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LTR-NRC-20-13

March 3, 2020

Subject: 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"

Enclosed are the proprietary and non-proprietary versions of 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".

This submittal contains proprietary information of Westinghouse Electric Company LLC ("Westinghouse"). In conformance with the requirements of 10 CFR Section 2.390, as amended, of the Nuclear Regulatory Commission's ("Commission's") regulations, we are enclosing with this submittal an Affidavit. The Affidavit sets forth the basis on which the information identified as proprietary may be withheld from public disclosure by the Commission.

Correspondence with respect to the proprietary aspects of this submittal or the Westinghouse Affidavit should reference AW-20-5012 and should be addressed to Korey L. Hosack, Manager, Licensing, Analysis, & Testing, Westinghouse Electric Company, 1000 Westinghouse Drive, Building 1, Cranberry Township, PA 16066.

Korey L. Hosack, Manager
Licensing, Analysis, & Testing

cc: Ekaterina Lenning (NRC)
Dennis Morey (NRC)

Enclosures:

1. Affidavit AW-20-5012
2. Responses to NRC Request for Additional Information for Westinghouse Topical Report WCAP-16045-P--, Addendum 2, Revision 0, and WCAP-16045-NP-A, Addendum 2, Revision 0, "Updated NEXUS Cross-Section Methodology" (Proprietary)
3. 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" (Non-Proprietary)

AFFIDAVIT

COMMONWEALTH OF PENNSYLVANIA:
COUNTY OF BUTLER:

(1) I, Korey L. Hosack, have been specifically delegated and authorized to apply for withholding and execute this Affidavit on behalf of Westinghouse Electric Company LLC (Westinghouse).

(2) I am requesting the proprietary portions of LTR-NRC-20-13 Enclosure 2 be withheld from public disclosure under 10 CFR 2.390.

(3) I have personal knowledge of the criteria and procedures utilized by Westinghouse in designating information as a trade secret, privileged, or as confidential commercial or financial information.

(4) Pursuant to 10 CFR 2.390, the following is furnished for consideration by the Commission in determining whether the information sought to be withheld from public disclosure should be withheld.

(i) The information sought to be withheld from public disclosure is owned and has been held in confidence by Westinghouse and is not customarily disclosed to the public.

(ii) Public disclosure of this proprietary information is likely to cause substantial harm to the competitive position of Westinghouse because it would enhance the ability of competitors to provide similar technical evaluation justifications and licensing defense services for commercial power reactors without commensurate expenses. Also, public disclosure of the information would enable others to use the information to meet NRC requirements for licensing documentation without purchasing the right to use the information.

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(5) Westinghouse has policies in place to identify proprietary information. Under that system, information is held in confidence if it falls in one or more of several types, the release of which might result in the loss of an existing or potential competitive advantage, as follows:

(a) The information reveals the distinguishing aspects of a process (or component, structure, tool, method, etc.) where prevention of its use by any of Westinghouse's competitors without license from Westinghouse constitutes a competitive economic advantage over other companies.

(b) It consists of supporting data, including test data, relative to a process (or component, structure, tool, method, etc.), the application of which data secures a competitive economic advantage (e.g., by optimization or improved marketability).

(c) Its use by a competitor would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing a similar product.

(d) It reveals cost or price information, production capacities, budget levels, or commercial strategies of Westinghouse, its customers or suppliers.

(e) It reveals aspects of past, present, or future Westinghouse or customer funded development plans and programs of potential commercial value to Westinghouse.

(f) It contains patentable ideas, for which patent protection may be desirable.

(6) The attached documents are bracketed and marked to indicate the bases for withholding. The justification for withholding is indicated in both versions by means of lower case letters (a) through (f) located as a superscript immediately following the brackets enclosing each item of information being identified as proprietary or in the margin opposite such information. These

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lower case letters refer to the types of information Westinghouse customarily holds in confidence identified in Sections (5)(a) through (f) of this Affidavit.

I declare that the averments of fact set forth in this Affidavit are true and correct to the best of my knowledge, information, and belief.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on: 20200303

Korey L. Hosack, Manager
Licensing, Analysis, & Testing

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"

(Non-Proprietary)

March 2020

Westinghouse Electric Company
1000 Westinghouse Drive
Cranberry Township, PA 16066

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"

The NRC staff completed an audit of Westinghouse on October 8 and 9, 2019 to facilitate the NRC staff review of the topical report. As a result of the audit, the NRC staff requires additional information to complete its review of this request. The Westinghouse responses to these RAIs ae provided herein.

RAI 1 - Modifications

Section 4 of Addendum 2 to WCAP-16045-P-A describes a process that, if approved, would be used to implement future changes to the NEXUS code/methodology without submission for NRC review and approval. The possibility exists that certain changes may affect the technical basis for NRC approval of the currently proposed NEXUS code/methodology. In these cases, the NRC approval may no longer be relevant to the modified version of the NEXUS code/methodology. Therefore, the NRC staff requests the following clarifications to ensure that the scope of changes allowed without prior NRC staff review and approval will be consistent with the technical basis for approval of the methodology, including the process for future code/methodology modifications.

1. Define the scope of the qualification, especially with respect to the intended area of applicability. Include information defining the area of applicability (e.g., key parameters to be bounded) for the updated code/methodology and demonstrate how the benchmarking data set is expected to adequately cover this area of applicability. Discuss how this area of applicability and accompanying benchmarking data sets may be modified due to updates (e.g., adding new state parameters to the formulation of the nuclear cross-sections).

   Response to Part 1

   Updates to the NEXUS/ANC code/methodology can be characterized into two categories. The first relates exclusively to changes to the cross-section representation by parameterization of PARAGON nuclear data for use by ANC. This is the essence of the NEXUS methodology. Such updates include adding or replacing state parameters to the formulation of the nuclear cross-sections. The intended scope of the qualification of such updates involves comparison of two-dimensional ANC mini-core model results with corresponding PARAGON mini-core model results to show the key parameters (reactivity, power distribution, control rod worth) across the range of thermal operating conditions, are essentially the same. Accurate replication of the PARAGON results in ANC is sufficient to show that the updated NEXUS formulation of the cross-sections in ANC accurately represents the basic cross-sections generated by PARAGON.

   The second category of updates to the code/methodology relates to changes not confined to how the PARAGON cross-sections are represented. Examples of this type include: improving the representation of boundary conditions (spectral interaction) between assemblies, and extension of the ANC nodal solution to using more than two energy groups. Since such updates to the code/methodology may affect ANC results beyond changes due to the NEXUS formulation, resulting in non-negligible changes to the ANC results, then further benchmarking is required. Such updates may affect the key core parameters used in safety analyses including core reactivity,

peaking factors, rod worths and temperature coefficient, which will be benchmarked by comparison with measured data. Startup test predictions will be used to compare reactivity (at zero power), rod worths and isothermal temperature coefficient (during these tests the core conditions are well characterized: zero power, isothermal). In addition, at-power reactivity comparisons of critical moderator boron concentration (adjusted for B-10 depletion) are used to compare core reactivity at operating conditions. Key peaking factors (FDH and FQ) are compared using power distribution measurements taken at various times during the cycle. Any changes to the code/methodology which non-negligibly impact these key parameters are assessed by assuring, prior to release of the code/methodology, that the comparisons of each parameter do not exceed the criteria shown in the table. These comparisons will consist of a number of different plants of different sizes (number of loops), fuel lattice size, and burnable absorber types. Startup M-P data will come from beginning of cycle; at-power boron and peaking factor M-P data will be taken from multiple times during the cycle. The results from all these comparisons will be pooled and the resultant M-P, to a 95/95 confidence interval, will be compared to the appropriate parameter shown in the table. If all criteria are met, the code/methodology change will have been validated for use. If any criteria are not met, the code/methodology will be refined such that the criteria are met. If the parameter remains outside the criteria, the code/methodology will be submitted to the NRC for review.

In summary: where updates to code/methodology affects the cross-section formulation, code-to-code comparisons between ANC and PARAGON mini-core models and calculations will be used to demonstrate that the formulation updates accurately recreate the PARAGON cross-sections in ANC. Where the updates have non-negligible impact on ANC results not directly related to the cross-section formulation, statistical comparisons of key parameters between ANC predictions and corresponding measured data shall be evaluated against acceptance criteria provided in the report.

2. Since the acceptance criteria are based on licensing uncertainties, discuss how any systematic biases would be identified and treated.

Response to Part 2

The benchmarking and validation of NEXUS has shown there is no significant bias and uncertainty introduced by the NEXUS methodology. In fact, the application of NEXUS in design applications requires confirmation that the fitting accuracy of the formulation for a given cross-section data set in ANC is within acceptable tolerances. Therefore, any updates to the code/methodology affecting the NEXUS formulation will not introduce significant biases or uncertainties. Where comparisons of PARAGON/ANC predictions to core measurement is concerned, the systematic biases in the key parameters are small, and additional enhancements are expected to further reduce these biases (improving the accuracy is the primary driver of any code/methodology update). Where M-P benchmarking is required (see the response to Part 1 of this Question), the intent is to compare the upper and/or lower tolerance limit, as appropriate, which accounts for both the bias and the uncertainty, with the acceptance criteria.

3. Discuss how this update process may be applied for novel fuel materials or structural materials not currently included in the benchmarking data set. Include information about how the updated methodology would be validated for first-time applications where measured data has not been collected yet.

Response to Part 3

For any novel fuel or structural material, if no methodology change is needed, the new material specific qualification will be performed before being applied for the actual core design calculation and safety analysis. This qualification always includes the single assembly and mixed fuel mini-core benchmarks and 3D core modeling cases. In the event that the methodology needs to be updated for this application, Westinghouse will follow the procedure as described in the response to Part 1 to perform full qualification for the updated methodology.

For qualification of novel fuel or structural material, Westinghouse will always try to compare the predicted results against measurements. However, if the measured data is not available for first-time application, well-recognized high-fidelity code (e.g. continuous energy Monte Carlo code) will be used to generate reference results for the comparison. The high-fidelity code must:

a) be mature
b) use high order transport methodology without limitation to the neutron spectrum
c) be able to model the exact material and geometry of the application conditions.

4. The acceptance criteria are based on typical cold and hot operating parameters, but the intended area of applicability for the updated NEXUS methodology includes off-normal conditions such as partially voided conditions. Discuss how the benchmarking would confirm that an updated NEXUS methodology will be valid for any intended applications involving off-normal conditions.

Response to Part 4

For off-normal condition application where no measured data are available, Westinghouse will validate the methodology through the following benchmark steps:

Step 1: Confirm the lattice code is qualified and approved at these off-normal conditions.

Step 2: Qualify the ANC methodology for the application by comparing the methods predictions with the lattice code results for the same model at the same off-normal conditions. This step is to confirm that the methodology can reproduce the lattice code results in both cross-sections and reactivities at the off-normal conditions.

RAI 2 – Mini-core

Due to the strong interaction between MOX and UO_2 fuel assemblies, it has been a challenge for traditional core design methods to model UO_2-MOX mixed cores. To evaluate the impact of the re-homogenization methods, a 3x3 UO_2-MOX checker-board mini-core case was setup with 5 MOX (M) and 4 UO_2 (U) fuel assemblies. The configuration of the mini-core case is given in Figure 10 of the TR. The reflective boundary condition is applied to the outer surface of the mini-core system.

NEXUS/ANC calculations were performed with and without the re-homogenization model, while a PARAGON calculation was performed with the same geometry to generate reference results. The k_∞ comparison of NEXUS/ANC predictions against the reference is given in Table 31 in the TR, while Figure 11 shows the comparison of assembly power distribution.

1. The NRC staff has determined that additional information is needed regarding the comparison of k_∞ (eigenvalues) in Table 31 of the TR. Based on the NRC staff's review of the docketed materials the correct eigenvalues are not currently listed in the TR. The staff is requesting that the applicant update Table 31 of the TR with the most accurate eigenvalues and docket the supporting information.

Response to RAI 2

Mini-core calculations were performed with PARAGON and ANC to demonstrate the re-homogenization effect. The initial calculations were done, and the results were reviewed and presented in the international conference PHYSOR2018 (Reference: "Advanced Cross-Section Re-Homogenization Based on 3D-Pseudo Pin-by-Pin Calculation (P3C) Methodology", PHYSOR2018 Reactor Physics paving the way towards more efficient system, Cancun, Mexico, April 22-26, 2018).

Subsequent to the conference presentation, the mini-core case was re-modeled at a different condition, which lead to a small change in the reactivity and no change to the assembly power distribution. As a part of the final qualification, the updated results were documented in the Westinghouse Calculation Note CN-NEU-REH-021.

The reactivity results currently given in the Table 31 in the Topical Report are the published results from the initial calculated case (per the conference presentation). The final qualification results are presented in Calculational Note CN-NEU-REH-021, which was reviewed with the NRC Staff at the October 2019 audit. Table 31 will be updated as follows:

Table 31 Comparison of $\boldsymbol{k}_\infty$ for 3X3 Mini-Core Case

[a,c

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RAI 3 – Validation

Section 3.1.3 of the updated NEXUS methodology incorporates cross-section calculations at voided conditions as a new feature. **[**

][a,c] The qualification of this new feature of NEXUS follows the same logic as the single assembly qualification – comparison between values updated NEXUS and PARAGON.

1. The NRC staff have determined that additional information is needed regarding the validation of PARAGON for the voided conditions. Explain the process used to demonstrate that PARAGON can accurately model the voided conditions.

Response to RAI 3

The challenge to model the fuel assembly at the voided condition is that neutron spectra is significantly different from those at non-voided conditions. Since MCNP with continuous energy library has no limit to the neutron spectrum and fuel composition, it was used to provide the reference results. **[**

][a,c]