REQUEST FOR ADDITIONAL INFORMATION 514-4040 REVISION 2

12/17/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

SRP Section: 15.06.05 - Loss of Coolant Accidents Resulting From Spectrum of Postulated Piping Breaks Within the Reactor Coolant Pressure Boundary

Application Section: DCD Chapter 15.6.5. Small Break LOCA

QUESTIONS for Reactor System, Nuclear Performance and Code Review (SRSB)

15.06.05-58

Section 2.2 of MUAP-07025-P categorizes Appendix K Requirement # 4, Initial Stored Energy in Fuel, as Category 2 “Inputs Address this Requirement”. However, Section 7.1.2 of MUAP-07013-P states that an annular pellet-to-clad gap heat transfer model derived from the FINE fuel rod design computer code has been implemented in M-RELAP5. The staff also notes that MUAP-07013-P categorizes Appendix K Requirement # 4 as Category 1 “Code Models”.

Revise or explain the categorization of Appendix K Requirement # 4, Initial Stored Energy in Fuel, in Section 2.2 of MUAP-07025-P.

15.06.05-59

Appendix K Requirement # 27, Reflood Rate, is categorized in MUAP-07025-P as Category 1 “Code Models”. In MUAP-07013-P, however, Appendix K Requirement # 27, Reflood Rate, is categorized as being addressed with code inputs.
Explain the difference in the categorization of Appendix K Requirement # 27, Reflood Rate, as presented in MUAP-07025-P and MUAP-07013-P. Describe any new models implemented in M-RELAP5 that pertain to the reflood rate calculation.

15.06.05-60

MUAP-07025-P Section 2.2, Table 2-1 states that Appendix K Requirement # 29, Refill/Reflood Heat Transfer, is not applicable to SBLOCA. However, during SBLOCA the water level in the core may drop below TAF during the loop seal clearance and boil-off phases of a SBLOCA. PIRT Phenomenon 11 ranks Rewet Heat Transfer as HIGH for the loop seal clearance, boil-off, and recovery phases of a SBLOCA. This statement may require modification based on responses to MUAP-07013-P (R0) RAI responses.

15.06.05-61

Table 2-1 of MUAP-07025-P states that Appendix K Requirement # 16 noding near the ECC water injection points will be appropriate, as described in Section 3 of MUAP-

07025-P. Appendix K requires that the noding at the injection points be chosen to ensure reliable analysis of the thermodynamics during blowdown.

Provide additional explanation of the adequacy of the model noding near the ECC injection points, including the rationale for not performing injection point noding sensitivity studies. The effects of steam leakage from the reactor vessel upper head region into the downcomer should be addressed.

15.06.05-62

PIRT Phenomena 37 Water Holdup in SG Inlet Plenum and 38 Water Hold-up in U-Tube Uphill Side highlight the importance of countercurrent flow limitation (CCFL0) characteristics in the SG tubes, SG inlet plenum, and hot leg piping during loop seal clearance phase of SBLOCA. MUAP-07013-P provides comparisons of M-RELAP5 to UPTF hot leg tests and the Dukler air-water flooding tests and concludes that the M-RELAP-5 model results are acceptable.

Considering the importance of CCFL relative to core cooling during the loop seal clearance phase of SBLOCA, evaluate the variability of PCT with CCFL model coefficients (both for the hot leg and the SG tubes) and justify the values used in the SBLOCA evaluation model. Responses to earlier RAIs may cover this topic.

15.06.05-63

MUAP-07025-P section 4.1.8 states that the accumulator nominal water volume is 2150 ft3 (excluding the ineffective water) whereas FSAR Section 6.3.2.2.2 and FSAR Table 6.3-5 give the accumulator water volume as 2126 ft3 excluding the ineffective volume. Explain the apparent discrepancy in the effective accumulator water volume cited in MUAP-07025-P section 4.1.8 and FSAR Section 6.3. Identify the accumulator water volume utilized in the SBLOCA evaluation model.

15.06.05-64

Section 5.1.1 (1) of MUAP-07025-P states that after about 10 minutes following the 2-inch cold-leg break, the collapsed downcomer level abruptly drops, as also shown in Figure 5.1.1.a-6.

Explain this rapid change in downcomer level.

15.06.05-65

Figure 5.1.1.a-3 of MUAP-07025-P shows the discharge flow rates (liquid and vapor) for 2-inch cold-leg break. During the periods of concurrent liquid and vapor discharge through the break, large oscillations in the calculated flow rates appear.
Explain the oscillations in discharge flow, including code modeling effects and/or physical phenomena. If the oscillations are attributed to code selection changes in the critical flow model, explain in detail.

15.06.05-66

Section 5.1.1 of MUAP-07025-P provides the results of the break location sensitivity study. Provide the following additional information on the results of the 1-ft2 cold-leg bottom break presented in Section 5.1.1:

Explain the relationships among the three collapsed liquid levels shown in Figure 5.1.1.a-16 and the reported core upper region uncovery occurrence at 103 seconds given in Table 5.1.1.a-3 for the 1-ft2 cold leg SBLOCA. Explain the statement contained in Section 5.1.1 (2) that the "…figure also implies that a remarkable core uncovery occurs …".

15.06.05-67

Section 5.1.3 summarizes the results of the steam phase pressurizer break and states that there is a "slight core uncovery of about 4-ft" for the pressurizer steam phase break; however, Table 5.1.3-1 for the pressurizer steam phase break states that core uncovery does not occur.

Explain the apparent discrepancy between the Section 5.1.3 text and associated Table 5.1.3-1.

15.06.05-68

Section 5.2 of MUAP-07025-P provides the break spectrum analysis for the cold-leg break SBLOCA. The break spectrum analysis is performed assuming LOOP concurrent with reactor trip. The sensitivity of the cold-leg SBLOCA to the availability of off-site power (non-LOOP) is provided in Section 5.6.2 for only the limiting loop-seal PCT and boil-off PCT cases, i.e., the 7 ½-inch and 1-ft2 top cold-leg break cases, respectively.

The availability of off-site power affects RCP trip time and ECC equipment response in a manner that could potentially affect PCT. Provide justification for analyzing only the limiting loop-seal and boil-off PCT cold-leg SBLOCA cases with off-site power available.

15.06.05-69

MUAP-07025-P Section 5.4.1 part (2), last paragraph, refers to loop-seal phenomena dominating PCT for the 1-ft2 top cold-leg break. Based on the results shown in the accompanying figures, the PCT appears to occur during the boil-off period, not during loop seal.

Explain the apparent discrepancy in the description and results of PCT occurrence relative to the loop seal or boil-off phase of the transient.

15.06.05-70

The loop noding sensitivity study presented in Section 5.4.2 shows that loop seal clearance is predicted to occur sooner with the finer noding model, resulting in no heatup (PCT).
Provide a comparative description of the loop seal period for both the base case and the sensitivity case, including the times for loop seal clearance and expanded figures of applicable parameters around the time period of loop seal clearance.

Assess the need for additional noding studies in order to establish PCT variability with loop noding.

15.06.05-71

10CFR50 Appendix K, Part II.2 requires that solution convergence be demonstrated by model noding and calculational time step studies. Sections 5.4 and 5.5 of MUAP-07025-P provide single sensitivity studies on noding and time step size specification. Traditionally, at least three points are evaluated to determine sensitivity.

Justify the adequacy of single sensitivity studies to evaluate variability with noding detail and time step size. Confirm that the time step solutions are sufficiently converged.

15.06.05-72

Section 5.5 of MUAP-07025-P provides a time step size sensitivity study for a 7 ½-inch top cold-leg SBLOCA. Figure 5.5.a-5 shows notable difference in the accumulator injection flow oscillations at points beyond 400 seconds into the transient.

Explain the phenomenon and its sensitivity to the specified maximum time step size, and the acceptability of the numerical error implied by these results.

15.06.05-73

Section 5.5 of MUAP-07025-P provides a time step size sensitivity study for a 1-ft2 top cold-leg SBLOCA. Figure 5.5.b-3 shows that the time step sensitivity case does not calculate several of the liquid discharge rate peaks at points beyond 300 seconds into the transient.

Explain the phenomenon and its sensitivity to the specified maximum time step size, and the acceptability of the numerical error implied by these results.

15.06.05-74

Figures 8.2.1-37 and 8.2.1-38 show the measured and predicted rod surface temperatures, respectively. However, it is very difficult to distinguish the temperatures given at several elevations. Please provide figures which show the temperatures clearly.

15.06.05-75

Section 5.5 of MUAP-07025-P provides a time step size sensitivity study for a 1-ft2 top cold-leg SBLOCA. Figure 5.5.b-5 shows that the time step sensitivity case results in lower accumulator injection rates between approximately 175 seconds and 275 seconds into the transient, affecting inventory levels, core uncover, and PCT results.

Assess the variability of the results with time step size and justify the choice of the base case evaluation model maximum time step size.

15.06.05-76

Section 5.6 of MUAP-07025-P provides an off-site power available sensitivity study for a 7 ½-inch top cold-leg SBLOCA and a 1-ft^2 top cold-leg SBLOCA. Tables 5.6.2-1 and 5.6.2-3 show RCP Trip for the non-LOOP cases occurring exactly 18 seconds following ECCS actuation, not 15 seconds as described in FSAR Section 7.3.1.5.1 and depicted in FSAR Figure 7.2-2 sheet 11.

Explain the apparent discrepancy between the SBLOCA analysis assumption and the US APWR design description contained in the FSAR.

15.06.05-77

The PCT values reported in the US APWR DCD FSAR Section 15.6.5 do not exactly agree with the values reported in MUAP-07025-P.

- For the 7½-inch Top Cold-Leg break, MUAP-07025-P Table 5.5.a-2 reports PCT = 775ºF whereas FSAR Section 15.6.5.3.3.2 reports PCT = 774ºF.
- For the 1-ft2 Top Cold-Leg break, MUAP-07025-P Table 5.5.b-2 reports PCT = 1297ºF whereas FSAR Section 15.6.5.3.3.2 reports PCT = 1317ºF.

Explain this discrepancy.

15.06.05-78

MUAP-07025-P Section 5.4.1 part (1) states that the accumulator injection rates for the base case and sensitivity case for the 7 ½ -inch cold-leg top break noding study are perfectly in agreement. The referenced Figure 5.4.1-5, however, does not demonstrate that the results are identical.

Clarify the assessment of accumulator injection rate provided in the text of Section 5.4.1 relative to the results shown in Figure 5.4.1-5.