Executive Summary for WCAP-18443-P/NP, "Qualification of the Two-Dimensional Transport Code PARAGON2"

(Non-Proprietary)

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Westinghouse Electric Company
1000 Westinghouse Drive
Cranberry Township, PA 16066

WCAP-18443-P/NP
Qualification of the Two-Dimensional Transport Code PARAGON2
Executive Summary

The PARAGON2 topical report provides the documentation necessary to seek the NRC's approval of the latest Westinghouse neutron transport code, PARAGON2, for use with Westinghouse's nuclear design code system (ANC), or as a standalone code. The code will be used primarily to calculate nuclear input data for three-dimensional core simulators, and is designed to be used as a direct replacement for the neutron transport codes in the primary nuclear design code systems used by Westinghouse.

PARAGON2 is an improved version of the PARAGON code, and is intended to replace PHOENIX-P (WCAP-11596-P-A) and PARAGON (WCAP-16045-P-A). The main improvements are the introduction of the Resonance Scattering Model, the adoption of an ultra-fine energy mesh (6064 energy groups) for the flux solution module, and the addition of more explicit fission products and isotope depletion chains. While the primary purpose of PARAGON2 is to provide the same types of data that PARAGON generates for use in three-dimensional core simulator codes, these improvements will allow for more accurate core design predictions for current and future fuel products, and also for high-assay low-enriched uranium and high-burnup applications. This includes macroscopic cross sections, microscopic cross sections for feedback adjustments to the macroscopic cross sections, pin factors for pin power reconstruction calculations, and discontinuity factors for a nodal method solution.

Because PARAGON2 is based on collision probability-interface current cell coupling methods, it provides the same flexibility in modeling that was available in PARAGON, including exact cell geometry representation, multiple rings and regions within the fuel pin and the moderator cell, and variable cell pitch. The improved solution method permits flexibility in choosing the quality of the calculation through both increasing the number of regions modeled within the cell, and the number of angular current directions tracked at the cell interfaces.

Westinghouse uses a systematic qualification process in this report, which was previously used when the NRC approved the PARAGON topical report (WCAP-16045-P-A). Along with a description of the methodology, the qualification process consists of comparing PARAGON2 results to:

- Critical experiments (including MOX and uranium oxide) and isotopic measurements from post irradiation examination data from several plants
- Assembly calculations with Monte Carlo method calculations (MCNP and SERPENT2), including high-assay low-enriched uranium fuel
- Measured plant data using PARAGON2/ANC code system

The first two parts qualify the methodology used in PARAGON2 and its implementation. The third part qualifies the use of PARAGON2 data for core design applications by comparing plant measurements to the results from coupling PARAGON2 with a three-dimensional core simulator model (in this case ANC).

The parameters compared are boron letdown curves, beginning of cycle (BOC) HZP critical boron, BOC isothermal temperature coefficients, and BOC rod worths. Where appropriate, comparisons are also made to PARAGON results.

Based on the qualification of PARAGON2 as described above, Westinghouse is seeking NRC review and approval of PARAGON2 as a standalone code or as a direct replacement for all previously licensed Westinghouse Pressurized Water Reactor lattice codes, such as PHOENIX-P, or PARAGON. Thus, existing and future topical reports that reference the Westinghouse nuclear design code system will maintain compatibility with PARAGON2.