Request for Additional Information 1
Application Title: Westinghouse SMR Pre-Application Activities
Operating Company: Westinghouse Electric Company
Docket No. PROJ 0797
Review Section: W-SMR Test Plan and Scaling

QUESTIONS

W SMR Test Plan and Scaling-1

Containment phenomenon such as [ ]^{a,c} are highly dependent on the containment design and layout of the internal structures. The condensation on the containment shell and on the passive heat sinks in the presence of non-condensable gases involves multi-dimensional phenomena. The Westinghouse Small Modular Reactor (W-SMR) containment is noticeably different in its size, construction and the containment internals as compared to other PWR containments including AP600/AP1000. In addition, thermal-hydraulically, the containment is tightly coupled to the Reactor Coolant System (RCS), again unlike other PWRs. Based on the responses to RAI-TR-SBLOCA-PIRT-04 and RAI-TR-SBLOCA-PIRT-30, the containment pressure during design basis events can vary from [ ]^{a,c} in contrast to the design pressure for AP1000 which is approximately 0.5 MPa. The conditions on the outside of the containment shell in the W-SMR also differ from those for AP1000 (i.e., a pool of water as compared to a falling and evaporating water film). Therefore, the available test data from AP600/AP1000 testing program cannot necessarily be considered to be applicable to W-SMR accident conditions [ ]^{a,c} Note that the knowledge ranking for containment phenomena has also, for similar reasons, been questioned separately in RAI-TR-SBLOCA-PIRT-78. Please provide justifications for [ ]^{a,c} The response should include delineation of specific design differences with AP600/AP1000, and substantiation of the basis for applicability of the specific AP600/AP1000 test data that is considered to be applicable to the W-SMR design.

W SMR Test Plan and Scaling-2

The proposed Integral Effects Test (IET) facility design for the containment appears to be [ ]^{a,c} As discussed in RAI #1 above, multi-dimensional effects are considered to be important in the prediction of containment response behavior under transient and accident conditions in W-SMR. It is questionable whether the containment characterization in the proposed IET facility will adequately capture the conditions that are expected in the prototype. Furthermore, an incorrect representation of the containment response will also affect the RCS behavior for the tested scenario. Please provide the rationale for the proposed containment modeling in the IET facility addressing the aforementioned concerns.

W SMR Test Plan and Scaling-3

SETs have not been proposed for investigating the potential for debris- and chemical precipitate-induced blockage in the reactor core. [ ]^{a,c} Furthermore, if it is intended to use the existing debris related test data for W-SMR, please address the following:

a. [ ]^{a,c}

b. WCAP-17573-P states that the knowledge level for blockage due to chemical precipitates is [ ]^{a,c} Please provide justification for not proposing SETs for W-SMR conditions and explain how the impact of debris- and chemical precipitate-induced blockage in the reactor core will be captured in the evaluation model.

W SMR Test Plan and Scaling-4

SETs have not been proposed for the pressurizer separator plates. The unique design of the pressurizer separator plates and the [ ]^{a,c} The IET design information (Addendum 1 to WCAP-17712-P) states that the plates in the IET will be scaled [ ]^{a,c} Please explain/justify the absence of plans for tests applicable to the W-SMR pressurizer separator plates.

W SMR Test Plan and Scaling-5

SETs have not been proposed to determine the applicability of the existing DNBR correlations to the W-SMR conditions and fuel assembly geometry. The responses to previous RAIs (e.g., RAI-TR-SBLOCA-PIRT-67) indicate that Westinghouse currently intends to use its [ ]^{a,c}

W SMR Test Plan and Scaling-6

Please confirm that all the proposed tests in the IET matrix (Table 7-1 in Addendum 1 to WCAP-17712-P) will be performed to be representative of the behavior expected in the prototype. As an example, for the DVI line break, [ ]^{a,c}

W SMR Test Plan and Scaling-7

Please explain the rationale for not including design basis transients, especially those that are expected to be limiting, in the test matrix for the IETs presented in Table 7-1 of

Addendum 1 to WCAP-17712-P. Examples include recirculation feedwater line break, and the recirculation steam line break [ ]^{a,c}

W SMR Test Plan and Scaling-8

The IET facility test matrix (Table 7-1 in Addendum 1 to WCAP-17712-P) does not include [ ]^{a,c} The matrix for the DVI line break does not appear to address this issue. Please elaborate.

W SMR Test Plan and Scaling-9

The four ADS-2 lines are designed to open in a [ ]^{a,c} will be effectively captured using only a sector of the upper plenum as is currently proposed for the test facility. Please elaborate.

W SMR Test Plan and Scaling-10

One of the reasons for the proposed SETs is to determine [ ]^{a,c}. Please provide information on the criterion (or criteria) for determining the optimal combination of the [ ]^{a,c}, and its basis.

W SMR Test Plan and Scaling-11

There appears to be a typographical error in Section 1.10.1 of Addendum 2 to WCAP-17712-P. The “Wright-Reyes paper (Reference 24)” is referred to in that section. The reference number, based on the list in Section 2, should be 25 instead of 24. In addition, the authors in the citation are Wright and Schulz. Please confirm and correct the LTR, if appropriate.

W SMR Test Plan and Scaling-12

Please explain the term [ ]^{a,c} in Section 1.12 of Addendum 2 to WCAP-17712-P. Furthermore, please explain how these will be factored into the test matrix (i.e., what will be the value of other test parameters at the “reserved” conditions?), and the expected results that will be achieved in terms of increasing the knowledge levels of the relevant phenomena.

W SMR Test Plan and Scaling-13

The results shown in Figures 1-7 through 1-14 are used to determine the range of superficial gas and liquid velocities. Please provide information on the scenario from which the cited figures have been obtained. Furthermore, please provide the justification for considering the selected scenario as being representative for determining the ranges.

W SMR Test Plan and Scaling-14

Figures 1-20 and 1-21 cited in Section A.1.2 of Addendum 2 to WCAP-17712-P do not exist. Please confirm and correct the LTR as appropriate.

W SMR Test Plan and Scaling-15

Based on the test matrix in Tables A-3 and A-4 of Addendum 2 to WCAP-17712-P, the ADS-2 tests appear to be planned with [ ]^{a,c} expected in the core and upper plenum during ADS-2 operation.

W SMR Test Plan and Scaling-16

Please address the following questions on the representation of the CMTs (via the balance line) in the ADS-2 test facility (Addendum 2 to WCAP-17712-P):

a. It is unclear from the description of the test and the test matrix how the flow splitting between the CMTs and ADS-2 will be investigated experimentally.

b. Please explain what CMT balance line boundary conditions will be imposed during the tests and how this will be achieved. The test matrix presented in Tables A-3 and A-4 of Addendum 2 to WCAP-17712-P does not include any boundary conditions related to the CMT balance line. Please explain the reason for not including the impact of CMT conditions in the test matrix.

c. The results shown in Figures 1-11 through 1-14 that are used to determine the range of conditions for the CMTs are believed to be based on computer code calculations. For each phase through the CMT balance line [ ]^{a,c} is expected to be influenced by natural circulation through the CMTs and condensation in the PRHR heat exchanger housed in the CMTs. The accuracy of the code predictions will affect the boundary conditions considered for the tests. Please explain whether the code has been benchmarked against any available natural circulation and tube condensation data test data for the prediction of these phenomena.

d. Please explain how the conditions imposed on the CMT balance line will be confirmed to be representative of the actual CMT behavior. Improper or non-representative CMT boundary conditions may skew the experimental results, especially related to flow splitting.

W SMR Test Plan and Scaling-17

Referring to Section A.1.3 of Addendum 2 to WCAP-17712-P, please explain what section of the reactor is considered to be part of the “upper plenum” and what constitutes the “upper head”.

W SMR Test Plan and Scaling-18

The caption for Figure A-7 in Appendix A to Addendum 2 to WCAP-17712-P appears to be incorrect. Please confirm and if appropriate, correct the LTR. Similarly, please check the caption of the section heading for references.

W SMR Test Plan and Scaling-19

The [ ]^{a,c} have not been used.

a. Please confirm this understanding.

b. If the understanding is correct, please explain how the [ ]^{a,c} in Table A-3 were selected based on the [ ]^{a,c}.

c. Please compare the [ ]^{a,c} selected in Table A-3 of Addendum 2 to WCAP-17712-P for the test matrix against the values at which [ ]^{a,c} are expected to occur

W SMR Test Plan and Scaling-20

According to Section A.1.3 of Addendum 2 to WCAP-17712-P, the [ ]^{a,c} Please clarify. If the [ ]^{a,c} is selected as the boundary condition, please clarify the method to determine the flow through the spargers.

W SMR Test Plan and Scaling-21

Table A-6 of Addendum 2 to WCAP-17712-P states that sensitivities to [ ]^{a,c}. Previous discussions in Appendix A to Addendum 2 to WCAP-17712-P lead one to believe that the [ ]^{a,c}. Please clarify.

W SMR Test Plan and Scaling-22

Table A-6 of Addendum 2 to WCAP-17712-P provides qualitative information about the proposed sensitivities. Please confirm that it is Westinghouse's intention to include in the Addendum 2 to WCAP-17712-P, when available, a detailed discussion, including justification, of the final sensitivity cases selected and a full factorial test matrix, similar to the one in Table A-4, for the sensitivity cases.

W SMR Test Plan and Scaling-23

Table ES-4 of WCAP-17573-P identifies the [ ]^{a,c} to separate effects testing.

a. In Addendum 1 to WCAP-17712-P, there is no equivalent indication of what phenomena will be evaluated and if all [ ]^{a,c} assigned to IETs will be assessed by tests listed in the matrix established for the IETs. Please propose a revision to the Addendum 1 to WCAP-17712-P introduction that indicates the phenomena to be evaluated.

b. The test matrices and test descriptions in both Addenda 1 and 2 of WCAP-17712-P do not indicate which tests in each matrix will be used to assess the individual phenomena assigned to IETs and SETs. Please propose a revision to the test matrices in Addenda 1 and 2 of WCAP-17712-P that relates the planned test to the specific phenomenon.

W SMR Test Plan and Scaling-24

Table ES-1 of WCAP-17712-P lists [ ]^{a,c}. The same table also states that additional details about this phenomenon that can be studied using the SETs. Table 1-1 of Addendum 2 to WCAP-17712-P does not include this phenomenon and there is no discussion of how the SET plan and test matrix will provide information on this phenomenon. Please explain.

W SMR Test Plan and Scaling-25

Since the SET section described in Addendum 2 to WCAP-17712-P is [ ]^{a,c} may not be well reproduced. When the CMT balance line is in operation, the entrainment and counter current flow process may occur in radial location which is outside of the [ ]^{a,c}

W SMR Test Plan and Scaling-26

The SET facility design pressure is [ ]^{a,c} Does the pressure operating range of the test facility cover the splitting of ADS-2 flow and CMT balance line flow in the early stage of ADS-2 operation?

W SMR Test Plan and Scaling-27

According to the SET plan described in Addendum 2 to WCAP-17712-P, the working fluid is an [ ]^{a,c}. The entrainment and countercurrent flow limiting processes are related to surface tension and interfacial drag. Please justify the applicable operating range of the correlations in lieu of fluid properties and test operating conditions.

W SMR Test Plan and Scaling-28

In Section 1.12.1 of Addendum 2 to WCAP-17712-P, please show the superficial liquid velocity for the ADS-2 line.

W SMR Test Plan and Scaling-29

In Section 1.13 TEST PROCEDURE of Addendum 2 to WCAP-17712-P, the [ ]^{a,c} may result in distortion that is difficult to quantify. Please justify this approach.

W SMR Test Plan and Scaling-30

In Section A.1.2 Entrainment Scaling of Addendum 2 to WCAP-17712-P, please explain why the test facility [ ]^{a,c} separately in order to measure all three regimes?

W SMR Test Plan and Scaling-31

In Table A-4 of Addendum 2 to WCAP-17712-P, please explain the purpose of varying [ ]^{a,c}.

W SMR Test Plan and Scaling-32

Appendix A-F (SPES-4 Scaling Basis) of Addendum 1 to WCAP-17712-P is incomplete and several errors were identified in the document. Some important components do not have scaling information. In addition, the report does not address the scaling of some important phase-specific local phenomena. The missing information and errors are identified with RAIs #33 through #58 below. The scaling methodology proposed in earlier Westinghouse presentation slides was [ ]^{a,c}. Please provide a complete top-

down and bottom-up scaling analysis justifying the similarity between the prototype and the scaled model.

W SMR Test Plan and Scaling-33

The quality of Addendum 1 to WCAP-17712-P and the accuracy of calculations documented in this addendum need to be improved. Please address the following issues:

a. The reviewer identified use of different values for the same scaling ratio in the document, [ ]^{a,c}. This inconsistency results in design inaccuracy. Please use consistent values for scaling ratios.

b. Please include complete information for both SPES-4 and W-SMR for comparisons. An example for missing information is the downcomer, which has design value table but no W-SMR values.

c. Different nomenclatures are used for scaling factor, e.g. F and SF. Please use consistent nomenclature.

d. Please correct the unit of the Outer Containment Pool (OCP) water level on page 67 of Addendum 1 to WCAP-17712-P.

e. Please show the prototype and model design values for each component in one table for side-by-side comparison.

W SMR Test Plan and Scaling-34

Please address the scaling of stored energy in the reactor vessel components, such as the core. For a fast transient, the fuel stored energy plays an important role.

W SMR Test Plan and Scaling-35

The single phase and two-phase loop flow resistance in the RPV loop and, in particular, in the core region and SG tubes were not considered. Please address this finding.

W SMR Test Plan and Scaling-36

The [ ]^{a,c} used in Addendum 1 to WCAP-17712-P lacks [ ]^{a,c} Please describe the compensating actions planned to address these distortions.

W SMR Test Plan and Scaling-37

SPES-4 was modified from SPES-2 which was developed for AP-600 testing. Please justify the modifications made to SPES-2, [ ]^{a,c}, and sufficiency for W-SMR testing based on the design differences.

W SMR Test Plan and Scaling-38

Please include core bypass scaling In Table A-7 and A-8 of Addendum 1 to WCAP-17712-P.

W SMR Test Plan and Scaling-39

In section A.2.7 of Addendum 1 to WCAP-17712-P, the [ ]^{a,c} is not well presented. The scaling calculation is not shown. The [ ]^{a,c} do not appear to be in agreement with the flow paths shown in Figures A13, A14, and A16. On page A21, please provide the description for parameters used in the equation.

W SMR Test Plan and Scaling-40

In section A.2.8 of Addendum 1 to WCAP-17712-P please verify and correct as necessary the [ ]^{a,c} scaling equation set and numbers. Please check and correct inconsistencies, such as: the constant value of [ ]^{a,c} in the first equation does not match the numbers shown in Table A-20 for L1, L2 and L3 pipe ID. Also, a scaling factor should appear in V5 and V6 terms.

W SMR Test Plan and Scaling-41

In section A.2.9 of Addendum 1 to WCAP-17712-P, the RCP scaling is not shown. Will the RCP scaling include the portion of the flow path from SG primary tube outlet to RCP input? As mentioned on Page 31, please also provide the pump curve and the design connecting the downcomer and the SGPSS.

W SMR Test Plan and Scaling-42

The PRHR heat transfer area distortion (difference between ideal and actual) shown on Table A-23 and discussed on Page A-34 of Addendum 1 to WCAP-17712-P was evaluated as [ ]^{a,c}. Please elaborate on ways to compensate for this distortion in the design. Also, since there are only [ ]^{a,c} (as shown on Figure A-21), the heat transfer flow boundary condition outside of the tube is changed from the prototype. Please address any distortion due to this tube pattern difference.

W SMR Test Plan and Scaling-43

The geometry data in Table A-24 of Addendum 1 to WCAP-17712-P should be for the W-SMR's and not SPES-4. Please verify and correct, as necessary.

W SMR Test Plan and Scaling-44

In Table A-25 of Addendum 1 to WCAP-17712-P, the SPES-4 [ ]^{a,c} were not scaled according to the scaling ratio. Please verify and correct, as necessary.

W SMR Test Plan and Scaling-45

In section A.2.11 of Addendum 1 to WCAP-17712-P, the scaling factor appears to be in the wrong part of the equations. Sign and subscripts are wrong in some places. Please verify and correct the equations, as necessary, and re-verify the SPES-4 geometry data.

W SMR Test Plan and Scaling-46

A constant factor of [ ]^{a,c} is applied to the horizontal length of CMT balance line (and other flow components) to obtain the total flow length in Addendum 1 to WCAP-17712-P. Please justify the use of this factor.

W SMR Test Plan and Scaling-47

In Table A-29 of Addendum 1 to WCAP-17712-P, the pipe ID [ ]^{a,c} does not match the ID derived from the equation [ ]^{a,c}. Please verify and correct, as necessary.

W SMR Test Plan and Scaling-48

In section A.2.13 of Addendum 1 to WCAP-17712-P, the scaling of the Sump Injection Line is incomplete. Please review and correct, as necessary.

W SMR Test Plan and Scaling-49

In Table A-35 of Addendum 1 to WCAP-17712-P, the pipe ID [ ]^{a,c} does not match the ID derived from the equation [ ]^{a,c}. Please verify and correct, as necessary.

W SMR Test Plan and Scaling-50

The scaling of the [ ]^{a,c} is considered in detail in Addendum 1 to WCAP-17712-P but the scaling of the [ ]^{a,c} is not provided. Please provide the missing scaling information including any minor losses.

W SMR Test Plan and Scaling-51

According to the Westinghouse SBLOCA analysis for the W-SMR, the SG isolation valve will close around [ ]^{a,c}. The heat transfer from the primary to the secondary side plays an important role in determining the primary side energy. The primary side volume and flow area are considered in Addendum 1 to WCAP-17712-P but it is not clear how the heat transfer from primary side to the secondary side is scaled. Please provide details on SG heat transfer scaling and quantify the scaling distortions.

W SMR Test Plan and Scaling-52

The [ ]^{a,c} of the SBLOCA event for the W-SMR. The containment scaling [ ]^{a,c} were not considered either. The analysis also considered the [ ]^{a,c} as heat sinks by adding additional mass in the [ ]^{a,c}. Please include more factors, such as the geometry of the component, in the analysis.

W SMR Test Plan and Scaling-53

On page A-54 of Addendum 1 to WCAP-17712-P, please clarify the symbols of the dome surface area equation.

W SMR Test Plan and Scaling-54

In Table A-47 of Addendum 1 to WCAP-17712-P, please clarify the rows and columns data of the W-SMR flood up volume versus elevation.

W SMR Test Plan and Scaling-55

In section A.2.21 of Addendum 1 to WCAP-17712-P, please provide the CMT secondary side cooling system scaling.

W SMR Test Plan and Scaling-56

In Table C-2 of Addendum 1 to WCAP-17712-P, the W-SMR volume conversion from SI units to English units is not correct. Also, the volume for SPES-4 is not correct. Please review and correct as necessary.

W SMR Test Plan and Scaling-57

In Table D-1 of Addendum 1 to WCAP-17712-P, the reactor coolant flow for SPES-4 is not correct. Please double check and correct value.

W SMR Test Plan and Scaling-58

On page F-1 of Addendum 1 to WCAP-17712-P, please clarify the symbols used in the [ ]^{a,c}

W SMR Test Plan and Scaling-59

Westinghouse has indicated that a separate methodology topical report related to the scaling of the test facilities will be submitted. A brief description of the content of the planned topical report, its relationship to the scaling formulation in the addenda to WCAP-17712-P, and information about the expected submission schedule would be beneficial to the on-going pre-application review by NRC.