Enclosure 3

Westinghouse Response to RAI Number 1 on WCAP-18773-P/NP, "Higher Enrichment for Westinghouse and Combustion Engineering Fuel Designs"

(Non-Proprietary)

August 2024

Westinghouse Electric Company
1000 Westinghouse Drive
Cranberry Township, PA 16066

Request for Additional Information 1:

The neutronics evaluation within WCAP-18773-P/NP, Revision 0, relies partly on the uncertainty propagation of PARAGON2 (Ref. 2) to the NEXUS/ANC9 methodologies (Refs. 3 and 4). The NRC staff recognizes that PARAGON2 has previously received approval for fuel enrichments greater than 5 wt% and that the performance of that code contributes to the performance of NEXUS/ANC9. However, certain aspects of neutronics code performance do not seem to be considered in sufficient detail for the NEXUS/ANC9 methodologies as they relate to higher enrichments. Please provide additional information related to the parameters listed below demonstrating acceptable performance in the range of increased enrichment for the NEXUS/ANC9 methodologies:

a) Peaking factor uncertainties
b) An increasing fast-to-thermal flux ratio at higher enrichments
c) Discontinuity factors and fitting coefficients
d) Radial power distribution uncertainty

Response to RAI 1:

The introduction of higher fuel pellet enrichments greater than 5 wt.% will impact the core performance by hardening the neutron spectrum with the relative increase in fission reactions caused by the increase in U-235. The greatest impact of this shift in the neutron spectrum will arise when the difference in relative excess reactivity is greatest. This is likely to occur when fresh fuel is placed next to highly burned fuel like on the core periphery or in transition cores. Therefore, computer codes must capture this change in local fuel assembly environment and the communication between fuel assemblies.

The code performance of PARAGON2 was demonstrated to accurately capture the local neutron spectrum for various critical experiments and fuel assembly configurations including fuel pellet enrichments **[ ]** a,c (Reference [2]). The NEXUS/ANC9 methodology uses PARAGON2 as a nuclear cross-section generation tool and processes the data through multivariable least squares fitting. Consequently, the accuracy of the predictions produced by NEXUS/ANC9 persists as the least squares fitting introduces minimal error to the single assembly and full core predictions. The performance of the fitting coefficients in various scenarios was captured in part of the plant qualification of PARAGON2 and the mini-core calculations provided by NEXUS/ANC9 (References [2], [3], [4]). Also, the cross-section representation model in References [3] and [4] is also applied to discontinuity factors. The validation of the model is outlined in Reference [4] for the cores with the high enriched fuel is demonstrated by the mini-cores test cases where the environment effect is exacerbated.

The Westinghouse reload safety methodology utilizes the power distribution uncertainties outlined in WCAP-7308 to conservatively estimate the core performance in normal operation and transients (Reference [1]). These uncertainties have been quantified for the use of PARAGON2 up to 5 wt.% using various benchmarking with experiments and higher order codes (Reference [2]). Section 4.3 of WCAP-18773 outlines the methodology for extending these uncertainties to **[ ]** a,c by comparing the predictive performance of PARAGON2 and NEXUS/ANC9 with respect to each uncertainty component.

The pin-to-box and axial uncertainty components are discussed in sufficient detail within Section 4.3 of WCAP-18773.

The methodology for assessing the radial power distribution uncertainty was provided in Section 4.3 of WCAP-18773 and investigated via an evaluation performed by Westinghouse. The evaluation was performed on different mini-core configurations, fuel pellet enrichments, fuel lattice types, and burnable absorber patterns/types. The evaluation showed **[**

] ^{a,c}.

The maximum peaking factor uncertainties calculated for FDH and FQ were **[** **]** ^{a,c}, respectively. Therefore, the peaking factor uncertainties reported in WCAP-7308 remain valid and conservative. Additional factors such as the performance of the pin power reconstruction methodology of ANC9 and detector sensitivity were assessed and deemed to be negligible

References

1. WCAP-7308, "Update to WCAP-7308-L Evaluation of Nuclear Hot Channel Uncertainties," June 1988.

2. WCAP-18443-P-A, "Qualification of the Two-Dimensional Transport Code PARAGON2," July 2021.

3. WCAP-16045-P, Addendum 1-A, "Qualification of the NEXUS Nuclear Data Methodology," November 2005.

4. WCAP-16045-P, Addendum 2-A, "Updated NEXUS Cross-Section Methodology," August 2020.