REQUEST FOR ADDITIONAL INFORMATION 485-3825 REVISION 1

11/9/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

SRP Section: 03.06.03 - Leak-Before-Break Evaluation Procedures
Application Section: 03.06.03

QUESTIONS for Component Integrity, Performance, and Testing Branch 1 (AP1000/EPR Projects) (CIB1)

03.06.03-18

In the original question RAI 3.6.3-3, the staff asked about the evaluations to demonstrate that stress corrosion cracking will not impact the structural integrity of piping. The staff finds that the applicant has addressed why SCC and PWSCC are not a potential source of pipe rupture and has provided additional information on the selection of pipe material grades and weld alloys that are resistant to cracking to PWSCC. However, there is a statement in the second paragraph on the applicant's response (reference 1) that appears to indicate that materials susceptible to PWSCC are used. The applicant stated the following:

> "The only material in existing PWR plants that has exhibited susceptibility to PWSCC is Alloy 600 and its compatible weld filler metals, Alloy 82/182. These materials are found in the dissimilar metal welds joining the ferritic nozzles to the stainless steel piping or safe-ends."

The applicant should clarify if the second sentence above should read, "These materials are NOT found in the dissimilar metal welds joining the ferritic nozzles to the stainless steel piping or safe-ends in the US-APWR DCD." Or, similarly, "These materials are found in the dissimilar metal welds of operating reactors joining the ferritic nozzles to the stainless steel filler metals, Alloy 82/182; but, are not used in the US-APWR plant." This would be consistent with the first paragraph of the applicant's response which indicated that dissimilar metal welds joining the piping and ferritic nozzles will be constructed with Alloy 52M/152 nickel-based weld filler metal. The staff finds that the applicant's response is acceptable, but the answer appears to have an inconsistent statement regarding the materials used in the dissimilar metal welds joining the ferritic nozzles to the stainless steel piping that needs to be clarified.

Reference:
1. MHI's Response to US-APWR DCD RAI No. 210-1948; dated April 23, 2009; MHI Ref: UAP-HF-09186; ADAMS accession number ML091170059

03.06.03-19

In the original question RAI 3.6.3-5, the staff requested additional information on the design features and operational and maintenance controls that will be in place to prevent water hammer. In its response (reference 1), the applicant provided clarifications and

additional information on the methods used to prevent water hammer. The applicant concluded that with these clarifications and additional information and with the requirements that will be included in the operation manual, no additional changes to the DCD or a COL is necessary. The information provided in the response is consistent with the requirements necessary to prevent and mitigate water hammer and that including strict venting requirements prior to operation in the operations manual will help to prevent water hammer. However, the applicant stated that these requirements are items that will be specified in the operations manual indicating they currently do not exist. During the design certification stage, there is no means for the staff to confirm that these requirements have been included in the operations manual, which will be written later. Therefore, the staff requests that the applicant add an appropriate commitment (COL item or ITAAC or other) to insure that instructions to prevent and mitigate water hammer for the RCL branch piping and Main Steam Lines included in the LBB analyses will be included in the operations manual. Additionally, the applicant should provide a discussion or commitment to minimize the use of elbows and miters to reduce the effects of steam and water hammer.

The staff requests that the applicant provide the requested appropriate commitments to allow the staff to complete its review requirements as identified in NUREG-0800 section 3.6.3.

Reference:
1. MHI's Response to US-APWR DCD RAI No. 210-1948; dated April 9, 2009; MHI Ref: UAP-HF-09148; ADAMS accession number ML091040323

03.06.03-20

The original RAI 3.6.3-6 covered US-APWR section 3.6.3.3.5 which addresses low-cycle and high cycle fatigue and states that the US-APWR is designed to address the potential for fatigue failures. The applicant was asked what specific design features are used to reduce the potential for fatigue failures in addition to the application of the ASME Code Section III. The applicant was also asked to clarify what operational controls are in place for vibration induced fatigue for the US-APWR design and to provide additional information on the methods used to mitigate the potential for fatigue failures.

In its response (reference 1), the applicant stated that to reduce the potential for low-cycle fatigue failures, the following design features are used:

1) water solid condition during startup and cool down, and
2) application of butt weld instead of socket weld.

The applicant also stated that because reactor coolant pump (RCP) vibration induces RCS piping vibration, design features are used to monitor vibrations at shaft, lower and upper frames of the RCP and to alarm when vibration exceeds the limit. This vibration monitoring and associated limits will be specified and controlled in the RCP operating instruction manual. The staff finds that the overall direction of the applicant's response is acceptable, but the applicants' response is incomplete. The applicants' statement "water solid condition during startup and cool down" could be described as an operational control/requirement, and from the brevity of the statement, it is unclear how this reduces the potential for fatigue failures. The applicant should provide a more complete description of the design features used to reduce the potential for fatigue

failures and provide additional detail on the design features used to monitor vibrations (other than the RCPs) in the RCS piping. In addition, the applicant should also describe in more detail what measures will be taken to minimize thermal stratification effects in the main steam line and the surge line piping.

Reference:
1. MHI's Response to US-APWR DCD RAI No. 210-1948; dated April 9, 2009; MHI Ref: UAP-HF-09148; ADAMS accession number ML091040323

03.06.03-21

The original RAI 3.6.3-9 commented on the reference the applicant cited as the source for the Ramberg-Osgood stress-strain curve and the J-T curve used for the LBB evaluation of the main steam piping. The staff asked for an alternative reference as an appropriate source for the Ramberg-Osgood and J-T curves that will be applied to develop BAC curves for the US-APWR main steam piping. In its response (reference 1), the applicant described an alternate procedure which has been evaluated against ferritic piping and weld material data that are published in the Pipe Fracture Encyclopedia, Test Data – Volume 3 (USNRC, December 1997) and summarized in Appendix B of NUREG/CR-6004. The staff finds that the overall direction of the applicants' response is acceptable as it did provide clarification and alternate references for material properties for the main steam line piping. However, the applicants' response does not address necessary corrections to the DCD. There was no discussion on revising the text and deleting the incorrect reference (3B-16) to the ESBWR DCD in Appendix 3B of the US-APWR. The staff requests that the applicant revise the US-APWR Appendix 3B to include the approach described in their response to RAI 3.6.3-9 and to add references to the Pipe Fracture Encyclopedia, Test Data – Volume 3 USNRC, December 1997 and to NUREG/CR-6004 Appendix B.

The staff requests that the applicant provide the requested revisions to allow the staff to complete its review requirements as identified in NUREG-0800 section 3.6.3.

Reference:
1. MHI's Response to US-APWR DCD RAI No. 210-1948; dated April 9, 2009; MHI Ref: UAP-HF-09148; ADAMS accession number ML091040323

03.06.03-22

In original question RAI 3.6.3-10, the applicant was asked about the BAC curves of Figures 3B-11 through 3B-17 which show a lower cutoff on the normal stress axis that serves as a minimum value of normal stress for the curve. Section 3B.3.1.1 of Appendix B of the DCD describes the steps used to construct the BAC plots. The applicant's response (reference 1) does not appear to be entirely consistent. The applicant clarified that they used an equation that results in a more realistic but smaller stress value. However, the use of a more realistic smaller stress value does not appear to be conservative when considering the BAC methodology. As stated in Appendix 3B of the DCD, "The area below the BAC is a leak mode and that beyond the BAC is the failure mode." Using an approach that results in a smaller stress value would appear to reduce the "failure mode" area, which may not be conservative in all cases. The applicant also

stated, “In the piping design, the membrane stress is conservatively obtained by the equation included within the associated NRC question” which is not consistent with the earlier discussion that a more realistic smaller stress value using the closed end assumptions were used. The staff requests that the applicant provide additional information to resolve these apparent inconsistencies in their response and to clearly define the most conservative approach for calculating the membrane stress.

The staff requests that the applicant provide the requested additional information to allow the staff to complete its review requirements as identified in NUREG-0800 section 3.6.3.

Reference:
1. MHI's Response to US-APWR DCD RAI No. 210-1948; dated April 9, 2009; MHI Ref: UAP-HF-09148; ADAMS accession number ML091040323

03.06.03-23

In original RAI 3.6.3-11, the applicant was asked about the basis for performing the LBB evaluation on the main steam piping. The BAC curve for the main steam piping addresses the operation temperature of 535°F. Standard Review Plan 3.6.3 (Section III.11.B.iv) cites the need for calculations to address possible fracture at temperatures lower than the temperature of normal operation (e.g., hot standby). These calculations would account for the possibility of reduced toughness at the lower temperatures. The applicant was asked to provide additional information on the basis for performing the LBB evaluation for the main steam piping only for the normal operating temperature.

The staff finds that the overall direction of the applicants’ response (reference 1) is acceptable, but the applicants’ response is incomplete. The applicant clarified the reduction in the loads for the main steam line but did not directly address the question of material toughness. Specifically, the reduced toughness of the main steam line material at lower temperatures. It is understood that the pressures and the loads will be reduced at lower temperatures, however, the applicant should clarify whether or not the reduced material toughness for lower temperature conditions would be a concern even under the lower loads (e.g., is there a concern that the toughness is decreasing faster than the loads). Additionally, the response does not clearly identify the basis for Pmax and Mtmax. Are they based on material toughness or some other material limitation. The staff requests the applicant clarify the responses concerning the main steam line material toughness and provide the additional information to ensure NUREG-0800 section III.11.B.iv has been properly addressed.

The staff requests that the applicant provide the additional information to allow the staff to complete its review requirements as identified in NUREG-0800 section 3.6.3.

Reference:
1. MHI's Response to US-APWR DCD RAI No. 210-1948; dated April 9, 2009; MHI Ref: UAP-HF-09148; ADAMS accession number ML091040323

03.06.03-24

In original question RAI 3.6.3-12, the staff identified that two BAC plots provided in Section 3.6.3 for the surge line. Figure 3B-11 is for normal operation at a pressure of 2235 psi and a temperature of 653°F, whereas Figure 3B-12 is for a pressure of 400 psi and a temperature of 449°F. The applicant was asked about the significance of the loading condition at the lower temperature and pressure used for Figure 3B-12. The staff requested additional information and the rationale for selecting the loading condition.

In its response (reference 1), the applicant stated that this condition represents the time during heatup and cooldown of the plant, where the pressurizer is heated (the saturation pressure at 449°F is 418 psia) and the reactor coolant loop piping temperature may be relatively low (especially during heatup). For this condition, the maximum thermal stratification can exist in the surge line piping. The applicant stated this curve is in the process of being revised to reflect that the normal operating stress will be that associated with normal plant operation, since it is during the normal plant operating conditions that the leakage must be detected, not taking credit for the stratification stresses that will occur at the low temperature conditions. The staff finds that the direction of the applicant's response is acceptable since it clarified the load conditions. However, the response needs clarify that applicant will be selecting load combinations that will result in the least favorable conditions for normal operations. In addition, consistent with NUREG-0800 section III.11.B.iv, the applicant should use material properties (toughness) that reflect the least favorable conditions considering both normal operation and conditions like hot standby where pipe break would present safety concerns similar to normal operation. The staff requests that the applicant provide additional information and clarify that the revised curve reflects the least favorable conditions for stresses and material properties.

The staff requests that the applicant provide the additional information to allow the staff to complete its review requirements as identified in NUREG-0800 section 3.6.3.

Reference:
1. MHI's Response to US-APWR DCD RAI No. 210-1948; dated April 9, 2009; MHI Ref: UAP-HF-09148; ADAMS accession number ML091040323

03.06.03-25

In original question RAI 3.6.3-14, the applicant was asked about the US-APWR DCD Appendix 3B, Table 3B-1 and Figure 3B-5 which provide critical inputs to the LBB evaluation for the main steam piping. This is the only piping in the submittal that is constructed of ferritic steel and, as such, requires a more complex tearing instability analysis. The applicant was asked to justify that these inputs provide a conservative or bounding basis for the LBB calculations. The applicant was also asked to provide additional information and the steps that will be taken to verify that the selected Ramberg-Osgood stress strain curve and $(J\text{-}T)_{mat}$ curve are suitable bounds for the properties of the as-built main steam piping.

In its response (reference 1), the applicant described an alternate approach which has been developed where minimum acceptable material properties will be specified for

procurement of main steam line piping materials and qualification of the welding processes. Fracture mechanics instability analysis has been conducted for a range of material yield and ultimate tensile strength properties based on the stress-strain curve shape using ASME Code minimum properties. From this analysis, a minimum required J-T curve is developed that is a function of the actual measured base metal yield and ultimate tensile strengths at the time of piping procurement. The procedure has been evaluated against ferritic piping and weld material data that are published in the Pipe Fracture Encyclopedia Test Data – Volume 3 (USNRC, December 1997) and summarized in Appendix B of NUREG/CR-6004. The staff finds that the overall direction of the applicants' response is acceptable as it provides clarification, and alternate references for material properties for the main steam line piping. However, the applicants' response does not address necessary corrections to the DCD. There was no discussion on revising the text and deleting the incorrect reference (3B-16) to the ESBWR DCD in Appendix 3B of the US-APWR. The staff requests the applicant revise Appendix 3B to the US-APWR to include the approach described in their response to RAI 3.6.3-14 and to add references to the Pipe Fracture Encyclopedia, Test Data – Volume 3 USNRC, December 1997 and to NUREG/CR-6004 Appendix B.

The staff requests that the applicant provide the additional information to allow the staff to complete its review requirements as identified in NUREG-0800 section 3.6.3.

Reference:
1. MHI's Response to US-APWR DCD RAI No. 210-1948; dated April 9, 2009; MHI Ref: UAP-HF-09148; ADAMS accession number ML091040323