REVISED 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.:	**418-8348**
SRP Section:	**SRP 19**
Application Section:	**19.1**
Date of RAI Issue:	**02/23/2016**

Question No. 19-49

10 CFR 52.47(a)(27) requires that a standard design certification applicant provide a description of the design specific PRA.

SRP Chapter 19.0, Revision 3 (Draft), Section “II. Acceptance Criteria,” states that the staff determines whether, “…the technical adequacy of the PRA is sufficient to justify the specific results and risk insights that are used to support the DC or COL application.

Toward this end, the applicant’s PRA submittal should be consistent with prevailing PRA standards, guidance, and good practices as needed to support its uses and applications and as endorsed by the NRC (e.g., RG 1.200).”

The staff noted that the PRA documentation (APR1400-K-P-NR-013503-P) considered flooding initiating events caused by inadvertent operation or erroneous operation of a plant component during maintenance.

The applicant concluded that these scenarios do not contribute significantly to the overall initiating event frequency. Please justify this conclusion in the DCD, for both at power and LPSD conditions.

Response – (Rev.1)

DCD Section 19.1.5.3.1.5 will be revised to include justification that maintenance-induced internal flooding events are considered to be negligible contributors to full power internal flooding risk (see Attachment 1).

DCD Section 19.1.6.4.1.3 will be revised to include justification that maintenance-induced internal flooding events are considered to be negligible contributors to LPSD internal flooding risk (see Attachment 2).

Table 19.1-4 in DCD 19.1 will be revised to include the key assumption for the maintenance induced flood events (See Attachment 3).

Section 2.1.1 of PRA documentation APR1400-K-P-NR-013503-P will be revised to include the maintenance induced flood event (The markup PRA documentation has been uploaded in the ERR (location: 01 PRA/SA/RAP – Audit / No_33(Submitted RAI Response)-1 /13_19-49 (RAI 418-8348))

Impact on DCD

Subsection 19.1.5.3.1.5, 19.1.6.4.1.3 and Table 19.1-4 in DCD 19.1 will be revised as shown in Attachments 1, 2 and 3.

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 Environment Report.

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piping penetrations, are assumed to be capable of withstanding the steam pressure transient.

j. Unless explicitly analyzed, failure of a pipe containing water above saturated conditions is assumed to actuate all fire protection systems in the room in which the break occurs as well as in any room where significant propagation occurs.

k. Significant propagation of steam is assumed to occur only through failed doors, open passageways, open stairwells, HVAC ducting, and open floor grating. While some propagation of steam would occur through open pipe and cable penetrations or EOL lines, this propagation is not considered significant and fire protection system actuation is not considered.

l. Failure of auxiliary steam (AS) or steam generator blowdown (SD) system piping in the auxiliary building is assumed to be incapable of resulting in pipe whip or unique jet impingement failures.

m. Lines that are not normally pressurized or charged, such as drain lines or abandoned in-place systems, are not considered as credible flood or spray sources. For example, relief lines downstream of a relief valve are not normally pressurized and are not included.

19.1.5.3.1.5 Initiating Event Analysis

The flooding-induced initiating events are divided into three categories of causes:

a. Tank rupture events causing flooding

b. Maintenance-related events causing flooding

c. System pipe rupture events causing flooding

No tank ruptures are identified as causing unique effects or contributing to internal flooding events. ~~Maintenance-induced flooding events are considered in the analysis, but a bounding analysis is performed to demonstrate that the maintenance-induced flooding event is a negligible contributor to the overall initiating event frequency.~~

New text is added as shown in A

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Maintenance-induced flooding events are considered in the analysis using a bounding analysis to estimate their frequency. The frequency of unisolated, maintenance-induced floods was calculated with the following equation:

$$F_T = F_m * P_f * P_I$$

where

F_T = Total frequency of unisolated, maintenance-induced floods while reactor is at power

F_m = Frequency of maintenance while reactor is at power

P_f = Probability that isolation fails initially and flood event is initiated

P_I = Probability that initiation of flooding is not detected immediately and flooding proceeds in the long term to adversely impact multiple systems

Maintenance unavailability values for fluid systems that could result in flooding events are shown in Table 6-1 of NUREG/CR-6928 (Reference 11).

The unavailability values are used as an annual frequency for maintenance events. Since no operational data exists for APR1400, a screening value of 5E-03 will be used to assess maintenance isolation failure. The probability that initiation of a flooding event is not immediately detected and the flooding event secured before causing subsequent equipment damage will use a screening value of 0.05.

The highest value for maintenance unavailability shown in Table 6-1 of NURG/CR-6928 (Reference 11) that is potentially applicable to APR1400 is 3E-02. Using this value and the screening values above, the frequency of maintenance events causing an internal flooding initiating event is calculated as:

$$F_T = 3E\text{-}02/yr * 5.0E\text{-}03 * 0.05$$

$$F_T = 7.5E\text{-}06 \text{ per year}$$

This value would bound flood events because it considers that all maintenance unavailability involves activities that breach the fluid pressure boundary. In practice, it is expected that only about ten percent of maintenance events actually breach the pressure boundary which would result in a maintenance-induced flood frequency of 7.5E-07 per year. Comparing this frequency to the pipe break frequency calculated values calculated for the internal flooding analysis, it is concluded that maintenance-induced flooding events are negligible contributors to the overall initiating event frequency.

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Maintenance-induced flooding events are expected to be insignificant contributors to overall flooding risk. However, absent the availability of plant-specific maintenance procedures and equipment unavailability data, calculation of maintenance-induced flood frequency cannot be performed. The COL applicant will demonstrate that maintenance-induced floods are negligible contributors to risk when such information is available.

to recover the SCS via the standby train, if it is available. If this action is not successful, the operators must proceed to feed and bleed cooling.

19.1.6.4.1.4 Success Criteria

No changes to the success criteria are made for the internal flooding analysis, relative to the LPSD internal events PRA model. The same criteria for shutdown cooling (including supporting heat sinks), feed and bleed (including supporting heat sinks), and containment cooling are used throughout the evaluation.

New text is added as shown in A

19.1.6.4.1.5 Operator Actions

No changes are made to the LPSD internal events human error probabilities (HEPs) for the LPSD flood analysis. The operator actions for isolating LPSD pipe breaks involve similar timing and required similar actions as those operator actions for isolating at-power pipe breaks, so no new HEPs for LPSD are introduced.

19.1.6.4.1.6 Systems Analysis

No new systems are modeled for LPSD flooding, nor are any existing models expanded or revised for the LPSD flood analysis.

19.1.6.4.2 Results from Internal Flooding PRA for Low Power and Shutdown Operations

19.1.6.4.2.1 Risk Metrics

The CDF for LPSD flooding is 1.8×10^{-8}/year. This figure will be approximately two orders of magnitude less than LPSD internal events and internal fire, both of which are in the low 1×10^{-6}/year range for LPSD CDF. The LPSD flooding large release frequency (LRF) is not quantified. As an upper bound, it is assumed to be less than 1.8×10^{-8}/year. It should be noted that units for CDF and LRF are expressed in terms of “reactor calendar year” (shortened to “/year” when displayed in the text in this section).

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~~Maintenance-induced flooding events are considered to be negligible contributors to LPSD internal flooding risk. As detailed in Section 19.1.5.3.1.5, the frequency of maintenance-induced flooding events was calculated using a bounding analysis to be less than 7.5E-07 per year, which is small in comparison to random system breaks. Furthermore, maintenance during shutdown is controlled on a divisional basis so that it is not likely that maintenance will be performed on the division of the operating shutdown cooling system if only one division is available. This practice further diminishes the potential for maintenance-induced floods to cause an initiating event during LPSD conditions.~~

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19.1.6.4.1.2 Initiating Events

The at-power flood analysis was reviewed to identify all floods that can submerge either of the SC pumps or their power supplies. In some cases, floods are identified that could submerge both pumps.

The flooding initiating events are verified to determine that the representative flow rates from the at-power model remained applicable for LPSD analysis. When necessary, some flow rates are adjusted (e.g., by expanding to include a wider range of potential flow rates). In addition, very low flood flow rates in the SC pump rooms are considered, in order to include potential spray vulnerability for the pump motors.

The volume of water necessary to cause submergence failure of the SC pumps was calculated and found to be different than the volume of water required to cause a reactor trip during power operations. This submergence volume is used to screen flooding sources that contained insufficient volume to damage the SC pumps. Additionally, this new volume is used to calculate a minimum flow rate required to result in submergence failure of the SC pumps within a time period in which the operators are expected to always be able to successfully isolate the break. A number of initiators are requantified using this new minimum flow rate.

Ruptures of the heat sinks for the SCS (component cooling and service water) are subsumed into general failures of the SCS and are not reanalyzed. Some CC system ruptures are retained because they could potentially fail a power supply and thus posed a broader threat than the loss of an SC train.

New Text is added as shown in A

19.1.6.4.1.3 Accident Sequence

The AS development for LPSD flooding uses the loss of shutdown cooling sequences in the LPSD internal events analysis. While there are many initiating events (i.e., many floods that can fail one or both trains of SC), each unique IE use the same, basic loss of shutdown cooling (LOSC) event tree for the subsequent accident analysis.

Since the initiating events are failures of the running train of shutdown cooling, the sequences include the same potential recovery actions. First, the operators would attempt

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bolts (versus the 40 bolts used to secure the hatch during at-power operation); four bolts are sufficient to secure the hatch so that no visible gap can be seen between the seals and the sealing surface. See Subsection 19.1.6.2.

COL 19.1(15) The COL applicant is to develop a configuration control program requiring that, during Modes 4, 5, and 6, the watertight flood doors and fire doors be maintained closed in at least one quadrant. Furthermore, the COL applicant is to incorporate, as part of the aforementioned configuration control program, a provision that if the flood or fire doors to this designated quadrant must be opened for reasons other than normal ingress/egress, a flood or fire watch must be established for the affected doors.

COL 19.1(15) The COL applicant is to develop outage management procedures that limit planned maintenance that can potentially impair one or both SC trains during the shutdown modes.

COL 19.1(16) The COL applicant is to develop procedures and a configuration management strategy to address the period of time when one SC train is unexpectedly unavailable (including the termination of any testing or maintenance that can affect the remaining train and restoration of all equipment to its nominal availability).

COL 19.1(17) The COL applicant will demonstrate that maintenance-induced floods are negligible contributors to flood risk when the plant specific data are available.

19.1.10 References

1. ASME/ANS RA-S-2008, "Standard for Level 1/Large Early Release Frequency Probabilistic Risk Assessment for Nuclear Power Plant Applications" (Revision 1 RA-S-2002), American Society of Mechanical Engineers, April 2008.

2. ASME/ANS RA-Sa-2009, "Addenda to ASME/ANS RA-S-2008," American Society of Mechanical Engineers, February 2009.

3. Regulatory Guide 1.200, "An Approach for Determining the Technical Adequacy of Probabilistic Risk Assessment Results for Risk-Informed Activities," Rev. 2, U.S. Nuclear Regulatory Commission, March 2009.

Table 19.1-4 (25 of 25)

No.	Insight	Disposition
Risk Insights from PRA Models		
58	The fire PRA assumes that the fire barrier management procedures used during LPSD will include directions to provide reasonable assurance that breached risk-significant fire barriers can be closed in sufficient time to prevent the spread of fire across the barrier. The procedural direction is to include the use of a fire watch whose duties are commensurate with the risk associated with the barrier. For example, for fire barriers that separate two fire compartments that both contain no equipment or cables necessary to prevent core damage or large early release during LPSD conditions, or have been demonstrated to have low risk significance, there will at least be a roving fire watch to check the barrier during rounds. For fire barriers separating fire compartments that contain equipment or cables necessary to prevent core damage or large early release during LPSD conditions, and have been demonstrated to be risk significant with respect to fire, a permanent fire watch will be established until the barrier is reclosed. In the latter case, the fire barrier management procedure is to direct that hoses or cables that pass through a fire barrier use isolation devices on both sides of a quick-disconnect mechanism that allow for reclosure of the barrier in a timely fashion to re-establish the barrier prior to fire spread across the barrier.	Subsection 19.1.6.3.1.2 COL 19.1(11)
##	The flood PRA assumes that maintenance-induced flooding events is an insignificant contributors to overall flood risk.	Subsection 19.1.5.3.1.5 Subsection 19.1.6.4.1.2 COL 19.1(17)