U. S. NUCLEAR REGULATORY COMMISSION

FINAL SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

TOPICAL REPORT WCAP-16045-P-A, AND WCAP-16045-NP-A,

ADDENDUM 2, REVISION 0,

"UPDATED NEXUS CROSS-SECTION METHODOLOGY"

WESTINGHOUSE ELECTRIC COMPANY

EPID L-2019-TOP-0026

1.0 INTRODUCTION

By letter dated June 26, 2019 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML19179A091), Westinghouse Electric Company (Westinghouse) submitted to U.S. Nuclear Regulatory Commission (NRC) WCAP-16045-P-A, Addendum 2, Revision 0, and WCAP-16045-NP-A, Addendum 2, Revision 0, "Updated NEXUS Cross-Section Methodology," for review and approval. The submittal is an addendum to the topical report (TR) which presents an update to the NEXUS cross-section parametrization methodology. The proposed methodology is a reformulation of the methodology described in WCAP-16045-P-A, Addendum 1. The TR addendum is entitled, "Updated NEXUS Cross-Section Methodology," and can be identified by its document and addendum number, WCAP-16045-P-A, Addendum 2.

The NEXUS methodology is used with the PARAGON and ANC codes. PARAGON is a standalone neutron transport code based on collision probability techniques and approved for use as a standalone lattice physics code and as a cross-section generation tool for core simulators, such as ANC, for uranium-fueled pressurized water reactors (PWRs). ANC is a core simulator code system which performs calculations based on nuclear data supplied by a code such as PARAGON or PHOENIX-P. The NEXUS methodology is a reparameterization of the PARAGON nuclear data output and a new reconstruction approach within the ANC core simulator code to simplify the use of this code system for practical applications. The NEXUS methodology acts as an intermediate step between PARAGON and ANC, establishing a new NEXUS/ANC code system, while still using PARAGON to generate the key cross-section data.

Westinghouse states that the updated NEXUS methodology will advance the ability of the Westinghouse NEXUS/ANC neutronics analysis methodologies to model accident conditions with high local void or core pressure changes, more effectively capture the effect of each individual physics parameter, and consistently and efficiently provide more accurate cross-sections at any core conditions.

2.0 BACKGROUND

The current version of the NEXUS cross-section methodology has been licensed by the NRC since 2007. The current NEXUS methodology has been licensed for uranium-fueled PWRs and as the subject of this evaluation is the second addendum to WCAP-16045-P-A, it will also be evaluated with respect to uranium-fueled PWRs.

Cross-sections vary with local neutron spectrum. In the 2007 NEXUS cross-section methodology, the local spectrum is characterized by the node-averaged parameters of spectrum index (SI), fuel temperature (T_f), and moderator temperature (T_m). This methodology is somewhat limited in that it cannot account for explicit feedback or perturbation from individual physics parameters because the SI, which represents the overall shape of the neutron spectrum and is affected by physics parameters, is not separable for individual parameters.

[

] A local spectrum can be represented and parameterized using the physical local state parameters of: **[**

] The physical local state parameters provide individual feedback effects in the cross-section representation.

The subject addendum of review, WCAP-16045-P-A, Addendum 2, Revision 0, is intended to replace all existing uses of the currently licensed NEXUS methodology.

3.0 <u>REGULATORY EVALUATION</u>

The current NEXUS methodology, and by extension, the proposed updated NEXUS methodology described in Addendum 2, were developed primarily to satisfy NRC regulatory guidelines to meet the regulatory requirements established in Title 10, “Energy,” of the U.S. *Code of Federal Regulations* (CFR), Part 50, “Domestic Licensing of Production and Utilization Facilities,” Section 34, “Contents of applications; technical information” to provide safety analysis reports to the NRC detailing the performance of structures, systems, and components provided for the prevention or mitigation of potential accidents. The core physics calculations from the NEXUS/ANC system are used to confirm that key parameters assumed in the safety analysis reports remain bounded by the licensing basis analyses for any given core design.

4.0 <u>TECHNICAL EVALUATION</u>

4.1 <u>Description of Methodology</u>

The NEXUS cross-section methodology provides a linkage between the lattice code PARAGON (WCAP-16045-P-A) and the core simulator ANC (WCAP-10965-P-A). PARAGON is a neutron transport code and is used as a standalone lattice physics code and as a cross-section generation tool for core simulators. ANC is a core simulator code system which performs calculations based on nuclear data supplied by a lattice code such as PARAGON. The NEXUS methodology is a reparameterization of the PARAGON nuclear data output and a reconstruction approach within ANC that simplifies the use of the PARAGON/ANC code system for design use. The currently licensed version of NEXUS characterized the local spectrum using the SI which is the ratio of fast-to-thermal group node average fluxes, T_f, and T_m. During accident conditions when the moderator is no longer in subcooled conditions or the core pressure changes significantly, temperature only representations of the moderator are not precise. The SI represents the overall shape of the neutron spectrum and is affected by any physical state parameter (e.g., boron concentration, moderator density, temperatures, actual fuel history). The SI is a calculated state parameter, so it presents specific challenges when explicit feedback is needed for an individual physics parameter.

The currently licensed NEXUS uses the following information to develop the lattice code calculations which are referred to in the TR as the calculational matrix:

[

]

Updated NEXUS replaces the SI approach with a new cross-section reformulation methodology.

[

] In addition, a thermal expansion correction will more accurately model the geometric differences between hot and cold reactor conditions. The updated NEXUS methodology will also explicitly include the samarium spectrum effect based on number densities, and a pin-wise spectrum correction that allows for a more accurate representation of the effects on the surrounding environment.

In addition, for the updated NEXUS methodology, the calculational matrix will also include the following:

[

]

While currently licensed NEXUS remains an accurate and valid cross-section methodology, updated NEXUS provides a broader range of capabilities and improved computational efficiency.

4.2 Qualification of Single Assembly Model Calculations

The NRC staff reviewed the qualification of the single assembly model calculations in Section 3.1 of the TR. In this section, Westinghouse compared the updated NEXUS results to those of the PARAGON lattice code. The single assemblies were 2D models with infinite boundary conditions. The qualification included six assemblies which containing various uranium enrichments and burnable poison loadings. The following lattices were evaluated:

- Westinghouse-type 17x17 OFA assembly, 5.0 w/o ^{235}U, 156 1.5x integral fuel burnable absorber (IFBA), 24 wet annular burnable absorber (WABA)
- Westinghouse-type 14x14 assembly, 4.0 w/o ^{235}U, 64 IFBA

- Westinghouse-type 15x15 assembly, 4.5 w/o ^{235}U, 116 IFBA
- Combustion Engineering-type 16x16 assembly, 4.2 w/o (average), 16 6 w/o Gd_2O_3 rods
- Westinghouse-type 17x17 standard-size fuel rod assembly, 4.95 w/o ^{235}U, 48 IFBA
- Westinghouse-type 17x17 OFA assembly, 2.6 w/o ^{235}U

Full-power and off-power calculations were completed for power levels between 40 percent and 160 percent. These calculations were completed for the burnup range of 0 to 82000 megawatt-days per metric ton uranium (MWD/MTU) and soluble boron concentrations of 0 to 1800 parts per million (ppm). The k-infinity, measured in percent milli (pcm), values generated from the updated NEXUS methodology were compared to the PARAGON generated k-infinity values. **[**

]
These conditions which exhibited the deviation from the acceptance criteria Westinghouse used are not typical in an operating reactor, do not depict reality, and therefore, are unnecessary to be met to qualify this application. The updated NEXUS results exhibited reasonable results in comparison to the PARAGON lattice code for single assembly calculations for full and off-power calculations.

The NRC staff also reviewed the results of the calculations at zero-power cold conditions. The same acceptance criteria were used for these calculations **[**
] The cold temperatures analyzed were 68°F, 300°F, and 500°F and two restart depletions of 0 ppm and 2600 ppm were used. Each of these restart temperatures and depletions were calculated at intervals between 0 MWD/MTU and 82000 MWD/MTU. Each of the above described lattices was first depleted at 0 ppm, 900 ppm, and 1800 ppm soluble boron before the restart conditions. The results of the calculations were within the acceptance criteria except for the **[**

] The updated NEXUS calculations at the zero-power cold conditions provided reasonable results when compared to the PARAGON lattice code.

The updated NEXUS methodology incorporates cross-section calculations at voided conditions as a new feature. The updated NEXUS methodology has de-coupled the moderator temperature from the moderator density, allowing for calculations during voided conditions. The qualification of this new feature of NEXUS follows the same logic as the single assembly qualification – comparison between values updated NEXUS and PARAGON. The first step in this process is to demonstrate that PARAGON can accurately model the voided conditions. PARAGON was validated against Monte Carlo N-particle Transport Code (MCNP). In the request for additional information (RAI)-3 response, Westinghouse states that MCNP has a continuous energy spectrum library. The continuous energy spectrum library means MCNP calculations are not limited by fuel composition. When qualifying updated NEXUS to PARAGON, Westinghouse used the targeted acceptance criteria of **[**

] consistent with the other single assembly validations.

[

]

The qualification calculations were completed at -2 percent, 5 percent, 15 percent, 25 percent, and 40 percent void and for the two soluble boron concentrations of 0 ppm and 2600 ppm. The negative void is an instance of increased pressure above normal operating pressure. The results of most of the calculations up to the 40 percent void were within the acceptance criteria.

[

] The updated NEXUS methodology demonstrates acceptable results.

The NRC staff reviewed the effect the cross-section re-homogenization has on the pin power distribution. It is noted that the fundamental pin power calculation methodology does not change between versions of NEXUS/ANC, only the cross-section calculations. In this qualification, the Westinghouse-type 17x17 standard-size fuel rod assembly, 4.95 w/o ^{235}U, 48 IFBA lattice was analyzed. The single assembly pin power calculations were directly compared between the improved NEXUS/ANC and the current NEXUS/ANC. The comparisons included both rodded and unrodded cases. For the unrodded case, calculated at a burnup of 20000 MWD/MTU, the maximum difference between improved NEXUS/ANC and the current NEXUS/ANC is 0.003, i.e. 0.3%, occurring at the edge of the lattice.

Additionally, the NRC staff reviewed two rodded case scenarios presented in the TR. In these calculations, the maximum assembly power and an individual pin power are evaluated. The individual pin chosen was next to a guide thimble which allows for the improved methodology to be evaluated in a scenario which there is a strong impact from the control rod on the pin. The maximum difference in power by using the improved NEXUS/ANC methodology is approximately 1 percent. This minor difference in power confirms the improved NEXUS/ANC methodology is acceptable.

4.3 Qualification of Mini-core Model Calculations

The NRC staff reviewed Section 3.2 of the TR which discusses the performance of a simulated mini-core model. The applicant's mini-core analysis was based on the ANC9 (designated as ANC971R) Re-homogenization Project methodology. The NRC staff reviewed the results of the applicant's verification and validation of ANC9 to confirm that the test adequately captured the re-homogenization effects. The TR accurately describes the applicant's analysis of a NEXUS/ANC mini-core model with reflective boundary conditions which was expected to produce similar eigenvalues when compared to the PARAGON calculation using reflective boundary conditions.

The NRC staff reviewed the TR which describes the process that the applicant used to develop and evaluate a 3x3 UO_2-MOX checker-board mini-core (TR Figure 10 Configuration of 3x3 Mini-

Core) so that they could accurately evaluate the impact of the NEXUS/ANC re-homogenization method. The NEXUS/ANC mini-core model used in the TR included five MOX and four UO_2 fuel assemblies with reflective boundary conditions to evaluate the potential impacts of inter assembly interactions between MOX and UO_2 assemblies in a core. The k_∞ with and without the re-homogenization correction were evaluated and compared to the PARAGON eigenvalues in Table 31 of the TR. During the closed regulatory audit conducted on October 8-9, 2019, the NRC staff noted that the values in Table 31 of the TR were incorrect as compared to the discussion. The NRC staff requested the Table 31 values to be corrected in RAI-2. The NRC staff reviewed the updated results of the $k\infty$ with re-homogenization and determined that the results were very similar to the PARAGON prediction. While the models discussed above used MOX fuel as an extreme example of a neutronically dissimilar fuel assembly, the NRC staff expects that any use of the NEXUS methodology in licensing applications involving MOX fuel would utilize the update process described in the TR and RAI responses.

The NRC staff also reviewed the applicant's comparison of the assembly power distribution in the mini-core model with and without the re-homogenization model (TR Figure 11 Comparison of Assembly Power Comparison for Mini-Core Case). The NRC staff compared the ANC assembly power distribution with and without re-homogenization in the mini-core model with the results of the PARAGON model. The NRC staff determined that the ANC re-homogenization model results were very similar to the PARAGON predicted eigenvalues. Based on the results of the mini-core assembly power distribution comparison the NRC staff believes that NEXUS/ANC will correctly capture the expected interaction effects between dissimilar fuel assemblies.

The NRC staff have reviewed the applicants mini-core re-homogenization model results and conclude that NEXUS/ANC will accurately predict fuel reactivity and pin power distribution in a mini-core model with reflective boundary conditions.

4.4 Qualification of Pressurized Water Reactor Core Calculations

The use of the improved NEXUS methodology to evaluate full-scale applications was assessed through validation studies using five different full-scale cores. Four of the cores represent actual plants for which measured values are available, and the fifth is a theoretical equilibrium core. In some cases, multiple cycles for the same core were simulated as part of the validation of the improved NEXUS methodology. The validation studies included the following core designs:

- Four cycles for a 217-assembly Combustion Engineering (CE) plant with 16x16 fuel utilizing gadolinia as a burnable absorber.
- Five cycles for a 193-assembly Westinghouse PWR plant with 17x17 OFA fuel utilizing IFBA as a burnable absorber.
- Three cycles for a 157-assembly Westinghouse PWR plant with 17x17 standard fuel utilizing IFBA as a burnable absorber.
- The initial cycle for a 157-assembly Westinghouse AP1000® plant with 17x17 fuel utilizing WABA and IFBA as burnable absorbers.
- A theoretical equilibrium cycle for a 193-assembly Westinghouse PWR plant with 17x17 standard fuel.[1]

[1] TR states that this is a 4-loop plant, which means 193 assemblies. The specific burnable absorbers used in this cycle design is not specified in the TR, however, the other cores cover the spectrum of

For all cores, key physics parameters were calculated using the improved NEXUS methodology with the ANC code (also known as the improved NEXUS/ANC system), as follows: at-power critical boron concentration curves, at-power axial offset, startup test physics predictions (i.e., cold critical boron concentration and isothermal temperature coefficients), assembly power and radial peaking distributions, control rod worths, and reactivity parameters for several temperatures representing cold conditions (critical boron concentration and rod worth). Representative results are presented in the TR; however, additional results were reviewed during the closed regulatory audit and the NRC staff confirmed that the results included in the TR are consistent with the overall body of validation work performed by the applicant.

The primary intent of the validation studies was to demonstrate that the improved NEXUS methodology provides equivalent or better results relative to the previously approved NEXUS methodology. In some cases, measured data was presented to show how the predictions from the improved NEXUS/ANC system compared to real-world results. Overall, the improved NEXUS/ANC system produces results that are comparable to, or better than, the previously approved NEXUS/ANC system. The NRC staff noted that in certain situations, such as the isothermal temperature coefficient, the improved NEXUS methodology results in an ANC prediction that is about 1 pcm/°F more negative than the previous methodology for the 157-assembly Westinghouse PWR plant. As a result, the measured values are about 0.8-0.9 pcm/°F more positive than the predicted values from the improved NEXUS/ANC system. However, this trend was not observed for the AP1000® plant, and this deviation is within the bounds of acceptable uncertainties.

The NRC staff also noted that as part of the description for a proposed update process, the applicant presented a set of acceptance criteria in Table 37 (Section 4 of the TR) that are consistent with the uncertainties typically assumed in any safety related applications. The differences between the measured and predicted values for the full PWR core calculations are within the bounds of the acceptance criteria (see next section of this SE for further discussion). However, the bulk of the calculations are intended to demonstrate that the differences between the improved NEXUS methodology and the previously approved NEXUS methodology are acceptable. Based on the small changes in most parameters and clear improvement in other parameters, the NRC staff finds this conclusion to be appropriate.

The NRC staff finds that the full PWR core calculations to be acceptable in demonstrating that the improved NEXUS methodology has similar or better predictive accuracy for ANC compared to the previously approved NEXUS methodology, based on comparison of the calculated data from both methodologies. Furthermore, based on the comparisons between measured and predicted data presented in the TR, the NRC staff finds that the improved NEXUS/ANC system can be expected to provide reasonably accurate predictions of key physics parameters for full PWR cores.

4.5 Evaluation of the Process for Future Code/Methodology Modifications

Section 4 of the TR describes a process that the applicant proposes to use in order to make modifications to the NEXUS code or methodology without requiring prior NRC review and approval. A list of different modifications that are envisioned by the applicant to be appropriate

---

burnable poisons used in the current fleet of light water reactors, so this was not important to support the NRC staff's findings.

for this process includes “the use of different or additional state parameters in the formulation of the nuclear cross-sections, improved thermal hydraulic modeling, improved fuel rod thermal modeling, and use of an improved multi energy group cross-section structure.” The NRC staff noted that this scope suggests a very broad set of changes. Essentially, the key features of the NEXUS methodology that would not be changed include:

- The use of an approved lattice code (e.g., PARAGON) to generate the data for parametrization.
- The use of selected parameters such as those described in the TR, with a calculational matrix to parametrize the cross-sections from the lattice code.
- The use of the NEXUS methodology with an approved 3D core simulator code (e.g., ANC) to produce predictions.

In order to implement future changes, Westinghouse proposes a benchmarking/validation process with acceptance criteria defined in Table 37. The acceptance criteria cover the key core physics parameters for startup testing and normal operations that confirm key assumptions in the safety analyses continue to be valid for a given core design. The criteria are based on currently licensed uncertainties, or the uncertainties assumed in licensing basis safety analyses. The proposed process would continue to maintain the presence of NRC approved codes to support the lattice and 3D core calculations and would ensure that any changes are confirmed to yield appropriate accuracy relative to measured data.

However, the NRC staff had some concerns about the robustness of the proposed process to ensure that the NEXUS methodology will remain applicable for all its intended applications as described in the TR. As a result, the NRC staff requested further information to clarify how the process would be applied in different situations.

First, the NRC staff requested more information in part 1 of RAI-1 to clarify the area of applicability for any updated NEXUS methodologies when validated using the process described in the TR. The applicant responded (Ref. 2) by clarifying that there are two different kinds of updates that may be made. First, a change may be made to the cross-section representation within the NEXUS methodology, for example, by addition or replacement of state parameters used to reformulate the cross-sections. The goal of the NEXUS methodology is to accurately represent the cross-sections generated by the lattice code. Therefore, the validation of any changes to the NEXUS cross-section representation would be based on a demonstration that calculations executed with the NEXUS/ANC system will lead to the same physics predictions as calculations performed using the lattice code. This validation would be performed using mini-core models which are modeled using both the lattice code and the NEXUS/ANC system. If the key physics parameters are essentially the same, then the NEXUS/ANC system is shown to accurately represent the cross-sections generated by the lattice code.

The other kind of change involves the lattice codes rather than the NEXUS cross-section representation, which may include changes to PARAGON or use of a different lattice code. In this case, not only does the cross-section representation need to be confirmed for accuracy, the overall NEXUS/ANC predictions also need to be benchmarked to ensure that the changes do not invalidate uncertainties assumed in the safety analyses. Table 37 in the LTR lists the relevant uncertainty bands to verify. The response provided for part 1 of RAI-1 provides a summary of the data from different conditions and plant configurations that would be used in this validation.

The proposed validation processes for each of the two types of changes that may affect the predictions made by the NEXUS/ANC methodology are consistent with the expected impacts of these changes. Therefore, the NRC staff finds that the proposed validation processes can reasonably be expected to capture any errors or inappropriate deviations in the accuracy of the NEXUS/ANC predictions, subject to the limitation and condition discussed at the end of this section.

The NRC staff questioned whether the proposed validation process for any updates to the NEXUS methodology would appropriately account for the potential presence of both biases and uncertainties. Treating a systematic bias could yield non-conservative results if treated like an uncertainty. The applicant stated in its response to Part 2 of RAI-1 that the goal of the NEXUS methodology is to produce the same results as the lattice code, therefore, any significant bias would be unacceptable. Section 3 of the TR defines the criteria by which deviations are assessed to be significant or not. However, the lattice code itself could have a bias compared to measured data. Therefore, any updates to the lattice code that propagate forward to the NEXUS/ANC code system must be benchmarked to ensure that the assumptions in the safety analysis codes remain valid. In the RAI response, the applicant stated that the conservative extreme of the tolerance band would be used, ensuring that both the bias and uncertainty are accounted for in the comparison to the acceptance criteria. The NRC staff finds this disposition to be acceptable based on the following findings: (1) any changes to the lattice code would be restricted to those which do not constitute a change to the methodology described in the approved TR associated with that lattice code; (2) any differences between the NEXUS/ANC predictions relative to the lattice code would be restricted to a tight tolerance range; and (3) the bias and uncertainty in the NEXUS/ANC predictions will be verified to be bounded by the values used for key parameters in the safety analyses.

Future applications for the NEXUS/ANC code system may involve novel fuel or structural materials, such as accident tolerant fuel cladding or advanced spacer grid materials. For first-time applications of such materials, measurements may not yet be available. Westinghouse stated in its response to Part 3 of RAI-1 that this information gap will be addressed through benchmarking of the NEXUS/ANC predictions against a high-fidelity transport code that meets certain criteria for acceptance as a state of art code capable of capturing the effects of the materials, geometry, and neutron spectrum on the neutronics of the lattice. First-time applications of new materials that are expected to have a significant impact on the neutronics are generally performed as part of a lead test assembly campaign, in which other controls exist to address the inherent uncertainties due to lack of measured data. This approach to validate the NEXUS/ANC methodology for such applications is consistent with current typical practices for application of neutronics methodologies to novel materials, and therefore, is acceptable.

Finally, the NRC staff noted that the proposed update to the NEXUS methodology would extend the range of applicability to partially voided conditions. Measured data are typically not available for such conditions, so this is not a viable approach for validation of the NEXUS/ANC code system. In response to Part 4 of RAI-1, the applicant stated that the lattice code would need to be approved for use at any off-normal conditions. This approval may occur based on alternative means beyond comparison to measured data at the plant. If the lattice code is qualified for the desired off-normal conditions, then the NEXUS/ANC predictions can be compared to the lattice code in order to confirm that the appropriate cross-sections and reactivities are reproduced by the NEXUS/ANC code system. Since the NRC must review and approve the lattice code for the intended application, and the NEXUS/ANC validation process will ensure that the predictions from the two code systems are consistent, the NRC staff finds this to be an acceptable approach to validate use of the code system for off-normal conditions.

As discussed above, the NRC staff reviewed the proposed update process for the NEXUS/ANC code and methodology and obtained some additional information from the applicant to clarify how the updated methodology would be validated. The responses provided by Westinghouse were generally satisfactory to describe the application of the validation process. However, the descriptions do not provide a clear definition of the area of applicability for any given validation. Therefore, the NRC staff found it necessary to impose a limitation and condition which requires any application of the NEXUS/ANC predictions that support safety related parameters or controls to have core geometry, compositions, and operating conditions that are reasonably represented or bounded by the mini-cores, operating data, and/or high-fidelity transport calculations, as appropriate. In addition, certain core aspects of the NEXUS parametrization process cannot be modified without undermining the technical basis for approval of the NEXUS methodology and its subsequent validation for use in licensing applications. Therefore, an additional limitation and condition is being imposed to ensure that these aspects of the NEXUS methodology are not modified through the update process.

5.0 LIMITATIONS AND CONDITIONS

The following limitations and conditions apply to any use of the updated NEXUS methodology, as updated through the update process described in Section 4 of the TR, for licensing applications.

1. For any specific licensing application of the NEXUS methodology to support safety related parameters or controls, the mini-cores, measured datasets, and/or high-fidelity transport calculations used to validate the NEXUS code being used must be sufficiently representative, or bound, all compositions, geometries, and operating conditions associated with the licensing application in question.

2. Certain features of the NEXUS methodology cannot be updated or changed using the process described in Section 4 of the TR. The features are as follows:

    a. The lattice code must be consistent with the methodology described in an NRC approved TR;
    b. The parametrization must be performed based on cross-sections generated by the lattice code within an appropriate calculational matrix that covers the range of expected operating conditions, as described in the TR; and
    c. The resulting use of NEXUS with an NRC approved 3D core simulator code must be independently validated through comparison to mini-core calculations, measured plant data, and/or high-fidelity transport calculations, as described in the TR and RAI responses.

6.0 CONCLUSIONS

In WCAP-16045-P-A, Addendum 2, Revision 0, “Updated NEXUS Cross-Section Methodology,” Westinghouse presented a reparameterization of the PARAGON nuclear data output and a new reconstruction approach within the ANC core simulator code to simplify the use of this code system for practical applications.

The NRC staff finds that the methodology, as described in Addendum 2 and responses to the NRC staff RAI questions, adequately demonstrates that NEXUS accurately predicts cross-sections under a wide range of core conditions. In addition, the NRC staff finds that the procedure described for modification of the methodology is adequate with the addition of the limitations and conditions as described in Section 5.0 of this SE. As such, NRC staff approval of WCAP-16045-P-A, Addendum 2, Revision 0, is contingent on adherence to the limitations and conditions.

7.0 REFERENCES

1. Letter from K. L. Hosack, Manager, Product Line Regulatory Support, Westinghouse, to NRC Document Control Desk, “Submittal of WCAP-16045-P-A Addendum 2/ WCAP-16045-NP-A Addendum 2, ‘Updated NESXUS Cross-Section Methodology,’ Revision 0 (Proprietary/Non-Proprietary),” dated June 26, 2019 (ADAMS Accession No. ML19179A091).

2. Letter from K. L. Hosack, Manager, Product Line Regulatory Support, Westinghouse, to NRC Document Control Desk, “Responses to NRC Request for Additional Information for Westinghouse Topical Report WCAP-16045-P-A, Addendum 2, Revision 0, and WCAP-16045-NP-A, Addendum 2, Revision 0, ‘Updated NEXUS Cross-Section Methodology,’” dated March 3, 2020 (ADAMS Accession No. ML20066G642).

3. Letter from B. F. Mauer, Acting Manager, Regulatory Compliance and Plant Licensing, Westinghouse, to NRC Document Control Desk, “Submittal of WCAP-16045-P-A, Addendum 1/WCAP-16045-NP-A, Addendum 1, ‘Qualification of the NEXUS Nuclear Data Methodology,’ for NRC Review and Approval (Proprietary/Non-Proprietary),” dated November 29, 2005 (ADAMS Accession No. ML053460154).

4. Letter from J. A. Gresham, Manager, Regulatory Compliance and Plant Licensing, Westinghouse, to NRC Document Control Desk, “Submittal of Approved Versions of WCAP-16045-P-A Addendum 1-A/WCAP-16045-NP-A Addendum 1-A, ‘Qualification of the NEXUS Nuclear Data Methodology’ (TAC No. MC9606); WCAP-16523-P-A/ WCAP-16523-NP-A, ‘Westinghouse Correlations WSSV and WSSV-T for Predicting Critical Heat Flux in Rod Bundles with Side-Supported Mixing Vanes’ (TAC No. MID0561); and CENPD-132-P-A Supplement 4-P-A Addendum 1-P-A/CENPD-! 32-NP-A Supplement 4-NP-A Addendum I-NP-A, ‘Calculative Methods for the CE Nuclear Power Large Break LOCA Evaluation Model: Improvement to 1999 Large Break LOCA EM – Steam Cooling Model for Less Than 1 in/sec Core Reflood’ (TAC No.MD2161) (Proprietary/Non-proprietary),” dated September 7, 2007 (ADAMS Accession No. ML072570325).

Attachment: Comment Resolution

Principal Contributors: Diana Woodyatt
Scott Krepel

Date: July 21, 2020