RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

APR1400 Design Certification

Korea Electric Power Corporation / Korea Hydro & Nuclear Power Co., LTD

Docket No. 52-046

RAI No.: **232-7864**

SRP Section: **SRP 19**

Application Section: **19.1**

Date of RAI Issued: **09/30/2015**

Question No. 19-9

10 CFR 52.47(27) requires that a standard design certification applicant provide a description of the design specific PRA and the results. SRP Chapter 19, Revision 3 (Draft), “Design-Specific PRA (PRA for Non-Power Modes of Operation)” states that, “Given that shutdown risk may be highly outage-specific, the staff reviews the shutdown PRA insights to confirm that operational assumptions used to develop an average shutdown model (e.g., use of nozzle dams, outage schedule, containment status, procedural requirements) have been clearly documented in the FSAR.” In DCD Section 19.1.6, the staff understands POS 12B was screened from the average shutdown model based on thermal-hydraulic analysis. The analysis assumes the time to core damage is greater than 24 hours after a loss of shutdown cooling. However, losses of inventory occurring in POS 12B may result in core damage before 24 hours. The staff understands that for the LOCA cases, the applicant has performed analyses that conclude that core uncovery does not occur until 23.7 hours, and core damage does not occur within the simulation time of 25 hours. Thus, the staff requests that the applicant (1) document in the DCD the results of POS 12B thermal-hydraulic analyses for LOCA and non-LOCA cases and (2) document in the DCD core cooling mitigation strategies for LOCA and non-LOCA cases to ensure that a safe and stable state is reached.

Response

(1) Table 1 shows the results of thermal-hydraulic analyses for POS12B.

Table 1 The Results of Thermal-Hydraulic Analyses for POS 12B

Items	Non-LOCA Case	LOCA Case
Event time (Decay heat)	539.1 hours after reactor trip (8.559 MWt)	
RCS Initial condition	Pressure: 0.101325 MPa(1 kg/cm2)(14.7 psia), Cold leg temperature: 40 oC (= 313.15 K)(104 oF)	
RCS Initial condition	28.2% Pressurizer level	28.2% Pressurizer level
SG secondary side Initial condition	Wet Lay Up level Main/Aux. feedwater closed MSIV closed	Wet Lay Up level Main/Aux. feedwater closed MSIV closed
SG secondary side Initial condition	ADV Closed	ADV Closed
Analysis condition	t=0 sec, Loss of shutdown cooling	t=0 sec, Loss of shutdown cooling t=0 sec, coolant leakage initiated
Simulation time (ts)	90000 sec (25.0 hours)	90000 sec (25.0 hours)
RCS Peak pressure	1.747 MPa (17.8 kg/cm^2) (253.4 psia), (t=25.0 hours)	1.558 MPa (15.9 kg/cm^2) (226.0 psia), (t=25.0 hours)
LTOP Valve opening time	N/A	N/A
RCS Peak temperature	469.0 K (205.7 oC) (402.2 ^{o}F), (t=25.0 hours)	473.2 K (200.0 oC) (392.1 ^{o}F), (t=25.0 hours)
Core boiling time (tcb)	37176sec(10.33 hours)	16713sec(4.64 hours)
Core uncovery time (tcu)	-	85395sec(23.72 hours)
Time to Core damage (tcf)	-	-

(2) Core cooling mitigation strategies for LOCA and non-LOCA cases are below.

(a) Early Inventory Makeup and Isolation for LOCA

- If the LOCA is detected early, prompt action to provide RCS makeup can prevent level from dropping below that needed to support SCS operation. Prompt action to maintain RCS inventory will provide simple subsequent recovery and mitigation efforts.

- If initial RCS makeup or operation of the standby SCS train fails, then isolation of the LOCA can allow an intact RCS to pressurize and heat up. With the intact RCS, secondary cooling can be used for decay heat removal.

- The success criterion for LOCA isolation is to isolate the initially-running SCS train before RCS inventory decreases below that needed to support secondary cooling.

(b) Restore SCS for LOCA and non-LOCA

- The SCS is the primary means of decay heat removal once RCS has been cooled and depressurized below operating limits for the SCS. There are two trains of SCS with one pump and one heat exchanger per train. During the shutdown operations, one of the trains is in operation providing cooling and the other normally is in standby but aligned and ready for use.

- The LOCA or non-LOCA initiating event renders the initially-operating SCS train unavailable. After failure of the operating SCS train, the operators will attempt to restore SCS cooling by starting the standby train. Restoration of the SCS must occur before RCS temperature and pressure increase above SCS operating limits or the loss of RCS inventory lowers level below that needed to support operation.

(c) Feed and Bleed Cooling for LOCA and non-LOCA

- If all other ways of decay heat removal fail, then the operators can initiate feed and bleed cooling. Injection by the SI system provides a source of makeup to the RCS.

- Depending on the POS, heat removal can be through several paths.

  - If the RCS is intact, operators can open the POSRVs and the pressure created by one SI pump injecting will provide sufficient back pressure to open and maintain the POSRVs open. Flow from the POSRVs is directed back to the IRWST and, therefore, available for continuous injection.

  - If the RCS is not intact, then fluid will flow from the opening into the containment.

Impact on DCD

DCD 19.1 will be revised to reflect the response of this RAI.

Table 1 which is provided as the response of this RAI will be added as Table 19.1-92 as shown in the Attachment 1.

And the core cooling mitigation strategies for LOCA and Non-LOCA will be added as item i in the DCD 19.1.6.1.1.5 and the content for explaining the added table will be added on the end of DCD 19.1.6.1.1.5 as shown in the Attachment 2.

Impact on PRA

There is no impact on the PRA.

Impact on Technical Specifications

There is no impact on the Technical Specifications.

Impact on Technical/Topical/Environmental Reports

There is no impact on any Technical, Topical, or Environmental Report.

Table 19.1-92 (3 of 3)

POS	Equation Name	System Success Criteria	Timing Information	Comments
12A	TCP12AFB TSP12AFB	Injection with 1 of 4 SI trains	Core damage occurs at 7.4 hours	
13	TCP13FB1 TSP13FB1	Injection with 1 of 4 SI trains Bleed with 1 of 4 POSRVs	Core damage occurs at 19.6 hours	This timing is based on LTOP relief valves closing after pressure is reduced.
13	TCP13FB2 TSP13FB2	Injection with 1 of 4 SI trains	Core damage occurs at 7.0 hours	This timing is based on one LTOP valve sticking open after first lift at 5.9 hours. Core damage is assumed to occur 1.1 hours after first LTOP lift at 7.0 hrs. This timing is based on the thermal-hydraulic analysis for POS3A.

Table 19.1-92a is added after Table 19.1-92 as shown in next page.

Table 19.1-92a

The Results of Thermal-Hydraulic Analyses for POS 12B

Items	Non-LOCA Case	LOCA Case
Event time (Decay heat)	539.1 hours after reactor trip (8.559 MWt)	
RCS Initial condition	Pressure: 0.101325 MPa(1 kg/cm2)(14.7 psia), Cold leg temperature: 40 °C (= 313.15 K)(104 °F)	
RCS Initial condition	28.2% Pressurizer level	28.2% Pressurizer level
SG secondary side Initial condition	Wet Lay Up level Main/Aux. feedwater closed MSIV closed	Wet Lay Up level Main/Aux. feedwater closed MSIV closed
SG secondary side Initial condition	ADV Closed	ADV Closed
Analysis condition	t=0 sec, Loss of shutdown cooling	t=0 sec, Loss of shutdown cooling t=0 sec, coolant leakage initiated
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Core uncovery time (tcu)	-	85395sec(23.72 hours)
Time to Core damage (tcf)	-	-

c. Failure to begin secondary cooling before RCS level drops below the top of the hot leg is assumed to result in failure of secondary cooling.

d. One SG is assumed to be rendered unavailable by planned outage activities when the plant enters POS 4A.

e. The success criteria and time available for operator actions and events occurring in POS 3B is assumed to be the same as for events that occur in POS 3A. Since RCS temperature is lower in POS 3B, the timing for events is expected to take longer and, therefore, this assumption is conservative.

f. If feed and bleed cooling is used in POS 3A, containment design pressure would be exceeded after 24 hours. Although containment ultimate pressure capability will not be exceeded within 24 hours, operator action to begin IRWST cooling is assumed to be required to provide reasonable assurance safe, stable conditions.

g. Success criteria for unrecoverable LOCA (JL) events are analyzed assuming that the maximum break is the 34.1 m^3/hr (150 gpm) flow rate of the CVCS letdown line that occurs at-power.

The text is added as i as shown in A

h. Success criteria for LTOP safety valve fails to reclose (RL) events are based on the relief capacity of one LTOP relief valve.

Tables for the success criteria for LPSD various initiating event categories and operating states are shown in Table 19.1-89 through Table 19.1-92.

And table for results of thermal-hydraulic analyses for success criteria of POS 12B is shown in Table 19.1-92a.

19.1.6.1.1.6 Human Reliability Analysis

The human reliability analysis (HRA) for the LPSD PRA is performed using the same methods as the at-power PRA described in Subsection 19.1.4.1.1.7.

Operator actions that respond to events that occur in Technical Specification Mode 2 or Mode 3 are assumed to be the same as the responses to events that occur at-power. Although the time available for response to an event in Mode 2 or Mode 3 is expected to be longer, thereby resulting in a lower HEP, this conservatism is considered to be negligible to overall risk because the time spent in these modes is short.

A

i. Core cooling mitigation strategies for LOCA and non-LOCA cases of POS 12B are below.

(a) Early Inventory Makeup and Isolation for LOCA

If the LOCA is detected early, prompt action to provide RCS makeup can prevent level from dropping below that needed to support SCS operation. Prompt action to maintain RCS inventory will provide simple subsequent recovery and mitigation efforts. If initial RCS makeup or operation of the standby SCS train fails, then isolation of the LOCA can allow an intact RCS to pressurize and heat up. With the intact RCS, secondary cooling can be used for decay heat removal. The success criterion for LOCA isolation is to isolate the initially-running SCS train before RCS inventory decreases below that needed to support secondary cooling.

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(c) Feed and Bleed Cooling for LOCA and non-LOCA

If all other ways of decay heat removal fail, then the operators can initiate feed and bleed cooling. Injection by the SI system provides a source of makeup to the RCS. Depending on the POS, heat removal can be through several paths. If the RCS is intact, operators can open the POSRVs and the pressure created by one SI pump injecting will provide sufficient back pressure to open and maintain the POSRVs open. Flow from the POSRVs is directed back to the IRWST and, therefore, available for continuous injection. If the RCS is not intact, then fluid will flow from the opening into the containment.