REQUEST FOR ADDITIONAL INFORMATION 391-2974 REVISION 1

6/15/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

SRP Section: 06.03 - Emergency Core Cooling System
Application Section: 6.3

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

06.03-1

RAI 6.3.1.2-1

In Section 6.3.1.2, identify those components of the ECCS required for safe shutdown in the event the normal systems are unavailable, including the number of pumps required and the flow control valves. Summarize the functions of these components during the shutdown without normal systems.

06.03-2

RAI 6.3.1.2-2

Is the safe shutdown mission of the ECCS components to enable the operator to maintain the plant in hot standby for approximately 14 hours, until the normal systems are restored? Or to bring the plant to either hot shutdown or cold shutdown conditions?

06.03-3

RAI 6.3.1.3-1

Revise the text to indicate that the function of the pH control is to enhance the *iodine* retention capacity in the containment *recirculation water*. On Page 6.3-9, it is stated that the dilution time of the NaTB is approximately 12 hours. Provide the diluted NaTB mass versus time and the RWST pH value versus time for a postulated large break LOCA. Demonstrate that the RWST water can reach pH 7.0 within acceptable time to suppress the iodine in the containment air space.

06.03-4

RAI 6.3.2.2.5-1

In Section 6.3.2.2, it is stated that “The size of the NaTB transfer pipes and refueling cavity drain pipes are selected to minimize the head loss during a transfer of solution. The containerized NaTB solution overflows at the same flow rate as the spray water that flows into the container. Therefore, the NaTB dissolved in the container flows into the

RWSP without losses from spilling over onto the containment operating floor. The dissolution time of the NaTB is approximately 12 hours."

The flows from the sprays that fall onto the NaTB containers appear to be very difficult to predict accurately. Where is this calculation performed that predicts the dilution via the sprays and has it be verified? During the aging of the plant, many characteristics of the sprays may change slightly because of maintenance activities and other effects that may change the spray distribution onto the NaTB containers to change. Has the change spray distribution after time been considered in your evaluation. How do you know that you do not lose NaTB into the containment environment? How does the amount and time of NaTB dilution impact the pH of water in the containment?

06.03-5

RAI 6.3.1.4-1

Revise DCD Table 6.3-1, "Response of US-APWR to TMI Action Plan," to show TMI Action Item II.K.3.15 is not applicable to the US-APWR design, by entering *N/A* under the US-APWR Design column.

06.03-6

RAI 6.3.1.4-2

Revise DCD Table 6.3-1 TMI Action Item II.K.3.45 to include the complete description of the concern, by adding the following text after *that would reduce* "the possibility of exceeding vessel integrity limits during rapid cooldown for BWRs". Therefore, it is not applicable to US APWR.

06.03-7

RAI 6.3.1.4-3

Update DCD Table 6.3-1 to address SRP 6.3, "Emergency Core Cooling System," Acceptance Criteria, which requests applicants address the following TMI Action Items (these items are not in RG 1.206, "Combined License Applications for Nuclear Power Plants (LWR Edition)," C.I.6.3, Emergency Core Cooling System):

1. II.K.3.16 of NUREG-0737, with regard to providing an evaluation of methods to reduce challenges and failures of reactor coolant system relief valves for BWRs.
2. II.K.3.24 of NUREG-0737, with respect to the adequacy of space cooling for long-term operation of HPCI and RCIC systems for BWRs to maintain the operating environment within allowable limits.
3. II.D.3 of NUREG-0737, with respect to the requirements that reactor coolant system relief and safety valves be provided with a positive indication in the control room of flow in the discharge pipe.

4. II.F.2 of NUREG-0737, with respect to the requirement that instrumentation or controls provide an unambiguous, easy-to-interpret indication of inadequate core cooling.

06.03-8

RAI 6.3.1.4-4

Table 6.3-2, "Response of US-APWR to Unresolved Safety Issues," USI A-1, states "*the probability of water hammer in ECCS is discussed in Subsection 6.3.2.1.1,*" under the column US-APWR Design. Revise this statement to be consistent with the text DCD Section 6.3.2.1.1, "High Head Injection System," which describes design features to preclude void formation and water hammer. The text under GL 86-07 should also be similarly revised. In addition, discuss the frequency of the periodic in-service full-flow testing. Clarify whether this is a technical specification requirement.

06.03-9

RAI 6.3.1.4-5

Table 6.3-2, USI A-2, "Asymmetric Blowdown Loads On Reactor Primary Coolant Systems," states consideration the hypothetical break is not necessary because the US-APWR uses the leak before break (LBB) concept. SRP 3.6.3, "Leak-Before-Break Evaluation Procedures," Acceptance Criteria *3*, states "*LBB cannot be applied to individual welded joints or other discrete locations.*" A break at a reactor coolant system (RCS) nozzle inside the reactor cavity area around the reactor pressure vessel (RPV) would result in asymmetric loads on the RPV internals (large differential pressure across the core barrel) that should be considered in the design of the RPV supports. Failure of the supports could affect core coolablity. Expand the explanation to justify why not taking into consideration this loading function and specifically explain how the LBB concept prevents asymmetric blowdown loads.

06.03-10

RAI 6.3.1.4-6

Table 6.3-3, "Responses of US-APWR to Generic Safety Issues," GI-105 states the design pressure of the residual heat removal (RHR) system is *900 lb*. Revise this number to the appropriate unit of psia or psig, as appropriate.

06.03-11

RAI 6.3.1.4-7

Table 6.3-3 GI-105 states the RHR is designed to discharge the RCS inventory to the in-containment RWSP if both motor operated valve should open during normal operations. Provide a reference point to the RHR design description and the relief system design description. Since 900 pounds (assuming psi is meant) is significantly less than the RCS system pressure (2250 psi), explain how the RHRS can withstand the full RCS pressure with only one MOV without check valves. Figure 6.2.4-1 indicates that there is a single MOV inside containment for system isolation. A single failure may result in a LOCA outside the containment. How will this be prevented?

06.03-12

RAI 6.3.1.4-8

Table 6.3-3, GSI-191, refers to Subsection 6.2.2.2.3 where it is stated the "…selection, purchase, and installation of specific insulation products are controlled by…the COL applicant." The RWSP is also the containment sump. What debris loads are used for the LOCA analysis? In addition, these debris loads must be assumed to be present at the onset of the ECCS operation. Discuss the effects of the fiber, particulates, and chemical debris on in-vessel cooling (downstream effects) throughout the LOCA event. Clarify what would be included in the DCD if some of these materials will be provided by COL applicants.

06.03-13

RAI 6.3.1.4-9

Table 6.3-4, "Responses of US-APWR to Generic Letters and Bulletins," BL 01-01 and BL 02-01 states these bulletins are not applicable as the US-APWR does not have penetrations in the RPV head for safety injection. These bulletins address the potential for boric acid leakage from the control rod drive mechanism nozzles or incore instrumentation system nozzles and subsequent corrosion of the RPV upper head. Identify the in-service inspection (ISI) plan which monitors the RPV upper head for boric acid accumulation and describe the design features that facilitate the inspection.

06.03-14

RAI 6.3.1.4-10

Revise Table 6.3.4, GL 89-10, "Item b" to include the complete description by adding the following text after review and revise ", as necessary, the methods for selecting and setting all switches."

06.03-15

RAI 6.3.1.4-11

Update Table 6.3-4 to include the following and address them in the relevant DCD sections properly:

1. NRC Generic Letter 2004-02: Potential Impact of Debris Blockage on Emergency Recirculation during Design Basis Accidents at Pressurized-Water Reactors.
2. NRC Generic Letter 2008-01: Managing Gas Accumulation in Emergency Core Cooling, Decay Heat Removal, and Containment Spray Systems.
3. NRC Bulletin 2003-01: Potential Impact of Debris Blockage on Emergency Sump Recirculation at Pressurized-Water Reactors.
4. NRC Bulletin 2003-02: Leakage from Reactor Pressure Vessel Lower Head Penetrations and Reactor Coolant Pressure Boundary Integrity.

06.03-16

RAI 6.3.2.1-1

The text in DCD Section 6.3.2.1.1, "High Head Injection System," uses decimal representations to describe elevations (for example 43.8 ft), while the referenced Figure 6.3-3, "SIS Elevation Diagram," provides the same information in the more traditional format of feet and inches (for example 43 ft-9 in). Revise the text to feet and inches to be consistent with the figure.

06.03-17

RAI 6.3.2.1-2

Has the hydrodynamic loads evaluation for the emergency letdown system spargers in the RWSP been completed? If the analysis has been completed, provide the reference to the evaluation.

06.03-18

RAI 6.3.2.1-3

Provide test data which demonstrates that Figure 6.3-15, the High Head Safety Injection Flow Characteristic Curve (Minimum Safeguards), is conservative relative to actual pump performance. Provide details on how the test data was generated. Describe the testing conditions and their relevance to the actual system conditions during normal operation and postulated accidents.

06.03-19

RAI 6.3.2.2-3

Modify the text in DCD Section 6.3.2.2.2 to include the evaluation used to develop the required capacity (724 ft^3) for the small injection flow rate or provide a reference.

06.03-20

RAI 6.3.2.2.1-1

In Section 6.3.2.2.1 Safety Injection Pumps , second sentence states that “This SI pump flow rate is based on two SI pumps operating (active failure of one SI pump and one SI pump out of service), with each SI pump delivering 1,057 gpm against near atmospheric pressure.” The design flow given on Table 6.3-5 is 1,540 gpm. Explain why the design flow of 1,540 gpm is greater than the run out flow of 1,057 gpm?

06.03-21

RAI 6.3.2.2.4-1

In Section 6.3.2.2.4 ECC/CS Strainers, the fourth sentence states that “The strainer sizing accommodates the estimated amount of debris potentially generated in containment.” Provide a relevant reference and explain how this is accomplished?

06.03-22

RAI 6.3.2.2.4-2

The fifth sentence of Section 6.3.2.2.4 ECC/CS Strainers states that “The RWSP water chemistry is controlled so as to minimize the chemical effects between the sump water and potentially corrosive materials in containment is considered. Clarify how the chemistry is controlled to minimize the chemical effects or point to the right reference.

06.03-23

RAI 6.3.2.2.5-2

In Section**,** it is stated that “NaTB in baskets is dissolved in spray water in the containers. The solution containing NaTB is discharged from each container to the RWSP through 4-inch diameter NaTB solution transfer pipes.” Are there any postulated LOCA breaks that could cause debris to block the four inch lines? If yes, provide the evaluation results and the relevant references.

06.03-24

RAI 6.3.2.2.3-1

It is stated in Section 6.3.2.2.3 that **“**The RWSP capacity includes an allowance for instrument uncertainty and the amount of holdup volume loss within the containment.” Where are the instrument uncertainty and holdup volume loss assessments documented? Provide the references.

06.03-25

RAI 6.3.2.2.3-2

"Figure 6.2.1-1 through Figure 6.2.1-4 are plots of containment internal pressure and temperature versus time for the most severe primary and secondary system piping failures." What is the most severe pipe break with respect to containment pressure and temperature? What is the worst case pipe break with respect to creating debris that could enter the RWSP and potentially plug the recirculation?

06.03-26

RAI 6.3.2.2.3-3

In Section 6.3.2.2.3, the auxiliary RWSP storage tank is designed to ensure the required volume for refueling operations. Provide sufficient information regarding this tank and the relevant piping/pump system and describe whether this tank is intended to be used during accident conditions (i.e., LOCA and AOOs). If it could be activated during these events, describe the necessary operator actions and the equipment availability during these events.

06.03-27

RAI 6.3.2.2-1

On Page 6.3-4, it is stated that void formation due to water column separation in the SI piping is precluded because the available head (24 ft-2 in) is less than the head (30 ft) which would result in column separation and no delay is assumed between the system initiation and the injection flow into the vessel downcomer. The liquid vapor pressure is generally accepted as the cavitation inception pressure in standard column separation numerical models. Is this model being used? Provide the details of the column separation analysis.

06.03-28

RAI 6.3.2.2-2

It is not clear that void formation in the SI piping can be precluded during a postulated LOCA. During the blowdown phase, quick depressurization would occur through the entire primary system. Flashing could occur in the un-isolated sections of SI piping (between the RPV DVI nozzle and the closest check valve (SIS-VLV-013A, B, C, and D). Justify why there is no void formation. If there is, demonstrate that the water hammer would not occur in these sections during a LOCA, or would not result in damage to the piping sufficient to degrade the SI injection.

06.03-29

RAI 6.3.2.2-3

The SI pumps are horizontal, multi-stage centrifugal type pumps. Typically these pumps require cooling (from non-safety related and safety-related cooling systems) to protect the motors and seals to ensure they can provide the required flow for the duration of the accident. Describe the cooling system(s) and include the cooling system(s) in the failure modes and effects analysis.

06.03-30

RAI 6.3.2.2-4

The building area which houses the SI pumps and instrumentation should be provided with HVAC to protect the pumps and instrumentation from excessive temperatures. Describe the HVAC system and include the HVAC system in the failure modes and effects analysis.

06.03-31

RAI 6.3.2.2-5

Summarize or reference, the NPSH analyses performed to ensure there is an adequate head available for all accident conditions.

06.03-32

RAI 6.3.2.2-6

Describe the "assumed large break LOCA" used to determine the SI and accumulator delivery requirements. Include any assumptions made concerning the initial conditions in the RCS, ECCS availability, and assumed failures.

06.03-33

RAI 6.3.2.2-7

In DCD Section 6.3.2.2.2, "Accumulators," it is stated "*Although four accumulators are provided, accumulator sizing is based on three accumulators to account for unavailability of flow from the accumulator installed on the broken loop during a LOCA whose contents are assumed to spill to the containment so that it does not contribute to the core injection. One third of the remaining accumulator volume is also assumed to be lost to the spill through the postulated pipe break. Two thirds of the remaining accumulator volume is available for injection.*" Is the additional loss used in the LOCA analyses or is it only used to size the accumulators by providing additional margin for the available fluid?

06.03-34

RAI 6.3.2.2-9

Explain why there is no upper value limit for the large injection flow rate capacity?

06.03-35

RAI 6.3.2.2-11

There is no ITAAC to verify the small injection flow rate required capacity. Explain why this value does not need to be verified.

06.03-36

RAI 6.3.2.2-12

The Direct Vessel Safety Injection Line Isolation Valves (SIS-MOV-011A, B, C, and D) have throttling capability for safe shutdown operations. The open or closed valve position is indicated in the MCR and RSC. TS 3.5.2, "Safety Injection System (SIS) – Operating," SR 3.5.2.2 only verifies valves to be in the correct position. For a valve has throttling capabilities shouldn't the valve position be part of the display? What process variable is monitored to determine if the correct throttled position is obtained? Please identify the process used to ensure that the valve is not left in a partially open configuration prior to entering an operating mode.

06.03-37

RAI 6.3.2.2-13

Please describe the need for a throttling capability for the Safety Injection Pump Full-flow Test Line Stop Valves (SIS-MOV-024A, B, C, and D). The open or closed valve position is indicated in the MCR and RSC. For a valve has throttling capabilities shouldn't the valve position be part of the display? What process variable is monitored to determine if the correct throttled position is obtained? Are there any negative consequences of the valve being in a partially open configuration when performing the SI full-flow test?

06.03-38

RAI 6.3.2.2-14

Provide the evaluation performed to size the Accumulator Safety Valves (SIS-VLV-126A, B, C, and D) relief capacity. Address the concern that the valve may need to discharge both nitrogen gas and water, if the SI failure fills the accumulator (going water solid).

06.03-39

RAI 6.3.2.2-15

The Emergency Letdown Line Isolation Valves (SIS-MOV-032B, D) have throttling capability, based on a review of DCD Figure 6.3-2, "ECCS Piping and Instrumentation Diagram." The open or closed valve position is indicated in the MCR and RSC. Please describe the need for a throttling capability and include this capability in the DCD description. For a valve has throttling capabilities shouldn't the valve position be part of the display? What process variable is monitored to determine if the correct throttled position is obtained? Are there any negative consequences of the valve being in a partially open configuration when starting the feed and bleed procedure?

06.03-40

RAI 6.3.2.2-16

On Figure 6.3-2, "ECCS Piping and Instrumentation Diagram (Sheet 3 of 4)," Note 4 states: "to be provided with overpressurization protection," on the nitrogen supply line segment outside containment. Explain the need for this protection and does this statement mean there is a COL action item to provide this feature in the design?

06.03-41

RAI 6.3.2.2-17

Figure 6.3-2 refers to equipment/system "CVDT." It also appears on Figure 6.2.4-1, "Containment Isolation Configurations (Sheet 3 of 50)." This is not identified in the Acronyms and Abbreviation table. Define the equipment/system and add the definition to the table.

06.03-42

RAI 6.3.2.2-18

The Accumulator Nitrogen Supply Containment Isolation Valve (SIS-AOV-114), does not appear to have position indication in the MCR and RSC. As a containment isolation valve, the open or closed valve position should be indicated in the MCR and RSC. Is the valve position indicated in the MCR and RSC? If not, why is position indication not required?

06.03-43

RAI 6.3.2.3-1

Summarize the Equipment Class for the ECCS components and piping inside containment to ensure that they meet, at a minimum, Equipment Class 2 and Seismic

Category I. For Equipment Class 3 and Class 4 components and piping identify the seismic design category associated with each class.

06.03-44

RAI 6.3.2.4-1

Describe the material specification characteristics for ECCS valves, both for the seating surfaces and stems, to prevent failures and to reduce wear.

06.03-45

RAI 6.3.2.5-1

The failure modes and effects analysis (FMEA) presented in Table 6.3-6, “Failure Modes and Effects Analysis - Safety Injection System,” appears to be a very high level summary. For example, the SI failure mode is described as “Failure to deliver flow.” This could result from, for example, failure to start (mechanical, electrical, or I&C failure), failure to run (mechanical or electrical failure), or failure to delivery required flow (mechanical failure). The flow could be excessive which could result in pump run-out, or could be inadequate and not provided adequate make-up. In addition, failure of a closed valve to open or of an open valve to close would result in no flow. Describe the level of detail used to develop Table 6.3-6, or provide a reference to the detailed FMEA evaluation.

06.03-46

RAI 6.3.2.5-2

Table 6.3-6 indicates the “Failure Detection Method” is based on information provided in the MCR. Is the same information available from the RSC? If not, explain how the operator monitors the status of safety systems when the MCR in uninhabitable.

06.03-47

RAI 6.3.2.5-3

Item 4. Accumulator discharge valve, in Table 6.3-6, Column “Effect on System Operation,” should be clarified as “No effect on plant safety because the accumulator nitrogen gas volume can be vented to the containment atmosphere by opening the accumulator nitrogen discharge valve SIS-MOV-121A or B.”

06.03-48

RAI 6.3.2.5-4

The long term cooling limiting failure is based on leakage from a valve or pump seal. Leakage is detected and alarmed in the MCR. Is the same information available from the RSC? If not, explain how the operator monitors the status of safety systems when the MCR in uninhabitable.

06.03-49

RAI 6.3.2.5-5

The failure modes and effects analysis needs to consider the inadvertent (I&C failure) opening of a hot leg injection isolation valve (SIS-MOV-014A, B, C, or D) prior to the operator switch over to hot leg injection. State whether the MHI analysis considers this and if not, provide justification why it does not.

06.03-50

RAI 6.3.2.6-1

Does the SIS design consider protection from fires? If so, identify the appropriate DCD section(s) which address SIS fire protection. If not, how does the design assure adequate SI availability should a fire occur?

06.03-51

RAI 6.3.2.8-1

Hot leg injection and emergency letdown operations are stated to be taken from the MCR. Can these operations be performed fro the RSC? If so, then Table 6.3-6 should be revised accordingly. If not, explain how these operations can be taken when the MCR is uninhabitable.

06.03-52

RAI 6.3.2.8-2

Table 6.3-6 identifies manual operation of the accumulator nitrogen discharge valve for the safe shutdown plant condition should the accumulator discharge valve fail. This action should be included in DCD Section 6.3.2.8, “Manual Actions.”

06.03-53

RAI 6.3.3.3-1

The DCD states: “The ECCS is designed with redundancy so that the specified safety functions are performed assuming a single failure of an active component for a short-term following an accident, and assuming either a single failure of an active component or a single failure of a passive component for a long-term following an accident.” However in DCD Section 6.3.2.5, “System Reliability,” it is stated “During long term cooling, the most limiting active failure, or a single passive failure, equal to the leakage that would occur from a valve or pump seal failure, may occur.” Does the description in Section 6.3.2.5 mean the two failure considerations are either (1) a limiting active failure with up to total loss of ECCS fluid or (2) a limited passive failure resulting in limited loss (leakage) of ECCS fluid?

06.03-54

RAI 6.3.3.1-1

Address the following discrepancies between the information provided in Table 15.6.5-1, “US-APWR Major Plant Parameter Inputs Used in the Best-Estimate Large break LOCA Analysis,” and TS 3.5.1, “Accumulators”:

1. There is no TS SR for the accumulator water temperature range used in the LBLOCA analysis (70°F ≤ T_{ACC} ≤ 120 °F)
2. The accumulator pressure range used in the LBLOCA analysis is 600psia ≤ P_{ACC} ≤ 710 psia, while the TS SR 3.5.1.3 range is ≥ 586 psig and ≤ 695 psig.
3. The accumulator water volume range used in the LBLOCA analysis is 2126ft^3 ≤ V_{ACC} ≤ 2179 ft^3, while the TS SR 3.5.1.2 range is ≥ 19,300 gallons and ≤ 19,700 gallons.

06.03-55

RAI 6.3.3.1-2

Address the following discrepancy between the information provided in Table 15.6.5-1, “US-APWR Major Plant Parameter Inputs Used in the Best-Estimate Large break LOCA Analysis,” and TS 3.5.4, “Refueling Water Storage Pit (RWSP)”: The safety injection temperature range used in the LBLOCA analysis is 45 °F ≤ T_{SI} ≤ 120 °F, while the TS SR 3.5.4.1 range is ≥ 32 °F and ≤ 120 °F.

06.03-56

RAI 6.3.3.1-3

Justify using a core power less than 100% of rated power (98% ≤ P_{core} ≤ 102% of 4451 MWt, Table 15.6.5-1).

06.03-57

RAI 6.3.4.1-1

Identify, by number, those tests in DCD Section 14.2, “Initial Plant Test Program,” that specifically address ECCS performance, for example, “14.2.12.1.57 - Safety Injection Accumulator Test.”

06.03-58

RAI 6.3.5.3-1

Operator actions may be required to protect the SI pumps. The MCR and RSC should have alarms that indicate unacceptable parameters such as high bearing oil, motor winding, or motor air temperatures. Are such alarms available? If not, explain how it can be assured that two SI pumps trains remain available (when one pump is out of service) if a support system degrades or fails, as described in DCD Section 6.3.3.3, “Single Failure Considerations,” which states (in part) “assuming a single failure of an active component for a short-term following an accident.”