U. S. NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
REGULATORY AUDIT REPORT FOR
TOPICAL REPORT WCAP-16996-P/NP-A, REVISION 1, SUPPLEMENT 1, "EXTENSION OF FULL SPECTRUM LOCA (FSLOCA) EVALUATION METHODOLOGY TO 2-LOOP WESTINGHOUSE PRESSURIZED WATER REACTORS (PWRs) WITH INFORMATION TO SATISFY LIMITATIONS AND CONDITIONS SPECIFIC TO 2-LOOP PLANT TYPES"
AND
TOPICAL REPORT WCAP-16996-P/NP-A, REVISION 1, SUPPLEMENT 2, "EXTENSION OF FULL SPECTRUM LOCA (FSLOCA) EVALUATION METHODOLOGY TO COMBUSTION ENGINEERING (CE) PRESSURIZED WATER REACTORS (PWRs)"
WESTINGHOUSE ELECTRIC COMPANY
DOCKET NO. 99902038; EPID L-2025-NTR-0002 AND EPID L-2025-NTR-0004

1.0 BACKGROUND

By letter dated February 25, 2025 (Agencywide Documents Access and Management System (ADAMS) Letter Accession No. ML25057A397), Westinghouse Electric Company (Westinghouse), LLC, submitted topical report (TR) WCAP-16996-P/NP, Revision 1, Supplement 1, "Extension of Full Spectrum LOCA (FSLOCA) Evaluation Methodology to 2-Loop Westinghouse Pressurized Water Reactors (PWRs) with Information to Satisfy Limitations and Conditions Specific to 2-Loop Plant Types," for U. S. Nuclear Regulatory Commission (NRC) review and approval. WCAP-16996-P/NP, Revision 1, Supplement 1, proposes an approach for performing LOCA analyses for Westinghouse-designed 2-loop plants using the FSLOCA evaluation methodology (EM).

By letter dated October 10, 2025 (ML25283A045), Westinghouse submitted TR WCAP-16996-P/NP, Revision 1, Supplement 2, "Extension of Full Spectrum LOCA (FSLOCA) Evaluation Methodology to Combustion Engineering (CE) Pressurized Water Reactors (PWRs)," for NRC review and approval. WCAP-16996-P/NP, Revision 1, Supplement 2, proposes an approach for performing LOCA analyses for CE-designed PWRs using the FSLOCA EM.

The NRC staff determined that a regulatory audit would increase efficiency, facilitate discussion, and clarify issues identified during the NRC staff's initial review and conducted a hybrid regulatory audit on February 11-13, 2026, based on the audit plan issued on January 9, 2026 (ML25363A021). The audit was held in accordance with the NRC Office of Nuclear Reactor Regulation procedure as described in LIC-111, "Regulatory Audits," and under the guidance provided in LIC-500, Revision 9, "Topical Report Process." The audit was closed due to the proprietary nature of the information discussed. 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 several technical questions on TR WCAP-16996-P/NP, Revision 1, Supplements 1 and 2, and examine supporting information. These technical discussions and audit review of the supporting documentation has 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
John Lehning	NRC
Noushin Amini	NRC
Brandon Wise	NRC
Carl Thurston	NRC
Ekaterina Lenning	NRC
Nathaniel Mackereth	Westinghouse
Kevin Barber	Westinghouse
Brian Ising	Westinghouse
Aaron Everhard	Westinghouse
Liping Cao	Westinghouse
Mark Sheaffer	Westinghouse
Jeffrey Kobelak	Westinghouse
Michael Shockling	Westinghouse
Megan Barca	Westinghouse
Jeffery Brown	Westinghouse
Joshua Yagozinski	Westinghouse
Jerrod Ewing	Westinghouse

3.0 REGULATORY AUDIT BASES

Regulatory requirements relevant to the review of LOCA evaluation models that use realistic models with explicit accounting for uncertainty are provided in Title 10 of the *Code of Federal Regulations* (10 CFR) 50.46. Regulatory guidance for the review of transient and accident analysis methods and adherence to 10 CFR 50.46 is provided in Standard Review Plan Section 15.0.2, "Review of Transient and Accident Analysis Methods."

4.0 DISCUSSION

During the initial review of TR WCAP-16996-P/NP, Revision 1, Supplement 1, the NRC staff identified several technical topics where additional information may be required to make regulatory findings. 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 how WCAP-14449-P-A influenced the

methodology described in Supplement 1 to WCAP-16996-P-A. Westinghouse provided comparisons of the WCAP-14449-P-A phenomena identification and ranking table (PIRT), reactor and system nodalization, validation results, and limitations to the new method. Westinghouse noted several similarities in these characteristics. The NRC staff did not identify any need for a request for additional information (RAI).

2. The NRC staff requested information related to the break size range that upper plenum injection (UPI) would play a significant role in mitigating a LOCA. Westinghouse described the cut-in pressure for the UPI systems and compared that value to expected reactor coolant system pressure values for various break sizes. The NRC staff determined that an RAI would be needed to document this information.

3. The NRC staff requested information related to the UPI discharge location, and geometric and flow parameters. Westinghouse provided diagrams of the UPI discharge locations, upper plenum geometry, as well as various other parameters associated with UPI. The NRC staff determined that an RAI would be needed to document this information.

4. The NRC staff requested information related to the hot leg nozzle gaps. Westinghouse described the treatment of the hot leg nozzle gap and noted that the treatment from the base methodology is maintained. The NRC staff did not identify any need for an RAI.

5. The NRC staff requested information related to the modeling of the upper core plate geometry above the hot assembly and the possibility for downflow that could influence the limiting peak cladding temperature (PCT). Westinghouse described the treatment of the hot assembly in the evaluation model and the impact that downflow may have on the results. Westinghouse also described the impact and distribution of downflow in cylindrical core test facility (CCTF) runs 72 and 76. The NRC determined that an RAI would be needed to document this information and justify the proposed modeling approach.

6. The NRC staff requested clarification regarding the use of the term “initial PCT” used to describe the range of test parameters in Table 2.2-5 of the TR. Westinghouse confirmed

   that the term “initial PCT” corresponds to the **[**
   ]. The NRC staff did not identify any need for an RAI.

7. The NRC staff requested information related to the prototypicality of the configurations used in the General Electric (GE) counter-current flow limit (CCFL) and CCTF tests cited in the TR with Westinghouse 2-loop upper core plate geometry for the purpose of modeling countercurrent flow. Westinghouse provided cross-sectional diagrams associated with the CCTF tests and typical Westinghouse 2-loop upper core plate geometry. Westinghouse also described the applicability of the CCFL data to Westinghouse 2-loop upper core plate geometries. The NRC staff determined that an RAI would be needed to document this information.

8. The NRC staff requested information related to predicted downflow behavior in the GE CCFL tests. Westinghouse confirmed that the observed liquid drainage behavior in GE CCFL test 69 is attributable to **[**
   ]. The NRC staff did not identify any need for an RAI.

9. The NRC staff requested clarity on the data being represented in various figures in the TR. Westinghouse clarified the information being represented in the figures. The NRC staff did not identify any need for an RAI.

10. The NRC staff requested information related to the prediction of **[ ]**. The Westinghouse representatives and the NRC staff discussed **[ ]**. The Westinghouse representatives clarified the conditions necessary for **[ ]**. The Westinghouse representatives also described the nodalization between the plant model and the CCTF UPI test model noting **[ ]**. The NRC staff determined that an RAI would be needed to document this information.

11. The NRC staff requested information related to the general behavior of **[ ]** as well as the applicability of the experimental results being scaled for Westinghouse designed 2-loop plant analyses. The Westinghouse representatives provided additional information related to multi-dimensional flow, identifying specific regions where **[ ]** and the scalability of results. The Westinghouse representatives provided details related to code performance in predicting **[ ]**. Nodalization sensitivity studies were also discussed to determine the impact on predicted flow. The NRC staff noted **[ ]**. The NRC staff determined that an RAI would be needed to document this information and justify the proposed modeling approach.

12. The NRC staff requested information related to the limitations of the methodology with respect to core power and steam flow conditions present in some of the tests. The Westinghouse representatives clarified that the limitations and conditions (L&Cs) from WCAP-14449-P-A, Revision 1, are being carried forward, which includes limitations on the maximum core power. The NRC staff did not identify any need for an RAI.

13. The NRC staff requested information related to the nodalization for the UPF Test 20 simulation. The Westinghouse representatives clarified that the model nodalization is designed to be reflective of a typical 2-loop plant with a focus on the upper plenum nodalization. The NRC staff did not identify any need for an RAI.

14. The NRC staff requested information related to an **[ ]**. The Westinghouse representatives provided clarification regarding the **[ ]**. Westinghouse also discussed some specific characteristics of the test and how these are represented in the simulation related to **[ ]**. The NRC staff noted that the test was intended to represent steady-state conditions, such that the **[ ]**. The NRC staff audited several additional calculated and measured test parameters to contextualize the predictions of

the FSLOCA methodology and assess the validity of **[ ]**. The NRC staff determined that an RAI would be needed to document this information and justify the proposed modeling approach.

15. The NRC staff requested clarification as to what data is being represented in Figure 2.5-14 **[ ]** and how well the results compare to experimental data. The Westinghouse representatives clarified what the values in Figure 2.5-14 represent and provided comparisons of the experimental results versus WCOBRA/TRAC-TF2 simulation results. The NRC staff determined that an RAI would be needed to document this information.

16. The NRC staff requested information related to mass balance inputs in Table 2.5-3 of the TR. The Westinghouse representatives identified which flow rates from the test facility are represented in Table 2.5-3 and which are not included. The represented flow rates are those of interest for the UPI phenomena. The NRC staff did not identify any need for an RAI.

17. The NRC staff requested information related to the **[ ]** in Phase B of upper plenum test facility (UPTF) Test 20 compared to other phases of Test 20. The Westinghouse representatives described the conditions that resulted in **[ ]** compared to Phases A and B. However, the NRC staff had further questions concerning this topic, since the **[ ]**. The NRC staff determined that an RAI would be needed to document this information and justify the proposed modeling approach.

18. The NRC staff requested clarification as to why the TR states that intermediate break (IB) LOCA scenarios represent **[ ]** despite the fact that downstream methods may place greater emphasis on these cases. The Westinghouse representatives indicated that **[ ]**. The NRC staff did not identify any need for an RAI.

19. The NRC staff requested information on how Westinghouse verified that the observed scaling trends for the four UPI quantities of interest represent true physical behavior and are not artifacts of compensating scaling effects across facilities **[ ]**. The Westinghouse representatives discussed the role of **[ ]** and referenced information in the base TR. The NRC staff did not identify any need for an RAI.

20. The NRC staff requested comprehensive evidence supporting the assertion that **[ ]**, as described in the TR. Westinghouse explained that **[ ]**. The NRC staff also noted that **[ ]**. The NRC staff noted that **[ ]**. The NRC staff

determined that an RAI would be needed to document this information and justify the proposed modeling approach.

21. The NRC staff sought clarification on whether condensation modifications applied in the GE CCFL sensitivity studies affect only flow regions above the CCFL location or also extend below it. The Westinghouse representatives stated that the **[** was modified both above and below the CCFL location, encompassing channels **]**. The NRC staff determined that an RAI was not needed to document these details in light of the general information summarized in the submitted TR.

22. The NRC staff requested further explanation of how **[** **]**. The Westinghouse representatives indicated that **[** **]**. The NRC staff determined that additional clarification may be needed and that an RAI may be appropriate to document this information and justify the proposed modeling approach.

23. The NRC staff requested clarification regarding the **[** **]**. The Westinghouse representatives explained that the **[** **]**. The NRC staff did not identify any need for an RAI.

24. The NRC staff requested confirmation that **[** **]**. Westinghouse confirmed that **[** **]**. The NRC staff did not identify any need for an RAI.

25. The NRC staff requested clarification regarding whether flows in Figure 2.7-6 are presented on a **[** **]**. The Westinghouse representatives stated that those flows represent **[** **]**. The Westinghouse representatives noted that the **[** **]**. The NRC staff did not identify any need for an RAI.

26. The NRC staff sought clarification regarding the impact of **[** **]**. The NRC staff suggested that **[** **]**. The Westinghouse representatives explained that the **[** **]**. The Westinghouse representatives agreed that the **[** **]**. Additionally, the NRC staff observed that the **[** **]**. The NRC staff did not identify any need for an RAI.

27. The NRC staff requested information regarding where it is shown in the analysis that **[ ]**, as indicated in the TR. The Westinghouse representatives provided figures showing **[ ]**. The NRC staff did not identify any need for an RAI.

28. The NRC staff requested further details regarding changes to vessel level-4 nodalization relative to the existing best-estimate methodology. The Westinghouse representatives stated that the revised nodalization **[ ]**. The NRC staff noted that additional documentation may be warranted concerning the modeling of inter-channel flow communication and Westinghouse's approach to constructing nodalization diagrams. The NRC staff determined that an RAI may be needed.

29. The NRC staff noted that the proposed break nodalization is not explicitly shown in Figure 3.2-14 and requested confirmation on whether the approach matches the base methodology. The NRC staff determined that an additional follow-up or an RAI may be needed to document the proposed approach concerning break nodalization and other topics not explicitly discussed in the Supplement 2 TR.

30. The NRC staff requested evidence supporting the generalization that split breaks tend to be more limiting for two-loop plant designs. The Westinghouse representatives indicated that this trend is consistent with prior methodologies and referenced Appendix B of WCAP-14449. The Westinghouse representatives further identified an additional study performed using the ASTRUM methodology, which applies an earlier version of the computational approach used in the FSLOCA methodology to the large-break portion of the spectrum of postulated LOCAs. The NRC staff did not identify any need for an RAI.

31. The NRC staff requested information regarding the applicability of the flow resistance values used in Table 3.3.1-1. The Westinghouse representatives explained that the selected values represent the **[ ]**. The NRC staff did not identify any need for an RAI.

32. The NRC staff requested clarification on whether sensitivity studies summarized in Sections 3.3 and 3.4 reflect results from only a single simulation. The Westinghouse representatives stated that **[ ]**. The NRC staff determined that an RAI is necessary for this topic.

33. The NRC staff requested confirmation that sensitivity study conclusions are applicable to all plants in the W-2LP category. The Westinghouse representatives stated that **[ ]**. The NRC staff concluded that an RAI is necessary to obtain additional clarification concerning this topic.

34. The NRC staff requested information about the evaluated range of SGTP values **[ ]**. The Westinghouse representatives explained that **[**

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

35. The NRC staff requested clarification regarding the somewhat elliptical justification on page 3-51 of the TR for the SGTP assumption proposed for Region II analysis. The Westinghouse representatives stated that **[**

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

36. The NRC staff requested clarification regarding potential gaps in sensitivity studies for W-2LP plants, especially regarding intermediate breaks. The Westinghouse representatives acknowledged that **[**

]. The NRC staff noted that this issue may result in either an RAI or a L&C.

37. The NRC staff requested clarification on whether sensitivity studies that result in non-limiting PCTs would remain applicable under potential power uprates. The Westinghouse representatives indicated that the studies are **[**

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

38. The NRC staff requested information on whether Westinghouse has examined the significant number of calculations performed with either the FSLOCA EM or prior-generations of existing W-2LP methodologies using similar computational codes to confirm that **[ ]** during the time window relevant for PCT and oxidation. The Westinghouse representatives stated that **[**

]. Westinghouse asserted that simulations and tests with UPI were reviewed, showing **[ ]**. The NRC staff inquired whether **[**

]. The Westinghouse representatives acknowledged that additional data review may be required to address the question rigorously. Near the end of the audit, Westinghouse **[**

]. The NRC staff determined that an RAI is necessary to document relevant information and justify the proposed modeling approach.

During the initial review of WCAP-16996-P/NP, Revision 1, Supplement 2, the NRC staff identified several technical topics where additional information may be required to make regulatory findings. These topics are described in the audit plan. The audit included limited discussion of topics associated with Supplement 2, which were intended to increase review efficiency and support preparation for a subsequent audit focused specifically on that TR. Due to time constraints and the prioritization of Supplement 1, the NRC staff did not comprehensively

address the pre-established audit questions for Supplement 2. The questions that remain open will be carried forward to the planned follow-on audit, where a more detailed and focused discussion of Supplement 2 will be carried out. The NRC staff's audit plan for the Supplement 2 TR will provide further clarification on which items are expected to be the subject of further discussion.

5.0 EXAMINED AUDIT DOCUMENTS

Documents related to WCAP-16996-P/NP-A, Revision 1, Supplement 1:

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Documents related to WCAP-16996-P/NP-A, Revision 1, Supplement 2:

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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.