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US-APWR Design Certification

Mitsubishi Heavy Industries

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SRP Section: 19 - Probabilistic Risk Assessment and Severe Accident Evaluation
Application Section: Section 19.1

QUESTIONS for PRA Licensing, Operations Support and Maintenance Branch 1 (AP1000/EPR Projects) (SPLA)

19-128

A failure probability of 1.2E-5 per demand is used for the failure to open of the accumulator injection line check valves as well as for the failure to open of the check valves at the direct vessel injection (DVI) lines and the check valves at the RHR/CSS cold leg injection lines. This failure probability was taken from NUREG/CR-6928 "Industry-Average Performance for Components and Initiating Events at U.S. Commercial Nuclear Power Plants." This failure to open probability estimate, which is significantly lower than most of the other failure probabilities reported in the literature and documented in Table 7.1-1 of the PRA report, raises questions about the applicability of the NUREG/CR-6928 data to the US-APWR injection line (accumulator, DVI and RHR/CSS) check valves. The staff notes that the failure to open probability of 1.2E-5 per demand for check valves reported in NUREG/CR-6928 is based on 38,550 demands with zero failures of 729 components over a seven year period (1997 to 2004). These components were from various systems and the check valves in many of these systems operate in different conditions (e.g., in terms of the pressures that keep them closed, the presence of borated water and the length of time between flow testing) than the US-APWR injection line check valves. This argument is also supported by the average demand per year (6.6 demands per component) for the check valve population considered in the NUREG/CR-6928 study. This average demand suggests that the average testing interval for the considered population is much smaller than the two-year flow testing interval (at shutdown) of the US-APWR injection line check valves. Furthermore, the NUREG/CR-6928 study includes a caution statement (Section A.2.12.5) regarding the use of the study results in case of limited system and failure mode data sets. It should, also, be noted that the probability recommended in the Advanced Light Water Reactor (ALWR) Utility Requirements Document for the failure of a check valve to open is 1E-4 per demand (which is about a magnitude higher that the probability used in the US-APWR PRA) and that this probability is based on seven actual failures that occurred before 1990. This issue should also be addressed in conjunction with uncertainties associated with common cause failure (CCF) to open probabilities of injection line check valves (considering CCF of valves both within a system and among systems using same or similar valves). Please respond with a discussion which addresses the staff concerns regarding the modeling of the failure to open of injection line check valves in the PRA.

19-129

The success criteria for the accumulators during a medium LOCA is shown as 2 of 3 accumulators in Section 6A.2.2.2 of the PRA report but as 1 of 3 in Table 6A.2-6 “Fault Tree Common Cause Events.” Please clarify and verify the success criteria used in the common cause failure analysis of accumulators for medium LOCAs.

19-130

An important design feature of the Accumulators is the installation of two pressure indicators and two level indicators in each accumulator with high and low alarms in the main control room. These indicators are tested every two years (at refueling), according to Table 6A.2-5 of the PRA report, and their single component failure probability is relatively high (1.2E-2). The staff could not find any common cause failures (CCF) modeled in the PRA for the accumulator pressure indicators and level indicators. Please explain.

19-131

According to information provided in Section 6A.3.1.4 of the PRA report, the periodic testing of CSS/RHR components is assumed to occur once every 24 months at refueling, except for the full flow line test of the pumps which is assumed to be performed every 48 months. These testing intervals are significantly longer than the ones used in operating nuclear power plants. Therefore, the applicability of operating reactor data to US-APWR must be investigated and justified. Studies, such as the one reported in NUREG/CR-5823 “Analysis of Standby and Demand Failures Modes,” October 1992, indicate that testing policies can have a significant impact on component performance since components fail from both “standby” stresses (e.g., corrosion, oxidation and boron precipitation) and “demand” stresses (e.g., vibration and stressing of shafts). For example, the NUREG/CR-5823 study found that motor-operated valves (MOVs) exhibit mostly standby stress failure modes while standby and demand stresses are equally important for emergency diesel generators (EDGs). The longer testing intervals of the US-APWR design as compared to operating reactors, raises questions about the applicability of the demand failure rate data that are obtained from operating reactor experience to the US-APWR design PRA. The staff believes that further investigation of the applicability of the operating experience data to US-APWR is necessary. The impact of any significant design and operational differences to the data used in the PRA should be addressed for all affected systems and components. Please discuss.

19-132

It is stated in Section 6A.3.3 “Boundary Conditions and Assumptions” of the PRA report that error of omission to close several valves following testing of the CSS/RHR system has been considered. However, no errors of omission are listed in Table 6A.3-11(basic events) or in Table 6A.3-13 (human errors) and no such basic events appear in the related fault trees. Please explain.

19-133

The fault tree analysis of the charging injection (CHI) system (fault tree CHI-VS) indicates that the reliability of the system is dominated by the common cause failure (CCF) of two pairs of motor-operated valves (MOVs) which are tested every 18 months. One pair is the two Volume Control Tank (VCT) stop valves which are open during normal power operation and at least one of them must close for success. The other pair is the charging pump Refueling Water Storage Auxiliary Tank (RWSAT) suction isolation valves which are closed during normal power operation and both must open for success. A failure probability of 1.0E-3 per demand is used for the failure to open as well as for the failure to close of these MOVs. This failure probability was taken from NUREG/CR-6928 "Industry-Average Performance for Components and Initiating Events at U.S. Commercial Nuclear Power Plants" and it is significantly lower than most of the other failure probabilities reported in the literature and documented in Table 7.1-1 of the US-APWR PRA report. The staff notes that the failure to open or to close probability of 1.0E-3 per demand for MOVs reported in NUREG/CR-6928 is mostly based on quarterly testing intervals as opposed to the 18-month testing intervals proposed by the US-APWR design CHI system MOVs. It should, also, be noted that the failure rate recommended in the Advanced Light Water Reactor (ALWR) Utility Requirements Document for the failure of an MOV to open or to close is 1E-5 per hour. If this failure rate were used, the failure probability of an MOV to open or to close would be 6.5E-2 per demand (instead of 1E-3 used in the US-APWR PRA) and the CCF probability would be 1.1E-3 (instead of 4.7E-5 used in the US-APWR PRA). Please provide justification for the failure data used for MOVs in the US-APWR PRA.

19-134

In Table 6A.4-3 of Chapter 6A.4 "Charging Injection System" of the US-APWR PRA document it is stated: "The water of the refueling water auxiliary tank is injected into the cold leg piping through the charging line by the charging pump, provided that the water of the refueling water storage pit is supplied to the tank." In the same Table, the operator action to "Supply water from the RWSP to RWSAT" is stated. However, this operator action is not listed in Table 6A.4-6 "Fault Tree Human Error Events for Charging Injection System" or anywhere else in Chapter 6A.4-3. Please clarify how the operator action needed to supply water from the RWSP to RWSAT, including the failures of any associated hardware, were modeled in the PRA.

19-135

The tag numbers used in Figure 19.1-2 (line diagram of the Charging Injection System) for the components modeled in the PRA are different from those used in the US-APWR Design Control Document (DCD). This major inconsistency, which is also present in several other systems (e.g., the Emergency Feedwater System), complicates the review of the PRA and its proposed applications, such as the implementation of the risk-managed technical specifications (RMTS) program, and makes the interpretation and communication of the PRA results and insights cumbersome. The staff expects the applicant to remove these inconsistencies throughout the PRA document before the staff's review of the design certification PRA is completed.