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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATING TO GPU NUCLEAR CORPORATION TOPICAL REPORT

TR-040 (REVISION 0)

"STEADY STATE AND QUASI-STEADY STATE METHODS

FOR ANALYZING ACCIDENTS AND TRANSIENTS

GPU NUCLEAR CORPORATION

OYSTER CREEK NUCLEAR GENERATING STATION

DOCKET NO. 50-219

1.0 INTRODUCTION

By letter dated April 15, 1987 (Reference 1) the GPU Nuclear Corporation (GPUN) submitted for review the topical report TR-040, "Steady State and Quasi-Steady State Methods for Analyzing Accidents and Transients." This report is the fourth in a series of five reports for use in Oyster Creek reload licensing. The information in this report was supplemented by information submitted in your letter of November 12, 1987 (Reference 7) in response to questions from the NRC staff and consultants. The review by the staff of this report and supplemental information was performed with the assistance of consultants from Brookhaven National Laboratory.

This topical report describes the methods and procedures used to analyze the fuel assembly misloading (assembly misorientation and assembly mislocation) error, the control rod withdrawal error and the loss of feedwater heater events. Since these events result in slow transients, they are evaluated with static codes. With the exception of the fuel bundle misorientation, GPUN intends to use the three-dimensional code NODE-B (Reference 2) in its analyses. The analysis of the fuel misorientation is carried out with CPM (Reference 3). The GPUN application of these codes has been found acceptable previously (References 4 & 5).

2.0 SUMMARY OF TOPICAL REPORT

The CPM and NODE-B codes are the principal GPUN calculational tools used in the analysis of the fuel assembly misloading error, the rod withdrawal error and the loss of feedwater heating events.

The critical power ratio (CPR) and the linear heat generation rate (LHGR) are the parameters of interest for analyzing these events. The safety limit Minimum Critical Power Ratio (MCPR) is determined using the General Electric Thermal Analysis Basis, GETAB (Reference 6). The data used by GPUN to carry out the analysis of these events presented in TR-040 is based on the Oyster Creek Cycle 10 reload. A brief description of each event discussed in TR-040 and an outline of the analysis performed by GPUN is presented in the following.

2.1 Fuel Assembly Misorientation Analysis

In the fuel assembly misorientation error analysis, a fuel assembly is loaded in its correct core location but it is misoriented. In the Oyster Creek D-lattice core, which is a square lattice arrangement including both wide-wide and narrow-narrow sized water gaps between neighboring fuel assemblies, a misoriented assembly can result in a substantial increase in the size of the water gap facing peripheral fuel rods. Such a misoriented assembly loading can result in excessive power peaking and has the potential of MCPR safety limit violation.

In the analysis of the misoriented assembly GPUN employs the CPM two-dimensional collision probability program for determining the necessary lattice physics parameters. Since CPM is geometrically limited to analyzing a single fuel assembly having diagonal symmetry, it can only be used for an assembly misorientation of 180°. A four-bundle PDQ calculation is performed to analyze the 90° misorientation. Exposure-dependent CPM calculations are performed to determine the exposure level at which the highest change in peaking occurs. The axial R-factor (in GETAB) is then determined at this exposure including the effects of the assembly-wise power distribution. An initial CPR calculation is performed for a correctly oriented fuel assembly with power, flow, peaking factors and maximum R-factor adjusted so that the assembly is at the CPR operating limit.

A CPR calculation is then performed for a misoriented assembly by applying the precalculated change in R-factor and increasing the bundle power by 3.2%.

2.2 Fuel Assembly Mislocation Error

The fuel misloading error may result in a significant change in the local power. The GPUN procedure for identifying the control cell (four fuel assemblies that surround a control rod) with the largest power increase requires a series of NODE-B calculations in which the highest exposure bundle in a given cell is replaced by a fresh bundle and the core is depleted to the end-of-cycle using projected control rod patterns for full power operation. The changes in CPR introduced by the mislocated assembly is determined at each exposure step. An adjustment to each CPR is made to place the assembly at its MCPR operating limit. This procedure is repeated for each candidate cell and the cell yielding the maximum delta CPR establishes the delta CPR for this event.

2.3 Control Rod Withdrawal Error (RWE)

This event is initiated by withdrawing a high worth control rod from the fully inserted position assuming a set of Local Power Range Monitor (LPRM) detector failures. The increase in the measured average core power resulting from the rod withdrawal initiates a rod block and the withdrawal is stopped. The parameters of interest in this event are the local CPR and LHGR. Since LPRM detectors in each Average Power Range Monitor (APRM) channel may be failed, various combinations of APRM bypass and LPRM failures are taken into account in the analysis of the RWE event.

A series of steady state calculations is performed with NODE-B. The highest worth control rod is identified at peak cycle reactivity and a control rod pattern is established with the highest worth rod at the fully inserted position and a nearby fuel assembly at thermal limits. For each step of withdrawal of the strongest rod, the power level is determined and the corresponding CPR, LHGR, APRM and LPRM responses are calculated. The largest delta CPR and delta LHGR for each APRM/LPRM failure combination is the value used in the analysis.

2.4 Loss of Feedwater Heater

The loss of feedwater heater results in an increase in core inlet subcooling which results in an increase in core power. The limiting parameters in this transient are the CPR and LHGR. This relatively slow event is analyzed with NODE-B and requires steady state calculations at both the initial core conditions and increased core inlet subcooling. The maximum change in both CPR and LHGR is determined by assuming that the fuel assembly is at its operating limit at the start of the transient.

3.0 EVALUATION

3.1 Fuel Assembly Misorientation

The GPUN analysis of the fuel assembly misorientation employs the CPM two-dimensional lattice physics code. The GPUN application of this code to Oyster Creek steady state analysis has been approved by the staff (Reference 4). Comparisons of the GPUN prediction of limiting delta CPR for the fuel assembly misorientation to independent calculations are presented in Reference 7. These comparisons indicate that the accuracy of the GPUN predictions of delta CPR is reasonable and acceptable. GPUN demonstrates that the 180° fuel assembly misorientation is more limiting than the 90° misorientation. This too is reasonable and acceptable. While the initial GPUN submittal did not include any allowance for uncertainty in the delta CPR calculation, GPUN has agreed to incorporate a .02 delta CPR penalty in the misorientation analysis to account for uncertainties in the calculation of CPR in the case of an axially varing R-factor. It is concluded that the GPUN procedures for analyzing the misorientation event are consistent with industry practice and are acceptable for determining the limiting delta CPR and delta LHGR.

3.2 Fuel Assembly Mislocation

The GPUN analysis of the fuel assembly mislocation employs the CPM and NODE-B neutronics codes which have been approved for GPUN application. The GPUN procedure for analyzing the fuel mislocation consists of two steps: (1) identification of the fuel mislocation which results in the largest delta CPR and (2) performing required three-demensional static calculation to determine the resulting delta CPR. While the second step is straightforward, the first step is relatively complicated. The GPUN procedure for identifying the limiting mislocation assumes that the largest delta CPR will occur in a four-bundle cell having close to (if not) the highest cell exposure (E), and that a bundle replacement results in a maximum change in bundle exposure (delta E). In implementing this analysis, the initial GPUN submittal recommended the calculation of nine four-bundle cells of this type. Additional data was provided in References 6 and 7 to support this methodology. Since GPUN does not account for uncertainty in this procedure, it has agreed to expand these calculations to include a minimum of fifteen four-bundle cells. These cells will include both high (E, delta E) locations as well as other bundle types (e.g., high delta k-infinity replacements) having potential for large delta CPRs. With these changes, the GPUN methodology for calculating the fuel assembly mislocation is acceptable.

3.3 Control Rod Withdrawal Error

The GPUN method for analyzing the rod withdrawal error (RWE) employs the NODE-B steady state physics code which has been approved for GPUN application. The GPUN procedure requires the analysis of the rod withdrawal for both the highest worth rod and the rod location allowing the most LPRM detector/APRM channel failures. This is consistent with current industry practice. The rod block monitor setting is determined by insuring that the changes in CPR and LHGR are acceptable. It is concluded that the GPUN procedure for analyzing the RWE is acceptable.

3.4 Loss of Feedwater Heating Event

As stated earlier, loss of feedwater heating (LFWH) results in increased inlet subcooling, and increase in core power and a reduction in margin to the local CPR and LHGR limits. These changes are relatively slow and allow a steady-state analysis with the approved NODE code (Reference 2). The GPUN LFWH procedure requires that the LFWH final-state calculation is performed for a 100° F reduction in feedwater temperature, maximum feedwater flow, constant pressure, and the core power at the scram setpoint. The increase in core inlet subcooling is related to the 100° F feedwater temperature decrease by a standard heat balance. This procedure has been reviewed in detail and it is concluded that it is in accord with standard industry procedures and is acceptable for analyzing the Oyster Creek loss of feedwater heat event.

4.0 CONCLUSION

The GPUN steady state and quasi-steady-state methods for analyzing the fuel assembly misloading, control rod withdrawal error and loss of feedwater heater events has been reviewed in detail. This review included the material provided in the GPUN TR-40 topical report and the supporting information supplied in References 7 and 8. The GPUN methods were found to be in accord with standard procedures and acceptable for performing Oyster Creek reload licensing analyses with the following exceptions: (1) in performing the fuel assembly mislocation analysis, a 0.02 delta CPR penalty is required to account for uncertainty in the prediction of CPR in the case of an axially varing R-factor and (2) in the analysis of the fuel assembly mislocation error, a minimum of fifteen four-bundle cells should be analyzed to identify the mislocation resulting in the largest delta CPR. GPUN has agreed to make these changes to its procedures.

5.0 REFERENCES

1. Letter from R. F. Wilson, GPUN, to NRC, April 15, 1987, "Oyster Creek--Reload Topical Report."

2. GPUN Nuclear Topical Report TR-021, "Methods for the Analysis of Boiling Water Reactors Steady-State Physics," January 1986.

3. A. Ahlin and M. Edenius, "The Collision Probability Module EPRI-CPM," ARMP; System Documentation, CCM-3 Part II.2, Electric Power Research.

4. Memorandum from G. Lainas, NRC, to J. A. Zwolinski, NRC, October 31, 1986, "SER for GPUN Lattice Physics Topical Report," (TR-020).

5. Memorandum from M. W. Hodges, NRC, to J. Stolz, NRC, September 3, 1987, "SER for GPUN Steady-State Physics Topical Report," (TR-021).

6. NEDE-10958-PA and NEDO-10958-A, "General Electric BWR Thermal Analysis Basis (GETAB) Data, Correlation and Design Application," January 1977.

7. Letter from R. Wilson, GPUN, to NRC dated November 12, 1987, "Oyster Creek -- Reload Topical Reports 033 and 040.

8. GPU/USNRC/BNL Conference Call, November 12, 1987.

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Dated: