

## KHNPDCDRAIsPEm Resource

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**From:** Ciocco, Jeff  
**Sent:** Tuesday, September 01, 2015 12:53 PM  
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**Cc:** Carlson, Donald; McKirgan, John; Wunder, George; Lee, Samuel  
**Subject:** APR1400 Design Certification Application RAI 179-8190 (09.01.01 - Criticality Safety of Fresh and Spent Fuel Storage and Handling)  
**Attachments:** APR1400 DC RAI 179 SRSB 8190.pdf; image001.jpg

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 days to respond to the RAI's questions. We may adjust the schedule accordingly.

09.01.01-14: 30 days  
09.01.01-15: 60 days  
09.01.01-16: 60 days  
09.01.01-17: 60 days  
09.01.01-18: 60 days  
09.01.01-19: 30 days  
09.01.01-20: 30 days  
09.01.01-21: 60 days  
09.01.01-22: 60 days  
09.01.01-23: 60 days  
09.01.01-24: 60 days  
09.01.01-25: 60 days  
09.01.01-26: 30 days

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

Thank you

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**Hearing Identifier:** KHNP\_APR1400\_DCD\_RAI\_Public  
**Email Number:** 241

**Mail Envelope Properties** (a63bfed67ce346c98708f077f336c69c)

**Subject:** APR1400 Design Certification Application RAI 179-8190 (09.01.01 - Criticality Safety of Fresh and Spent Fuel Storage and Handling)  
**Sent Date:** 9/1/2015 12:52:42 PM  
**Received Date:** 9/1/2015 12:52:45 PM  
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<b>Files</b>	<b>Size</b>	<b>Date &amp; Time</b>
MESSAGE	990	9/1/2015 12:52:45 PM
APR1400 DC RAI 179 SRSB 8190.pdf		140314
image001.jpg	5040	

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**Priority:** Standard  
**Return Notification:** No  
**Reply Requested:** No  
**Sensitivity:** Normal  
**Expiration Date:**  
**Recipients Received:**

# REQUEST FOR ADDITIONAL INFORMATION 179-8190

Issue Date: 09/01/2015

Application Title: APR1400 Design Certification Review – 52-046

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

Docket No. 52-046

Review Section: 09.01.01 - Criticality Safety of Fresh and Spent Fuel Storage and Handling

Application Section:

## QUESTIONS

09.01.01-14

### **RAI Question 9.1.1-2: Location of the APR1400 fuel storage and handling facilities**

#### REQUIREMENTS AND GUIDANCE

In 10 CFR Part 50 Appendix A, General Design Criterion (GDC) 62 requires the prevention of criticality in fuel storage and handling. 10 CFR 50.68(b) sets specific requirements for the demonstration of nuclear criticality prevention in fuel storage. NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition," Section 9.1.1, guides the reviewer to verify that the applicant has provided sufficient design information to support the evaluation findings.

#### ISSUE

Certain DCD Tier 2 sections, including Section 9.1.1, indicate that the new and spent fuel storage and handling facilities are located in the "fuel handling area of the auxiliary building." Statements in other DCD sections, including Sections 9.1.4 and 9.5A, locate these facilities in a "fuel building."

#### INFORMATION NEEDED

In its response, the applicant should clarify whether the subject facilities reside in a distinct fuel building or in the fuel handling area of the auxiliary building. The applicant should then revise the affected parts of the DCD and its incorporated references accordingly.

09.01.01-15

### **RAI 9.1.1-9: Deformation of neutron absorber material**

#### REQUIREMENTS AND GUIDANCE

In 10 CFR Part 50 Appendix A, General Design Criterion (GDC) 62 requires the prevention of criticality in fuel storage and handling. 10 CFR 50.68(b)(4) sets specific requirements for the demonstration of nuclear criticality prevention in wet fuel storage. NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition," Section 9.1.1, guides the reviewer, in part, to verify that the criticality analysis conservatively incorporates fuel storage rack design data, including materials and dimensional data. In addition, NRC Interim Staff Guidance DSS-ISG-2010-01 states that any degradation in rack materials should be modeled conservatively.

#### ISSUE

In DCD Section 9.1.1, the applicant states that "only 75 percent of B-10 density in the neutron absorbing materials is assumed in order to reflect the deformation of the neutron absorbing material," but does not indicate the cause or nature of the material deformation.

#### INFORMATION NEEDED

The applicant should explain in its response and clarify in the DCD or its incorporated references the purpose of the stated spent fuel rack criticality analysis assumption with regard to the potential existence of material deformation, degradation, or other material characteristics or phenomena (e.g., non-uniform

## REQUEST FOR ADDITIONAL INFORMATION 179-8190

poison concentrations, poison granularity effects of neutron channeling or streaming) that could reduce or degrade the performance of the neutron absorbing material.

09.01.01-16

### **RAI 9.1.1-19: Compliance results for spent fuel pool region II without soluble boron**

#### REQUIREMENTS AND GUIDANCE

In 10 CFR Part 50 Appendix A, General Design Criterion (GDC) 62 requires the prevention of criticality in fuel storage and handling. 10 CFR 50.68(b)(4) sets specific requirements for the demonstration of nuclear criticality prevention in wet fuel storage. NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition," Section 9.1.1, guides the reviewer to verify that the applicant has provided sufficient design and analysis information to support the evaluation findings of compliance.

#### ISSUE

The criticality analysis report does not clearly present the analysis results that show compliance with the regulatory requirement to demonstrate that the neutron multiplication factor  $k_{\text{eff}}$  without soluble boron remains below 1.0 at a 95 percent probability, 95 percent confidence level. The report's Table 3.5-24 lists ranges of  $k_{\text{eff}}$  values that support development of the burnup credit loading curve but these include values above 1.0.

#### INFORMATION NEEDED

The applicant should provide in its response and in the DCD or its incorporated references the final analysis results that clearly show compliance without soluble boron. In particular, the analysis results should indicate the compliance margin by presenting a calculated maximum  $k_{\text{eff}}$  value that is a finite amount less than 1.0 at a 95 percent probability, 95 percent confidence level.

09.01.01-17

### **RAI 9.1.1-20: Limitations of analysis**

#### REQUIREMENTS AND GUIDANCE

In 10 CFR Part 50 Appendix A, General Design Criterion (GDC) 62 requires the prevention of criticality in fuel storage and handling. 10 CFR 50.68(b) sets specific requirements for the demonstration of nuclear criticality prevention in fuel storage. NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition," Section 9.1.1, guides the reviewer to verify that the applicant has provided sufficient design and analysis information to support the evaluation findings.

#### ISSUE

In describing limitations of the analysis, the applicant states that the poison plate B-10 areal density shall be greater than or equal to a specified minimum areal density value. However, the quoted value is not the design value but rather the conservatively modeled value, which is 75 percent of the design value.

#### INFORMATION NEEDED

In its response and in the DCD or its incorporated references, the applicant should clarify or change the stated areal density in relation to its design value or else provide special justification for retaining the modeled value in view of the need to preserve approved levels of conservatism in the analysis.

## REQUEST FOR ADDITIONAL INFORMATION 179-8190

09.01.01-18

### **RAI 9.1.1-21: Tier-1 design descriptions and ITAAC on design features for preventing criticality in fuel storage and handling**

#### REQUIREMENTS AND GUIDANCE

10 CFR 52.47(b)(1) requires that a DC application contain the proposed inspections, tests, analyses, and acceptance criteria (ITAAC) that are necessary and sufficient to provide reasonable assurance that, if the inspections, tests, and analyses are performed and the acceptance criteria met, a plant that incorporates the design certification is built and should operate in accordance with the design certification, the provisions of the Atomic Energy Act, and the NRC's regulations.

Guidance on the review of ITAAC for all review areas is provided in NUREG-0800 Section 14.3, "ITAAC," and in Section 14.3.7, "Plant Systems ITAAC," for this review area. NUREG-0800 Section 14.3 guides the staff to review the ITAAC to verify that they encompass the complete DC, to review the Tier 1 design descriptions to ensure that the key performance characteristics and safety functions of SSCs are appropriately treated at a level of detail commensurate with their safety significance, and to review Tier 1 for whether all information is clear and consistent with the Tier 2 information. NUREG-0800 Section 14.3.7 states that the review areas for plant systems ITAAC include the new and spent fuel handling systems and that the design features in Tier 1 should be selected to ensure that the integrity of the analyses are preserved in an as-built facility. It further guides the reviewer to ensure that the plant systems are clearly described in Tier 1, including the key performance characteristics and safety functions of SSCs based on their safety significance.

#### ISSUE

The respective design descriptions in DCD Tier 1 Section 2.7.4 consist of two short paragraphs that contain circular references. Those short paragraphs do not adequately describe the design features that will ensure that the as-built systems for new and spent fuel storage and handling will comply with GDC 62 and 10 CFR 50.68(b) in a manner that is fully consistent with the information that the NRC staff will have previously reviewed and approved for design certification.

The staff also notes that DCD Tier 2 Section 14.3 appears to completely omit the ITAAC described in Tier 1 Tables 2.7.4.1-1 and 2.7.4.2-1. The staff further notes that the ITAAC in those Tier 1 tables include analysis elements in Design Commitment 2 whose purpose for as-built verification is not clear in relation to the criticality analyses of DCD Tier 2, Section 9.1.1, that the NRC staff will have previously reviewed and approved during design certification.

#### INFORMATION NEEDED

In its response and in the DCD, the applicant should expand upon and clarify the design descriptions in Tier 1 Section 2.7.4 and remedy the circular references. Furthermore, in Tier-2 Section 14.3, the applicant should either justify or remedy the omission of the ITAAC described in Tier-1 Tables 2.7.4.1-1 and 2.7.4.1.2. Finally, the applicant should clarify the intent and justify the use of the analysis portions of those ITAAC or else remove the analysis portions as may be appropriate.

09.01.01-19

### **RAI 9.1.1-22: Citation of applicant documents that support Tier 2 Section 9.1.1**

#### REQUIREMENTS AND GUIDANCE

In 10 CFR Part 50 Appendix A, General Design Criterion (GDC) 62 requires the prevention of criticality in fuel storage and handling. 10 CFR 50.68(b) sets specific requirements for the demonstration of nuclear criticality prevention in fuel storage. NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition," Section 9.1.1, guides the reviewer to verify that the applicant has provided sufficient design and analysis information to support the evaluation findings of compliance.

## REQUEST FOR ADDITIONAL INFORMATION 179-8190

### ISSUE

The NRC staff makes its safety finding based on information provided in the DCD and any documents incorporated by reference into the DCD. It is essential that all documents with essential information that is not contained in the DCD be docketed and clearly referenced in the DCD wherever needed to support or supplement the Tier 2 design and analysis information.

The staff notes that Section 9.1.1 of DCD Tier 2 fails to cite or reference in any manner both the criticality analysis report and the criticality validation report. Both reports clearly contain essential information that the staff must use in reaching its safety finding. Therefore, both reports should be clearly cited wherever used to support information in Tier 2 Section 9.1.1.

### INFORMATION NEEDED

In its response, the applicant should add to Tier 2, Section 9.1.1, appropriately placed citation references to supporting applicant documents deemed essential by the NRC staff the applicant to support the claims of compliance.

09.01.01-20

#### **RAI 9.1.1-23: Incorporation of design and analysis details into Tier 2 Section 9.1**

### REQUIREMENTS AND GUIDANCE

In 10 CFR Part 50 Appendix A, General Design Criterion (GDC) 62 requires the prevention of criticality in fuel storage and handling. 10 CFR 50.68(b) sets specific requirements for the demonstration of nuclear criticality prevention in fuel storage. NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition," Section 9.1.1, guides the reviewer to verify that the applicant has provided sufficient design and analysis information to support the evaluation findings of compliance.

### ISSUE

The staff notes that neither the criticality analysis report nor its referenced criticality validation report are listed in DCD Tier 2, Chapter 1, Table 1.6-2, as documents to be incorporated by reference into Tier 2. Furthermore, the staff notes that the number of documents containing details that will ultimately have to be captured in the DCD Tier 2 section or else incorporated by reference by listing in Tier 2, Table 1.6-2, may have to grow in response to further RAI questions, audit items, and related discussions between the applicant and NRC staff at publicly noticed meetings.

### INFORMATION NEEDED

In its response, the applicant should describe how it will either capture essential design and analysis details in the DCD sections or incorporate by reference the documents that contain such details. If the subject documents are to be incorporated by reference, then Tier 2, Table 1.6-2 should be updated accordingly.

09.01.01-21

#### **Question 9.1.1-3: Design of new fuel storage rack system**

### REQUIREMENTS AND GUIDANCE

In 10 CFR Part 50 Appendix A, General Design Criterion (GDC) 62 requires the prevention of criticality in fuel storage and handling. 10 CFR 50.68(b) sets specific requirements for the demonstration of nuclear criticality prevention in fuel storage. NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition," Section 9.1.1, guides the reviewer to verify that the facility designs are such that a fuel assembly can only be inserted in the designed locations in the fuel racks. NUREG-0800 Section 9.1.1 also refers the reviewer to ANSI/ANS 57.3, "Design Requirements for

## REQUEST FOR ADDITIONAL INFORMATION 179-8190

New Fuel Storage Facilities at Light Water Reactor Plants,” which states that “construction shall be such that it will not be possible to place fuel assemblies closer to one another than the minimum specified separation. This prohibition also applies to adjacent regions external to the racks.” The applicant cites ANSI/ANS 57.3 in DCD Section 9.1.

### ISSUE

As described in DCD Section 9.1.1 and the criticality report, the design of the APR1400 new fuel storage pit appears to have spaces between the fuel racks and between the racks and pit walls that are large enough to fit one or more new fuel assemblies. The NRC staff is therefore not able to verify that the design is such that a fuel assembly can only be inserted in the designed locations in the new fuel racks and that construction will be such that it will not be possible to place fuel assemblies closer to one another than the minimum specified separation in the racks and any adjacent regions external to the racks.

### INFORMATION NEEDED

The applicant should provide information showing that the design is such that a fuel assembly can only be inserted in the design locations in the new fuel racks or justify the acceptability of the current design where spaces between and around the racks that are large enough to fit one or more fuel assemblies. This should include information describing how the design is bounded by the accompanying criticality analysis report. Any revised or supplemental information addressing this issue should be provided in the applicant’s response and reflected in the DCD or its incorporated references as appropriate.

09.01.01-22

### **Question 9.1.1-5: Reactivity of new fuel storage pit concrete**

#### REQUIREMENTS AND GUIDANCE

In 10 CFR Part 50 Appendix A, General Design Criterion (GDC) 62 requires the prevention of criticality in fuel storage and handling. 10 CFR 50.68(b) sets specific requirements for the demonstration of nuclear criticality prevention in fuel storage. NUREG-0800, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition,” Section 9.1.1, guides the reviewer, in part, to verify that the materials of structures near racks that may provide neutron reflection, such as floors and walls, are provided and conservatively incorporated into the criticality analysis.

### ISSUE

The applicant’s criticality analyses for the new fuel storage pit explicitly model the reactivity effects (i.e., neutron moderation and reflection) of the concrete walls and floor. The staff is aware that the concrete reactivity effects in such cases can vary significantly with the various compositions of common concretes. In describing the analyses, the applicant neither states nor demonstrates that the modeled concrete composition is no less reactive than the specified design composition of the new fuel storage pit walls. Moreover, the staff is aware that other concrete compositions identified in the SCALE code and elsewhere can be significantly more reactive than the composition modeled by the applicant.

### INFORMATION NEEDED

The applicant should provide a justification or analysis to address this issue and describe the analysis and results in the DCD or its incorporated references. If an analysis is provided, included should be an analysis of the sensitivity of new fuel storage criticality results to various modeled compositions of storage pit concrete. If the justification or analysis concludes that more reactive concrete compositions could be used in the storage pit, it may be appropriate to (a) replace the modeled concrete composition with one that is more clearly conservative, and/or (b) establish a related design specification for the range of allowed concrete compositions, and/or (c) add or modify ITAAC to verify that the as-built composition of the storage pit concrete is no more reactive than the modeled composition.

## REQUEST FOR ADDITIONAL INFORMATION 179-8190

09.01.01-23

### **Question 9.1.1-6: Calculation of sensitivities to new fuel rack tolerances and variations**

#### REQUIREMENTS AND GUIDANCE

In 10 CFR Part 50 Appendix A, General Design Criterion (GDC) 62 requires the prevention of criticality in fuel storage and handling. 10 CFR 50.68(b) sets specific requirements for the demonstration of nuclear criticality prevention in new fuel storage. NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition," Section 9.1.1 guides the reviewer, in part, to verify the conservatism of normal-conditions models and the appropriateness of assumptions and approximations made therein. Sensitivity studies are one way to support normal-conditions model development.

#### ISSUE

For the new fuel rack criticality analysis, the applicant calculates sensitivities to design tolerances and variations on a model of an infinite-array of rack cells moderated by full-density water. The staff notes that this calculation model neglects the neutronic effects of storage pit concrete and does not address sensitivities under the potentially more limiting accident conditions of optimum moderation by low-density water.

#### INFORMATION NEEDED

The applicant should describe in its response and in the DCD or its incorporated references additional sensitivity calculations on an analysis model that addresses the neutronic effects of storage pit concrete as well as the respective conditions of optimum moderation by low-density water and moderation by full-density water. The results of the supplemental sensitivity studies should be applied as necessary to the neutron multiplication factors computed for the respective moderation accident conditions.

09.01.01-24

### **Question 9.1.1-8: Modeled elevation of new fuel in the storage pit racks**

#### REQUIREMENTS AND GUIDANCE

In 10 CFR Part 50 Appendix A, General Design Criterion (GDC) 62 requires the prevention of criticality in fuel storage and handling. 10 CFR 50.68(b) sets specific requirements for the demonstration of nuclear criticality prevention in new fuel storage. NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition," Section 9.1.1, guides the reviewer, in part, to verify that appropriate fuel storage rack data are used in the analyses.

#### ISSUE

The elevation drawing of the new fuel racks in DCD Section 9.1.2 shows the separation between the pit floor and the bottom of the fuel rack to be substantially larger than assumed in the analysis model depicted in the applicant's criticality analysis report. The staff needs to understand whether the applicant's analysis model is conservative in this regard.

#### INFORMATION NEEDED

The applicant should provide in its response and in the DCD or its incorporated references a revised or supplemental analysis that demonstrates conservative modeling of the actual elevation of the fuel racks in the storage pit. The analysis should be done for the required accident cases of flooding with optimum-density hydrogenous moderator and flooding with full-density water.



## REQUEST FOR ADDITIONAL INFORMATION 179-8190

09.01.01-25

### RAI 9.1.1-24: Dimensional tolerances for the new fuel storage racks

#### REQUIREMENTS AND GUIDANCE

In 10 CFR Part 50 Appendix A, General Design Criterion (GDC) 62 requires the prevention of criticality in fuel storage and handling. 10 CFR 50.68(b) sets specific requirements for the demonstration of nuclear criticality prevention in fuel storage and handling. NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition" (SRP), Section 9.1.1 guides the reviewer, in part, to verify that normal and abnormal conditions are modeled correctly and that all modeling approximations and assumptions are appropriate. This includes appropriate handling of dimensional and material tolerances and uncertainties. The SRP Acceptance Criteria for Section 9.1.1 refer to ANSI/ANS-57.3, which provides in Subsection 6.2.4.1.5 a list of parameters that should be evaluated in the determination of the most reactive fuel assembly, including maximum fissile fuel loading, fuel rod pitch, and fuel rod cladding thickness.

#### ISSUE

Table 2.4-2 of the criticality technical report provides a list of the mechanical tolerances or variations for the input parameters to the new fuel storage rack model used in a sensitivity analysis for the new fuel storage rack criticality uncertainty evaluation. It is not clear to the staff why the tolerances in this table are not consistent with those for the region I spent fuel storage rack criticality uncertainty evaluations in that the new fuel tolerances do not consider uncertainty in uranium enrichment and both positive and negative tolerances in dimensions such as fuel rod pitch, fuel clad diameter, and rack cell thickness.

#### INFORMATION NEEDED

In its response and in the DCD or its incorporated reference, the applicant should either (1) provide justification for not including the uncertainty in uranium enrichment and both positive and negative dimensional variations or (2) update the sensitivity analysis for the new fuel storage racks to include these tolerances and apply the revised results to the new fuel storage rack criticality analysis accordingly.

09.01.01-26

### **RAI 9.1.1-25: Clarification items for APR1400-Z-A-NR-14011-P, Rev. 0**

#### REQUIREMENTS AND GUIDANCE

In 10 CFR Part 50 Appendix A, General Design Criterion (GDC) 62 requires the prevention of criticality in fuel storage and handling. 10 CFR 50.68(b) sets specific requirements for the demonstration of nuclear criticality prevention in fuel storage and handling. NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition," Section 9.1.1 guides the reviewer to verify the completeness and appropriateness of fuel and fuel storage rack design data and their use in the analyses.

#### ISSUES AND INFORMATION NEEDED

- a. Technical report APR1400-Z-A-NR-14011-P, Rev. 0, "Criticality Analysis of New and Spent Fuel Storage Racks," provides guide tube dimensions in Tables 2.1-1, 3.1-3, and 3.5-3. Table 2.1-1 identifies the dimensions as diameters, whereas Tables 3.1-3 and 3.5-3 identify the same measurements as radii. The staff notes that, based on the actual fuel assembly dimensions,

## REQUEST FOR ADDITIONAL INFORMATION 179-8190

“diameter” is correct for Tables 3.1-3 and 3.5-3. Therefore, the applicant should revise the affected tables in APR1400-Z-A-NR-14011-P, Rev. 0 to reflect that the guide tube dimensions listed correspond to diameters, not radii.

- b. A dimension between the new fuel storage racks and the new fuel storage pit wall is shown above the right section of the new fuel storage racks in APR1400-Z-A-NR-14011-P, Rev. 0, Figure 2.1-1 but not labeled with a distance. The applicant should indicate the distance shown by the unlabeled arrow in Figure 2.1-1 of APR1400-Z-A-NR-14011-P, Rev. 0.
- c. DCD Tier 2, Section 9.1.1 states that various U-235 enrichments from 1.8 to 5.0 wt% are used for the region II spent fuel storage rack criticality calculation. However, the tables in Section 3.5 of APR1400-Z-A-NR-14011-P, Rev. 0 seem to indicate that the enrichments range from 2.0 to 5.0 wt%. The applicant should revise DCD Section 9.1.1 and/or the criticality analysis technical report to accurately indicate the enrichment levels used for the criticality calculation.

