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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION SUPPORTING THE THERMAL HYDRAULIC MARGINS FOR EXXON TOPROD FOR PRAIRIE ISLAND NUCLEAR GENERATING PLANT UNIT 1, CYCLE 7

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The Exxon Nuclear Company (ENC) TOPROD fuel assembly was designed for use in two loop Westinghouse reactors having fuel assemblies with a 14 x 14 array of fuel rods. The outside diameter of the fuel rods and the fuel pellet diameter have been reduced by approximately 2% relative to the ENC standard assembly. This change results in an improved water-to-fuel ratio of about 7%.

From a thermal-hydraulic standpoint the effects on interbundle diversion crossflow of the different fuel pin diameters and increased flow area (3%) and the consequential effects on DNB must be analyzed. Supplement No. 1 (Ref. 1) to XN-NF-80-56, "Generic Mechanical, Thermal Hydraulic and Neutronic Design for Exxon TOPROD Reload Fuel Assemblies for Pressurized Water Reactors, Thermal Margin Analysis" presents the methodology used by Exxon to assess the thermal-hydraulic impacts of a mixed core containing TOPROD and ENC standard assemblies. The generic review of this documentation is still being performed. However we have evaluated the impact of this mixed core arrangement on the Prairie Island Unit No. 1 (PI-1) Cycle 7 Reload, and our evaluation is as follows:

The thermal margin analysis results for the PI1 Cycle 7 are presented in Table 4.1 of Reference 1 assuming a full core of the TOPROD fuel assemblies. The limiting transient has been determined to be the two-pump coastdown. With 102% rated power, the initial DNBR is 2.24 using the W-3 CHF correlation. The minimum DNBR of 1.85 occurs at 3.35 seconds into the transient. In order to show that the full core TOPROD assumption is the most limiting, ENC also performed a sensitivity study of the effect on minimum DNBR of core fuel arrangement. As shown in table 4.2 of reference 1 for the same transient, a full core of the standard ENC fuel assemblies would result in minimum DNBR of 1.92, whereas, a mixed core of 1/3 standard fuel and 2/3 TOPROD would result in minimum DNBR of 1.86 and 1.88, respectively, for standard fuel and TOPROD fuel limiting cases. Therefore, the full core TOPROD assumptions results in the most limiting minimum DNBR compared to the mixed core or full core of standard assemblies.

The thermal margin analysis is done in two steps. First a core wide assembly flow distribution is performed to establish minimum flow to the limiting assembly. A subchannel calculation is then done to determine the minimum DNBR for the limiting subchannel in the hot assembly. The core-wide analysis is performed with an open lattice model. The interbundle diversion crossflow and turbulent mixing are considered using small values of crossflow resistance and turbulent mixing. A mass velocity flow factor is obtained for the limiting

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hot assembly by averaging the axial flow distribution in the assembly. This mass velocity flow factor is then used to perform the limiting assembly hot channel minimum DNBR analysis. In the hot channel analysis the limiting assembly is assumed closed to the neighboring assemblies with the assembly mass velocity equal to the product of the flow factor and core average mass velocity. ENC contends that this simplified approach is conservative.

The staff is still reviewing the uncertainty due to the simplified closed hot assembly approach. The effect of crossflow resistance on interbundle diversion crossflow in the core wide analysis, and the validity of input parameters and assumptions implicit to the analytical technique are being evaluated with respect to the overall effect of mixed core on minimum DNBR calculation. However, our review has progressed sufficiently to conclude that the full core TOPROD calculation is a reasonable approximation if not a conservative analysis of the limiting assembly in the mixed core.

Using the methodology described in XN-NF-75-32, Supplement 1 (Ref. 2), ENC also presented, in Table A-4 of reference 1, a rod bow penalty of 13.7% based on a maximum fuel burnup of 42500 MWD/MTU Since this methodology is still under review by the staff, we have calculated the amount of gap closure, for the TOPROD assembly, using the methods described in our interim safety evaluation report on rod bowing (Ref. 3). We have calculated the amount of gap closure to be 62.1% for a burnup of 15000 MWD/MTU which is the maximum burnup for the limiting TOPROD assembly by the end of Cycle 7. The resultant DNBR penalty is 21.1%. With this rod bow penalty, the MDNBR for PI1 TOPROD will be reduced from 1.85 to 1.46 for the limiting two pump coastdown transient compared to the 1.30 MDNBR limit for W-3. The staff concludes that the available thermal margin of 12% is large enough to account for the interbundle crossflow uncertainties. We therefore, conclude that the operation of PI1 Cycle 7 is acceptable. However, we shall continue our generic review on the effect of mixed core arrangement and interbundle crossflow on DNBR, and the rod bow methodology described in reference 2. Our findings will be addressed separately in a generic evaluation report and will be applicable to Prairie Island.

References:

1. XN-NF-80-56, Supplement 1, "Generic Mechanical, Thermal Hydraulic and Neutronic Design for Exxon Nuclear Neutronic Design for Exxon Nuclear TOPROD Reload Fuel Assemblies for Pressurized Water Thermal Margin Analysis", October 1981

2. XN-NF-75-32, Supplement1, "Computational Procedure for Evaluating Fuel Rod Bowing", July 1981

3. Memo from D. R. Ross to D. B. Vassallo, "Revised Interim Safety Evaluation Report on the Effects of Fuel Rod Bowing on Thermal Margin Calculations for Light Water Reactors", dated February 16, 1977

October 20, 1981