KHNPDCDRAIsPEm Resource

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Sent: Tuesday, March 08, 2016 9:58 AM
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Cc: Neuhausen, Alissa; Xu, Jim; Phan, Hanh; Steckel, James; Lee, Samuel; Williams, Donna
Subject: APR1400 Design Certification Application RAI 433-8363 (19 - Probabilistic Risk Assessment and Severe Accident Evaluation)
Attachments: APR1400 DC RAI 433 SEB1 8363.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.

19-70: 90 days
19-71: 90 days
19-72: 90 days
19-73: 60 days
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19-80: 60 days
19-81: 90 days
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19-84: 90 days

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

Thank you,

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REQUEST FOR ADDITIONAL INFORMATION 433-8363

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

19-70

10 CFR 50.44(c)(5) and SECY-93-087 require a deterministic analysis that demonstrates containment structural integrity under internal pressure loads. Regulatory Guide 1.216, Regulatory Position 3 discusses the methods acceptable to the staff to address the Commission's performance goal related to the prevention and mitigation of severe accidents. The use of the Factored Load Category (FLC) for concrete containments is acceptable to demonstrate the deterministic performance goal for the first 24 hours.

APR1400 design control document (DCD) Tier 2, Section 19.2.4, "Containment Performance Capability," does not provide a description of the finite element models of the containment. The staff reviewed the information contained in the DCD, and in supporting calculations 1-316-C304-006 "Containment Building Capacity Evaluation on Severe Accident (Global) and 1-316-C304-007 "Containment Building Capacity Evaluation on Severe Accident (Local)". The staff identified information that needs to be clarified and explained in the DCD to complete its evaluation. This information includes modeling details, description of computer codes, material properties and material modeling, loading and loading sequences, failure modes, and interpretation or results. The staff requests the applicant provide reference to the Severe Accident Report in the appropriate section of the DCD. In accordance with Regulatory Position 3 of RG 1.216, the applicant is requested to address the following at a level of detail consistent with 10 CFR 50.47 and include this information in the DCD:

1. A description of the global and local nonlinear finite element models. Include a description of computer codes. The description should discuss how the large penetrations were treated in the models. The discussion should also include the treatment of smaller penetrations and penetration closure components.
2. The accident temperature associated with the severe accidents conditions. The staff requests the applicant provide a basis for assuming the accident temperature. Additionally, provide an explanation of how accident temperatures were considered in selecting the material properties in the analysis, specifically for concrete strength. Calculation 1-316-C304-006 describes the effects of temperatures on the material properties for concrete, steel reinforcement, prestressing tendons, and the steel liner that should be included in the DCD.
3. A description of the material modeling for the concrete containment in the DCD. These properties are currently described in calculation 1-316-C304-006 and include the stress-strain relationship used for steel corresponding to the accident temperature, the stress-strain relationship used for concrete corresponding to the accident temperature, and any other material properties important to the model.
4. An adequate technical justification for all simplifications and the applicability to the particular containment design and loading condition. Simplifications include assumptions made based upon the use of test results. The staff notes that test results are presented in Appendix E of the Severe Accident Report, and requests that these be incorporated

into the DCD. As an example, address the appropriateness of a static analysis and whether dynamic response effects are important.

5. A description of the analysis results.

19-71

10 CFR 50.44(c)(5) and SECY-93-087 require a deterministic analysis that demonstrates containment structural integrity under internal pressure loads. Regulatory Guide 1.216, Regulatory Position 3 discusses the methods acceptable to the staff to address the Commission's performance goal related to the prevention and mitigation of severe accidents. Specifically, RG 1.216 states that "an acceptable way to identify the more likely severe accident challenges is to consider the sequences or plant damage states that, when ordered by percentage contribution, represent 90 percent or more of the core damage frequency".

APR1400 design control document (DCD) Tier 2, Section 19.2.4, "Containment Performance Capability," does not clearly explain how the more likely severe accidents were identified. The staff reviewed the information contained in the DCD, and in supporting calculations 1-316-C304-006 and 1-316-C304-007. The staff identified information that needs to be explained in the DCD to complete its evaluation. In accordance with RG 1.216, Regulatory Position 3, the applicant is requested to address the following in the DCD:

1. Provide the technical basis for identifying the more likely severe accident challenges. In Section 19.2.4, the methodology for selecting the more likely severe accident challenges is not clearly explained. In calculation #1-316-C304-006, Table 4-1, the maximum pressures and temperatures corresponding to severe accident scenarios station blackout (SBO), large-break loss-of-coolant accident (LBLOCA), and total loss of feed water (TLOFW) are provided. The basis for selecting these severe accidents is not clear to the staff.
2. In Section 19.2.3.3.7.2.2, the applicant states that the bounding containment pressure expected during a severe accident is 95.3 psig (110 psia). This section does not explain which severe accident corresponds to this accident pressure, which is greater than those accident pressures provided in calculation #1-316-C304-006 stated to produce the most significant pressure loading histories. Additionally, in calculation #1-316-C304-006 the highest pressure generated is a result of the LLOCA scenario. The staff requests that the bounding severe accident and pressure are included in DCD Section 19.2.4. This is consistent with RG 1.216 Regulatory Position 3, Section 3.1b, "From the set of pressure and temperature transient loadings… identify which pair of pressure and corresponding temperature loadings envelope the entire set of pressure and temperature loadings." The staff also requests the applicant explain why SBO was selected as the representative severe accident, since it is not bounding, and describe how the analysis would have been different had a different severe accident been selected as the representative severe accident.
3. In calculation #1-316-C304-006, the results of the analysis are presented for SBO loading. Clarify what pressure load corresponds to the results provided in Table 5-2. Confirm that the results presented in calculation #1-316-C304-007 Section 5 correspond to the same pressure load.

4. In calculation #1-316-C304-006, the applicant describes a process using a pressure amplification factor between Tables 4-1 and 4-2. It is not clear what is meant by pressure amplification factor. Please explain what is meant by pressure amplification factor and explain how it is related to the ratio between the pressure obtained for each severe accident scenario and the maximum pressure and temperature for performance assessment. Please also explain how the maximum pressure provided in Table 4-2 was determined.

19-72

10 CFR 50.44(c)(5) and SECY-93-087 require a deterministic analysis that demonstrates containment structural integrity under internal pressure loads. Regulatory Guide 1.216, Regulatory Position 3, discusses the methods acceptable to the staff to address the Commission's performance goals related to the prevention and mitigation of severe accidents. The use of the Factored Load Category (FLC) for concrete containments is acceptable to demonstrate the deterministic performance goal for the first 24 hours.

In Section 19.2.4.2.1, the applicant states: "Considering the safety margin of APR1400 containment, for the FLC, the pressure resulting from 100 percent metal water reaction of fuel cladding and resulting from uncontrolled hydrogen burning is determines as 8.7 kg/cm^2 (123.7 psia)". Please clarify whether this pressure corresponds to the pressure at which the liner strain equals the limits established by the FLC requirements of ASME Code, Section III, Division 2, Subarticle CC-3720. Otherwise, please clarify how the 8.7 kg/cm^2 (123.7 psia) pressure value was determined. Clarify what "considering the safety margin" means.

19-73

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. SECY 93-087 approves an alternative approach to seismic PRA for the design certification (DC) application and interim staff guidance (ISG) 20 provide guidance on the methods acceptable to the staff to demonstrate acceptably low seismic risk for a DC.

Based on the staff review of APR1400 DCD Tier 2, Section 19.1.5, the staff needs additional information to confirm the validity of the applicant's high confidence in low probability of failure (HCLPF) capacities. The staff expectation at the DC stage is that the design of structures within the scope of DC is essentially complete. Consequently, it is also expected that all the critical structural sections are identified, and the structural HCLPF values are specific to APR1400. In order to evaluate the application, the staff requests the applicant address the following:

a. Provide the bases and justifications for the assumed HCLPF values (including screened out components). Provide a detailed description of the methodologies used for obtaining the structures, systems, and components (SSCs) HCLPF capacities. Provide a detailed description of HCLPF capacities for structures, systems and components (SSCs) obtained through calculations. Provide strategies for ensuring adequate as-built HCLPF

capacities for those SSCs whose capacities were determined by means other than calculations. For all the above, as applicable, provide the basis and justification for determining HCLPF capacities via alternate methods relative to ISG-20.

b. Demonstrate the seismic margin of 1.67 times the certified seismic design response spectra (CSDRS) for the seismic Category I structures against the seismic induced sliding and overturning.

c. Based on the information provided in Section 19.1.5.1.1.2, List Item f, provide the basis for the assumption that failure of buildings that are not seismic Category I do not impact SSCs designed to be seismic Category I for the review-level earthquake (RLE). Explain how this will be confirmed by the combined license (COL) applicant.

19-74

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. SECY 93-087 approves an alternative approach to seismic PRA for the DC application and interim staff guidance (ISG) 20 provide guidance on the methods acceptable to the staff to demonstrate acceptably low seismic risk for a DC.

(a) Design control document (DCD) Section 19.1.5.1.1(e) states “At the design certification phase, specific design data such as material properties, analysis results, qualification test information, etc. are not available. Where available, information from the reference plant is used for the component fragility. The generic data are based on the fragilities provided by the Electric Power Research Institute (EPRI) Utility Requirements Document (Reference 37).” Clarify whether at the DC stage the design of structures within the scope of DC is essentially complete, and the above statement applies to systems and components only.

(b) DCD Table 3.2-1 lists the classification of structures, systems, and components. The emergency diesel generator building (EDGB) is listed as Seismic Category I. Further, Table 19.1-43 of the DCD lists the High Confidence of Low Probability of Failure (HCLPF) capacity for the EDGB as 0.67g, and indicates that it is an assumed value. HCLPF capacities for the other Category I structures included in the design certification are stated to be qualified by analysis. Given that EDGB is designated as seismic Category I, is within the scope of DC, is addressed in the seismic analysis in DCD Section 3.6, and design details are shown in DCD Chapter 3, Section 3.8A, Figures 38A-53 through 3.8A-56, the staff requests the applicant to provide a fragility and HCLPF capacity derivation specifically for the EDGB.

19-75

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. SECY 93-087 approves an alternative approach to seismic PRA for the DC application and interim staff guidance (ISG) 20 provide guidance on the methods acceptable to the staff to demonstrate acceptably low seismic risk for a DC. As per the guidance in DC/COL-ISG-020, Section 5.1.2, two methods, namely the

separation of variables (EPRI Report TR-103959) and conservative deterministic failure margin (CDFM; EPRI Report NP-6041) are acceptable to the staff for determining seismic fragility.

a. Design Control Document (DCD) Section 19.1.5.1, Table 19.1-43 provides specific fragilities (i.e., high confidence in low probabilities of failure (HCLPFs)) for the Containment Building Exterior Walls, Containment Building Interior Structure, and the Auxiliary Building. The table indicates that these specific seismic fragilities were derived by analysis. The staff requests the applicant to describe the methodology used for developing these specific seismic fragilities, and to include pertinent references for the methodology and any generic data or assumptions (e.g., failure modes, capacity and response factors, and associated uncertainties) used to develop HCLPF capacities for the Containment Building Exterior Walls, Containment Building Interior Structures, and Auxiliary Building.

b. DCD Section 19.1.5.1.1.2 states, “The seismic fragilities (mean failure probabilities) for the component groups are calculated based on values of A_M, β_R, β_U for these components at an HCLPF value of 0.5g and a relative acceleration of 1.0g”. Clarify what is meant by a relative acceleration of 1.0g with regards to the seismic fragility.

19-76

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. SECY 93-087 approves an alternative approach to seismic PRA for the DC application and interim staff guidance (ISG) 20 provide guidance on the methods acceptable to the staff to demonstrate acceptably low seismic risk for a DC.

Design Control Document (DCD) Table 3.2-1 lists the classification of structures, systems, and components. The Essential Service Water (ESW) Building and Component Cooling Water (CCW) Heat Exchanger Building are listed as Seismic Category I. DCD Section 19.1.5.1.1.2 also identifies the CCW heat exchanger building and ESW building as Seismic Category I structures that involve safety-related structures, systems and components (SSCs) to prevent core damage. In DCD Section 3.7.2, the applicant states that “the COL applicant is to provide the seismic design of seismic Category I SSCs that are not part of the APR1400 standard plant design”. Since these buildings are categorized as Seismic Category I structures, the COL applicant is responsible for ensuring that the Essential Service Water Building and Component Cooling Water Heat Exchanger Building satisfy the APR1400 seismic design basis for Seismic Category I structures.

Given that the ESW and CCW heat exchanger building house safety-related components to prevent core damage which are included on the seismic equipment list (SEL), the staff requests the applicant provide the justification for not including these structures on the SEL.

19-77

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. SECY 93-087 approves an alternative approach to seismic PRA for the DC application and interim staff guidance (ISG) 20

provide guidance on the methods acceptable to the staff to demonstrate acceptably low seismic risk for a DC.

Design Control Document (DCD) Section 19.1.5.1, Table 19.1-43, lists the high confidence in low probability (HCLPF) capacities resulting from several qualification methods (i.e. analysis, generic data, generic DB, and test data). The staff requests the applicant describe what is meant by the entries: analysis, Generic DB, Generic, and Test.

The staff requests the applicant describe the methodology used to calculate seismic fragilities for strictures, systems, and components (SSCs). For the components screened out, the staff requests the applicant provide a basis for screening out these structures and components. These include components identified as screened out based on the assumption of seismically rugged capacity in Section 19.1.5.1.1.1 to develop the seismic equipment list (SEL) and those components identified as screened out in Table 19.1-43. As per the guidance in ISG-20, screening of rugged SSCs can be performed based on the DC's certified seismic design response spectra (CSDRS) with its peak ground acceleration (PGA) scaled by a factor of 1.67.

For capacities that are determined using seismic qualification testing, the staff requests the applicant to demonstrate how seismic qualification by testing or by type testing will satisfy the SECY-093-087 requirement of 1.67 times safe shutdown earthquake (SSE). As per the guidance in interim staff guidance (ISG) 20, for equipment on the seismic equipment list (SEL), which is to be qualified by seismic qualification tests, the procedure described in E.5 of the EPRI Report 1002988 is acceptable for developing fragilities. Further, when implementing this method for developing fragilities, there should be less than a 1 percent probability of failure at a ground motion equal to 1.67 times the CSDRS, including consideration of testing uncertainties.

As applicable, the staff requests the applicant to provide basis and justification for alternate methods relative to the guidance in ISG-20.

19-78

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 SECY 93-087, the Commission approved use of the seismic margin approach (SMA) for DC applications. ASME/ANS RA-Sa-2009 Part 5 and interim staff guidance (ISG) 20 provide guidance acceptable to the staff for the SMA. The industry standard, ASME/ANS RA-SA-2009, requires a peer review to promote consistency among similar PRAs and reasonableness in the numerical results and risk insights. ISG 20 endorses the performance of a peer review for the SMA.

The APR1400 DCD does not identify whether the peer review was performed. The staff considers this an essential element in the assessment of the quality of the PRA. Clarify whether a peer review has been performed as part of the SMA. If it has, document the results in DCD Section 19.1.5. If it has not, provide a detailed technical basis for concluding that it is not necessary.

19-79

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. SECY 93-087 approves an alternative approach to seismic PRA for the DC application and interim staff guidance (ISG) 20 provides guidance on the methods acceptable to the staff to demonstrate acceptably low seismic risk for a DC.

Design control document (DCD) FSAR Section 19.1.5.1, Table 19.1-43, lists the high confidence in low probability of failure (HCLPF) capacities for APR1400 Structures, Systems and Components (SSCs). Some HCLPF values in this table were derived using the approach referenced in EPRI Utility Requirements Document (URD) (Reference 37). The URD uses local (i.e., actual component location) spectral acceleration capacities which are derived from generic equipment ruggedness spectra (GERS).The fragility and corresponding HCLPF capacity of a specific component, relative to ground motion peak ground acceleration (PGA), can vary significantly depending upon the stiffness of the structure and the location of the component within the structure.

To verify that the HCLPF capacities based on generic capacities and generic structural amplifications are reasonable and achievable for design certification of the APR1400, and consistent with the guidance in ISG-20 Section 5.1.2, the staff requests the applicant provide justification that demonstrates the generic data used to estimate the HCLPF capacities are consistent and applicable to SSCs within the scope of the standard design.

19-80

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. SECY 93-087 approves an alternative approach to seismic PRA for the DC application and interim staff guidance (ISG) 20 provides guidance on the methods acceptable to the staff to demonstrate acceptably low seismic risk for a DC.

Design control document (DCD) Section 19.1.5.1.2.2 “Seismic Fragility Analysis” states that the fragility information shown in Table 19.1-43 is the reference plant’s fragility information. Provide the technical basis for concluding that the reference plant fragility information provided in Table 19.1-43 applies to the APR1400 DC and associated seismic spectra.

The applicant states that the exception to the use of fragility information from the reference plants is when a component has a high confidence in low probability of failure (HCLPF) value less than required. In this case, it is assumed that the APR1400 design will be modified to increase the capacity of these components. This increase in capacity should be documented as a commitment (combined license (COL) Information Item) by the applicant.

19-81

10 CFR 50.44(c)(5) and SECY-93-087 require a deterministic analysis that demonstrates containment structural integrity under internal pressure loads. Regulatory Guide 1.216, Regulatory Position 3, discusses the methods acceptable to the staff to address the

Commission's containment performance goal for the period following the initial 24 hours after the onset of core damage.

The staff noted inconsistencies in the plots of maximum pressures for the large-break loss-of-coolant accident (LBLOCA) scenarios between Figure 19.2.3-21 and the Containment Building Capacity Evaluation on Severe Accident (Global) Calculation #1-316-C304-006. The staff requests that the applicant clarify the differences between the two scenarios and explain why the accident scenarios considered are actually those with the most significant pressure loading histories.

19-82

10 CFR 50.44(c)(5) and SECY-93-087 require a deterministic analysis that demonstrates containment structural integrity under internal pressure loads. Regulatory Guide 1.216, Regulatory Position 3, discusses the methods acceptable to the staff to address the Commission's containment performance goal.

Section 3 of the Containment Building Capacity Evaluation on Severe Accident (Global) Calculation #1-316-C304-006 states "Material properties could not be obtained from plant-specific statistical data at the phase of the project. In all cases, therefore, generic data were used, aided when necessary by qualified engineering judgement". Describe the source of the generic data, and explain why it is applicable to the APR1400 containment capacity calculation. Additionally, the applicant made references to median strengths and the use of logarithmic standard deviations. Clarify whether material properties are the specified minimum properties or provide justification for an alternate set of material properties.

19-83

All design certification applications under 10 CFR 52.47 shall satisfy the requirements of 10 CFR 52.47(a)(27) that a description and results of a design-specific PRA be provided as part of the application for design certification. The estimate of containment fragility as a function of pressure and associated temperature loads needs to be developed for use in the design-specific PRA.

APR1400 DCD Tier 2, Figure 19.1-47: Total Containment Fragility Curve shows the results of the containment fragility analysis, which includes the sum of the probability density functions for each failure mode considered. Section 19.1.4.1.2.2 and Table 19.1-28 provide the failure locations and failure modes considered for the containment ultimate pressure capacity and also for the containment fragility calculation.

a. In Section 19.1.4, the applicant lacks a description of a specific analytical process used to determine the containment pressure fragility and associated failure modes. The staff reviewed the Ultimate Pressure Capacity Report (APR1400-K-P-NR-013605-P) and requests the applicant provide the following information in the DCD:

i. An explanation of whether severe accident temperature effects on material properties were considered.

ii. A clarification of the basis for the assumed temperature (400 F) and the relationship between that temperature and the temperature reduction factors in Section 5.6 of the report.

iii. A description of the consideration of uncertainties

iv. A description of how the uncertainty for the different parameters considered in the analysis is estimated and aggregated.

b. In Section 19.1.4.2.1.2.2, the applicant lists the personnel emergency exit airlock as a failure location contributing to the containment pressure fragility. There are no corresponding failure modes included in Table 19.1-28 or Figure 19.1-47. Describe the basis for the selection of failure locations and failure modes considered and confirm whether the failure of the personnel emergency exit airlock was included in the analysis.

19-84

10 CFR 50.44(c)(5) and SECY-93-087 require a deterministic analysis that demonstrates containment structural integrity under internal pressure loads. Regulatory Guide 1.216, Regulatory Position 3 discusses the methods acceptable to the staff to address the Commission's performance goal related to the prevention and mitigation of severe accidents. This includes guidance on the development of global and local finite element models of the containment.

a. As per RG 1.216, ASME, Section III. Division 1, Subsection NE, covers metal portions of concrete containments that are not backed by concrete. Therefore, such components need to be shown to meet the Service Level C requirements in Subsection NE-3220. The staff review of the Containment Building Capacity Evaluation on Severe Accident (Local) did not find sufficient information to confirm that the covers for the large penetrations analyzed meet the Service Level C requirements in Subsection NE-3220. The staff requests the applicant demonstrate that the covers for the large penetrations meet the Service Level C requirements in Subsection NE-3220 of the ASME code.

b. As per RG 1.216, the evaluation should consider the potential for containment leakage at pressure levels below the calculated structural capacity. The applicant should perform analyses to demonstrate that leakage from containment components, such as penetrations, bolted connections, seals, hatches, or bellows, is sufficiently small for the calculated pressure and temperature capacity conditions. Otherwise, the pressure capacity should be based on a defined total leakage limit from these components. The staff requests the applicant explain how the consideration of containment leakage was accounted for when modeling local regions of containment.


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