U.S. NUCLEAR REGULATORY COMMISSION

OFFICE OF NUCLEAR REACTOR REGULATION

REGULATORY AUDIT REPORT FOR WESTINGHOUSE ELECTRIC COMPANY

TOPICAL REPORT WCAP-18965-P/NP, REVISION 0,

"QUALIFICATION OF PHOENIX5 AND POLCA8 FOR THE NUCLEAR DESIGN OF BOILING WATER REACTORS"

DOCKET NO. 99902038; EPID: L-2025-TOP-0032

1.0 BACKGROUND

By letter dated September 18, 2025 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML25261A307), Westinghouse Electric Company (Westinghouse), submitted Topical Report (TR) WCAP-18965-P/NP, Revision 0, "Qualification of PHOENIX5 and POLCA8 for the Nuclear Design of Boiling Water Reactors" (ML25261A306 - Package) for U.S. Nuclear Regulatory Commission (NRC) review and approval. WCAP-18965-P/NP, Revision 0, proposes a standalone update to the nuclear design methodologies described in CENPD-390-P-A, "The Advanced PHOENIX and POLCA Codes for Nuclear Design of Boiling Water Reactors."

The NRC staff conducted a virtual regulatory audit to increase efficiency, facilitate discussion, and clarify issues identified during the NRC staff's initial review of the TR, on April 14-16, 2026, based on the audit plan issued on March 31, 2026 (ML26085A112 - Package). The audit was conducted in accordance with the NRC Office of Nuclear Reactor Regulation procedure as described in LIC-111, "Regulatory Audits" (ML24309A281), and under the guidance provided in LIC-500, Revision 9, "Topical Report Process" (ML20247G279). The information discussed during the audit was determined to be proprietary by the NRC staff.

2.0 REGULATORY AUDIT OBJECTIVES

The objective of this audit was to increase review process efficiency through direct interaction with Westinghouse's technical experts. The audit allowed the NRC staff to discuss a number of technical questions on WCAP-18965-P/NP, Revision 0, and examine supporting information. These technical discussions and audit review of supporting documentation have aided the NRC staff in identifying areas of the review that need additional focus.

Enclosure 1

The list of participants is contained in the table below:

Name	Affiliation
Alex Collier	NRC
Jack Vande Polder	NRC
Brandon Wise	NRC
Ekaterina Lenning	NRC
Nathaniel Mackereth	Westinghouse
Jerrod Ewing	Westinghouse
Kevin Laswell	Westinghouse
Mohamed Ouisloumen	Westinghouse
Scott Vrtiska	Westinghouse
Antonios Mylonakis	Westinghouse
Carl Adamsson	Westinghouse
Konstantinos Paschalidis	Westinghouse
Richard Lindvall	Westinghouse
Brandon Drusbasky	Westinghouse

3.0 REGULATORY AUDIT BASES

Regulatory requirements relevant to the review of nuclear design methods are provided in Title 10 of the *Code of Federal Regulations,* Appendix A to Part 50, General Design Criteria (GDC)-11, "Reactor inherent Protection," GDC-12, "Suppression of Reactor Power Oscillations," GDC-13, "Instrumentation and Control," GDC-20, "Protection System Functions," GDC-25, "Protection System Requirements for Reactivity Control Malfunctions," GDC-26, "Reactivity Control System Redundancy and Capability," GDC-27, "Combined Reactivity Control Systems Capability," and GDC-28, "Reactivity Limits." Regulatory guidance for the review of nuclear design methods and adherence to the aforementioned GDCs is provided in NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants" (SRP) Section 4.3, "Nuclear Design."

4.0 DISCUSSION

During the initial review of WCAP-18965-P/NP, Revision 0, the NRC staff identified several technical topics where additional information may be required to make regulatory findings. These topics are listed in the audit plan and will be briefly summarized here along with relevant discussion from the audit:

The NRC staff discussed each topic with Westinghouse, and the following is a summary of the important points and outcomes for each topic:

1. The NRC staff requested information related to a statement describing SERPENT2 and MCNP as equivalent in certain manners when equivalent inputs are provided. The Westinghouse representatives clarified for what conditions this equivalence is true and also stated that this description was found to be acceptable in the NRC review of TR WCAP-18443-P-A, Revision 0, "Qualification of the Two-Dimensional Transport Code PARAGON2." The NRC staff did not identify any need for a request for additional information (RAI) for this topic.

2. The NRC staff requested information related to a cross-section data adjustment in PHOENIX4 and whether that data adjustment should be included in PHOENIX5. The Westinghouse representatives stated that the data adjustment was required for a combination of factors including the cross-section library, number of energy groups, and solution methods. All three of these factors are improved in the PHOENIX5 method. The NRC staff did not identify any need for an RAI for this topic.

3. The NRC staff noted that the table headings for Tables 2-1 and 2-6 were missing. The Westinghouse representatives provided those table headings. The NRC staff identified the need for an RAI for this topic.

4. The NRC staff requested information related to the sensitivity studies described on page 2-51 of the TR. The Westinghouse representatives provided the supporting documentation. The NRC staff reviewed the information and did not identify any need for an RAI for this topic.

5. The NRC staff requested information related to the range of burnups considered in the validation studies and the requested burnup limit, noting a difference between the two. The Westinghouse representatives noted that there is limited experimental data to compare against high burnups. The NRC staff identified the need for an RAI to resolve this topic.

6. The NRC staff requested information related to the magnitude of some uncertainties calculated in the PHOENIX5 validation studies. The Westinghouse representatives noted that high uncertainties, particularly with certain isotopics, are common and compared the PHOENIX5 isotopic assay results with those in PARAGON2 noting comparable uncertainties. The NRC staff did not identify any need for an RAI for this topic.

7. The NRC staff requested information related to **[**

   ]. The NRC staff identified the need for an RAI would be required to document this justification.

8. The NRC staff requested information related to the range of applicability for the Monte Carlo benchmarks. The Westinghouse representatives clarified the description provided in Section 2.2.1 of the TR. The NRC staff did not identify any need for an RAI for this topic.

9. The NRC staff requested information related to the branch parameter and ranges variations of the Monte Carlo benchmarks. The Westinghouse representatives clarified the branch parameter and range combinations. The NRC staff did not identify any need for an RAI for this topic.

10. The NRC staff requested information related to the PHOENIX5 and SERPENT2 code-to-code comparisons. The Westinghouse representatives acknowledged **[**

]. The NRC staff did not identify any need for an RAI for this topic.

11. The NRC staff requested information related to the fuel temperatures used in the validation study. The Westinghouse representatives clarified that the fuel temperatures originated from reported values in the supporting documents provided as part of the audit question 4 or are estimated using experimental data. The NRC staff did not identify any need for an RAI for this topic.

12. The NRC staff requested information related to the calculated uncertainties associated with the isotopic assay evaluation. The Westinghouse representatives clarified that the uncertainties for these isotopes are within expected ranges and that comparable results have been accepted in TR WCAP-18443-P-A. The NRC staff did not identify any need for an RAI for this topic.

13. The NRC staff requested clarification related to where the assembly discontinuity factors appeared in the solution of the diffusion equation. The Westinghouse representatives provided additional equations and indicated that the discontinuity factors appear in Equation 3-18. The NRC staff did not identify any need for an RAI for this topic.

14. The NRC staff requested a description of the differences between the flux solvers described in TRs CENPD-390-P-A and WCAP-18965-P/NP, Revision 0. The Westinghouse representatives stated that the flux solvers are essentially identical with minor exceptions. The NRC staff did not identify any need for an RAI for this topic.

15. The NRC staff requested a description of the differences between the detector models in TRs CENPD-390-P-A and WCAP-18965-P/NP, Revision 0. The Westinghouse representatives stated that the models are identical, acknowledging that some variables have only changed symbolically. The NRC staff did not identify any need for an RAI for this topic.

16. The NRC staff requested a description of the differences between the pin power reconstruction models in TRs CENPD-390-P-A and WCAP-18965-P/NP, Revision 0, with a focus on the radial shape function. The Westinghouse representatives clarified that the models are identical with the exception that POLCA8 represents detector guide tubes and employs two energy groups, as opposed to one in CENPD-390-P-A.

17. The NRC staff requested information related to the axial nodalization scheme for exposure nodes with a focus on axial heterogeneities associated with the control rod/blade position. The Westinghouse representatives clarified that tracking isotopics in exposure nodes that change in volume over time introduces significant complexities and that the proposed nodalization represents a strict improvement from the nodalization

approved in CENPD-390-P-A. The NRC staff identified the need for an RAI to document this justification.

18. The NRC staff requested confirmation if the tracked nuclides described in the Appendix A to CENPD-390-P-A also apply to POLCA8. The Westinghouse representatives confirmed the tracked nuclides and fission chains are the same in POLCA8 and referenced some of the validation studies which demonstrate acceptable performance. The NRC staff did not identify any need for an RAI for this topic.

19. The NRC staff requested clarification as to which axial nodalization scheme was used by the thermal-hydraulics model. The Westinghouse representatives confirmed that the exposure node scheme is used. The NRC staff identified the need for an RAI to document this information.

20. The NRC staff requested information related to the calculation of void fractions in POLCA8. The Westinghouse representatives provided a detailed description of the model and provided references to some validation studies. The NRC staff did not identify any need for an RAI for this topic.

21. The NRC staff requested information related to referenced correlations and validation Section 3.1.12.4 of the TR. The Westinghouse representatives provided the validation studies which confirm information provided in the TR. The NRC staff did not identify any need for an RAI for this topic.

22. The NRC staff requested clarification related to how critical power ratio (CPR) correlations are applied within POLCA8. The Westinghouse representatives confirmed that the CPR correlations used within this methodology are fuel design-specific and must be from NRC-approved TRs. The NRC staff did not identify any need for an RAI for this topic.

23. The NRC staff requested a more detailed description of the inter-assembly bypass model, the smoothing parameters, and studies performed to justify the smoothing treatment. The Westinghouse representatives provided a document which contained all this information. The NRC staff identified the need for an RAI would be needed to provide justification that the model produces reasonable results.

24. The NRC staff requested information regarding the burnup and enrichment limits for Westinghouse's fuel performance code with respect to the range of applicability of WCAP-18965-P/NP, Revision 0, for the purposes of providing fuel temperature data. The Westinghouse representatives stated that the burnup application range of TR WCAP-18965-P/NP, Revision 0, may be limited by the range of applicability of the fuel performance code. The NRC staff determined that a limitation and condition on the burnup range of applicability of WCAP-18965-P/NP, Revision 0, may be necessary to ensure that the code system produces adequate results as a function of burnup.

25. The NRC staff requested information related to the nodal benchmarks described in Section 3.2.2 of WCAP-18965-P/NP, Revision 0. The Westinghouse representatives clarified that the benchmarks are well established and provided a reference which contains additional information for each benchmark. The NRC staff did not identify any need for an RAI for this topic.

26. The NRC staff requested clarification regarding the unique behavior seen in Figure 3-17, Configuration 3. The Westinghouse representatives clarified that this study includes control blade insertion and withdrawal which explains the unique trends observed compared to other configurations. The NRC staff did not identify any need for an RAI for this topic.

27. The NRC staff requested information regarding measured k_{eff} values in the core follow calculations in Section 4.1.1 of WCAP-18965-P/NP, Revision 0. The Westinghouse representatives explained the calculation process for criticality conditions and noted that the repeatability of reactivity predictions and establishment of target k_{eff} is of more importance than reactivity differences. The NRC staff did not identify any need for an RAI for this topic.

28. The NRC staff requested information regarding the nodalization scheme and root mean square calculation methods for the traversing in-core probe and gamma scan comparisons. The Westinghouse representatives provided an explanation of the nodalization scheme and the error definitions. The NRC staff did not identify any need for an RAI for this topic.

29. The NRC staff requested information regarding the measurement uncertainty of the gamma scans. The Westinghouse representatives clarified that the differences presented in WCAP-18965-P/NP, Revision 0, include the measurement uncertainty and therefore provides a conservative estimate of the code prediction uncertainty. The NRC staff did not identify any need for an RAI for this topic.

5.0 EXAMINED AUDIT DOCUMENTS

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6.0 CONCLUSION

The regulatory audit accomplished the objectives listed in Section 2.0 by allowing direct interaction with Westinghouse's technical experts. The NRC staff obtained clarification on the contents of the TR, examined calculation notes and other documentation supporting the TR, and discussed technical issues described in the audit plan. The clarifications and the examined calculation notes have helped the NRC staff increase the efficiency of its review and create effective RAIs.