UNITED STATES
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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATING TO GPU NUCLEAR CORPORATION TOPICAL REPORT TR-033 (REVISION 0)

"METHODS FOR THE GENERATION OF CORE KINETICS DATA FOR RETRAN-02"

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-033 (Revison 0), "Methods for the Generation of Core Kinetics Data for RETRAN-02". This report is the third in a series of five reports for use in Oyster Creek reload licensing. The information in this report was supplemented by information submitted in a letter dated November 12, 1987 (Reference 2) 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 used by GPUN to generate physics input data for transient analysis of the Oyster Creek Nuclear Generating Station using RETRAN-02. RETRAN-02 allows both a point kinetics (0-D) and a one dimensional spatial kinetics (1-D) representation of the reactor core, and both options are used by GPUN. For the point kinetics option void, Doppler and scram reactivity functions are determined using a three-dimensional (3-D) nodal code (NODE-B) with thermal-hydraulic feedback. The delayed neutron fraction and prompt neutron lifetime are calculated with an auxiliary code (BELLEROPHON) utilizing the results of NODE-B calculations. For the 1-D model, three-dimensional cross-sections and feedback parameters generated with SIMULATE-E are collapsed to one dimension using a processing code (SIMTRAN) and procedures developed by EPRI.

2.0 SUMMARY OF TOPICAL REPORT

Section 1.0 of the topical report contains an introduction and a short description of the contents of the following sections. It also includes brief statements of the purpose and scope of the report.

The conventional point kinetics equations are discussed in Section 2, and the relationship between the parameters of the point kinetics equation and the inner products involving the neutron flux, its adjoint and linear operators for fission production of neutrons, net loss of neutrons, etc., is presented. Calculation of the delayed neutron fraction and prompt neutron lifetime using the computer code BELLEROPHON and power densities and cross-sections calculated with NODE-B is described in Section 2.2 of the report. The definitions of the Doppler and void reactivity coefficients and the scram reactivity function as well as the procedures for calculating these quantities using NODE-B are presented in Section 2.3 of the report.

Generation of input data for utilization of the 1-D kinetics option of RETRAN-02 is described in Section 3. The procedures for radially collapsing the neutron fluxes, cross-sections, neutron velocities, the delayed neutron fraction, etc., as developed by EPRI using SIMULATE-E and SIMTRAN are described, and the relevant equations are presented in Table 3-1. These procedures include cross-section collapsing procedures, perturbation procedures to calculate feedback coefficients, procedures to develop reflector cross-sections and account for radial leakage in the RETRAN-02 1-D model, and those used to develop the one dimensional control rod model.

Two startup tests (setpoint changes to the pressure regulator and the reactor water level) have been analyzed using the point and 1-D kinetics models in RETRAN-02, and the calculated core power and dome pressure have been compared to measurements in Section 4 of the report. Comparisons between axial power shapes and eigenvalues calculated with the 3-D SIMULATE-E model and the 1-D RETRAN-02 model have also been presented for selected levels of insertion of control rods. Section 4 also includes a discussion of the sensitivities of overpressurization transients to the scram curve shape, the Doppler coefficient, the void coefficient, the delayed neutron fraction and the prompt neutron lifetime.

3.0 EVALUATION

3.1 Scope and Applicability

The topical report being reviewed is intended to describe methods for the generation of appropriate kinetics input to the RETRAN-02 model for analyzing Oyster Creek reload cores. Although a limited amount of comparisons between the predictions of the 0-D and 1-D model and measured data and/or 3-D calculations has been presented, it is meant to demonstrate only that the methods of generating input data have been reasonably and correctly applied. The detailed qualification and determination of the adequacy of the 0-D or 1-D RETRAN-02 model for analyzing a particular transient is beyond the scope of this topical report.

3.2 The Point Kinetics Model

The point kinetics equations used are the conventional ones utilizing six delayed neutron precursor groups, and are acceptable. The definitions of the point kinetics parameters follow the generalized definitions that ensure compatibility between three-dimensional and point calculations, and are therefore acceptable. The procedures described to determine the Doppler and void coefficients and the scram reactivity function are consistent with the corresponding definitions, and are acceptable. Although some estimates of the impact of the uncertainties in the input parameters on the results of RETRAN-02 calculations have been provided, a more comprehensive uncertainty analysis will be required for the detailed qualification of the RETRAN-02 model. Such qualification is expected to be a part of a subsequent GPUN Topical Report on RETRAN, and is beyond the scope of the report being reviewed. Standard methods are followed to determine the prompt neutron lifetime. The expression for the delayed neutron fraction, Eq. (2-14), is derived on the assumption that the fission cross-section is uniform across the reactor core. The impact of this approximation on the calculated value of beta(i) has been evaluated by GPUN and found to be small. This is reasonable and acceptable.

3.3 The 1-D Kinetics Model

There are several techniques for collapsing 3-D fluxes and cross-sections to 1-D, and the scheme chosen by GPUN was that developed by EPRI utilizing the SIMTRAN code. In the SIMTRAN methodology (i) the 1-D flux is obtained by collapsing the 3-D flux in the horizontal plane; (ii) the normalization conditions are identical for 1-D and 3-D fluxes; and (iii) collapsed cross-sections are defined such that the adjoint flux weighted reaction rates are conserved in the horizontal plane. In addition, variable radial bucklings are used in the 1-D model to reproduce the 3-D eigenvalue and axial power shape in the steady state. For a set of dependent static calculations (the control fraction varied while other independent variables were held constant) the error in eigenvalue is less than 0.6%, while the error in peak node power density is less than 3%. Similar comparisons have also been presented for a set of perturbed cases (e.g., void fractions and fuel temperatures varied to values approaching their transient limits) in response to our request for additional information. The error in eigenvalue for these cases is less than 0.2%, while that in the peak nodal power is less than 3.7%. Such error levels are acceptable provided their impact is accounted for in the qualification of the RETRAN-02 model.

4.0 CONCLUSIONS

It is concluded that the methods for the generation of core kinetics data described in TR-033 (Rev. 0) are acceptable for referencing in licensing documents. The point kinetics parameters are generated using standard methods and procedures that are consistent with the generalized definitions of these parameters. The 1-D kinetics parameters are generated using an EPRI recommended collapsing procedure which has been demonstrated to be acceptable for preserving eigenvalues and axial power shapes. It is necessary, however, that the uncertainties in the input parameters and their impact on the RETRAN results be determined for subsequent qualification of the RETRAN model. The acceptance of the methods described in this topical report does not establish the adequacy of the RETRAN-02 0-D or 1-D model for analyzing a particular transient.

5.0 REFERENCES

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

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

Dated:

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