulic loads. Therefore, for normal operation and anticipated operational occurrences, the submerged fuel assembly weight and hold-down must be greater than the hydraulic loads. The criteria covers both cold and hot conditions and uses the maximum flow limits specified for the reactor."

SPC fuel in two reactors is calculated to have negative hold-down margin at both cold and hot beginning of life (BOL) conditions. Generally, the cold condition is more limiting because of the greater dynamic head associated with the higher fluid density. The cold condition is defined as the temperature at which the last pump is started. This point is the maximum volumetric flow rate. A negative hold-down margin at the hot condition can occur because the differential thermal expansion between the upper and lower core plates and the fuel reduces the hold-down spring deflection relative to the cold case. In addition, the spring material has lower stiffness at the elevated temperature. For the two reactors, the reduced hold-down load at operating temperature is calculated to be overcome by the hydraulic loads if the flow rate is at the technical specification maximum flow rate, including uncertainties.

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If the fuel assembly does levitate, it would lift off of the lower core plate until the increased deflection of the hold-down springs counteracts the hydraulic load. Under a conservative combination of operating conditions, the fuel is calculated to lift up to a maximum of 0.11 inch during startup (cold conditions). The maximum lift during operation, again under conservative conditions, is approximately 0.03 inch. The assembly will not levitate during operation for nominal hot operating conditions. Assembly irradiation growth during the first cycle will increase the hold-down load and preclude liftoff. Therefore, if fuel lift occurs, it would only be for short periods during startup and early in the fuel life. No detrimental effects on the fuel have been observed at either of the two reactors affected.

The design criterion was written to satisfy the requirements as described in SRP 4.2 for fuel system damage. In addition to precluding fuel rod failure, the criteria are intended to ensure that fuel system dimensions remain within operational tolerances and that functional capabilities are not reduced below those assumed in the safety analysis.

The primary intent of the criterion is to restrain the fuel assembly during operation so that the axial location of the fuel, as assumed in the nuclear and safety analyses, is accurately established; and the potential for fuel damage due to flow-induced excitation is minimized during operation. With the fuel assembly resting on the lower core support plate, the criterion reduces the likelihood of damage to the fuel by wear against adjacent fuel assemblies, and damage to the core plate alignment pins by wear. By retaining contact between the lower tie plate with the lower core support plate, the friction between the two surfaces will help to prevent assembly vibration at the lower end of the fuel assembly. Also, possible fuel assembly impact with the lower core support plate during control rod insertion is avoided.

The core plate alignment pins are long enough that disengagement cannot occur if the fuel assembly is elevated to the point of solid contact with the upper core plate. Since disengagement cannot occur, the lateral position of the fuel assembly is maintained and control rod insertion is not impaired.

To evaluate the effect of assembly levitation on the fuel and core interface, SPC conducted a levitation test on a 17x17 fuel assembly. The test was performed at the SPC hydraulic test facility in 1983. A proof-of-fabrication assembly was levitated for 120 hours and included flow changes to produce intermittent contact with the lower support plate. The fuel assembly vibration was characterized during the test and a post-test examination was conducted to evaluate wear and damage.

The results from the test demonstrate that fuel lift, under a limited duration of time, does not result in damage to either the fuel or core interfaces. No significant wear was noted on the alignment pins or the tie plate holes. Wear on the spacer side plates was in small localized spots with a maximum depth of 0.003 inch at the deepest spot. SPC concludes that the levitated fretting test demonstrates that operation for short periods of time in a levitated condition will not be detrimental to the fuel assembly or interfacing reactor internals.

SPC is evaluating a combination of analytical changes, design changes, and operating condition changes to ensure that fuel loaded in the future satisfies the NRC-approved PWR fuel assembly liftoff criteria. These changes will be in place for the next reload at the two affected reactors.

Very truly yours,

James F. Mallay

James F. Mallay, Director
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cc: N. Kalyanam
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