August 22, 2001

Mr. Michael M. Corletti
Advanced Plant Safety & Licensing
Westinghouse Electric Company
P.O. Box 355
Pittsburgh, Pennsylvania 15230-0355

SUBJECT: AP1000 PRE-APPLICATION REVIEW - REQUESTS FOR ADDITIONAL INFORMATION

Dear Mr. Corletti:

Further to the agreements reached at the meeting between Westinghouse and NRC staff held at the U.S. Nuclear Regulatory Commission Headquarters offices on June 6, 2001, I can confirm that the NRC staff has concluded the initial acceptance review of your Pre-application submissions on Scaling and Safety Analysis Codes for AP1000. You have already been sent a number of initial Requests for Additional Information (RAIs) relating principally to the use of these Analysis Codes. I am enclosing a further group relating to Scaling issues. Our continued review work in this area is contingent on your responses to these RAIs. We anticipate that part of the ongoing work will require you to provide staff with access to the following documents for review: Code Safety Engineering Standards; code input development notes; and code input manuals. In addition, the staff will require access to your analysis codes to perform an independent verification.

We await your response to the outstanding RAIs and your proposals for access to the above information.

If you have any questions please contact me at 301-415-1102.

Sincerely

/RA/

Alan C Rae, AP1000 Project Manager
New Reactor Licensing Project Office
Office of Nuclear Reactor Regulation.

Project 711

Enclosure: Request for Additional Information

cc w/encl: See next page

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REQUEST FOR ADDITIONAL INFORMATION
SCALING FOR AP1000

P47. The volume of the AP1000 Core Makeup Tank (CMT) is increased to 2500 ft^3 from 2000 ft^3 in the AP600. Not specified however is the diameter for the AP1000 CMT, which is needed to consider the interfacial area for condensation. Please provide the CMT inner diameter, and resistance to flow leaving the CMT. In particular, verify that the ratio of the Richardson and Friction Π groups for the AP1000 CMT remain reasonably close to the ratio of those same groups in the Westinghouse CMT experiments.

In addition, provide evidence that the other CMT scaling groups that are affected by the new geometry and drain rate for the AP1000 CMT including Stanton number Π_{st}, liquid heat source ratio $\Pi_{q,l}$, and heat source ratio Π_q.

P48. The scaling rationale presented in Section 4.1.2.2 (page 4-15) of WCAP-15613 claims that two-phase natural circulation and passive residual heat removal (PRHR) heat transfer are high ranked Phenomena Identification and Ranking Table (PIRT) phenomena for a small break loss-of-coolant accident (LOCA). Table 2.4-2, "PIRT for AP1000 Small Break Accident," however, does not list any highly ranked process for the PRHR, and only "Pool Level" and "Gravity Draining" for the In-containment Refueling Water Storage Tank (IRWST). Clarify where in the PIRT the processes natural circulation and/or PRHR heat transfer are given high rankings.

P49. On page 3-68 of WCAP-14727, Rev. 2, reference is made to Appendix B, Section B.1 which lists calculations for single loop Π groups derived for various periods of a small break LOCA. This information, however, was not included in Appendix B. Appendix B contains only the multi-loop Π group calculations. In order to evaluate the OSU, SPES, and ROSA tests for applicability to the AP1000, please provide these calculations and/or a list of values used in the single-loop Π groups or verify that the information contained in Appendix E is that which applies.

P50. Provide the Automatic Depressurization System Stage 4 (ADS-4) vapor phase flow rate for the 2-inch cold leg break to accompany Figure 3.3.1.4-31of WCAP-15612, and a figure or table providing the water level in the hot legs for this transient. Also provide the core exit vapor flow rate.

P51. Provide the expected ADS-4 vapor phase flow rate for the DEDVI (double-ended direct vessel injection line) break, and the water level in the hot legs for this transient.

P52. Higher vapor generation rates in the core may result in a lower inner vessel mixture level for some transients due to entrainment in the upper plenum. Please provide the axial flow area in the AP1000 upper plenum at an elevation just below the bottom of the hot legs. In addition, specify the net free volume between the top of the heated core and the bottom of the hot legs.

P53. In NUREG/CR-5541 it is reported that there were two important phenomena that were either distorted by, or not present in the three major integral effects test facilities (APEX, SPES, and ROSA). These were "flow inertia," or the ratio of inertia over pump forces during the initial depressurization, and "effect of reactor pressure vessel injection from the pressurizer" during the ADS-4 depressurization phase. Since:

(i) The flow inertia distortion was not considered important to reactor vessel inventory for the AP600. Verify that the flow inertia distortion continue to have no effect for the AP1000, taking into account the differences between the AP1000 and AP600 pump parameters.

(ii) The second distortion, "effect of reactor pressure vessel injection from the pressurizer," was present in all three integral effects test facilities and is due to distortion in the pressurizer surge line flow. The distortion in APEX was considered non-conservative, because of disproportionally low ADS-4 flow. The scaling parameter for "Effect of pressurizer injection" is:

$$\Pi_{V,W_l} = \frac{(W_l)_0}{(W_{ADS4})_0}$$

Which represents the ratio of the vessel liquid inflow and outflow from the CMT and pressurizer and the flow out the ADS-4. Provide flows to determine $(W_l)_0$ and $(W_{ADS4})_0$ for the DEDVI line break for the ADS-4 blowdown period such that $\Pi_{V,Wl}$ can be determined.

P54. The AP1000 PRHR Heat Exchanger is a C-shaped heat exchanger that transfers heat from the primary to the IRWST. Tests at Oregon State University (OSU) in the APEX facility found that the majority of heat transfer occurs in the upper part of the "C", where the tubes are primarily horizontal. In comparison to the AP600 PRHR heat exchanger, the horizontal section are longer in the AP1000. The PRHR tests, however, considered only the performance for vertical tubes. To assess the applicability of the AP1000 PRHR, please provide design information on the PRHR that includes:

(i) the lateral and transverse pitch to diameter ratios for the tube bank,

(ii) the heated lengths of the shortest and longest tubes in the horizontal span.

P55. WCAP-15613 shows that APEX is not appropriately scaled for the Natural Circulation phase. Since the PRHR design has been modified to significantly reduce the flow resistance, the Π groups representing the ratios of inertia to buoyancy and resistance to buoyancy may change considerably. To fully justify the applicability of the SPES tests for this phase, provide numerical values for the Π groups listed in Table 3.2-8 and 3.2-9 of WCAP-14727, Rev. 2 and values for terms used within these Π groups such that they can be calculated for the AP1000.

P56. The scaling groups for the ADS Blowdown phase depend on the core power, which is substantially higher in the AP1000 than AP600. This will reduce the value of the Π group and in some cases such as for Π_{S-4} , the ratio of sensible heat rate to core power, may cause the AP1000 value to fall outside the range supported by APEX and SPES. Provide numerical values for the Π groups listed in Table 3.2-10 of WCAP-14727, Rev. 2 and values for the terms used within these Π groups such that they can be calculated for the AP1000.

P57. For IRWST injection, the Π groups (Π_{S-1}, ...- $\Pi_{S.8}$) identified by Westinghouse in WCAP-14727, Rev. 2 as being important were as listed in table 3.2-11. Since several of the areas, lengths and thermal conditions of the ADS-4 and IRWST have changed, provide revised values for

$$W_0^2, L_{gr}, A_0, \left(\frac{L}{A}\right)_{ML}, and \sum R_{ML}.$$

Also, provide an estimate of the core power and RCS pressure at the start of the ADS-4 phase.

P58. Several of the scaling groups for the Sump Injection phase depend on resistances through the ADS-4 and active systems, and on the core power. Provide numerical values for the Π groups listed in Table 3.2-12 of WCAP-14727, Rev. 2 and values for the terms used within these Π groups such that they can be calculated for the AP1000.

P59. For the one-inch cold leg break, provide figures showing predictions of water levels in the vessel upper head and upper plenum, the accumulators, the CMTs, and the pressurizer. Also, provide a figure showing the core exit flow quality, the steam flow at the core exit, the core inlet flow, the core inlet subcooling and the pressurizer pressure.

P60. Provide the design information that in the following Table, (noting that some of this information is included in information previously supplied by Westinghouse.)

Parameter	Unit	AP1000
Primary RCS volume	ft^3	
*Pressurizer volume	ft^3	
*Pressurizer length	ft	
*Pressurizer area	ft^2	
Pressurizer initial water level	%	
*Pressurizer heater power	kW	
*Pressurizer surge line volume	ft^3	
PRHR to core thermal center difference (middle of PRHR HX to mid-elevation of core)	ft	
PRHR hydraulic resistance	ft^{-4}	
*PRHR inlet temperature	^oF	
*PRHR Outlet temperature	^oF	

Mass of liquid in and above hot legs	lbm	
*Accumulator water volume	ft^3	
*CMT tank volume	ft^3	
CMT tank height	ft	
CMT tank ID	ft^2	
CMT exit form loss (K/A^2)	ft^{-4}	
Lower plenum volume	ft^3	
RPV volume	ft^3	
Elevation difference between the bottom of the CMT and the bottom of the core	ft	
Nominal sum of ADS-1+2+3 flow areas	ft^2	
Nominal sum of ADS-4 flow area	ft^2	
DVI line form loss (K/A^2)	ft^{-4}	
Elevation difference between DVI line and bottom of the core	ft	
Elevation difference between bottom of IRWST and bottom of core	ft	
Total DVI path resistance	ft^{-4}	
Total ADS-4 path resistance	ft^{-4}	
Inertial length (L/A) for DVI line	ft^{-1}	
Inertial length (L/A) for ADS-4	ft^{-1}	
Maximum sump level (determined by curb height)	ft	

Note parameters indicated * already known to NRC.

P61. Section 4 of WCAP-15613 states that “processes, phenomena, components, and interactions found to be less important for AP600 as a result of testing, scaling, and analysis are not scaled for AP1000 so as to focus attention on those phenomena found to be dominant.” However, certain phenomena, which were not identified as high importance in the AP600 but are ranked high importance in the AP1000, are evaluated for scaling. Discuss the criteria used to determine which high importance phenomena in the AP1000 but not in the AP600 are scaled for the AP1000, or otherwise.

P62. Section 4.1.2.1, “Blowdown Phase Scaling,” of WCAP-15613, states that the blowdown phase will not be scaled because the blowdown phase behavior of the AP600 and AP1000 and the sensitivity of the plant behavior to core decay heat is similar to conventional PWR plants and the passive safety systems have virtually no influence on the blowdown phase. Given this:

(i) Without a scaling evaluation of the blowdown phase, how is it assured that the APEX, SPES, and ROSA test facilities depressurize as the AP600 and AP1000 plants?

(ii)What would be the consequence of the differences between the tests and the prototype in the subsequent phases in a SBLOCA?

P63. Section 4.1.2.2 of WCAP-15613 states that quality is a fundamental parameter of importance to be scaled during the two-phase PRHR natural circulation phase as RCS pressure is nearly constant. Also the scaling analysis in WCAP-14727 for AP600 assumed constant pressure during the natural circulation phase. However, as shown in see Figure 4.1-2 of WCAP-15613, during the PRHR natural circulation phase the RCS pressure decreases from almost 1000 psia to 650 psia before the ADS actuation for a 2-in cold leg break. Then:

(i) What is the basis for the assumption of constant RCS pressure in the scaling assessment?

(ii) What is the effect of this assumption on the scaling assessment result?

P64. Section 4.1.2.3.1of WCAP-15613 states that AP600 scaling analyses by Wulff and Reyes found that mass and energy injection into the RCS during the ADS phase from the CMTs and accumulators is small relative to the ADS discharge flow and energy, and therefore, that the boundary of the RCS volume is rigid, and the rate of pressure change is governed by the core steam generated by the decay heat, and the ADS vented steam.
(i) Provide a comparison of the relative magnitudes of ADS steam flow rate, core steam generation rate, CMT drain rate, and accumulator injection rate during the ADS phase (see Figure 4.1-2).

(ii) Is the conclusion valid for all sizes of SBLOCA including DVI line break?

(iii) In the ADS phase, the rate of pressure change equation (Eq. 4-35) does not include the effect of nitrogen gas in the accumulators. Provide justification of neglecting the nitrogen in the pressure change rate.

P65. There appears to be typographic errors in Equations 4-113, 4-114, and 4-115 of WCAP-15613 as they are inconsistent with Equations 4-111 and 4-112.

(i) Either confirm that these equations are correct as published, or make corrections if necessary.

(ii) What are the procedures used to assure the quality of the report?

P66. Explain how Eq. 4-118 is derived from Eq. 4-117 of WCAP-15613.

P67. Section 1.0 of WCAP-15613 states that in the AP600, where scaling analyses of the tests identified that certain phenomena were not well scaled for the AP600 plant, conservatisms were applied to the analysis codes such that their predictions of the plant response were conservative with respect to safety, and proposes that such an approach also be used for the AP1000.

(i) Describe the phenomena which were not well scaled for AP1000.

(ii) Describe how the conservatisms are determined for these phenomena and applied to the analysis codes for the AP1000 analyses.

AP 1000

cc:

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