REQUEST FOR ADDITIONAL INFORMATION 718-5402 REVISION 0

3/17/2011

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)

15.06.05-83

The response to RAI Question 15.6.5-56 provided in UAP-HF-09384 "MHI's Response to US-APWR DCD RAI No. 352-2369 Revision 1" states that "significant amount of the de-borated water may flow into the core when the natural circulation is reestablished or RCPs are restarted after the potential long-term reflux condensation."
Describe the dilution scenarios involving RCP restart that have been considered in the US-APWR evaluation of core recriticality associated with the inherent boron dilution mechanism occurring during small break LOCAs. Identify and describe the conditions that are found to lead to the worst core recriticality consequences. In particular, describe the conditions in the reactor coolant system (RCS) and in the primary loops at the time of pump restart, RCP restart timing considerations, and loop transient flow characteristics following pump restart. Discuss the core recriticality consequences under the identified limiting conditions including the coupled thermal-hydraulic system response and conditions.

15.06.05-84

The response to RAI Question 15.6.5-56 given in UAP-HF-09384 "MHI's Response to US-APWR DCD RAI No. 352-2369 Revision 1" states that "significant amount of the de-borated water may flow into the core when the natural circulation is reestablished or RCPs are restarted after the potential long-term reflux condensation."
Describe the dilution scenarios assuming resumption of RCS natural circulation that have been considered in the US-APWR evaluation of core recriticality associated with the inherent boron dilution mechanism occurring during small break LOCAs. Identify and describe the conditions that are found to lead to the worst core recriticality consequences. In particular, discuss the RCS loop conditions preceding natural circulation resumption, the process of natural circulation resumption in individual loops, timing aspects of interruption and resumption of natural circulation, and loop flow transient characteristics during natural recirculation resumption. Provide the technical base in support of the identified and applied limiting boron dilution conditions. If test data are used as part of the technical base, demonstrate their applicability, sufficiency, and scaling with regard to the US-APWR reactor design. Discuss the results from the analysis of the core recriticality consequences under the identified limiting conditions including the coupled thermal-hydraulic system response and conditions.

15.06.05-85

In the response to RAI Question 15.6.5-56 in UAP-HF-09384 "MHI's Response to US-APWR DCD RAI No. 352-2369 Revision 1," it is stated that a prolonged reflux condenser phase appears probable for US-APWR cold leg breaks that range between 2 and 4 inches of equivalent break diameters. It is further claimed that breaks below 1 inch do not lead to natural circulation interruption and break sizes larger than 6 inch depressurize the primary reactor system to a degree that precludes the occurrence of significant reflux condensation.

Identify the US-APWR small break cases that have been analyzed in the US-APWR evaluation of the inherent boron dilution mechanism during small break LOCAs. Identify the US-APWR small break LOCA model and computer codes used to perform supporting analyses. Substantiate the sufficiency of the analyzed cases in terms of establishing the break size range of interest and the break cases analyzed. Indentify the examined modeling assumptions with regard to availability, quantity and distribution of ECCS injection and SG emergency feed water supply. Present assessments for the amount of steam condensate generated by reflux condensation in the steam generators (SGs). As part of this analysis, present the results for the condensate amount returned in countercurrent flow to the reactor vessel hot leg, condensate collected in SG regions including the SG exit chamber, loop crossover pipe, cold leg, and condensate transported to the vessel downcomer. Include consideration of stratified conditions involving hot boron-depleted condensate and colder borated coolant in the reactor cold leg and downcomer regions. Explain how results from performed thermal-hydraulic analyses were applied in the US-APWR boron dilution recriticality evaluation.

15.06.05-86

The inherent boron dilution process can take place during the event of a small break LOCA in the US-APWR. When the water level in the reactor pressure vessel drops below the hot leg inlet and steam only starts flowing to the SGs, the natural circulation in the RCS will cease and will switch to a reflux condenser cooling mode. It is the reflux condenser cooling mode during which boron-depleted condensate is generated within the primary RCS via heat extraction to the secondary side through the SG U-tubes. In this mode, a fraction of the condensate flows from the vertical SG U-tubes toward the pump seal and the remaining fraction of the condensate returns back to the upper plenum via the hot-leg. In the hot leg, the returning condensate and the steam form a counter-current flow pattern. The counter-current flow of condensate and steam in the horizontal section of the hot leg and in the connected bend and inclined piping is possible only under a certain range of flow rates, which are limited by the counter-current flow limitation phenomenon.

The ratio of the US-APWR core thermal output to that of a current four-loop PWR is higher than the ratio of the hot leg inner diameters. Experimental evidence from PWR hot leg test facilities, including recent geometrically scaled tests at the TOPFLOW test facility, reveals that steam-liquid interaction processes in the horizontal hot leg piping as well as in the elbow and inclined section of the hot leg are described by their own distinct governing characteristics. Considering that the US-APWR hot leg was not sized up proportionately to the reactor thermal power increase when compared to current US PWRs, present the experimental data base that validates the US-APWR small break LOCA methodology for modeling reflux condenser cooling. Describe the relevant scaling methodology along with the scaling results for the US-APWR design. Include consideration of flow conditions and parameters of governing importance for reflux condenser cooling including counter-current flow limitation.