ATTACHMENT

TECHNICAL EVALUATION REPORT

# TECHNICAL EVALUATION REPORT OF TOPICAL REPORT WPPSS-FTS-127 ( QUALIFICATION OF CORE PHYSICS METHODS FOR BWR DESIGN AND ANALYSIS) FOR WASHINGTON NUCLEAR POWER UNIT 2.

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## 1.0 INTRODUCTION

By letter dated 29, 1990 (Reference-1) Washington Public Power Supply System (WPPSS) has indicated its plans to use the CASMO-2 (Reference-2) assembly depletion code and the SIMULATE-E (Reference-3) three-dimensional core simulator code for steady-state core physics calculations in support of WNP-2 licensing analyses. The topical report presents results of benchmark analyses intended to demonstrate both the validity of the WPPSS steady-state core physics model and the ability of the WPPSS engineering staff to perform calculations to support the operation of the WNP-2 nuclear plant.

Both lattice physics and core simulation benchmarks are presented in the topical report. Results of calculated local pin power distributions are compared to the results of gamma scan measurements made at Quad Cities Unit 1 (References-4,5). Measured hot and cold critical and traversing in-core probe (TIP) measured power distribution data from four cycles at WNP-2, two cycles at Peach Bottom Unit 2 (Reference-6) and two cycles at Quad Cities Unit 1 are compared with corresponding calculational results.

An overview of the topical report is given in the next section. The technical evaluation is presented in Section-3 and the technical position is given in Section-4.

## 2.0 SUMMARY OF THE TOPICAL REPORT

The WPPSS steady-state physics methodology employs CASMO-2 for the calculation of the lattice parameters and SIMULATE-E for the calculation of core reactivity and three-dimensional power distributions. CASMO-2 is a multigroup, two-dimensional transport theory code for fuel assembly burnup calculations. The transport equation is solved by the method of transmission probabilities. The code performs a pin cell calculation for each fuel rod type in the assembly and a two-dimensional power distribution and k-infinity calculation for the fuel assembly. A separate calculation to determine the effective cross-section of gadolinium, used as a burnable absorber, is carried out with the MICBURN code (Reference-7). MICBURN calculates effective microscopic fuel pin cross-sections, containing uniformly distributed gadolinium, as a function of exposure. CASMO-2 uses a 25-energy group cross-section library. The one-dimensional pin cell calculation is performed by collapsing the 25-group library down to 17 energy groups, while the two-dimensional fuel assembly calculation is carried out in seven energy groups. The macroscopic cross-sections generated with CASMO-2 are used by the NORGE-B (Reference-8) processing code, for input to the SIMULATE-E three-dimensional core simulation. The SIMULATE-E coupled neutronics/thermal-hydraulics nodal code calculates a wide range of reactor parameters including nodal powers, void and exposure distributions and core reactivity. SIMULATE-E hydraulic input is developed from the FIBWR code (Reference-9) which is used in determining the assembly flow distribution. The hydraulic calculation performed with FIBWR uses a representative power distribution. The FIBWR input is adjusted to provide agreement with plant data.

In the WPPSS methodology the calculation of TIP readings is accomplished with the CALTIP code. This code uses detector signals and bundle powers calculated by CASMO-2 to determine the detector contribution from a given assembly node. The detector signals for each assembly are converted to TIP traces after correction for control rod insertion and appropriate normalization.

The qualification of the WPPSS steady-state core physics methodology has been carried out by comparing CASMO-2/SIMULATE-E calculations with measured data from WNP-2, Peach Bottom Unit 2 and Quad Cities Unit 1. The measured operating data used in the qualification was obtained throughout cycle operation and included hot eigenvalues and TIP responses. Cold eigenvalues were calculated at statepoints for which cold critical data have been measured. The Quad Cities Unit 1 benchmarking also included comparisons of calculated and gamma scanned axial and radial power distributions.

## 3.0 SUMMARY OF TECHNICAL EVALUATION

The evaluation of WPPSS-FTS-127 is based on (1) the MICBURN/CASMO-2/SIMULATE-E calculations of the benchmark power distribution measurement data base, (2) the performance of both cold and hot models vis-a-vis measured critical data and (3) the evaluation of the WPPSS responses to the questions which were raised during the review of the topical report (Reference-10). The important issues raised during this review are summarized in this section.

### 3.1 Cross-Section Representation

In the WPPSS physics methodology, fuel assembly lattice parameters are calculated with CASMO-2. Depletion calculations are performed for each uncontrolled fuel assembly type at three void levels (0, 40 and 70%) and for each controlled assembly at zero voids. Branch calculations are made at various exposure points to correct for effects such as Doppler, control rod insertion and cold conditions. The output of these calculations consists of extensive arrays of lattice parameters which are processed by NORGE-B. This procedure and cross-section representation in SIMULATE-E constitutes standard industry practice and is considered acceptable.

### 3.2 Treatment of Albedos

Reflector constants at the core periphery are evaluated with the ABLE code (Reference-11). The ABLE code uses core and fuel design data to determine horizontal albedo boundary conditions. The effects of temperature, exposure, voids and rod insertion are included in the two-group cross-section sets for both the fuel and the reflector. Since albedos do not change significantly with changing core conditions, average albedo sets are used in the methodology. This approach is acceptable.

### 3.3 Calculated vs. Measured Power Distributions

Comparisons of calculated and measured power distributions have been made at various statepoints of WNP-2 Cycles 1 through 4, Peach Bottom-2 Cycles 1 and 2, and Quad Cities-1 Cycles 1 and 2. With the exception of WNP-2 Cycles 3 and

4 and Quad Cities-1 Cycle 2, benchmark data presented in the topical report show significant underprediction of the calculated TIP power in the bottom of the core. In analyzing these data WPPSS has concluded that this underprediction is due to an underprediction in the rate at which gadolinium burns out in the bottom of the core. The data presented in the topical report have been selected at random from the complete data base for WNP-2, Peach Bottom-2 and Quad Cities-1. Underpredictions in the bottom of the core occur in ~20% of the data base and agree closely, or are slightly high, in the remaining 80% of the data base. Since the power is relatively low in the region of the core where the underpredictions occur, we conclude that these results are acceptable.

3.4 Calculational Uncertainties

The data base used in the benchmarking of the WPPSS codes consisted of measured power distribution data from WNP-2, Peach Bottom-2 and Quad Cities-1, and the Quad Cities-1 local and assembly-averaged gamma scan data. In addition, cold critical data from the above plants were used to benchmark the SIMULATE-E cold model. Calculated TIP results for WNP-2 cycles 1 through 4, using all data points from all of the 43 TIP strings, show a range of root-mean-square (rms) values which is typical of licensee predictions.

In the Peach Bottom-2 benchmarking, due to asymmetries in the loading, a full core SIMULATE-E model was used. While both experimental and calculational errors contribute to the overall rms error, the 10.2% Cycle 1 TIP calculational error is larger than the experimental error by a factor of ~two. WPPSS has attributed this larger calculational contribution to the difficulties in modelling the Peach Bottom-2 core due to the Cycle 1 plugging of the bypass holes. Results of the Cycle 2 calculations show a lower overall rms error where the contributions of the experimental and calculational errors are approximately the same.

Based on the performance of the WPPSS modelling of the WNP-2, Peach Bottom-2 and Quad Cities-1 cores, we find the treatment of the uncertainties satisfactory and the overall results acceptable.

3.5 Calculational Consistency

Changes in the procedures, code options, numerical convergence and geometrical modelling of the TIP response can significantly affect the results of the calculations and benchmarking comparisons. In the WPPSS methodology (Reference-10), the basic procedures used in the modelling of the WNP-2, Peach Bottom-2 and Quad Cities-1 cores were the same. The code options were the same except for variations required for specific calculations. Numerical convergence was the same for all hot calculations. In the case of the cold calculations, the outer source convergence was tightened and the number of outer source iterations was increased. The geometric modelling of the TIP response calculation was consistent throughout the analyses and accounted for changes in the core loading differences in each respective core. We find this approach to be acceptable.

## 4.0 CONCLUSION

The benchmarking of the MICBURN/CASMO-2/SIMULATE-E code system against operating data from the WNP-2, Peach Bottom-2 and Quad Cities-1 cores has been reviewed. The review was based on the information given in the Topical Report WPPSS-FTS-127, and supporting material provided in Reference-10. The WPPSS methodology is found to be acceptable for performing reload licensing calculations for WNP-2 cores containing fuel types similar to those included in the benchmarking data base. If significantly different fuel designs are introduced or operating conditions vary significantly from those included in the benchmarks, the MICBURN/CASMO-2/SIMULATE-E code system will require additional validation to demonstrate the accuracy of predictions and the adequacy of the calculational uncertainties.

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