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.:	**409-8325**
SRP Section:	**SRP 19**
Application Section:	**19**
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Question No. 19-28

10 CFR 52.47(a)(27) requires that a standard design certification applicant provide a description of the design specific PRA and the results. The low-power shutdown (LPSD) large release frequency (LRF) contribution from midloop operation is reduced because credit is taken for initiation of safety injection (SI) to arrest core damage in the vessel as a severe accident mitigation guidelines (SAMG) action. However, a key contributor to the LPSD core damage frequency (CDF) in the mid-loop plant operational state (POS) is due to operator failure to initiate SI before core damage. The staff noted that credit for the SAMG action of initiating SI is included in the Containment Event Tree top event, MELTSTOP. The staff searched through the LPSD human reliability analysis (HRA) notebook and could not find how dependence between the Level 1 and Level 2 LPSD PRA was calculated for these two actions or what factors were considered in the dependence calculation (e.g. similar alarms and cues). The staff is requesting KHNP to provide the staff additional information on how dependence was calculated between the operator action to initiate SI to prevent core damage and the SAMG action to initiate SI to arrest core damage in the vessel and to update the DCD, as necessary. The staff needs this information to better understand the numerical results of the KHNP LPSD PRA.

Response – (Rev. 4)

To provide more detail of the action credited, DCD Section 19.1.6.2.1.3 was revised in the DCD, Rev. 1, as described in the Attachment 1 of Rev. 0 response of this RAI. COL 19.1(25) is added to ensure that it is appropriate to credit entry into SAMGs when the core exit thermocouples reach 1200°F, see Attachment 1.

The LPSD CDF and LRF are highly dependent on the LPSD human error probabilities, as is expected for an LPSD PRA. To ensure that the dependence between HEPs is properly evaluated, the LPSD model includes an HEP dependency analysis using the same methodology as in the at-power PRA which includes identifying and incorporating dependency between Level 1 and Level 2 HEPs.

With regard to how dependence was calculated, the LPSD LRF HEP dependency analysis utilizes the same methodology as in the at-power PRA which includes identifying and incorporating dependency between Level 1 and Level 2 HEPs. Significant combinations of events were identified and the dependence between the events analyzed. If the combination of all HEPs within a cutset would result in a total HEP of less than 10-6 for the cutset, then a floor HEP of 10-6 was applied.

To evaluate the significant of the use of a floor HEP of 10^{-6}, a sensitivity evaluation was performed on the LPSD internal events Level 2 PRA. The sensitivity utilized a floor HEP of 10^{-5}. The result was that the internal events LRF from POSs 4B-12A increased from 7.0×10^{-8}/year to 9.3×10^{-8}/year, and the total LPSD internal events LRF (all POSs) increased from 1.2×10^{-7}/year to 1.4×10^{-7}/year. This sensitivity demonstrates that the total impact of the floor HEP utilized in the dependency analysis does not significantly impact the LRF.

To reflect the sensitivity calculation, DCD Section 19.1.6.2.2.7 will be revised as shown in the Attachment 2.

The sensitivity demonstrates that the impact on the total LPSD LRF is small and would not alter the conclusions of the DCD.

Impact on DCD

The DCD changes from the previous responses to this RAI have been incorporated into Revision 1 of the DCD; therefore, only the pages containing changes as a result of Revision 4 of this response are included in the Attachment 1 and 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 Technical/Topical/Environmental Report.

seismic-fire ignition sources, or near fire protection equipment is adequate, and 3) either the duration of activities which could impact manual firefighting is minimized, or alternative firefighting equipment (e.g., pre-stage portable smoke removal equipment, prestage additional firefighting equipment, etc.) is supplied.

COL 19.1(22) The COL applicant is to demonstrate that failure of buildings that are not seismic Category I (e.g., turbine building and compound building) does not impact SSCs designed to be seismic Category I.

COL 19.1(23) The COL applicant is to ensure that asymmetric conditions due to modeling simplicity will be addressed or properly accounted for when the PRA is used for decision making.

COL 19.1(24) The COL applicant will demonstrate that maintenance-induced floods are negligible contributors to flood risk when the plant specific data are available.

COL 19.1(25) SAMGs are entered to initiate SI with the core exit thermocouple indicating 1200°F.

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.

4. NUREG/CR-2300, "PRA Procedures Guide," U.S. Nuclear Regulatory Commission, January 1983.

5. NUREG/CR-1150, "Severe Accident Risks: An Assessment for Five U.S. Nuclear Power Plants," U.S. Nuclear Regulatory Commission, December 1990.

COL 19.1(25) SAMGs are entered to initiate SI with the core exit thermocouple indicating 1200°F.

Table 1.8-2 (36 of 38)

Item No.	Description
COL 19.1(21)	The COL applicant is to develop outage procedures to ensure that in fire compartments containing post-seismic or post-fire safe shutdown equipment that: 1) the seismic ruggedness of temporary ignition sources is adequate, or that the duration that these temporary ignition sources are in these areas is minimized, 2) the seismic ruggedness of temporary equipment such as scaffolding in fire compartments containing potential seismic-fire ignition sources, or near fire protection equipment is adequate, and 3) either the duration of activities which could impact manual firefighting is minimized, or alternative firefighting equipment (e.g., pre-stage portable smoke removal equipment, prestage additional firefighting equipment, etc.) is supplied.
COL 19.1(22)	The COL applicant is to demonstrate that failure of buildings that are not seismic Category I (e.g., turbine building and compound building) does not impact SSCs designed to be seismic Category I.
COL 19.1(23)	The COL applicant is to ensure that asymmetric conditions due to modeling simplicity will be addressed or properly accounted for when the PRA is used for decision making.
COL 19.1(24)	The COL applicant will demonstrate that maintenance-induced floods are negligible contributors to flood risk when the plant specific data are available.
COL 19.2(1)	The COL applicant is to perform and submit site-specific equipment survivability assessment in accordance with 10 CFR 50.34(f) and 10 CFR 50.44 which reflects the equipment identified and the containment atmospheric assessments of temperature, pressure and radiation described in Subsection 19.2.3.3.7.
COL 19.2(2)	The COL applicant will demonstrate that the covers for large penetrations such as equipment hatch and personnel airlocks meet the Service Level C requirements in Subsection NE-3220 of the ASME code and explain how the consideration of containment leakage is accounted for when modeling local regions of containment.
COL 19.2(3)	The COL applicant is to develop and submit an accident management plan.
COL 19.3(1)	The COL applicant is to perform site-specific seismic hazard evaluation and seismic risk evaluation as applicable in accordance with NTTF Recommendation 2.1 as outlined in the NRC RFI.
COL 19.3(2)	The COL applicant is to address the flood requirements for wet sites
COL 19.3(3)	The COL applicant is to develop the details for offsite resources.
COL 19.3(4)	The COL applicant is to address the details of selecting suitable storage locations for FLEX equipment that provide reasonable protection during specific external events as provided in NEI 12-06 guidance Sections 5 through 9, and the details of the guidance for storage of FLEX equipment provided in the Technical Report (Reference 5) Section 6.2.9.
COL 19.3(5)	The COL applicant is to confirm, satisfy, or fulfill the specific design functional requirements of raw water tank including the associated instrument, capacity, location, flow path to on-site, the valve pit connected to FLEX equipment, and any other design features as described in Section 19.3 in support of BDBEE mitigation strategies.
COL 19.3(6)	The COL applicant is to confirm and ensure that the raw water tank and flow path to the FLEX equipment (structures, piping, components, and connections) are designed to be robust with respect to applicable hazards (e.g., seismic events, floods, high winds, and associated missiles).

Table 19.1-4 (23 of 26)

No.	Insight	Disposition
	Risk Insights from PRA Models	
55	Passive autocatalytic recombiners (PARs) and igniters are normally placed to cope with at-power accidents, but hydrogen control should also be considered for LPSD configurations. The COL applicant should provide reasonable assurance that there is sufficient hydrogen control during a severe accident condition when the RCS is open (e.g., pressurizer manway, etc.).	COL 13.5(7)
56	Solid state switching devices and electro-mechanical relays resistant to relay chatter are used in the safety I&C platforms. Use of these devices and relays either eliminates or minimizes the mechanical discontinuities associated with mechanical relays at operating reactors.	Subsection 7.4.2.5
57	The COL applicant is to perform a seismic walkdown to provide reasonable assurance that the as-designed and as-built plant conforms to the assumptions in the PRA-based seismic margins analysis and that seismic spatial systems interactions do not exist. Details of the seismic walkdown are to be developed by the COL applicant.	COL 19.1(4)
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(15) COL 19.1(14)
~~##~~	~~SAMGs are entered to initiate SI with the core exit thermaocouple indicating 1200F~~	~~Subsection 19.1.6.2.1.3~~ ~~COL 19.2(2)~~

~~The LPSD CDF and LRF are highly dependent on the LPSD human error probabilities, as is expected for an LPSD PRA. In the development of the LRF model, the application of the dependent HEP event for SAMG initiation of safety injection to prevent vessel failure resulted in some cutsets that contain 3 or 4 operator actions to have a total combined human error probability below 1E-5. A sensitivity was performed examining what the impact to LRF would be if a floor HEP of was applied to each cutset in which the total probability of all operator actions was restricted to 1E-5 or higher. The result of the sensitivity was that the total LRF of POSs 4B-12A would increase from 6.64E-8/yr to 7.23E-8/yr (8.9% increase). The total LRF of all POSs would increase from 1.18E-7/yr to 1.24E-7/yr (5.1% increase). Therefore, the sensitivity demonstrates that the impact on the total LPSD LRF is small and would not alter the conclusions of the DCD.~~

19.1.6.3 Internal Fire PRA for Low Power and Shutdown Operations

The following subsections describe the development of the internal fires risk evaluation during low power and shutdown conditions, and the analysis results.

19.1.6.3.1 Description of Internal Fire PRA for Low Power and Shutdown Operations

The low power and shutdown (LPSD) fire PRA (FPRA) methodology for the APR1400 is based on NUREG/CR-7114 (Reference 52) and NUREG/CR-6850 (Reference 6). NUREG/CR-7114 provides a framework for quantitative analysis of fire risk during LPSD conditions. NUREG/CR-6850 provides a state-of-the-art methodology for fire PRAs. The steps in the LPSD fire PRA methodology are the same as those used in the full-power internal fire PRA (FP-FPRA) (see Subsection 19.1.5.2.1) with the exception that they are applied to the LPSD internal events model (see Subsection 19.1.6.1). The exceptions to the at-power FPRA methodology used in the development of the LPSD FPRA are described below. 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).

19.1.6.3.1.1 Deviations from the Industry Methodology

All of the tasks described in Subsection 19.1.5.2.1 are required to perform a LPSD FPRA. These tasks involve various types of screening to eliminate assessment of non-risk-significant fire scenarios. Since the plant is in the design stage, some specific plant details

The LPSD CDF and LRF are highly dependent on the LPSD human error probabilities, as is expected for an LPSD PRA. In the development of the LRF model, consistent with the CDF model, a floor HEP of 10^{-6} was applied to cutsets with a combined probability of all human errors below 10^{-6}. A sensitivity was performed examining what the impact to LRF would be if a floor HEP of 1E-5 was utilized. The result of the sensitivity was that the total LRF of POSs 4B-12A would increase from 7.0×10^{-8}/year to 9.3×10^{-8}/year (33 percent increase). The total LRF of all POSs would increase from 1.2×10^{-7}/year to 1.4×10^{-7}/year (20 percent increase). Therefore, the sensitivity demonstrates that the impact on the total LPSD LRF is small, and would not alter the conclusions of the DCD.