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SUBJECT: Responds to NRC 911223 request for addl info on Topical Rept PL-NF-89-005, "Qualification of Transient Analysis Methods for BWR Design & Analysis." Table listing hot bundle modeling study results encl.

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FEB 12 1992

Director of Nuclear Reactor Regulation
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Project Directorate I-2
Division of Reactor Projects
U.S. Nuclear regulatory Commission
Washington, D.C. 20555

SUSQUEHANNA STEAM ELECTRIC STATION
RESPONSE TO RAI ON TRANSIENT ANALYSIS METHODS
PLA-3729 FILES A7-8/R41-2

Docket Nos. 50-387
and 50-388

Dear Mr. Miller:

References:

1) *PL-NF-89-005, "Qualification of Transient Analysis Methods for BWR Design and Analysis", December 1989.*

2) *PL-NF-90-001, "Application of Reactor Analysis Methods for BWR Design and Analysis", August 1990.*

3) *NRC Letter dated December 23, 1991, "Request for Additional Information on PPL Topical Report PL-NF-89-005".*

4) *PLA-3698, "Proposed Amendment 150 to License No. NPF-14 : Unit 1 Cycle 7 Reload", December 11, 1991.*

On December 10, 1991, a telephone call was held between the NRC and PP&L regarding PP&L's licensing methods described in Reference 1. Reference 3 contains an NRC request for additional information based on this phone call. This letter documents PP&L's response to the NRC request. The calculational results contained in this letter have been documented and verified in accordance with PP&L's Operational Quality Assurance Program.

The NRC questioned the use of a constant axial power distribution in the RETRAN hot bundle model. The approach used by PP&L at the time the licensing methods were developed included a very conservative hot bundle gap conductance methodology (described in Reference 2) to cover the effects of assuming a constant axial power distribution. To directly address the current NRC concern, PP&L (with the assistance of Computer Simulation & Analysis, Inc.) modified the

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RETRAN02 MOD4 code version used for its licensing analyses to explicitly model a time-varying axial power distribution in the hot bundle. PP&L intends to use this modified version of RETRAN to explicitly model the time varying hot bundle axial shape starting with Unit 2 Cycle 6.

Specific analyses were performed on Unit 1 Cycle 7 that demonstrate the conservatism of the MCPR operating limits (Reference 4) generated with the Reference 2 methodology (i.e., very conservative gap conductance coupled with a constant axial power distribution).

A revised hot bundle gap conductance methodology is used along with the explicit treatment of a time-varying axial power distribution to more realistically model the hot bundle (see Attachment 1). It should be noted that the system model gap conductance methodology described in Reference 2 and approved by the NRC is unchanged.

The Attachment 1 methodology for hot bundle gap conductance calculations uses a power history taken from the SIMULATE-E cycle step-out for the cycle being analyzed. To address the concerns raised in Reference 3, the effect of small variations in the power history on calculated hot bundle gap conductance was determined. Two ESCORE calculations were performed. The first calculation used the SIMULATE-E cycle step-out power history and the second calculation increased the powers from this cycle step-out power history by 10% (note that the SIMULATE-E bundle power uncertainty is less than 4%). The power history which was increased by 10% produced a calculated gap conductance that is approximately 9 BTU/hr-ft^2-°F higher than the gap conductance produced by the power history taken directly from SIMULATE-E. This difference in gap conductance produced a change of less than 0.002 in calculated ΔCPR for the Generator Load Rejection at rated conditions. Thus, the expected range of variations in power history (including the effects of code uncertainty) will not have a significant impact on either hot bundle gap conductance or calculated ΔCPR. It should be noted that the more realistic value of gap conductance used in this methodology is still significantly higher (more conservative) than the value calculated by Siemens Nuclear Power Corporation using their NRC-approved methodology.

As discussed during the phone call, the more realistic hot bundle gap conductance at rated conditions was calculated (for Unit 1 Cycle 7) to be 924 BTU/hr-ft^2-°F compared to a value of 1462 BTU/hr-ft^2-°F using the very conservative Reference 2 method. The power history from the Reference 2 method does not represent real cycle operation. Rather, it was designed to produce a large gap conductance. The reason for the large value of gap conductance produced by the Reference 2 method is that the power history entails unrealistically high powers early in bundle life which maximizes pellet cracking and relocation, while minimizing fission gas release, thus maximizing gap conductance.

Calculations of limiting transients for Unit 1 Cycle 7 were performed with both the new approach (explicit treatment of time varying axial power distribution) and the Reference 2 method. The effect of including the axial shape shift versus not including it (at a given gap conductance) was calculated to be an increase of about 0.025 ΔCPR for the Generator Load Rejection at rated conditions. Results of ΔCPR calculations for Unit 1 Cycle 7 using the Reference 2 methodology and the methodology which explicitly models the time varying axial power distribution are provided in Table 1. As shown by the data presented in Table 1, the use of a time varying axial power distribution does not change the fact that a faster scram speed produces a lower ΔCPR.

As the Table 1 results indicate, use of the Reference 1 and 2 methodology produces comparable or conservative ΔCPRs compared to the more explicit treatment of the hot bundle for Unit 1 Cycle 7. In addition, the Reference 1 and 2 methodology produces higher MCPR operating limits than those produced by SNP's NRC-approved methodology. Thus, PP&L believes that the MCPR operating limits generated for Unit 1 Cycle 7 (Reference 4) are conservative. Future cycles will be analyzed by explicitly modelling the time dependent axial power distribution using the modified version of RETRAN and the Attachment 1 gap conductance methodology.

Very truly yours,

H. W. Keiser

Attachment

cc: NRC Document Control Desk (original)
NRC Region I
Mr. G. S. Barber, NRC Sr. Resident Inspector
Mr. J. J. Raleigh, NRC Project Manager

ATTACHMENT to PLA-3729

TABLE 1

HOT BUNDLE MODELLING STUDY RESULTS

Event	Delta-CPR	
	Reference 2 Method	**New Method***
Generator Load Rejection at 100% power/100% flow Scram Speed = 4.4 ft/sec	0.29	0.29
Generator Load Rejection at 100% power/100% flow Scram Speed = Tech Spec Min	0.36	0.31
Feedwater Controller Failure at 65% power/100% flow Scram Speed = 4.4 ft/sec	0.36	0.32

* The new method consists of the explicit modelling of the time dependent axial power distribution and the Attachment 1 gap conductance method.

ATTACHMENT 1

Hot Bundle Gap Conductance Method for use with Time Varying Axial Power Distribution

A.1 INTRODUCTION

To perform non-LOCA transient ΔCPR analyses, the RETRAN hot bundle model (Section 4 of Reference A.1) requires a value of fuel rod gap conductance. The NRC approved ESCORE code (Reference A.4) is used to calculate the hot bundle gap conductance. This attachment describes a methodology for calculating the hot bundle gap conductance for ΔCPR analyses with RETRAN. This methodology is intended to be used in conjunction with an explicit modelling of the time dependent hot bundle axial power distribution.

A.2 ESCORE INPUTS

Table A.2-1 contains a list of the ESCORE input parameters used to model the hot bundle and contains information on the basis for selecting the input values for a given reload analysis.

A.3 POWER HISTORY AND AXIAL POWER DISTRIBUTION

The axial power distribution and bundle power history used as input to ESCORE to model the hot bundle are derived from the SIMULATE-E cycle-step-out calculation for the cycle being analyzed. Both the axial power distribution and the bundle power history are based on changes in exposure as discussed below.

Parametric studies have indicated that the axial power distribution has minimal impact on calculated gap conductance. For each of the 25 axial nodes, the axial power peaking factor is determined based on the amount of nodal exposure accrued during the cycle of interest. For example, if an axial node accumulates 5 GWD/MTU during the cycle being analyzed and the axial average exposure accumulated is 10 GWD/MTU, then the axial power peaking factor for that node would be 0.5.

The SIMULATE-E cycle-step-out for a cycle consists of a number of depletion steps on the order of 0.5 GWD/MTU in length. For each depletion step, the bundle average energy produced in the hot bundle fuel type (usually fuel that was first loaded at the beginning of the cycle of interest) is divided by the core average bundle energy produced to obtain a radial peaking factor. If all fuel types in the core have the same weight of uranium, the energy produced is proportional to the change in exposure. ESCORE is run using the same exposure steps as the SIMULATE-E cycle-step-out, and the bundle power for each depletion step is set equal to the core average bundle power multiplied by the radial peaking factor described above. At the power/flow conditions and time in cycle of interest (usually end of cycle is the time in cycle at which pressurization transients are most severe), the gap conductance for the SIMULATE-E hot bundle is calculated by ESCORE. This calculated hot bundle gap conductance is used in the RETRAN hot bundle transient analysis.

A.4 CONCLUSION

The hot bundle gap conductance methodology described in this attachment is similar to the approach used by Siemens Nuclear Power Corporation (PP&L's current fuel supplier) and produces values of hot bundle gap conductance for use in RETRAN transient analyses. This gap conductance methodology will be used in conjunction with an explicit modelling of the time dependent RETRAN hot bundle axial power distribution.

A.5 REFERENCES

A.1 PL-NF-89-005, "Qualification of Transient Analysis Methods for BWR Design and Analysis", December 1989.

A.2 PL-NF-90-001, "Application of Reactor Analysis Methods for BWR Design and Analysis", August 1990.

A.3 NRC Letter dated December 23, 1991, "Request for Additional Information on PPL Topical Report PL-NF-89-005".

A.4 EPRI NP-5100-L-A, "ESCORE-the EPRI Steady State Core Reload Evaluator Code : General Description", April 1991.

TABLE A.2-1

ESCORE Input Values for Hot Bundle Gap Conductance Calculation

Parameter	Value	Note
1. Core Inlet Temperature	Nominal full power value	1
2. Mass Flow Rate	Nominal Full Flow Average Value	1
3. Enrichment	"Bundle type" average	1
4. Cladding Surface Roughness	nominal	1
5. Fuel Pellet Surface Roughness	nominal	1
6. Fast Leakage Factor	.975	2
7. Fraction of Open Porosity	.001	3
8. Fraction of Relocation Crack Volume in Porosity Correction Factor	1.0	3
9. Burnup at which Densification is complete	5.0	3
10. Clad ID texture Angle	nominal	1
11. Fast Neutron Flux to LHGR factor	minimum	4
12. Change in Fuel Density	nominal	5
13. Grain size	nominal	6
14. Cladding Yield Strength	nominal	
15. Pellet O.D.	nominal	7
16. Pellet I.D.	nominal	7
17. Rod Pre-pressure	nominal	8
18. System Pressure	nominal	9
19. Resonance Escape Probability	large	10
20. Axial Power Distribution	--	11
21. Power History	--	11

NOTES TO TABLE A.2-1

1. Parametric studies demonstrated that this parameter has negligible impact on gap conductance.

2. Value recommended by Reference A.4

3. These values were used for the ESCORE benchmarking analyses described in Reference A.4. Thus, they are considered as part of the code/model that was approved by the NRC.

4. This value is obtained from CPM-2 code calculations. A set of CPM-2 runs covering the range of void fractions, exposures, and fuel types is examined. Parametric analyses determined that a low value of this parameter produces a slightly higher (i.e., more conservative) value of gap conductance.

5. The nominal value based on the fuel vendor resinter tests is used.

6. The nominal grain size is used since, while some grains will be larger and some will be smaller than the average, the net effect of variations in grain size on the hot bundle average gap conductance is negligible.

7. It is unlikely that all fuel pellets or cladding dimensions in a fuel bundle would be at their tolerance limits because they are fabricated at different times and there are different pellet lots used in each assembly.

8. Rod pre-pressure variations will have minimal impact on gap conductance since the tolerance is small (on the order of 5 psi). In addition, it is unlikely that all rod pre-pressures in a bundle will be at the tolerance limit.

9. Since system pressure does not vary significantly throughout the operating cycle, a value of nominal full power system pressure is used.

10. Conservative value based on ESCORE gap conductance sensitivity analyses is used.

11. Axial power distribution and power history are taken from SIMULATE-E cycle-step-out analyses. See Section A.3.