REQUEST FOR ADDITIONAL INFORMATION 750-5675 REVISION 2

4/28/2011

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

SRP Section: 19 - Probabilistic Risk Assessment and Severe Accident Evaluation
Application Section: DCD Chapter 19 (PRA)

QUESTIONS for PRA and Severe Accidents Branch (SPRA)

19-507

There is no COL action item in the DCD that addresses generically the issue of updating and upgrading the PRA to meet requirements needed for its intended uses and applications. Instead, a COL action item (COL 19.3(1) in DCD) is identified in the DCD which is specific to risk-managed technical specifications and calls only for updates of the PRA but not upgrades. COL Action Item 19.3(1) must be revised to indicate that it is the responsibility of COL applicants and licensees, as applicable, to update and upgrade the PRA model as necessary to meet the requirements needed for its intended uses and applications and as new or more detailed information becomes available during each of the COL application, construction, and operation phases. Specifically, COL Action Item 19.3(1) must be revised to address the following:

(a) COL applicants or licensees, as applicable, that reference the US-APWR design will update and upgrade the information in the design-specific PRA to incorporate site-specific and as-built as-operated information per 10 CFR 52.79(d)(1) or 10 CFR 50.71(h)(1).

(b) PRA will be upgraded before the implementation of risk-informed applications, as necessary, to ensure that asymmetric conditions due to modeling simplicity are eliminated or properly accounted when the PRA results are used for decision making.

(c) Revised and updated evaluations of the identified operator actions and human error probabilities will be performed as detailed design information becomes available and plant-specific EOPs are developed.

(d) COL licensees referencing the US-APWR design must develop a PRA maintenance and update program that is consistent with the PRA Standard ASME RA-S-2002 and associated addenda, RG 1.200, and the key elements listed in Section 19.1.2.4 of the DCD.

(e) It is the responsibility of COL applicants and licensees, as applicable, to update and upgrade the PRA model as necessary to meet the requirements needed for its intended uses and applications and as new or more detailed information becomes available during each of the COL application, construction, and operation phases.

(f) COL licensees will perform peer reviews of the plant-specific PRA in accordance with RG 1.200 guidance and will verify that the PRA model is of adequate quality and detail to support the proposed licensee programs and risk-informed applications.

19-508

The staff review finds that the current COL action item 19.3(6) must be modified per SRP Chapter 19.0 to address the following:

· Reference to the development and implementation of emergency operating procedures

· Reference to the risk-significant operator actions identified by the PRA and associated assumptions (listed in DCD Table 19.1-119) that a COL applicant/licensee should take into account in the development and implementation of procedures for operation, accident management, training and other human reliability related programs

· Reference to the disposition of risk-significant operator actions discussed in “key insights and assumptions” and/or elsewhere in the DCD

· Ensure that insights gained from the design-specific PRA, including the site and plant-specific information available at the COL application phase, are incorporated in the development of programs and processes which are initiated during or following the COL application phase, such as severe accident management guidelines, emergency operating procedures, reliability assurance, training and human factors engineering.

19-509

A new COL action item is needed to ensure that risk insights are used in the development of program and processes and assumptions remain valid. This new COL action item should address the following:

· Ensure that assumptions made about design features and operator actions credited in the PRA should remain valid when the PRA is used to develop such programs and processes.

· Ensure that a COL licensee referencing the certified US-APWR design will review as-designed and as-built information and conduct walk-downs as necessary to confirm that important assumptions made in the PRA about design features and characteristics (e.g., routing and location of piping and cables and HCLPF fragilities) and operator actions remain valid with respect to all applicable events and modes of operation. COL licensees referencing the US-APWR design will perform as-designed and as-built information verification and will conduct walk-downs to confirm that the assumptions used in the PRA remain valid with respect to the internal fire and flood events.

· The design-specific PRA will be updated as necessary when site-specific and plant-specific (as-built) information become available. Differences between the as-built plant and the design used as the basis for the US-APWR PRA will be reviewed to

determine whether there is significant impact on PRA results. Special emphasis will be placed on areas of the design that either were not part of the certified design or were not detailed in the certification.

19-510

MHI has included several statements in Chapter 19 of the DCD regarding the technical adequacy of the design-specific PRA that are not consistent with RG 1.200. The following statements made in Section 19.1.2 of the US-APWR DCD must be removed or revised. Alternatively, the statements can be revised to state that PRA upgrades should be considered for some future risk-informed applications (e.g., RMTS) and that the entire PRA model, not just the upgrades, will have to receive a peer review in accordance with RG 1.200 requirements:

· "The quality of the PRA is sufficient to provide confidence in the results such that the PRA may be used in regulatory decision-making to support risk-informed applications."

· "The PRA has been developed in accordance with industry consensus standards as described in Section 19.0, and has been subjected to a peer review process as defined in ASME-RA-S-2002 and associated addenda (Reference 19.1-1, 19.1-2, 19.1-3) and as outlined in the Nuclear Energy Institute (NEI) peer review guide (Reference 19.1-14)."

· "Upgrades of the PRA will receive a peer review in accordance with the requirements detailed in Section 6 of ASME-RA-S-2002 and associated addenda, but will be limited to aspects of the PRA that have been upgraded."

19-511

MHI must perform a systematic search to identify "key sources of uncertainty" from all PRA areas and list them in the DCD as part of the risk insights required by the design certification process and to ensure that uncertainties are addressed in future PRA applications. In addition, MHI should include in the DCD the following identified (in RAI responses) key sources of uncertainty:

1. CCF probability of CCW and ESW pumps
2. Unavailability due to maintenance of CCW pumps, ESW pumps, and other risk-important components
3. Failure probability of risk-important components with long testing intervals
4. Modeling of the PSVs in the PRA due to maintenance of CCW pumps, ESW pumps, and other risk-important components
5. Modeling of the CCF of I&C hardware and associated probability
6. CCF probability of basic software
7. CCF probability of support software

19-512

Based on SRP 19.0, the staff review finds that MHI must perform a systematic search to identify “key insights and assumptions” regarding design and operational features which must be included in the DCD (e.g., revise existing Table 19.1-119) with a proper disposition which ensures that these “assumptions” will remain valid in the as-to-be-built, as-to-be-operated plant. In addition, MHI must include in the DCD “key insights and assumptions,” with a proper disposition, that have been identified in responses to staff RAIs related to the following items:

1. Design and operational features that prevent interfacing systems LOCA.
2. Design and operational features that prevent intersystem CCF of check valves in the injection lines, such as: (a) different driving forces applied to the passive accumulators from the driving forces of pumps that are present in the HHI and CS/RHR systems; (b) different system testing cycles; and (c) different maintenance practices.
3. Assumptions made regarding hardware and software diversity must be stated clearly along with their basis and an appropriate disposition.
4. The assumption to install a diverse non-safety related EFW pit water level sensor.
5. Design and operational features identified in the responses to RAI Questions 19-275 and 19-383.
6. The basis for not modeling the loss of HVAC in the ESF area, where HHI and CS/RHR pumps are located.
7. The presence of interlocks, implemented on the EFW control valves and EFW isolation valves, which ensures that the SG water level is within the range for effective secondary cooling regardless of operator action.
8. The PRA assumption that the availability and reliability of all trains of safety-related systems will be controlled by the maintenance rule and configuration risk management programs, including the setting of availability goals for each one of the four trains, the tracking of availability, and comparison to the set goals.
9. The means for controlling the availability of the reactor trip and ESF actuation function of DAS.

19-513

The staff requested additional information (RAI Questions 19-97, 19-98 and 19-364) regarding the implementation of the approach that was followed to determine PRA success criteria. In some cases, credit is taken in the T-H analysis of “bounding” sequences involving multiple failures for more than the minimum set of equipment that could be available based on the success criteria. In other cases, it is not clear whether some “success” sequences are bounded by an analyzed “success” sequence. In addition, there are no T-H analyses performed to support the assumed success criteria of some mitigating systems and functions, such as the alternate containment cooling

function. Please perform a systematic investigation to demonstrate the robustness of the assumed PRA success criteria for all “success” sequences of significant frequency.

19-514

In RAI Question 19-108 the staff requested more information regarding the basis for not having modeled in SGTR sequences an operator action to depressurize the RCS in order to equalize primary and secondary pressures and stop the leak after the ruptured SG is isolated. MHI responded that this operator action was assumed to be always successful because the operator has plenty of time to perform such an action. The staff followed up with RAI Question 19-366 requesting more detailed justification. In response, MHI included a top event (event DEP) in the SGTR event tree, which represents operator failure to equalize primary and secondary pressures, without any quantification. The staff review finds that event DEP is highly risk significant (e.g., risk achievement worth (RAW) value is about $4x10^{+3}$) and it is not obvious without the benefit of a T-H analysis that its contribution to risk (e.g., as measured by the Fussell-Vesely risk importance measure) is insignificant. Furthermore, if a cutoff probability of $1x10^{-5}$ is used for DEP, the sequence CDF would be $4x10^{-8}$ per year, which is comparable to the CDF of some of the reported dominant accident sequences. For these reasons, the failure probability of DEP must be estimated and documented together with all key assumptions and bases (e.g., T-H analysis) used in the estimation. In addition, event DEP should be addressed in the accident sequence quantification and importance analysis.

19-515

In RAI Questions 19-35 and 19-327 the staff requested additional information about I&C software failures modeled in the PRA, I&C hardware CCF, assumptions regarding diversity and their probabilities and associated uncertainties. MHI responded by performing sensitivity studies, including hardware CCF, and by re-classifying applications software failures into three groups. Groups 1 and 2 impact the safety-related performance and safety monitoring system (PSMS) while Group 3 impacts non-safety related I&C systems. This information was also included in Revision 2 of the DCD. The staff’s review identified discrepancies between the provided event definitions and expected results, such as related cut sets (e.g., missing an expected cut set that includes the “transient” initiating event followed by I&C hardware CCF and failure of DAS with a frequency of $1x10^{-8}$ per year) and risk importance values (e.g., expected Group 1 software failure RAW value). The staff followed up with RAI Question 19-428 requesting clarification of the provided definitions of I&C hardware CCF and application software failures. Although in its response MHI provided more detailed information about the treatment of I&C hardware and software CCF in the system analysis, a more precise definition of these basic events is needed, in terms of what signals are impacted by each event.

19-516

In RAI Question 19-275 the staff requested additional information regarding the basis for not including failure of HVAC in fault trees other than the fault tree developed for the motor-driven EFW pumps. In its response to RAI Question 19-275, MHI stated that HVAC operation has been considered in the PRA (Class 1E GTG area, ESF area (HHI and CS/RHR pumps), Class 1E electrical area (I&C, switchgear, batteries), main control room (MCR), and EFW pump area) but it was determined that the loss of HVAC has a significant impact only on the M-D EFW pumps for the following reasons:

· HVAC is not considered essential during the PRA mission time for T-D EFW pumps and GTGs due to design features

· HVAC in the ESF area, where HHI and CS/RHR pumps are located, is not modeled because analysis has shown that design limits will not be exceeded during the PRA mission time

· HVAC in the Class 1E electric area is not modeled due to its small contribution because it is running during normal operation and operator action, if necessary, to open doors and install temporary fans

· HVAC in the MCR is not modeled because of redundancy and the fact that operator actions can also be performed from the remote shutdown console (RSC) which has a diverse HVAC.

In its response to RAI Question 19-275, MHI also identified the following design and operational features in support of their modeling of HVAC in the PRA: (1) EFW T-D pumps are designed to operate for several hours without HVAC; (2) HVAC of the MCR and RSC are diverse; and (3) Operations, such as opening the doors and installation of temporary fans, will be performed in the event of loss of HVAC of the Class 1E electrical area. The staff followed up with RAI Question 19-383 requesting clarification of the statement that “the T-D EFW pumps are designed to operate for several hours without HVAC” and more detailed information regarding the transfer of control from the MCR to the RSC. MHI responded that the time the T-D EFW pumps are required to operate during accidents is shorter than the time these pumps are designed to operate without HVAC cooling. However, the basis for this statement was not provided. Please provide a basis for this statement.

19-517

In RAI Questions 19-200 and 19-381, the staff requested clarification regarding the assumption of “different crews” made in evaluating the dependency level among human errors in SGTR sequences, such as the dependency among operator failure to close the MSIV associated with a faulted SG, the operator failure to isolate a faulted TBV and the operator failure to depressurize the primary using the SDVs. In its responses, MHI stated that “different” and “same” crews are defined based on the location where the operator action is performed. However, it appears that the same crew is performing the cognition aspects for all these actions from the control room and, therefore, the assumption of “different” crews is not valid. Please perform a systematic search of all significant accident sequences in the PRA to ensure that dependencies among operator errors are properly assessed.

19-518

In RAI 19-287, the staff requested additional information regarding the screening criteria of external hazards. Although MHI discusses criteria for screening out external hazards from detailed risk assessment, the specific analysis (PRA or bounding) of the capability of the US-APWR design to withstand site-specific external hazards other than earthquakes (e.g., external flooding and high winds) was left to be performed by the COL applicant referencing the US-APWR design. The COL Action Item 19.3(4), included in Revision 2 of the DCD, requires COL applicants referencing the US-APWR design to assess site specific information and associated external events (high winds and tornadoes, external floods, transportation, and nearby facility accidents). Please clarify this COL action item in the DCD to state that all site-specific external hazards must be addressed by screening or analysis and not just those listed in parenthesis.

19-519

In RAI Questions 19-290 and 19-389, the staff requested additional information and clarification regarding missing dominant mixed cut sets containing random failure probability higher than $1.0x10^{-3}$ in the PRA-based SMA results. Specifically, the staff requested an explanation regarding missing mixed cutsets comprised of random common cause failure (CCF) of gas turbine generators (GTGs) to start and run and seismic failure of the switchyard ceramic insulators (HCLPF of 0.08g pga). These mixed cut sets lead to station blackout with no recovery possible since no credit is taken in the PRA-based SMA for the non-safety grade alternate ac gas turbine generators. In its response MHI stated that the above described mixed cutsets have been screened out because the failure probability of the random event (i.e., unavailability of all GTGs) is lower than the cutoff value of $1.0x10^{-3.}$ The staff notes that the probability of random failure of the GTGs to start and run for their entire mission time (assumed to be 24 hours in the US-APWR PRA) is higher than the cutoff value of $1.0x10^{-3}$ when all failure modes and the entire mission time are considered. Please address in the DCD the mixed cutset resulting from a seismically-induced LOOP and the random CCF of the GTGs together with a discussion of the resulting risk, as necessary.