**ITEM 1 – Information needed to complete technical review**

Topical Report (TR) WCAP-17938-P, "AP1000 In-Containment Cables and Non-Metallic Insulation Debris Integrated Assessment," describes Westinghouse's evaluation of the ability of non-metallic insulation (NMI) within the AP1000 reactor vessel (RV) cavity to withstand the effects of a loss-of-coolant accident (LOCA) consistent with the AP1000 licensing basis. Westinghouse used a combination of free expansion jet impingement testing and compartment pressurization analysis to support its conclusion that the NMI would be a suitable alternative to the previously approved reflective metal insulation (RMI). Essentially, the justification relies on the compartment pressurization analysis to quantify the pressure that the NMI is expected to be subject to, and then compares this pressure to the tested free expansion jet impingement pressure.

The NRC staff has found during the acceptance review that the TR does not provide a technically sufficient justification that the NMI would withstand the effects of a LOCA in the RV cavity. An approach that relies on free expansion jet modeling or testing has not been demonstrated to be appropriate for the RV cavity location. The TR needs to be augmented through testing and/or analysis in four key areas:

1. The TR should provide a discussion of how the jet behaves within the reactor cavity region. Any use of a free expansion jet model to support reaching a conclusion that NMI is a suitable equivalent insulation to metal reflective insulation must be justified.

2. Section 3.4.4.4, "Considerations Resulting from Confined Jet Behavior," of the TR states that a RV compartment pressurization analysis was performed using a GOTHIC model for a double-ended cold leg guillotine break. The compartment pressurization approach relies on an assumption that the NMI is not subject to jet impingement, as GOTHIC cannot assess jet impingement effects. Westinghouse needs to characterize each NMI location to justify whether there are jet impingement effects or not.

3. For the locations where the NMI is subject to jet impingement (e.g., where no sufficiently robust intervening structures exist), the subcompartment analysis is not sufficient. The dynamic jet loads at the NMI location (including potential jet deflection and reflection) need to be quantified, for comparison to the test pressure.

4. For the locations where the NMI is not subject to jet impingement, the nodalization of the GOTHIC model is not sufficient to provide a fair representation of the localized pressures within the volume (specifically, the NMI target pressure). In cases where intervening structures are credited to support this assumption, the structural integrity of these structures to withstand the jet needs to be quantified.

Enclosure 1

## ITEM 2 – Additional GAPs to be addressed

| GAP # | Topical Report Section Number | Topical Report Section Title | Regulatory Gap | Regulatory Basis for Concluding a Gap Exists | Information that should to be included in Topical Report |
|---|---|---|---|---|---|
| 1. | Executive Summary and 2.1 | Executive Summary/ Cables | The topical report does not describe if all cable locations are outside the ZOI or if cable protection is needed for those cables within the ZOI.<br><br>Licensing basis (6.3.2.2.7.1 of DCD) states that a LOCA in the AP1000 design does not generate fibrous debris. | 10 CFR 50.46(b)(5) GDC 35 | Provide a discussion in the report on whether cables are located within the ZOI and if they are, explain how these cables are evaluated.<br><br>For example, If there are designed-in barriers that function to protect cabling in a similar manner as the outer steel container protects the "neutron shield block materials," i.e., a barrier functions to prevent fibrous debris generation during a LOCA, then (at some point in the detailed design) technical justification is necessary (test and/or analysis) that supports the conclusion that fibrous debris is not generated during a LOCA from the cables within the ZOI. |
| 2. | 3.5 | Neutron Shield Block Submergence Test Summary and Objectives | Submergence testing was designed with seven test specimens to address the test objectives. Results are discussed for only one specimen. [ ] is described as one of the primary releases, but there is no information about how it was evaluated. | 10 CFR 50.46(b)(5) GDC 35 | Provide a summary of the whole test program and how it fits into the conclusions and the approvals requested in the report. |
| 3. | 3.5 | Neutron Shield Block Submergence Test Summary and Objectives | There is a requirement that suitable equivalent insulation not generate chemical effects. The submergence testing indicated [ ]. This leaves a gap between the test results and the conclusion that this is a suitable equivalent. | 10 CFR 50.46(b)(5) GDC 35 | Somewhere in the report provide a direct and complete explanation of why the material being proposed in the WCAP does not generate chemical effects. |
| 4. | 3.5.2.4 | Submergence Test Results | This section refers to an update of the AP1000 chemical effects model. This appears to include a non-conservative amount of aluminum (inventory values) with respect to the 60-pound design limit (DCD Section 6.1.1.4). The report appears to be [ ]. | 10 CFR 50.46(b)(5) GDC 35 | Clarify how the chemical effects model was used to evaluate this change. How does the updated chemical effects model affect the model used in the approved AP1000 design (e.g., 60 pounds aluminum)? |

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| 5. | xi , xii | Executive Summary | This section has quantitative information related to ZOI. It's not clear if the distances are from the break or volume-equivalent spherical ZOIs. | 10 CFR 50.46(b)(5) GDC 35 | The report should clarify if the distances are from the break or volume-equivalent spherical ZOIs. The report should clearly define the ZOI as used in the report and compare/contrast with ZOI used in staff approved guidance. |
| 6. | 1.1 | Purpose | 1) A stated purpose of the report is to obtain NRC approval for the following item:<br><br>A threshold for incipient damage from the blowdown jet of [ ] for AP1000 plant in-containment cabling.<br><br>2) How can this be considered incipient damage when [ ]? For example, can it be shown that [<br><br>] | 10 CFR 50.46(b)(5) GDC 35 | The report should provide a basis for including item 1) for NRC approval.<br><br>A basis should be provided for concluding that item 2) [ ] is proprietary. |
| 7. | 3.1 | Jet Impingement Test Background | "The steel used in the RVIS UNS test samples [ ] is thinner than the steel used in the CA31 and the RVIS LNS and water inlet doors are located much farther from a potential pipe break than the UNS."<br><br>This could be confusing as some may interpret that the LNS and water inlet doors do not have the same construction as the UNS. | 10 CFR 50.46(b)(5) GDC 35 | Clarify in the report whether the LNS and water inlet doors have the same construction materials as the UNS. |
| 8. | 3.1 | Jet Impingement Test Background | The report mentions that the NRC assigned a 'penalty' to destruction pressures. The NRC does not consider that a penalty was assigned to destruction pressures. | 10 CFR 50.46(b)(5) GDC 35 | The report should clarify that the onset of destruction was reassessed to account for a two-phase PWR jet. |
| 9. 9 | 3.4.2.2 | Neutron Shield Block Specimens | The report does not identify that testing was not conducted for the CA31shield block construction and does not provide a basis for not testing. | 10 CFR 50.46(b)(5) GDC 35 | The report should identify that the CA31 configuration was not tested and provide a basis for why the CA31 configuration was not tested. |

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| 10. | 3.4.3.2 | Cable Jet Impingement Test Acceptance Criteria | The report states that "Any damage caused by interaction with the test fixture will not be considered in the assessment of damage for determining the cable ZOI." This statement requires justification. | 10 CFR 50.46(b)(5) GDC 35 | The report should provide a basis that this type of interaction cannot occur in the plant if not considered in testing. |
| 11. | 3.4.3.4 | Cable Jet Impingement Test Results | Table 3-6 terminology for "front" and "rear" is not defined. | 10 CFR 50.46(b)(5) GDC 35 | The report should define "Front" and "Rear" terms used in Table 3-6. |
| 12. | 3.4.4.3 | Neutron Shield Block Jet Impingement Test Conclusions | The report states the following:<br><br>Based on jet impingement test results the [ ] design of the neutron shielding is a suitable equivalent to MRI.<br><br>The report does not provide a clear basis for concluding that NMI is a suitable equivalent. | 10 CFR 50.46(b)(5) GDC 35 | The report should provide a basis for this conclusion with appropriate modifiers. For example, It's only suitable at certain locations that have been shown by test and analysis to not generate debris.<br><br>NMI is not a suitable equivalent for MRI at all MRI locations. |
| 13. | Section 3.4, Page 3-22 | Comparison of AP1000 Licensing basis with AP1000 Facility Data | The report, at the top of page 3-22, states the following:<br><br>The comparison of the AP1000 plant licensing basis large break LOCA and the API000 plant cable jet impingement test program shows that the AP1000 plant cable jet impingement tests are conservative for the AP1000 plant.<br><br>Is there a similar conclusion for the shield blocks? | 10 CFR 50.46(b)(5) GDC 35 | The report should Include a discussion or assessment of the appropriateness of shield block testing. |
| 14. | 3.4.4.4 and page 3-40 | Considerations Resulting from Confined Jet Behavior | The last paragraph on page 3-40 uses the phrase "gap between." It's not clear what gap is being described. | 10 CFR 50.46(b)(5) GDC 35 | The report should clarify the discussion regarding "gap" description. |
| 15. | 3.4.4.4 and page 3-45 | Considerations Resulting from Confined Jet Behavior | Table 3-10 is confusing. Psia is listed under column labeled SI units and bar is listed under column labeled as US units. | 10 CFR 50.46(b)(5) GDC 35 | The report should clarify units. |
| 16. | Figure 5-3, 5-4 etc. | Depictions of break ZOI | Figures contain unlabeled structures, components, etc.<br><br>Figures/cutaways only show one perspective. Additional cutaways may provide a more complete picture of the ZOI in the confined space of the reactor cavity. | 10 CFR 50.46(b)(5) GDC 35 | The report should include labels for structures, components, etc., shown in the cutaway. From the figures It appears that the shielding is in direct contact with the RV.<br><br>The report should contain additional cutaways if they provide a more complete picture of the ZOI in the confined space of the reactor cavity. |

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| 17. | 4.4.1 | Analysis Overview | The report discusses five break scenarios that were analyzed. The report does not discuss if the break selection is consistent with staff guidance provided in the staff SER on NEI 04-07. | 10 CFR 50.46(b)(5) GDC 35 | The report should discuss how the break selection approach is consistent with staff guidance. If not consistent with staff guidance, then justification for the selected approach is needed. |
| 18. | 7 | Conclusions | The report states that the methodology is applicable to:<br><br>Demonstration of AP1000 plant RV cavity NMI suitable equivalency.<br><br>It appears that NMI could be located within the RV cavity and be within the ZOI, and therefore not suitable<br><br>Therefore, this statement appears to be too broad. | 10 CFR 50.46(b)(5) GDC 35 | The report should state (for example) that a neutron shield block is a suitable equivalent to MRI only when the shield block is situated in the RV cavity region and outside a material specific ZOI. |
| 19. | Appendix A | AP1000 DCD Revision 19 Markups | The DCD markup states:<br><br>The non-metallic insulation…has been determined to be a suitable equivalent (Reference 5).<br><br>The suitable equivalence of the neutron shield block is dependent upon being outside a ZOI.<br><br>Therefore, this description appears to be too broad. | 10 CFR 50.46(b)(5) GDC 35 | The AP1000 DCD markup should list the appropriate restrictions, documented in Reference 5, that determine when the use of the neutron shield block can be considered as a suitable equivalent insulation to MRI. |
| 20. | Appendix A | AP1000 DCD Revision 19 Markups | The DCD markup states:<br><br>A ZOI radius of 4D will be used…**using a mechanistic pipe break methodology**.<br><br>The report does not appear to provide a discussion or basis for stating the use of a mechanistic pipe break for cables.<br><br>The reports only use of the word "mechanistic" is contained in a discussion on breaks in the RV cavity. | 10 CFR 50.46(b)(5) GDC 35 | The basis for a DCD markup should be contained in the report.<br>(The report should clearly describe and explain or provide a basis for all DCD markups.)<br><br>The report should compare/contrast the approach it takes relative to the guidance. Specifically, the report should justify any deviations from guidance. |
| 21. | Appendix A | AP1000 DCD Revision 19 Markups | The DCD markup states:<br><br>A **ZOI radius** of…<br><br>The report should clearly support the DCD markup with respect to ZOI radius.<br><br>See Gap # 5 above. | 10 CFR 50.46(b)(5) GDC 35 | The report should clearly define the ZOI as used in the report and compare/contrast with the ZOI used in staff approved guidance and elsewhere in the AP1000 DCD. |

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| 22. | 3.4.4.4 | Considerations Resulting from Confined Jet Behavior | The report states the [ ] does not yield mechanistic results. While the justification provided with respect to [ ], the [ ] is still widely used for similar applications. In addition, the justification stating that the choice of break is non-mechanistic should have no bearing on the choice of model used given the break is being analyzed. | 10 CFR 50.46(b)(5) GDC 35 | If the report continues to use subcompartment analysis, [ ] should be presented in conjunction with [ ] to provide the staff with additional data to draw conclusions regarding the subcompartment pressure. |
| 23. | 3.4.4.4 | Considerations Resulting from Confined Jet Behavior | The report compares analytical pressures calculated in GOTHIC for the AP1000 plant geometry to test data from the [ ] in a different geometry.<br><br>To justify this, the report compares the [ ] with the rake data from the test facility. | 10 CFR 50.46(b)(5) GDC 35 | The report should compare [ ] to an analytical model matching the [ ] if the report intends to use the data to validate the subcompartment analysis. |