

KHNPDCRAIsPEm Resource

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Sent: Tuesday, March 08, 2016 10:13 AM
To: apr1400rai@khnp.co.kr; KHNPDCRAIsPEm Resource; Andy Jiyong Oh; James Ross; Young H. In (yhin@enercon.com)
Cc: Phan, Hanh; Mrowca, Lynn; Steckel, James; Lee, Samuel; Williams, Donna
Subject: APR1400 Design Certification Application RAI 434-8352 (19 - Probabilistic Risk Assessment and Severe Accident Evaluation)
Attachments: APR1400 DC RAI 434 SPRA 8352.pdf

KHNP,

The attachment contains the subject request for additional information (RAI). This RAI was sent to you in draft form. Your licensing review schedule assumes technically correct and complete responses within 30 days of receipt of RAIs. However, KHNP requests, and we grant, the following RAI question response times. We may adjust the schedule accordingly.

120	19-85:	120 days
120	19-86:	120 days
90	19-87:	90 days
90	19-88:	90 days
90	19-89:	90 days
90	19-90:	90 days
30	19-91:	30 days
90	19-92:	90 days
90	19-93:	90 days
90	19-94:	90 days

Please submit your RAI response to the NRC Document Control Desk.

Thank you,

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Issue Date: 03/08/2016

Application Title: APR1400 Design Certification Review – 52-046

Operating Company: Korea Hydro & Nuclear Power Co. Ltd.

Docket No. 52-046

Review Section: 19 - Probabilistic Risk Assessment and Severe Accident Evaluation

Application Section:

QUESTIONS

19-85

10 CFR 52.47(a)(27) states that a DC application must contain an FSAR that includes a description of the design-specific PRA and its results. In addition, Standard Review Plan (SRP) Chapter 19.0, draft Revision 3, Items 25 through 37 on Pages 19.0-18 and 19.0-19 provide the acceptance criteria for a PRA-based seismic margin analysis (SMA) submitted in support of a design certification (DC) application, in part, it states that “The staff will determine that the applicant has performed a PRA-based SMA to determine the seismic capacity of the plant and for each sequence that may lead to core damage or large release.” In addition, SRP Chapter 19, Section III “Review Procedures / Design-Specific PRA (PRA-Based SMA),” states “It is important that the plant systems analysis focus on those sequences leading to core damage or containment failures, including applicable sequences leading to the following containment failures: (1) loss of containment integrity, (2) loss of containment isolation, and (3) loss of function for prevention of containment bypass. The applicant should address the following operating modes in the analysis: (1) at power (full power), (2) low power, and (3) shutdown.”

In APR1400 DCD, Section 19.1.5.1.1 “Description of the Seismic Risk Evaluation,” the applicant describes the methodology (Tasks (a) through (g)) used to evaluate the seismic margin. However, the staff review finds that, among these tasks, only Task (b) “Development of seismic equipment list” and Task (e) “Fragility analysis” are discussed in detail in Sections 19.1.5.1.1.1 and 19.1.5.1.1.2, respectively. Therefore, in order for the staff to reach a reasonable assurance finding, please address by providing and discussing in detail the analyses performed for Tasks (a), (c), (d), (f), and (g) in the APR1400 DCD, including the following items:

- a) Consequential initiating events that were actually quantified in the seismic model
- b) Recoveries of mitigating systems and seismic related failures that were credited in the PRA-based seismic margin analysis (SMA)
- c) The modeling of structures, systems, and components (SSCs) that are not on the seismic equipment list (SEL) in SMA analysis, if any
- d) The protection against flooding, spraying, steam impingement, pipe whip, jet forces, missiles, fire and the effect of failure of any non-seismic Category I equipment
- e) Evaluation of human error probabilities (HEPs) for the operator actions included in the analysis
- f) Operator actions that were identified as being important to mitigating seismic accident sequences
- g) Accident sequences (at cutset level) that were examined to assess the plant-level high confidence of low probability of failures (HCLPF) capacity
- h) Evaluation of containment performance as described in Section 5.1.1 of DC/COL-ISG-20 as referenced in the SRP so that the appropriate Level 2 SSCs are appropriately included in the SEL
- i) Significant functions, SSCs, and operator actions that are limiting in determining the plant-level HCLPF capacity.

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19-86

10 CFR 52.47(a)(27) states that a design certification (DC) application must contain an FSAR that includes a description of the design-specific PRA and its results. For additional guidance, Standard Review Plan (SRP) Chapter 19.0, draft Revision 3, Section II "Acceptance Criteria," Item 28 states "The staff will determine that a seismic equipment list (SEL) has been prepared which documents the SSCs associated with the accident sequences that will require seismic fragility evaluation for determining sequence-level HCLPF."

The staff reviewed APR1400 DCD Section 19.1.5.1.1.1 "Development of Seismic Equipment List" and the SEL provided in Table 19.1-42 and found the information provided in this section is insufficient for the staff to make a determination regarding the completeness and acceptability of this SEL.

Therefore, in order for the staff to reach a reasonable assurance finding, please address by discussing in detail in the APR1400 DCD the following items:

- a) Why the medium loss of coolant accident (LOCA) is not considered as seismic initiating event
- b) How the reactor coolant pump (RCP) seal cooling (especially, the components necessary to maintain RCP thermal barrier cooling) is modeled in PRA-based seismic margins assessment (SMA) to maintain cooling to the RCP seals and thereby maintain the integrity of RCS
- c) Why the large fuel oil storage tanks are not included in the SEL
- d) Why the non-seismic Category I major structures, where failure could impact the structures, systems, and components (SSCs) on the SEL, are not included in the SMA analysis (i.e., access building, fuel oil storage tanks building, etc.)

19-87

10 CFR 52.47(b)(1) and 10 CFR 52.80(a) require, in part, that applications for a design certification (DC) include the inspections, tests, analyses and acceptance criteria (ITAAC) necessary to demonstrate that the facility has been constructed and will be operated in conformity with the NRC regulations. In addition, Section 14.3, "Inspections, Tests, Analyses, and Acceptance Criteria," indicates that "the important insights and assumptions from the PRA provided in DCD Chapter 19 should be used to determine the appropriate top-level design features for inclusion in Tier 1. A discussion of how the important insights or assumptions from the PRA should be addressed in the selection of the Tier 1 material. The important integrated plant safety analyses from Tier 2 should be considered, such as analyses of internal events, fires, floods, severe accidents, and shutdown risk."

Accordingly, in order for the staff to reach a reasonable finding that the application includes the appropriate ITAAC associated with the PRA as noted above, please describe in detail how the APR1400 PRA was used in determining the scope of ITAAC and include the discussion in the DCD. In addition, the staff reviewed APR1400 DCD and could not find any ITAAC that were derived from the important PRA assumptions and insights, therefore, please revise the DCD to identify these ITAAC.

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19-88

10 CFR 52.47(a)(27) states that a DC application must contain an FSAR that includes a description of the design-specific PRA and its results. For additional guidance, Standard Review Plan (SRP) Chapter 19.0, draft Revision 3, Section II, "Acceptance Criteria," Item 9E on Page 19.0-14 states "Peer review of the DC PRA is not required prior to application. However, if a peer review was conducted prior to the application; the staff should examine the peer review report. If a certain aspect of the PRA deviates from accepted good practices, the applicant/holder should justify that this deficiency does not impact the PRA results or risk insights. Otherwise, applicants/holders need to correct the deficiency and resubmit the PRA results and risk insights. If a peer review has not been performed, the applicants/holders should justify why their PRAs are adequate in terms of scope, level of detail, and technical acceptability. PRA self-assessment is an acceptable tool for assessing the technical adequacy of a PRA performed in support of an application for a design certification."

The staff reviewed APR1400 design control document (DCD) Section 19.1.2, "Quality of PRA" and Table 19.1-1 "Characterization of PRA Relative to Supporting Requirements in ASME PRA Standard," and compared the information against the peer review report, entitled "RG 1.200 PRA Peer Review Against the ASME PRA Standard Requirements for the APR-1400-DC PRA," dated August 2013, and found discrepancies and inconsistencies among these documents.

Therefore, in order for the staff to reach a reasonable finding that the scope, level of detail, and technical adequacy of the design-specific PRA are appropriate, please address the following items and revise the DCD accordingly:

- a) Provide more detailed information and justification for the statement(s) stated in DCD Table 19.1-1 that most aspects of the PRA elements satisfy ASME/ANS PRA Standard Capability Category II or greater.
- b) Clarify whether the supporting requirements (SRs) identified in Table 19.1-1 as "do not meet at least Capability Category II" would meet Capability Category I of the ASME/ANS PRA Standard "RA-Sa-2009", and if not state why.
- c) Identify the actions taken to disposition the peer review findings provided in the peer review report and discuss the associated impacts of these findings on APR1400 DC Application.
- d) Identify the ASME/ANS PRA Standard SRs categorized as "not applicable" during the DC stage and state why.
- e) Justify the impacts on DCD Chapter 19 for those SRs, if any, identified as "does not meet" during DC stage.
- f) Characterize the impacts on APR1400 DC PRA resulting from the SRs identified as "cannot meet" during DC stage.
- g) Explain the inconsistency in the Capability Category grading as provided in the peer review report and DCD Table 19.1-1.
- h) Discuss the technical adequacy of APR1400 fire and low power and shutdown PRAs and justify their sufficiency to support the DC application.

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19-89

10 CFR 52.47(a)(27) states that a DC application must contain an FSAR that includes a description of the design-specific PRA and its results. In addition, SRP Chapter 19.0, draft Revision 3, Section I, "Areas of Review," states "The purpose of the staff's review is to ensure that the applicant has adequately addressed the Commission's objectives regarding the appropriate way to address consideration of severe accidents and the use of PRA in the design and operation of facilities under review."

The staff reviewed APR1400 DCD Section 19.1.1, "Uses and Applications of the PRA," and found the following statement "At the design phase, the PRA results are used as information providing input to Technical Specifications (Chapter 16), reliability assurance program (RAP) (Section 17.4), human factors engineering (Section 18.6), severe accident evaluation (Section 19.2), and other design areas." However, the staff found no explanation on how the APR1400 PRA affected these programs.

In order for the staff to reach a reasonable assurance finding that the APR1400 PRA is appropriately used during the DC stage, please describe in detail, in addition to the discussion provided in Section 19.1.3.4 "Uses of the PRA in the Design Process," how the APR1400 PRA has been used in providing input to the Technical Specifications (Chapter 16), human factors engineering (Section 18.6), and severe accident evaluation (Section 19.2) as mentioned in the APR1400 DCD and the impacts on these programs.

19-90

10 CFR 52.47(a)(27) states that a DC application must contain an FSAR that includes a description of the design-specific PRA and its results. In addition, Standard Review Plan (SRP) Chapter 19.0, draft Revision 3, Section IV "Evaluation Findings," Item 3 states "The PRA reasonably reflects the as-designed, as-built, and as-operated plant, and the PRA maintenance program will ensure that the PRA will continue to reflect the as-designed, as-built, and as-operated plant, consistent with its identified uses and applications."

Therefore, in order for the staff to reach an assurance finding on the conformance to SRP Chapter 19.0 regarding PRA maintenance and update, please describe the process for monitoring PRA inputs and tracking the issues/findings (e.g., design changes, peer review findings, staff review findings, model errors, etc..) for which PRA update is needed. Also, describe the process for maintaining and upgrading the PRA to be consistent with the certified design and revise the DCD accordingly.

19-91

10 CFR 52.47(a)(27) requires that a design certification (DC) application must contain an FSAR that includes a description of the design-specific PRA and its results. In addition, Standard Review Plan (SRP) Chapter 19.0, draft Revision 3, Section II, "Acceptance Criteria," Item 10 on Page 19.0-14 states "The staff will determine that 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)." Regarding the computer codes used to support PRA development and quantification, the NRC regulatory positions on Pages B-62 and B-71 of the Appendix B to Revision 2 of RG 1.200, on the Supporting Requirements QU-B4 and QU-F2 of ASME/ANS PRA Standard, include the following: "the base computer code and its

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inputs have been tested and demonstrated to produce reasonable results,” and “Normal industry practice requires documentation of computer code capabilities. Confirm availability of documentation, or generate as necessary to support applications. Also needed to confirm computer code has been sufficiently verified such that there is confidence in the results,” respectively.

During the discussion in the June 25, 2015 public conference call between the NRC and KHNP and in its response to Question PRA-120 from the APR1400 PRA audit, KHNP informed the staff that the entire PRA software platform will be switched to EPRI R&R Workstation, i.e., SAREX and TREX to CAFTA.

Therefore, in order for the staff to reach an assurance finding on the conformance to SRP Chapter 19.0 and RG 1.200, which endorses ASME/ANS PRA Standard “RA-Sa-2009,” regarding the use of PRA codes, please identify any associated APR1400 DC changes as a result of the software platform changes. Also, make available for audit the following:

- a) The change documentation including meaningful results comparisons and disposition of differences between the old and new codes as discussed in Example 11 on Page 35 of ASME/ANS PRA Standard RA-Sa-2009.
- b) The PRA notebooks (mark-up version if available) reflecting the PRA quantification from the new platform.

19-92

10 CFR 52.47(a)(27) states that a design certification (DC) application must contain an FSAR that includes a description of the design-specific PRA and its results. In addition, SRP Chapter 19.0, draft Revision 3, Section II “Acceptance Criteria,” Item 4 on Page 19.0-13 states “The staff will determine that the applicant has identified risk-informed safety insights based on systematic evaluations of the risk associated with the design such that the applicant can identify and describe the following: A. The design’s robustness, levels of defense-in-depth, and tolerance of severe accidents initiated by either internal or external events and B. The risk significance of potential human errors associated with the design.” In addition, Item 13 on Page 19.0-16 states “The staff will determine that the assumptions made in the applicant’s PRA during design development and certification, in which a specific site may not have been identified or all aspects of the design (e.g., balance of plant) may not have been fully developed, are identified in the DC application and either remain valid or are adequately addressed within the COL application.” Furthermore, Item 14 on Page 19.0-16 states that “The staff will determine that FSAR Chapter 19 includes PRA qualitative results, including the identification of key PRA assumptions, the identification of PRA-based insights, and discussion of the results and insights from importance, sensitivity, and uncertainty analyses.”

Thus, in this context, the staff reviewed APR1400 DCD Table 19.1-4 “Risk Insights and Key Assumptions” and found this table is not comprehensive in identifying the APR1400 PRA-related key assumptions and insights. Therefore, in order for the staff to reach a reasonable assurance finding, please enhance Table 19.1-4 of the DCD to identify all PRA key assumptions and PRA-based insights, and also the insights from the importance, sensitivity, and uncertainty analyses.

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19-93

10 CFR 52.47(a)(27) states that a DC application must contain an FSAR that includes a description of the design-specific PRA and its results. For additional guidance, SRP Chapter 19.0, draft Revision 3, Section I, "Areas of Review," states that "The staff should issue a request for additional information (RAI) and conduct audits of the complete PRA (e.g., models, analyses, data, and codes) to obtain clarifying information as needed. The staff will document any NRC audits performed in audit reports so that they may be referenced in the staff's safety evaluation report (SER)."

During the review of APR1400 DCD, Revision 0, and the regulatory audit (conducted from April 15, 2015 through October 15, 2015) of PRA, severe accident (SA) evaluation, and reliability assurance program (RAP), the staff has found several potential issues regarding the information provided in the design control document (DCD) and discussed these concerns at public meetings and teleconferences. In a number of instances, KHNP committed in its responses to revise the APR1400 DCD to resolve the staff's findings. These actions are documented in the PRA/SA/RAP tracking list (ADAMS ML15292A030), which contains proprietary information.

Therefore, in order for the staff to complete its review of the APR1400 DC application and to reach a reasonable assurance finding, the staff requests that KHNP revise the APR1400 DCD as committed during the PRA/SA/RAP regulatory audit, for the following tracking list items:

- a) PRA-176 - Provide additional information in Chapter 19 to be consistent with Item "o" on Page 10.4-75 of Chapter 10, which stated "The AFWS is designed to have unavailability from 1E-5 to 1E-4 per demand as described in Chapter 19."
- b) PRA-209 - Provide clarification for not including the probability of in-containment refueling water storage tank (IRWST) suction strainer plugging as a key risk insight. This probability value is assumed not to increase relative to the power operation PRA model.
- c) PRA-210 - Provide clarification for not including the containment closure during reduced inventory conditions and the operability of safety injection during Modes 4, 5, and 6 as a key risk insights.
- d) PRA-227 - Provide clarification for not including the assumption that the core exit thermocouples monitor coolant temperature down to 37.8 °C (100 °F) prior to withdrawal of containment event trees (CETs).
- e) PRA-128 - Describe in the DCD the methodology and key assumptions used in evaluating the core-concrete interaction in the sump.
- f) PRA-224 - Revise DCD Table 19.1-29 to be consistent with Notebook APR100-K-P-NR-013603-P."
- g) SA-3 - Provide justification for flow path of dispersed corium to the upper containment during high pressure melt ejection event.

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19-94

10 CFR 52.47(a)(27) states that a design certification (DC) application must contain an FSAR that includes a description of the design-specific PRA and its results. As discussed in Standard Review Plan (SRP) Chapter 19.0, draft Revision 3, Section I "Areas of Review," the NRC expects that, generally, the information that it needs to perform its review of an application from a PRA perspective is that information contained in the applicant's FSAR Chapter 19. The staff should issue a request for additional information (RAI) and conduct audits of the complete PRA (e.g., models, analyses, data, and codes) to obtain clarifying information as needed. The staff will document any NRC audits performed in audit reports so that they may be referenced in the staff's safety evaluation report (SER).

During the review of APR1400 DCD, Revision 0, and the regulatory audit (conducted from April 15, 2015 through October 15, 2015) of PRA, severe accident (SA) evaluation, and reliability assurance program (RAP), the staff has found inconsistencies with information in the DCD and audited documents and discussed these concerns at public meetings and teleconferences. In its responses, KHNP committed to revise the APR 1400 PRA notebook(s) to be consistent with the information provided in the DCD. These actions are documented in the PRA/SA/RAP tracking list (ADAMS ML15292A030), which contains proprietary information.

Therefore, in order for the staff to complete its review of the APR1400 DC application and to reach a reasonable assurance finding, the staff requests that KHNP revise the PRA notebooks or DCD, as committed during the PRA/SA/RAP regulatory audit, for the following tracking list items:

- a) PRA-140 - The Level 2 at-power internal flooding information.
- b) PRA-190 - The) PRA-190 - The hydrogen control system notebook regarding the operations of passive autocatalytic recombiners during Modes 1 through 6.
- c) PRA-218 - Notebook "APR1400-K-P-NR-013602-P," Event 5 branch split fraction.
- d) PRA-219 - The core damage frequency (CDF) and large release frequency (LRF) values in notebook APR1400-K-P-NR-013604-P.



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