REQUEST FOR ADDITIONAL INFORMATION 443-3332 REVISION 1

8/25/2009

US-APWR Design Certification

Mitsubishi Heavy Industries

Docket No. 52-021

SRP Section: 19 - Probabilistic Risk Assessment and Severe Accident Evaluation
Application Section: 19.1.6

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

19-391

(Follow-up to Questions 19-340 and 19-27) The sensitivity study performed in response to Question 19-340 of RAI 369 revealed the importance of starting safety injection (SI) pumps to recover level following a shutdown initiating event. In this case, a change to the dependence model increased this human error probability (HEP) (HPIOO02S-DP2) by a factor of three and shutdown CDF by a factor of about two, because the HEP appears in cutsets that contribute more than 60 percent to the shutdown CDF. This response, as well as the response to Question 19-27 of RAI 1 (which states that no features are available to automate reactor coolant system (RCS) injection), led the staff to examine the reliance on operator action during shutdown more closely.

Several operator actions appear in cutsets that contribute significantly to the plant operating state (POS) 8-1 CDF, and thereby total shutdown CDF. In particular, failure to start an SI pump for RCS injection appears in cutsets that contribute more than 5 percent to POS 8-1 CDF; as a dependent failure following failure to perform a previous task, this action appears in cutsets that contribute more than 63 percent of the POS 8-1 CDF. In addition, starting a charging pump, either to recover level and enable use of residual heat removal (RHR) or for RCS injection, with action to align a makeup water source if needed, is important. Independent and dependent failures related to the charging system appear in cutsets that contribute nearly 70 percent of the POS 8-1 CDF.

Therefore, automation of some means of RCS injection (whether from charging or SI) is likely to cause a significant decrease in shutdown risk. If this function were safety-related and included in technical specifications (TS), further confidence in its availability would be gained. Because one of the standard review plan (SRP) criteria for the staff's review is that the design represents a reduction in risk compared to operating plants, please describe the process for evaluating design changes based on their potential risk benefit. In addition, please provide the results of sensitivity studies showing the risk reduction if either charging or SI or both were automated (based on a signal such as low RCS level) during shutdown, and compare this risk reduction to the threshold for considering changes to the design. Finally, if changes are planned, discuss whether these changes necessitate more detailed modeling of systems (e.g., support systems for the gravity injection and secondary heat removal functions) that are currently simplified because operator actions dominate the PRA results.

19-392

(Follow-up to Question 19-342) The response to Question 19-342 describes plans to improve the shutdown PRA by adding software common-cause failures (CCF) and sensor failures related to operator actions. However, the response states that failure of instrumentation and control (I&C) hardware is unlikely to occur within the mission time and will not be modeled. This assumption requires further justification. The response to Question 19-324 of RAI 364 states that I&C hardware CCFs will be added to the at-power model. The mission times for the at-power and shutdown models are equivalent. In addition, the mean time to repair (MTTR) for some equipment in the at-power model is based on TS requirements, of which there are few during shutdown. Please justify why I&C hardware failures should be included in the at-power PRA but not the shutdown PRA, or revise the PRA and DCD to include the effect of these failures.

19-393

(Follow-up to Questions 19-317 and 19-144) The responses to Questions 19-144 and 19-317 clarified that nozzle dams will not be installed without a large opening in the RCS (i.e., the pressurizer manway) that will prevent repressurization following a loss of decay heat removal. DCD Tables 19.1-76 and 19.1-77 indicate “RCS close” and steam generators (SG) isolated in POS 4-3 and 8-1, respectively. This designation is misleading because it does not reflect the large opening. Please revise this table to reflect the expected shutdown configuration.

19-394

(Follow-up to Question 19-280) In response to Question 19-280 of RAI 149, the applicant provided a list of operator actions performed during shutdown. This table shows that a time window of one hour was assumed for each. The staff could not locate a justification for this one-hour window either in the PRA or the DCD. Although one hour is less than the time to uncover the core estimated for each plant operating states (POS) in the PRA, it is unclear that the operators can wait until the core is nearly uncovered to take the actions outlined in the attachment. For example, successful starting of a standby residual heat removal (RHR) pump may depend on taking action before boiling occurs in the reactor coolant system (RCS). In some POS, boiling may commence in less than one hour following a loss of RHR. Also, the time until the core is uncovered may be less than an hour following an unisolated loss-of-coolant accident (LOCA), over-drain, or failure to maintain level. Therefore, the staff requests, for each operator action credited in the shutdown PRA:

a. a statement of the condition (e.g., boiling or uncovering the core) that ends the time window for this action (for various initiating events if applicable)

b. the estimated time before this condition occurs in each POS

b. a justification that the action can be completed within the time window

19-395

(Follow-up to Question 19-346) Please clarify whether the water level sensor (which compares pressure at the vessel head vent line and crossover leg) described in the response to Question 19-346 is a temporary or permanent sensor. If it is temporary, discuss how issues with temporary sensors such as Tygon tubing, described in NUREG-1449, have been addressed for this device. If it is permanent, please discuss whether it should be included in the design description of the RCS rather than as a potential measure to be implemented.

19-396

(Follow-up to Question 19-349) The response to Question 19-349 states that "[t]he ability to close the containment without AC [alternating current] power is minimal and may not be possible." The industry guidance in NUMARC 91-06 refers to the need for AC power to achieve containment closure and the use of temporary staged power supplies when needed.

(a) Please clarify whether containment closure (including hatch replacement) depends on offsite power or can be supported by the onsite gas turbine generators.

(b) Please discuss whether the insight related to obtaining "maximum confidence in off-site and on-site power reliability" (e.g., limiting switchyard maintenance) when RCS inventory is reduced should be added to the DCD.

(c) Given that losses of offsite power contribute about 20 percent of shutdown risk, please discuss whether any insights related to provision of power for containment closure (temporary or otherwise) should be added to the DCD.

(d) Please discuss whether the insight that "[c]ases in which inventory is low in the reactor are preferentially performed with the containment intact" should be added to the DCD.

19-397

(Follow-up to Question 19-351) The response to Question 19-351 describes temperature indications during shutdown as follows: "As for inaccurate hot leg temperature measurement after loss of flow, reactor coolant hot leg temperature instruments are located in the flow path during RHR operation, so this parameter can be accurately indicated." This statement is confusing, because it discusses both a loss of flow and RHR operation. The attachment to Generic Letter (GL) 88-17 suggests that two independent, continuous temperature indications representative of the core exit conditions be available in mid-loop when the head is on the vessel, as well as that these indications be monitored and alarmed. In addition, the statement is made that instrumentation in the hot and cold legs will not reflect vessel temperatures in a loss of decay heat removal system flow. Please discuss how the guidance in GL 88-17 has been applied to the US-APWR temperature indication and update the proposed DCD revision from the response to Question 19-351 as appropriate.