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BSP Evaluation Report
MELLLA Backup Stability Protection Evaluation for Hope Creek Cycle 14 at CPPU Conditions

[The CPPU cycle in this report is referred to as Cycle 14 for report generation purposes only. Cycle 14 will not be the EPU implementation cycle.]

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BSP Evaluation Report

MELLLA Backup Stability Protection Evaluation for Hope Creek Cycle 14 at CPPU Conditions

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BACKGROUND

The stability Interim Corrective Actions (ICA) published by the BWR Owners' Group in Reference 1 can be summarized as guidance for reactor operation in regions of the power/flow domain where the margin to thermal hydraulic instability has been reduced. The ICA regions were based upon empirical evaluations and experience of BWR operation, and were described in terms of relative core flow and flow control lines (rod lines). The regions were not based upon specific analyses and hence do not provide constant margin to potential thermal hydraulic instability events. In Reference 2, the BWR Owners' Group recommended that plants review the applicability of the generic ICA regions on their respective core designs based on the fact that "...aggressive core design changes may have reduced stability margin". Reference 3 describes the method that GE proposed for licensees to review the applicability of their ICA regions.

INTRODUCTION

The objective of this evaluation is to demonstrate the stability performance of a mixed core of SVEA 96+ and GE14 fuel at a Constant Pressure Power Uprate (CPPU) condition of 115% of the current licensed thermal power (CLTP) with operation in the Maximum Extended Load Line Limit Analysis (MELLLA)[1] domain and no change in the normal maximum operating pressure. The evaluation is performed for a Hope Creek core containing 348 SVEA 96+ fuel assemblies and 416 GE14 fuel assemblies. The quantity of each fuel type may vary in the actual Cycle 14 core. The Backup Stability Protection (BSP, Reference 3) regions are determined at a bounding feedwater temperature for this demonstration. The BSP Scram Region I and Controlled Entry Region II are established using ODYSY stability acceptance criterion as shown in Figure 1. The base BSP region boundary intercepts are the same as the ICA region boundary intercepts on the natural circulation line (NCL) and the highest flow control line (HFCL). If the ODYSY calculations determine that the BSP regions are larger than the corresponding ICA regions, then the larger BSP regions are used for stability monitoring in the event that the Oscillation Power Range Monitor (OPRM) system is declared inoperable.

[1] The MELLLA Boundary Line in the power/flow map represents a generically developed load line for Hope Creek. The actual plant operating load line is expected to vary through the cycle and from cycle to cycle and may not follow this MELLLA boundary line.

ANALYSIS

The following application procedure is designed to produce a conservative calculation of the BSP stability regions on the MELLLA power/flow map as shown in Figure 2, that have the potential for reactor instability, considering all manual BSP requirements (Reference 3). The procedure for the decay ratio (DR) calculations is summarized as follows:

1. Obtain accurate cycle and exposure dependent inputs from the core simulator. Rodded depletions are used in these calculations. The core and channel DR calculations are performed for a number of exposure points through the cycle to determine the limiting exposure.

2. Perform DR calculations at the limiting exposure along the HFCL and the NCL to search for the bounding state points. Table 1 outlines the key assumptions used in this analysis.

3. Plot the decay ratio results on the stability criterion map (see Figure 1). Use a linear interpolation scheme along the HFCL and along the NCL to determine the power/flow state points that produce core decay ratios that satisfy the acceptance criterion shown in Figure 1. The power/flow state points that meet this acceptance criterion define the region boundary intercepts on the HFCL and the NCL.

4. Use the following Generic Shape Function (GSF) to construct the region boundary:

$$P = P_B \left[\frac{P_A}{P_B} \right]^{\frac{1}{2}\left[\left(\frac{W-W_B}{W_A-W_B} \right) + \left(\frac{W-W_B}{W_A-W_B} \right)^2 \right]}$$

where:

P = percent rated power at a point on region boundary

P_A = percent rated power at point A (HFCL)

P_B = percent rated power at point B (NCL)

W = percent rated core flow

W_A = percent rated core flow at point A

W_B = percent rated core flow at point B.

Table 1 Key Assumptions for BSP Regions Calculation

Application	Assumptions
Xenon concentration	• For Region I on the NCL, constant Xenon at rated operating condition • For Region II on the NCL, no Xenon • For Region I on the HFCL, constant Xenon at rated operating condition • For Region II on the HFCL, equilibrium Xenon
Feedwater Temperature (FWT)	• For Region I, constant feedwater temperature at rated operating condition • For Region II, equilibrium feedwater temperature at off-rated operating condition

RESULTS AND DISCUSSION

Core and channel DR calculations are performed at the base BSP Scram Region NCL and HFCL boundary points for a number of exposure points through the cycle to determine the limiting exposure for both the NCL and the HFCL. The results are calculated based on a verified ODYN base deck prepared for the Hope Creek CPPU and is acceptable for the Cycle 14 evaluation. For Hope Creek Cycle 14 operation, the limiting exposure occurs at BOC based on limiting highest channel DR and at EOC-1234 MWD/ST (11,000 MWD/ST) based on limiting core DR for both BSP Scram Region boundary points as shown in Table 2. Therefore, the determination of the BSP boundary intercepts on the NCL and the HFCL for the Scram Region I and the Controlled Entry Region II is performed at BOC and 11,000 MWD/ST.

Proposed BSP Regions for Cycle 14

The computed DR results at the BOC bounding state points A_1, B_1, A_2 and B_2 and the 11,000 MWD/ST bounding state points A_1', B_1', A_2' and B_2' on the NCL and the HFCL for MELLLA operation are shown in Figure 1 and Table 3. The base BSP Region HFCL and NCL boundary points A_1-ICA, B_1-ICA, A_2-ICA and B_2-ICA are also shown in Table 3. The calculated BSP state point A_1 on the HFCL is greater than A_1' and A_1-ICA and therefore becomes the proposed BSP scram region boundary intercept on the HFCL. Because the point sets B_1 and B_1', A_2 and A_2', and B_2 and B_2' are located inside the corresponding base BSP boundary points B_1-ICA, A_2-ICA and B_2-ICA along the HFCL or the NCL on the power/flow map, the calculated BSP region boundary intercepts are replaced by the corresponding base BSP boundary points B_1-ICA, A_2-ICA and B_2-ICA, respectively, in accordance with Reference 3. Hence, the proposed BSP scram region boundary intercepts are A_1 and B_1-ICA and the proposed BSP controlled entry region boundary intercepts are the base BSP boundary points A_2-ICA and B_2-ICA, as shown in Table 3. The proposed BSP region boundaries are established using the GSF as shown in Figure 2 at the bounding feedwater temperature (409°F). All calculated BSP region boundary intercepts based on the BOC ODYSY DR results are shown in Figure 2 for comparison.

Table 2 Decay Ratios of BSP Scram Region NCL and HFCL Boundary Points as a Function of Cycle Exposure at a Bounding Feedwater Temperature of 409°F

Power/Flow Point (Case Name)	% Rated Power	% Rated Flow	Exposure (MWD/ST)*	Core DR	Highest Channel DR	Feedwater Temperature (°F)
Scram Region I, NCL Points						
[[				0.577	0.017	409.0
				0.567	0.024	409.0
				0.585	0.007	409.0
				0.577	0.029	409.0
				0.634	0.008	409.0
				0.629	0.080	409.0
				0.564	0.314	409.0
				0.426	0.416	409.0
				0.269	0.447	409.0
				0.236	0.464	409.0
				0.384	0.499	409.0
				0.388	0.530	409.0
				0.371	0.552	409.0
Scram Region I, HFCL Points						
				0.702	0.199	409.0
				0.688	0.212	409.0
				0.710	0.185	409.0
				0.703	0.246	409.0
				0.745	0.146	409.0
				0.725	0.325	409.0
				0.654	0.428	409.0
				0.506	0.484	409.0
				0.346	0.541	409.0
				0.207	0.576	409.0
				0.373	0.627	409.0
				0.411	0.672	409.0
			]]	0.405	0.708	409.0

* EOC exposure for the BSP analysis is 12,234 MWD/ST.

Table 3 ODYSY Decay Ratio Results at Bounding Feedwater Temperature (409°F) for determining MELLLA BSP Regions

Power/Flow Point	Rated Power (%)	Rated Flow (%)	Exposure MWD/ST	Core DR	Highest Channel DR	Feedwater Temperature (°F)
Scram Region I, NCL Point						
[[				0.427	0.653	409.0
				0.795	0.183	409.0
Controlled Entry II, NCL Points						
				0.457	0.638	329.2
				0.792	0.078	334.3
Scram Region I, HFCL Point						
				0.389	0.670	409.0
				0.795	0.196	409.0
Controlled Entry Region II, HFCL Point						
				0.492	0.627	364.1
				0.794	0.069	364.3
			]]			

REFERENCES

1. "BWR Owners' Group Guidelines for Stability Interim Corrective Action," BWROG-94078, June 6, 1994.

2. "Review of BWR Owners' Group Guidelines for Stability Interim Corrective Action," BWROG-02072, November 20, 2002.

3. "Backup Stability Protection (BSP) for Inoperable Option III Solution," GE to BWR Owners' Group Detect and Suppress II Committee, OG 02-0119-260, July 17, 2002.

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Figure 1 Calculated BSP Region Boundary Decay Ratios for HCGS Cycle 14

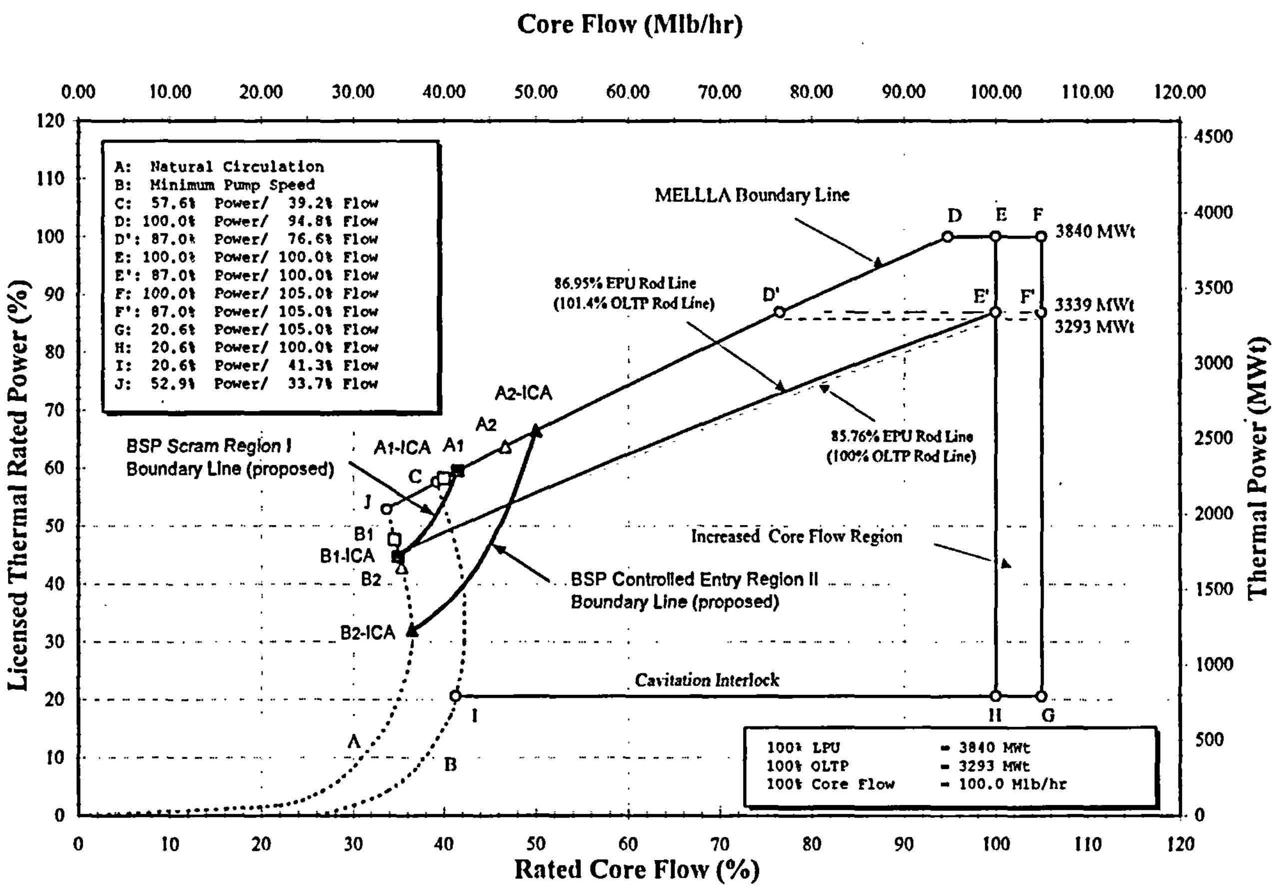

Figure 2 Proposed BSP Regions for Cycle 14