

AW-15-4228
July 10, 2015

ENCLOSURE 3 for AW-15-4228

Technical Exchange Meeting Related to WCAP-17938 Acceptance Review Gaps
APP-GW-GLY-067 Rev. 0

(Non-Proprietary)



Technical Exchange Meeting Related to WCAP-17938 Acceptance Review Gaps

Westinghouse Electric Company

June 18, 2015



Closed Portion of Meeting



Overview

- Acceptance Review Gaps
 - AP1000 Testing Approach to Confined Jet Behavior
 - AP1000 Analysis Approach to Confined Jet Behavior
- Discussion of “Additional” Gaps
- Schedule



Four Acceptance Review Issues

- Acceptance review questions are all related to confined jet behavior and the methods used to address it in WCAP-17938, Rev. 0 (Section 3.4.4.4)
- Two parallel paths are currently being pursued to reach a resolution
 - Expanding the jet impingement test program to include a test in the jet core region to characterize the maximum damage the NMI blocks could see in the RV cavity
 - Analytical modeling using CFD and GOTHIC to show that jet expands in the RV cavity in such a way that the test program from Summer 2014 subjected the NMI blocks to bounding conditions



AP1000 Testing Approach to Confined Jet Behavior



Overview of NMI Suitable Equivalency Test Program – June 2014

- Jet impingement testing
 - Neutron shielding blocks subjected to jet impingement from a conservative nozzle break in the Reactor Vessel Nozzle gallery
 - All intervening structures removed from consideration for testing
 - The test evaluated the encapsulation’s ability to maintain its integrity
- The most limiting test occurred with the test specimen placed at []^{a,c} from the nozzle []^{a,c}



Jet Impingement Test Conclusions

- []^{a,c} Configuration []^{a,c}
 - No seam separation occurred
 - No loss of material
- The []^{a,c} design maintained integrity for jet impingement at distances of []^{a,c} and greater
- The []^{a,c} in combination with robust intervening structures provides high assurance that no debris will be generated
- The test at []^{a,c} does not specifically address how the block behaves if the jet does not freely expand



Overview of NMI Suitable Equivalency Test Program – June 2015

- Perform jet impingement testing inside the jet core region
 - Test will be performed inside the jet core as determined by NUREG 2913 (“Two-Phase Jet Loads”)
 - Possibility of testing the block with an intervening structure; most limiting intervening structure is the ^{a,c}
- If jet does not freely expand, any postulated LOCA jet that would impact the NMI in the plant at ^{a,c} would be less destructive than the jet core region



Upper Neutron Shield as Installed at Sanmen Unit 1

- Insulation is protect by robust intervening structures

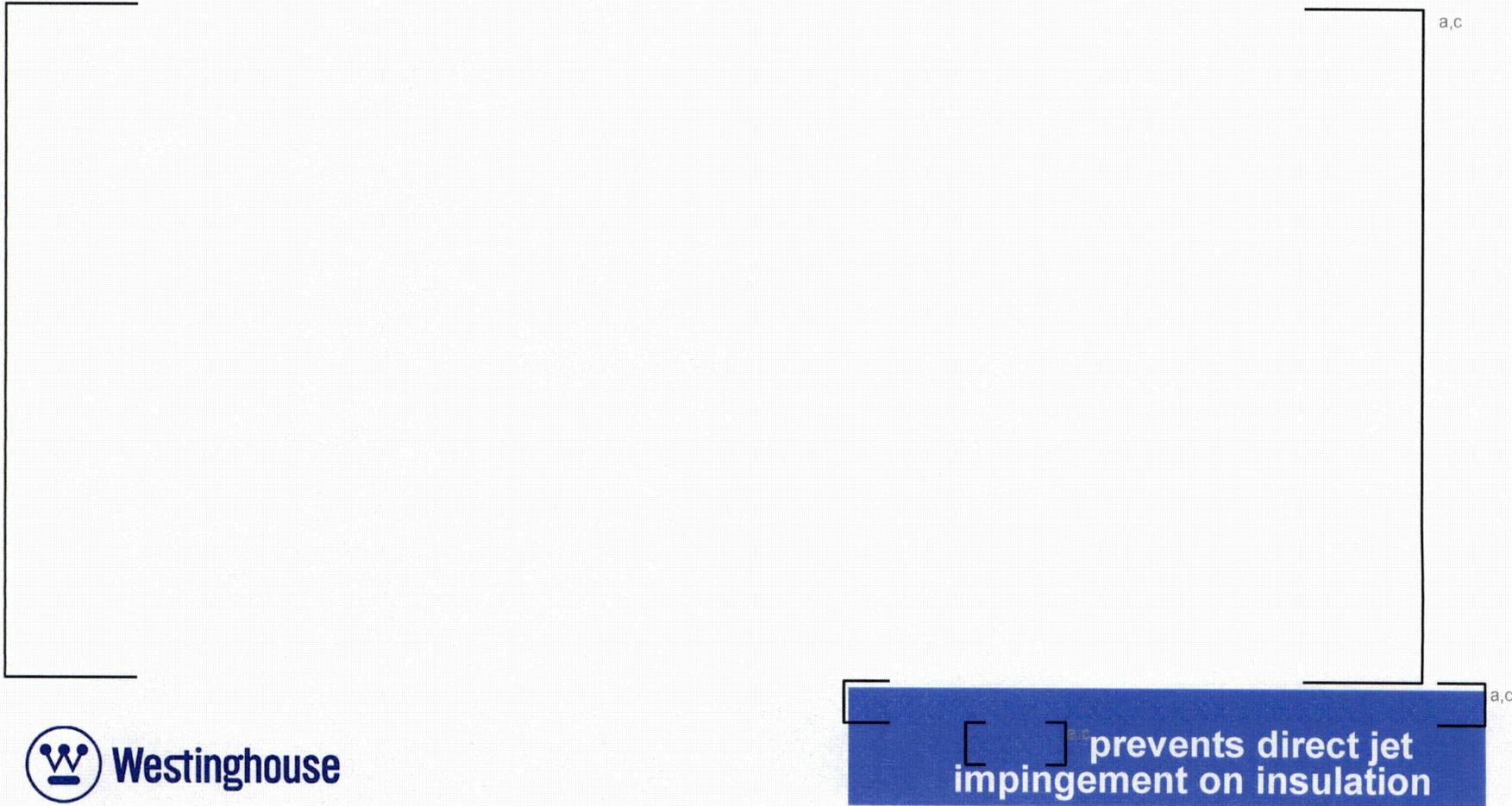
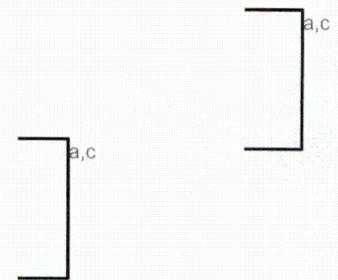
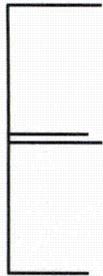


Plate Configuration

- Prototypic of plate configuration in plant



Potential Modifications - Illustrations



a,c



Mitigation Plan for Unacceptable Test Results

- Testing the NMI blocks in the jet core is conservative when compared to plant configuration
- Failure of the blocks characterized by opening of seams and/or loss of material from this test program is not indicative of failure of the blocks in the plant
- This path is being pursued as the most time efficient path to address confined jet behavior – additional strategies will be employed if testing in the jet core leads to unacceptable results



AP1000 Analytical Approach to Confined Jet Behavior



Agenda

- Overview of WCAP-17938 Section 3.4.4.4 contents and intent
- Discussion of GOTHIC approach
- Discussion of CFD approach
- Discussion of challenges and how they will be addressed
- Assimilation of methods into overall analysis approach



WCAP-17938 Section 3.4.4.4 Overview

- Section added to “quantify” the magnitude of confinement as a result of a sub-compartment pressurization analysis.
- Results demonstrate that [redacted] [redacted] a,c and that the magnitude of confinement was not as severe as initially perceived [redacted] a,c

- [redacted] [redacted] a,c

Confined jet behavior does not have a significant impact on the testing conclusions or the bounding nature of the AP1000 approach.



GOTHIC

- GOTHIC approach
 - GOTHIC contains flexibility in nodalization utilizing a CV approach and allows for user-specified sub-nodalization.
 - GOTHIC currently utilized for operating plants to predict dynamic loads on walls and other SSCs from pipe breaks (ML14239A370)
 - GOTHIC benchmarked to Marviken containment as part of International Standard Problem 17 to demonstrate GOTHIC could accomplish a prototypic blowdown of a LWR RCS.
 - Jet impingement pressure is the static pressure plus the dynamic pressure $P_s = P_0 + \frac{1}{2}\rho V^2$ GOTHIC cell velocities and thermodynamic properties can be used to characterize 3D geometries.

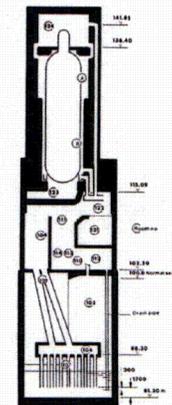
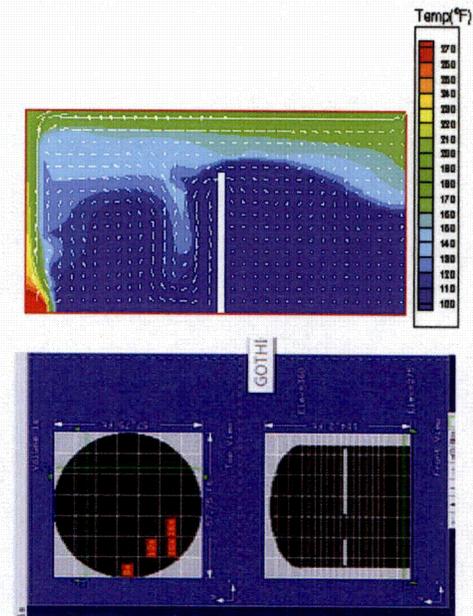


FIGURE 17-1. Marviken Containment.

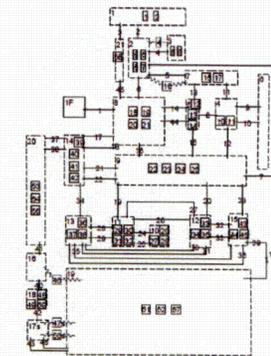
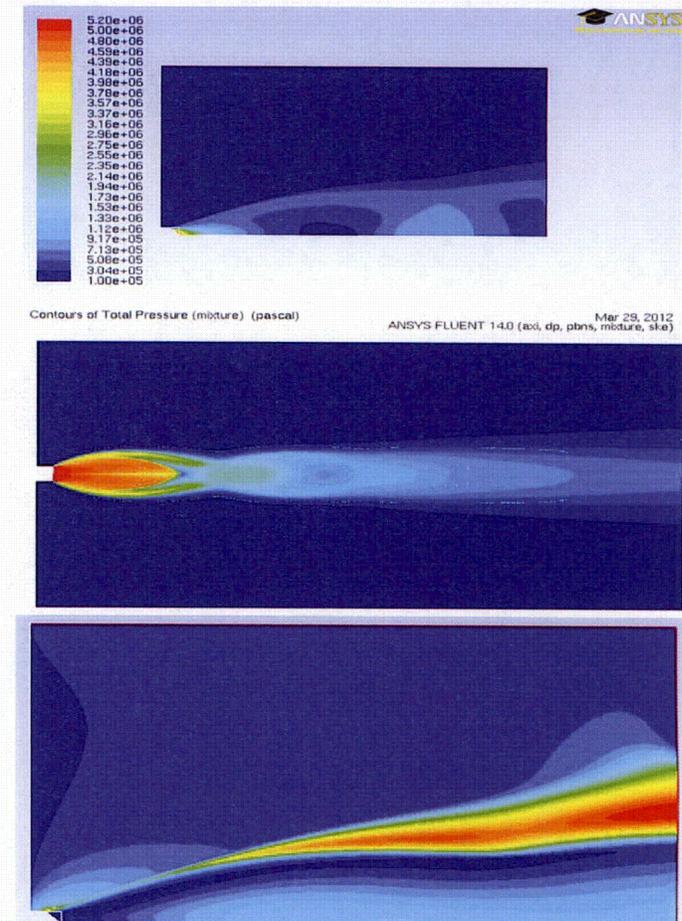


FIGURE 17-10. GOTHIC Model: Marviken Test 17.

CFD

- Represents approximation to closed form solution of Navier-Stokes equation for Turbulent Flows (RANS solution technique).
- Utilize current state of the art Eulerian phase change models (ML12145A438) for two phase critical flow.
- Choking condition characterized by $Ma=1$ flows.
- Turbulent Kinetic energy dissipation due to jet boundary layer mixing resulting in jet expansion rate.



Validation



a,c



Conclusion

Results of analysis effort will demonstrate current testing bounds the effects of confined jet behavior.



Discussion of “Additional” Gaps

Additional Gaps

GAP #	Regulatory GAP	Information that should be included in TR	Expected Resolution
1	<p>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.</p> <p>Licensing basis (6.3.2.2.7.1 of DCD) states that a LOCA in the AP1000 design does not generate fibrous debris</p>	<p>Provide a discussion in the report on whether cables are located within the ZOI and if they are, explain how these cables are evaluated.</p> <p>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.</p>	<p>Within Chapter 4 of WCAP-17938, a brief description will be added related to cables that are located within the ZOI. This section will reference the design document []^{a,c} that provides justification for why these cables do not contribute to debris.</p>
2	<p>Submergence testing was designed with eight test specimens to address the test objectives. Results are discussed for only one specimen. []^{a,c} is described as one of the primary releases, but there is no information about how it was evaluated.</p>	<p>Provide a summary of the whole test program and how it fits into the conclusions and the approvals requested in the report.</p>	<p>Section 3.5 of WCAP-17938 will be expanded to include a comprehensive and integrated submergence test results. Included in the discussion will be how the test results were integrated into the chemical effects analysis and why the results of the submergence testing are acceptable.</p>



Additional Gaps

GAP #	Regulatory GAP	Information that should be included in TR	Expected Resolution
3	<p>There is a requirement that suitable equivalent insulation not generate chemical effects. The submergence testing indicated [redacted] ^{a,c}. This leaves a gap between the test results and the conclusion that this is a suitable equivalent.</p>	<p>Somewhere in the report provide a direct and complete explanation of why the material being proposed in the WCAP does not generate chemical effects.</p>	<p>See Resolution to 2.</p>
4	<p>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 [redacted] ^{a,c}. [redacted] ^{a,c}</p>	<p>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)?</p>	<p>The chemical precipitate amount reported in WCAP-17938 reflects the updated chemical effects analysis calculation, which incorporated several design changes. One change resulted in a new aluminum limit of 40 pounds, which is conservative with respect to the current inventory. The calculation utilized the limit (not the inventory amount) and a [redacted] ^{a,c} [redacted] ^{a,c} which is also conservative with respect to the inventory.</p>
5	<p>This section has quantitative information related to ZOI. It's not clear if the distances are from the break or volume-equivalent spherical ZOIs.</p>	<p>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.</p>	<p>A detailed explanation of ZOI determination contrasted to that contained in the approved guidance will be provided in Section 3.4. The description will clarify that the ZOI is developed based on empirical test data with a prototypic jet, rather than developed with a model that uses an air jet.</p>



Additional Gaps

GAP #	Regulatory GAP	Information that should be included in TR	Expected Resolution
6	<p>1) A stated purpose of the report is to obtain NRC approval for the following items:</p> <p>A threshold for incipient damage from the blowdown jet of [] for AP1000 plant in-containment cabling.</p> <p>2) How can this be considered incipient damage when [] For example, can it be shown that []</p>	<p>The report should provide a basis for including 1) for NRC approval.</p> <p>A basis should be provided for concluding that [seam welded] is proprietary.</p>	<p>Discussion of the cable diameter to jacket thickness ratio will added to 3.4, as justification for why []</p> <p>[]</p> <p>[]</p>
7	<p>"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."</p> <p>This could be confusing as some may interpret that the LNS and water inlet doors do not have the same construction as the UNS.</p>	<p>Clarify in the report whether the LNS and water inlet doors have the same construction materials as the UNS.</p>	<p>Wording clarification will be added in sections 2.2 and 3.1 of WCAP-17938.</p>
8	<p>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.</p>	<p>The report should clarify that the onset of destruction was reassessed to account for a two-phase PWR jet.</p>	<p>Section 3.1 of WCAP-17938 will be re-worded to clarify that the onset of destruction was reassessed to account for a two-phase PWR jet.</p>



Additional Gaps

GAP #	Regulatory GAP	Information that should be included in TR	Expected Resolution
9	The report does not identify that testing was not conducted for the CA31 shield block construction and does not provide a basis for not testing.	The report should identify that the CA31 configuration was not tested and provide a basis for why the CA31 configuration was not tested.	Justification will be added to Section 3.4 explaining that the test configuration is conservative with respect to the CA31 location.
10	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	The report should provide a basis that this type of interaction cannot occur in the plant if not considered in testing.	Information will be added within Section 3.4 of WCAP-17938, providing explanation of the [] that occurred due to the test fixture, and why it is not expected to occur in the plant.
11	Table 3-6 terminology for "front" and "rear" is not defined	The report should define "Front" and "Rear" terms used in Table 3-6.	These terms will be better defined within Section 3.4.3.4 of WCAP-17938.
12	<p>The report states the following:</p> <p>Based on jet impingement test results the [] design of the neutron shielding is a suitable equivalent to MRI.</p> <p>The report does not provide a clear basis for concluding that NMI is a suitable equivalent</p>	<p>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.</p> <p>NMI is not a suitable equivalent for MRI at all MRI locations.</p>	Section 3.4 of WCAP-17938 will clarify the locations where NMI applications qualify as a suitable equivalent.
13	<p>The report, at the top of page 3-22, states the following:</p> <p>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.</p> <p>Is there a similar conclusion for the shield blocks</p>	The report should include a discussion or assessment of the appropriateness of shield block testing.	This statement in Section 3.4 will be extended to the NMI jet testing.

Additional Gaps

GAP #	Regulatory GAP	Information that should be included in TR	Expected Resolution
14	The last paragraph on page 3-40 uses the phrase "gap between." It's not clear what gap is being described.	The report should clarify the discussion regarding "gap" description.	The "gap" description will be clarified in Section 3.4.4.4 of WCAP-17938.
15	Table 3-10 is confusing. Psia is listed under column labeled SI units and bar is listed under column labeled as US units.	The report should clarify units.	Table 3-10 will be separated to add clarity.
16	<p>Figures contain unlabeled structures, components, etc.</p> <p>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.</p>	<p>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.</p> <p>The report should contain additional cutaways if they provide a more complete picture of the ZOI in the confined space of the reactor cavity.</p>	Additional cutaway views will be provided with labels to clarify orientation of NMI.
17	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.	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	Further discussion on break selection will be added to Chapter 4. This will include explanation that moment arms were calculated and reviewed to determine the biggest break displacements, which bounded other postulated breaks.



Additional Gaps

GAP #	Regulatory GAP	Information that should be included in TR	Expected Resolution
18	<p>The report states that the methodology is applicable to:</p> <p>Demonstration of AP1000 plant RV cavity NMI suitable equivalency.</p> <p>It appears that NMI could be located within the RV cavity and be within the ZOI, and therefore not suitable</p> <p>Therefore, this statement appears to be too broad.</p>	<p>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.</p>	<p>The conclusions section will be clarified to state that NMI is a suitable equivalent for the locations that have been justified by the testing and analysis discussed within the remainder of the WCAP.</p>
19	<p>The DCD markup states:</p> <p>The non-metallic insulation...has been determined to be a suitable equivalent (Reference 5).</p> <p>The suitable equivalence of the neutron shield block is dependent upon being outside a ZOI.</p> <p>Therefore, this description appears to be too broad.</p>	<p>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</p>	<p>More information will be added to the DCD markup for the NMI locations that are justified by testing and analysis as suitable equivalents.</p>
20	<p>The DCD markup states:</p> <p>A ZOI radius of 4D will be used...using a mechanistic pipe break methodology.</p> <p>The report does not appear to provide a discussion or basis for stating the use of a mechanistic pipe break for cables.</p> <p>The reports only use of the word "mechanistic" is contained in a discussion on breaks in the RV cavity.</p>	<p>The basis for a DCD markup should be contained in the report. (The report should clearly describe and explain or provide a basis for all DCD markups.)</p> <p>The report should compare/contrast the approach it takes relative to the guidance. Specifically, the report should justify any deviations from guidance.</p>	<p>Terminology will be made consistent between the DCD markup and other portions of WCAP-17938. The verbiage added will clarify how the ZOI used for cables is different than other ZOI's used in the AP1000 DCD. The WCAP will also be modified to indicate where alternate methodology from NEI-04-07 was used.</p>

Additional Gaps

GAP #	Regulatory GAP	Information that should be included in TR	Expected Resolution
21	<p>The DCD markup states:</p> <p>A ZOI radius of...</p> <p>The report should clearly support the DCD markup with respect to ZOI radius.</p> <p>See Gap # 5 above.</p>	<p>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.</p>	<p>The DCD markup will clarify that the basis for determining the ZOI resides within the WCAP. The WCAP will also be modified to indicate where alternate methodology from NEI-04-07 was used.</p>
22	<p>The report states the []^{a,c} does not yield mechanistic results. While the justification^{a,c} provided with respect to []^{a,c} the []^{a,c} 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.</p>	<p>If the report continues to use subcompartment analysis,^{a,c} []^{a,c} should be presented in conjunction with []^{a,c} to provide the staff with additional data to draw conclusions regarding the subcompartment pressure</p>	<p>The approaches used to address the Acceptance Gaps will also address this comment. The WCAP will be revised as necessary to reflect the new justification.</p>
23	<p>The report compares analytical pressures calculated in GOTHIC for the AP1000 plant geometry to test data from the []^{a,c} in a different geometry.</p> <p>To justify this, the report compares the []^{a,c} with the rake data from the test facility.</p>	<p>The report should compare []^{a,c} to an analytical model matching the []^{a,c} if the report intends to use the data to validate the subcompartment analysis.</p>	<p>The approaches used to address the Acceptance Gaps will also address this comment. The WCAP will be revised as necessary to reflect the new justification</p>

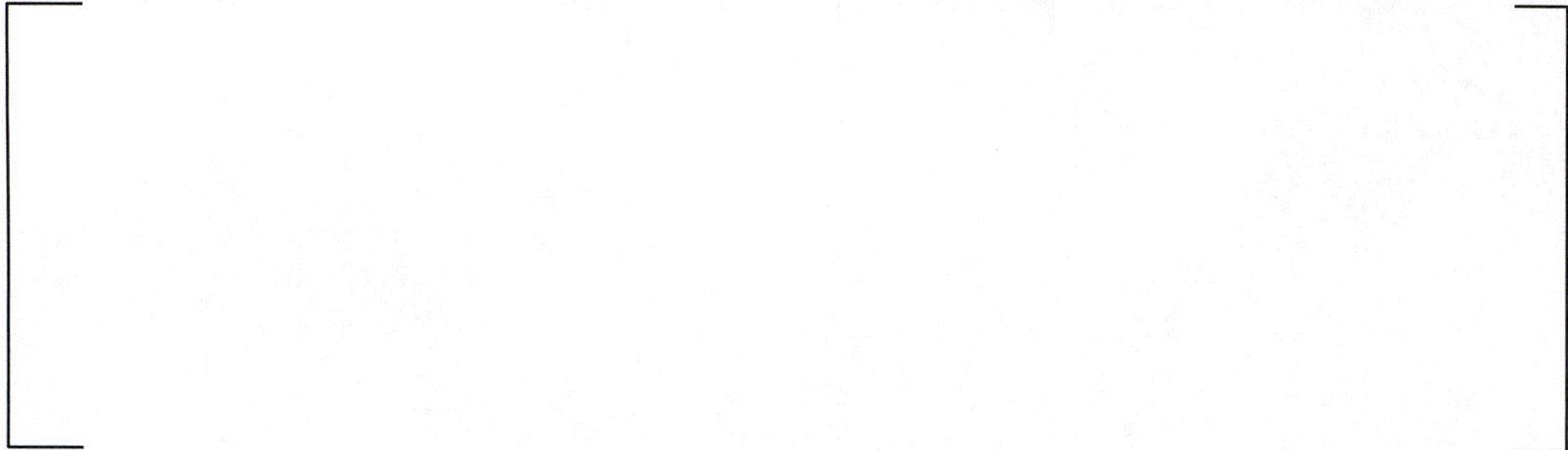


Schedule



Key Steps and Preliminary Schedule

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Questions

