REQUEST FOR ADDITIONAL INFORMATION 706-5339 REVISION 0

3/1/2011

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: 15.6.5

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

15.06.05-79

Reformation of the loop seals due to ECCS injection during the US-APWR long term cooling phase of a LOCA can cause suppression of the two-phase mixture level on the reactor core side. If this level drops below the top of the active fuel, cladding heatup and oxidation can occur.
Provide the results of a thermal-hydraulic analysis quantifying the two-phase mixture level in the US-APWR reactor during the long term cooling phase assuming the most limiting break size, break location, and ECCS performance conditions. Include predictions for the following parameters: (1) axial void distribution in the vessel at the point of minimum two-phase mixture level; (2) core steaming rate as a function of time; (3) vapor mass flow rates in the loops as a function of time; (4) liquid density and void fraction in the vertical upward section of the loop seals as a function of time; and (5) mass flow rate through the upper plenum/downcomer bypass paths as a function of time.
Provide an analytical description of the assessment model as well as the source coding of computer programs used to perform the calculations. The model description and results should consider the effect of assumptions regarding the selection and treatment of important modeling parameters that can vary during the transient in order to demonstrate the conservatism of the obtained results. As appropriate, sensitivity assessments over the expected range of variation of such parameters should be presented. In particular, consider the liquid temperature and void fraction in the vertical upward section of the loop seals, stratified level position in the horizontal loop seal piping, break elevation, and axial power shape

15.06.05-80

Provide the results from comparing the predictions from the level swell model, used in the US-APWR two-phase mixture level assessment during the LOCA long term cooling phase, against low-pressure level swell test data of relevance for the plant analysis.

15.06.05-81

US-APWR FSAR Subsection 15.6.5.3.1.3 “Post-LOCA Long Term Cooling Evaluation Model” describes the model that is used to predict the boric acid concentration in the reactor core during the LOCA long term cooling period. A more detailed description of

the model is provided in Appendix B to UAP-HF-09384 “MHI's Response to US-APWR DCD RAI No. 352-2369 Revision 1” (July 2009), as part of the response to RAI Question 15.6.5-44. According to this response, the evaluation model has not been previously reviewed by the U.S. NRC.

In the provided US-APWR boron precipitation analysis, the control mixing volume for calculating the boric acid concentration in the core includes the volume of the following regions: (1) core region volume, (2) upper plenum volume below the hot leg bottom elevation, and (3) one half of the lower plenum volume.

The average boric acid concentration computed with the above defined mixing volume is based on the assumption that 50% of the liquid in the lower plenum mixes homogeneously and instantly with the liquid content of the two remaining regions of the mixing volume. At the same time, it is recognized that if the density of the colder liquid residing in the lower plenum is higher than the coolant density in the core region, thermal stratification can preclude mixing between the regions.

According to Table 4.4-4 in the US-APWR FSAR, one half of the lower plenum volume corresponds to 61% of the entire active core fluid volume. As such, inclusion of this lower plenum portion in the control mixing volume can significantly affect the predicted boric acid buildup.

Provide the technical basis in support of the proposed inclusion of 50% of the lower plenum volume in the control mixing volume for the US-APWR boric acid precipitation analysis. If test data are used as part of the technical basis, demonstrate their applicability to the US-APWR reactor design by describing the applicable scaling methodology along with the scaling results for the US-APWR design.

15.06.05-82

In the US-APWR boron precipitation analysis, consideration of fluid mixing between coolant in areas of the reactor lower plenum and such residing in adjacent reactor core regions would require conditions under which the boric acid solution in these core regions becomes denser than the coolant in the lower plenum. Under such conditions, participation of a certain fraction of the lower plenum in the control mixing volume can be considered for crediting in the US-APWR boric acid precipitation evaluation.

Provide a conservative assessment of the expected coolant temperature in the reactor vessel lower plenum region during the post-LOCA long term cooling phase along with a list of all relevant assumptions under the most limiting LOCA conditions. Show the lower plenum liquid density based on the provided temperature and any other contributing factors if applicable. Provide the density of the liquid in the core based on corresponding coolant temperatures, boric acid concentrations, and any other contributing factors along with a list of all relevant assumptions. Explain how the representative core liquid density conservatively accounts for possible boric acid concentration variations within the reactor core. Present comparison plots for the representative coolant temperatures, boric acid concentrations, and liquid densities attributed to the lower plenum and core regions as functions of time.

Based on the performed assessments, provide the time period and conditions under which lower plenum participation in the control mixing volume can be considered for crediting in analyzing the effectiveness of the hot leg switchover to avoid boron precipitation. As appropriate, show sensitivity analyses to support the conclusions and include an assessment of the uncertainties associated with main contributing parameters.