

KHNPDCDRAIsPEm Resource

From: Ward, William
Sent: Monday, November 02, 2015 6:48 PM
To: apr1400rai@khnp.co.kr; KHNPDCDRAIsPEm Resource; Harry (Hyun Seung) Chang; Andy Jiyong Oh; Tyree, Christopher (christopher.tyree@aecom.com)
Cc: Lee, Samuel; Ciocco, Jeff; Jain, Bhagwat; Xu, Jim; Wunder, George
Subject: APR1400 Design Certification Application RAI 287-8272 (9.1.2 - New and Spent Fuel Storage)
Attachments: APR1400 DC RAI 287 SEB1 8272.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.

09.01.02-9: 30 days
09.01.02-10: 45 days
09.01.02-11: 45 days
09.01.02-12: 45 days
09.01.02-13: 45 days
09.01.02-14: 45 days
09.01.02-15: 45 days
09.01.02-16: 45 days
09.01.02-17: 45 days
09.01.02-18: 45 days
09.01.02-19: 60 days
09.01.02-20: 90 days
09.01.02-21: 45 days
09.01.02-22: 45 days
09.01.02-23: 45 days
09.01.02-24: 90 days
09.01.02-25: 45 days
09.01.02-26: 30 days
09.01.02-27: 60 days
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09.01.02-46: 30 days

09.01.02-47: 30 days

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

Thank you,

William R. Ward, P.E.
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Issue Date: 11/02/2015
Application Title: APR1400 Design Certification Review – 52-046
Operating Company: Korea Hydro & Nuclear Power Co. Ltd.
Docket No. 52-046
Review Section: 09.01.02 - New and Spent Fuel Storage
Application Section: 9.1.2

QUESTIONS

09.01.02-9

1. The 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4, 5, 63, and 10CFR 52.80 (a) provide the regulatory requirements for the design of the new and spent fuel storage facilities. Standard Review Plan (SRP) Sections 9.1.2 and 3.8.4, Appendix D describes specific SRP acceptance criteria for the review of the fuel racks that are acceptable to meet the relevant requirements of the Commission's regulations identified above. In DCD Tier 2, Section 9.1.2.2.3, "New and Spent Fuel Storage Rack Design", the applicant stated that "The dynamic and stress analyses are performed as described in report APR1400-H-N-NR-14012-P & NP". In SRP Section 9.1.2.III.2A, the staff is required to verify whether the new fuel vault, new fuel storage racks, spent fuel storage racks, pool, and pool liner are capable of withstanding all design loads. The staff did not find a detailed description and the structural design criteria of the spent fuel pool and the pool liner in appropriate DCD Sections 9.1.2 or 3.8.4 for its safety evaluation. In accordance with SRP Section 9.1.2.III.2A, the applicant is requested to provide this information so the staff can perform its safety evaluation of the fuel racks, spent fuel pool and the pool liner.

The applicant is requested to identify any proposed changes to and provide a mark-up of Subsections in the DCD Tier 2 and the report APR1400-H-N-NR-14012-P, Rev.0, as appropriate.

09.01.02-10

The 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4, 5, 63, and 10CFR 52.80 (a) provide the regulatory requirements for the design of the new and spent fuel storage facilities. Standard Review Plan (SRP) Sections 9.1.2 and 3.8.4, Appendix D describes specific SRP acceptance criteria for the review of the fuel racks that are acceptable to meet the relevant requirements of the Commission's regulations identified above. In DCD Tier 2, Section 9.1.2.2.3, "New and Spent Fuel Storage Rack Design", the applicant stated that "The dynamic and stress analyses are performed as described in report APR1400-H-N-NR-14012-P & NP". SRP 3.8.4 Appendix D, section I.1 (B) "Description of the Spent Fuel Pool and Racks" requires that the applicant should provide sketches and sufficient details of the fuel-handling system to facilitate the review of the fuel drop parameters. In the report APR1400-H-N-NR-14012-P, Rev.0, Section 4.1 "Description of Mechanical Accident", the applicant assumed that a dropping mass (fuel assembly along with the handling tool) drops down from a height of 2 ft. The applicant did not provide (1) the technical basis for this assumption. In accordance with SRP 3.8.4 Appendix D, section I.1 (B) the applicant is requested to provide sketches and sufficient details of the fuel-handling system to facilitate the review of the fuel drop parameters (2) the justification for the assumption and description of the fuel handling operation that determines the drop height of 2 ft. and describe the operational controls on spent fuel handling that will ensure that the analyzed 2

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ft. drop height will not be exceeded. The applicant is requested to provide COL information items that include the development of plant procedures and control of fuel handling activities over the spent fuel pool. The applicant is requested to provide a mark-up of Subsections in the DCD Tier 2 as appropriate.

09.01.02-11

1. The 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4, 5, 63, and 10CFR 52.80 (a) provide the regulatory requirements for the design of the new and spent fuel storage facilities. Standard Review Plan (SRP) Sections 9.1.2 and 3.8.4, Appendix D describes specific SRP acceptance criteria for the review of the fuel racks that are acceptable to meet the relevant requirements of the Commission's regulations identified above. In DCD Tier 2, Section 9.1.2.2.3, "New and Spent Fuel Storage Rack Design", the applicant stated that "The dynamic and stress analyses are performed as described in report APR1400-H-N-NR-14012-P & NP". In the report APR1400-H-N-NR-14012-P, Rev.0, Section 3.4.7.4 (3), the applicant stated that "The thermal stress is classified as secondary stress on the ASME Code Section III, Division 1. Therefore, it is independently evaluated without combining with primary stress of other load condition." The staff notes that the thermal stress may not be combined with the primary stress; however, the thermal expansion will reduce the gaps between the fuel assembly and the cell as well as between racks. The gap reduction increases the possibility for impact between the fuel assembly and the cell as well as between racks. The applicant in Subsection 3.7.1.3, "Impact Loads" stated that "the baseplate the fuel storage rack for the APR1400 design is installed almost in contact with the adjacent baseplate". The thermal expansion of the rack potentially imposes load at the base of the pedestal. In accordance with SRP 3.8.4 Appendix D I(4), the applicant is requested to quantify thermally imposed loads at the base of the pedestal and discuss how these thermal load effects have been considered in the analysis and design of the new and spent fuel storage racks.

09.01.02-12

1. The 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4, 5, 63, and 10CFR 52.80 (a) provide the regulatory requirements for the design of the new and spent fuel storage facilities. Standard Review Plan (SRP) Sections 9.1.2 and 3.8.4, Appendix D describes specific SRP acceptance criteria for the review of the fuel racks that are acceptable to meet the relevant requirements of the Commission's regulations identified above. The SRP 3.8.4 Appendix D I.3 'Seismic and Impact loads' requires that "For free-standing spent fuel pool racks, which are potentially subject to sliding, uplift, and Impact between racks and with the pool walls, time-varying seismic excitation along three orthogonal directions (2 horizontal and vertical) should be imposed simultaneously". The staff did not find sufficient information regarding the input seismic time histories considered for the nonlinear seismic evaluation of the new and the spent fuel racks.

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In accordance with SRP 3.8.4 Appendix D I.3, the applicant is requested to provide the following information so that the staff can perform its safety evaluation of the seismic and impact loads.

- a. Design target response spectra at the locations of new and spent fuel storage that were used to generate the synthetic time histories. Please describe the basis for selecting the target response spectra.
- b. Seeds of earthquake ground motions used to generate the synthetic time histories.
- c. The record length and the time increment of the synthetic time histories.
- d. Coefficient of correlation to verify the statistical independence of the generated artificial time histories from given target response spectra.
- e. Provide a comparison of PSD (Power Spectral Density) of original (target) with PSD developed from synthetic time histories.
- f. Clarify and confirm that the seismic excitation time histories along three orthogonal directions (2 horizontal and vertical) in the nonlinear seismic analysis are applied simultaneously.
- g. Discuss the validation and verification procedure used for the computer codes ATIGEN and STCOR referenced in Table 3-5 of the report APR1400-H-N-NR-14012, Rev.0. The applicant is also requested to provide reference to operating or new nuclear power plants that have been licensed using ATIGEN and STCOR computer codes.

09.01.02-13

1. The 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4, 5, 63, and 10CFR 52.80 (a) provide the regulatory requirements for the design of the new and spent fuel storage facilities. Standard Review Plan (SRP) Sections 9.1.2 and 3.8.4, Appendix D describes specific SRP acceptance criteria for the review of the fuel racks that are acceptable to meet the relevant requirements of the Commission's regulations identified above. The SRP 3.8.4 Appendix D section I (3), "Seismic and Impact Loads" requires that "Because of gaps between fuel assemblies and the walls of the guide tubes, additional loads will be generated by the impact of fuel assemblies during a postulated seismic excitation. Additional loads resulting from this impact effect may be determined by estimating the kinetic energy of the fuel assembly. The maximum velocity of the fuel assembly may be estimated to be the spectral velocity associated with the natural frequency of the submerged fuel assembly. Loads thus generated should be considered for local as well as overall effects on the walls of the rack, the supporting framework. It should be demonstrated that the consequent loads on the fuel assembly do not lead to damage of the fuel." In order for the staff to perform its safety evaluation of the racks for impact loads, the applicant in accordance with SRP 3.8.4 Appendix D I.3, is requested to provide the details of how the additional loads due to the impact of fuel assemblies during a postulated seismic excitation are computed and how these loads are considered in the analysis and design of the walls of the rack and supporting framework and demonstrating the structural integrity of the fuel.

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09.01.02-14

1. The 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4, 5, 63, and 10CFR 52.80 (a) provide the regulatory requirements for the design of the new and spent fuel storage facilities. Standard Review Plan (SRP) Sections 9.1.2 and 3.8.4, Appendix D describes specific SRP acceptance criteria for the review of the fuel racks that are acceptable to meet the relevant requirements of the Commission's regulations identified above. In DCD Tier 2, Section 9.1.2.2.3, "New and Spent Fuel Storage Rack Design", the applicant stated that "The dynamic and stress analyses are performed as described in report APR1400-H-N-NR-14012-P & NP". In the report APR1400-H-N-NR-14012-P, Rev.0, Table 3-9 "Maximum Loads on single Pedestal", the staff noted that for the spent fuel storage rack, generally the force on the pedestal in the north-south direction is much less (about 50%) than that in the east-west direction. The staff did not find sufficient details and description of the underlying analyses in the report and is not able to confirm large variation in forces in the two horizontal directions. In order for the staff to perform its safety evaluation of the racks, the applicant is requested to provide the basis and justification for such large difference in pedestal forces in the two horizontal directions.

09.01.02-15

1. The 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4, 5, 63, and 10CFR 52.80 (a) provide the regulatory requirements for the design of the new and spent fuel storage facilities. Standard Review Plan (SRP) Sections 9.1.2 and 3.8.4, Appendix D describes specific SRP acceptance criteria for the review of the fuel racks that are acceptable to meet the relevant requirements of the Commission's regulations identified above. In DCD Tier 2, Section 9.1.2.1(f), the applicant committed to meet the requirements of SRP 3.8.4 Appendix D for the new and spent fuel storage racks rack design. The SRP 3.8.4 Appendix D, Section I (5) requires that "For nonlinear seismic analysis of the racks, multiple time histories analysis should be performed in accordance with the criteria for nonlinear analysis described in SRP 3.7.1, unless otherwise justified".

The DCD Tier 2 Section 9.1.2.2.3 makes reference to a technical report APR1400-H-N-NR-14012-P, Rev.0, for the dynamic and stress analysis of the racks. In Subsection 3.1.1 of the technical report, the applicant stated that "An accurate evaluation of nonlinear response requires a 3-D time-history analysis to establish the proper response during a seismic loading. Therefore, the initial step in a 3-D time-history analysis is to develop time-history seismic loadings for three orthogonal directions that comply with the guidelines of the NRC SRP 3.7.1."

The SRP Section 3.7.1 acceptance criteria for the nonlinear seismic analysis states that "For nonlinear structural analysis problems, multiple sets of ground motion time histories should be used to represent the design ground motion. Each set of ground motion time histories can be selected from real recorded or artificial time histories. The amplitude of these ground motions may be scaled but the phasing of Fourier components should be maintained. The adequacy of this set of ground motions, including duration estimates, is reviewed on a case-by-case basis." The SRP Section 3.7.1, option 2 delineates the requirements for multiple sets of time histories. It states, "For nonlinear structural analyses, the number of time histories should be greater than four and the technical basis for the appropriate number of time histories are reviewed on a case-by-case basis. This review also includes the adequacy of the characteristics of the multiple time histories."

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Based on the review of the DCD Tier 2 Section 9.1.2 and the referenced technical report APR1400-H-N-NR-14012-P, Rev.0, it is not clear to the staff whether the applicant met the acceptance criteria for nonlinear seismic analyses in SRP 3.8.4 Appendix D and in SRP 3.7.1 as stated above. In order for the staff to perform its safety evaluation of the seismic input to the racks, the applicant in accordance with SRP 3.8.4 Appendix D and SRP Section 3.7.1 is requested to clarify and confirm that it used at least the five sets (greater than the required four) of time histories for the nonlinear structural analyses of the new and spent fuel storage racks and provide the technical basis and justification for selecting the number of time history sets used in the nonlinear seismic analyses. The applicant is requested to identify any proposed changes to and provide a mark-up of Subsections in the DCD Tier 2 and the report APR1400-H-N-NR-14012-P, Rev.0, as appropriate.

09.01.02-16

The 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4, 5, 63, and 10 CFR 52.80 (a) provide the regulatory requirements for the design of the new and spent fuel storage facilities. Standard Review Plan (SRP) Sections 9.1.2 and 3.8.4, Appendix D describes specific SRP acceptance criteria for the review of the fuel racks that are acceptable to meet the relevant requirements of the Commission's regulations identified above. In DCD Tier 2, Section 9.1.2.2.3, "New and Spent Fuel Storage Rack Design", the applicant stated that "The dynamic and stress analyses are performed as described in report APR1400-H-N-NR-14012-P & NP". In the report APR1400-H-N-NR-14012-P, Rev.0, Section 3.6, "Dynamic Simulations", it is stated that "The storage rack configurations at the full loading are considered in the dynamic simulations." This sentence implies that assuming every rack with the full loading in the seismic or impact analyses results in a conservative design. It is not apparent to the staff that assuming the full loading for every rack is conservative. For example, consider the following scenario: Assume a fully loaded rack subjected to an earthquake does not slide; now consider two racks with one rack empty; and the other rack fully loaded. During the same earthquake, the lighter rack slides because its friction force at the base is now less than if it were fully loaded. The fully loaded one by itself would not slide; however, it may slide due to the impact from the lighter rack; thus, the whole system (the lighter rack and the fully loaded rack) slides. Based on the above example, the applicant is requested to provide a technical rationale and the results of any study performed to demonstrate that the assumption of all fully loaded racks will always result in a conservative design. Otherwise, the applicant is requested to consider appropriate loading patterns in the analyses. The loading patterns considered should include the case of all racks completely empty to demonstrate that the racks and liner of the spent fuel pool would not be damaged due to the impact.

09.01.02-17

1. The 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4, 5, 63, and 10CFR 52.80 (a) provide the regulatory requirements for the design of the new and spent fuel storage facilities. Standard Review Plan (SRP) Sections 9.1.2 and 3.8.4, Appendix D describes specific SRP acceptance criteria for the review of the fuel racks that are acceptable to meet the relevant requirements of the Commission's regulations identified above. In DCD Tier 2, Section 9.1.2.2.3, "New and Spent Fuel Storage Rack Design", the applicant stated that "The dynamic and stress analyses are performed as described in report APR1400-H-N-NR-14012-P & NP". In the report APR1400-H-N-NR-14012-P, Rev.0,

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Subsection 3.1.2.2 “Details for Rack and Fuel Assembly” it is stated that “A vertical movement of fuel assembly is assumed to be the same as the vertical movement of the storage rack”. The applicant’s assumption implies that there is no fuel rattling in the vertical direction because the vertical displacement of the fuel is the same as the vertical displacement of the rack. However, there is a potential for the fuel assembly to separate from the baseplate during vertical ground motion depending on the vertical frequencies, phasing, and relative maximum vertical input acceleration of the fuel assembly and the storage rack.

In order for the staff to perform its safety evaluation of the fuel and the rack assembly for the vertical seismic input motion, the applicant in accordance with SRP 3.8.4 Appendix D I.3 is requested to provide a technical basis to justify the assumption that the vertical movement of fuel assembly and the storage rack is the same. The applicant is requested to provide the information for the fundamental frequency of the fuel assembly and the storage rack in the vertical direction; and the design response spectrum for the vertical motion at the new and the spent fuel rack locations. The applicant is also requested to show that the fundamental frequency of the fuel assembly and the fuel rack in the vertical direction is above the frequency where the spectral acceleration returns to the ZPA and that the ZPA is less than 1.0g.

09.01.02-18

1. The 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4, 5, 63, and 10CFR 52.80 (a) provide the regulatory requirements for the design of the new and spent fuel storage facilities. Standard Review Plan (SRP) Sections 9.1.2 and 3.8.4, Appendix D describes specific SRP acceptance criteria for the review of the fuel racks that are acceptable to meet the relevant requirements of the Commission's regulations identified above. In DCD Tier 2, Section 9.1.2.2.3, “New and Spent Fuel Storage Rack Design”, the applicant stated that “The dynamic and stress analyses are performed as described in report APR1400-H-N-NR-14012-P & NP”. In the report APR1400-H-N-NR-14012-P, Rev.0, Subsection 3.4.3 “Structural Damping”, Rayleigh damping is used to specify mass (M) and stiffness (K) proportional damping (C)”. The applicant stated that the constant multiplier to the mass and stiffness matrix are calculated in the range of the lowest and highest frequencies of interest in the dynamic analysis. In accordance with SRP 3.8.4 Appendix D I.5, the applicant is requested to provide (1) the numerical value of the range of the lowest and the highest frequency considered (2) natural frequencies of new and spent fuel storage racks identifying primary horizontal, vertical and rocking frequencies of vibration, and (3) the technical basis why the range of the lowest and highest frequencies specified in the analysis will provide conservative results.

09.01.02-19

1. The 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4, 5, 63, and 10CFR 52.80 (a) provide the regulatory requirements for the design of the new and spent fuel storage facilities. Standard Review Plan (SRP) Sections 9.1.2 and 3.8.4, Appendix D describes specific SRP acceptance criteria for the review of the fuel racks that are acceptable to meet the relevant requirements of the Commission's regulations identified above. In APR1400 DCD Tier 2, Subsection 9.1.2.2.1 “New Fuel storage”, it is stated that “The new fuel storage pit is covered by steel plates and an access platform. The access

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platform provides passage between racks for inspection of the new fuel. Both the steel plates and access platform are designed not to fall or collapse in the event of an SSE". In order for the staff to perform its safety evaluation of the new fuel storage, the applicant is requested to provide the dynamic characteristics of steel plates and the access platform and describe the methodology, seismic input used and the results of seismic analysis performed, and the acceptance criteria used to assure that the steel plates and the access platform will not fall or collapse in the event of SSE.

09.01.02-20

1. The 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4, 5, 63, and 10CFR 52.80 (a) provide the regulatory requirements for the design of the new and spent fuel storage facilities. Standard Review Plan (SRP) Sections 9.1.2 and 3.8.4, Appendix D describes specific SRP acceptance criteria for the review of the fuel racks that are acceptable to meet the relevant requirements of the Commission's regulations identified above. The SRP 3.8.4 Appendix D section I.5, 'Design and analysis Procedure" requires that "Details of the mathematical model, including a description of how the important parameters are obtained, should be provided". The seismic response of the freestanding fuel storage rack modules is highly nonlinear and involves a complex combination of motions (sliding, rocking, and twisting).The staff did not find sufficient information of the mathematical model and its parameters considered for the seismic evaluation of the new and the spent fuel racks. In accordance with SRP 3.8.4 Appendix D section I.5, the applicant is requested to provide the following information so that the staff can perform its safety evaluation of the seismic analysis.
 - a. In Subsection 3.3 (3), it is stated that "Each concentrated mass has a degree of freedom in horizontal direction". The applicant is requested to clarify if the same mass is considered effective in both the horizontal directions. Also, the applicant is requested to provide the technical basis for not including the rack and the fuel lumped masses associated with the rocking and twisting degrees of freedom to simulate sliding, rocking and twisting of the free standing racks.
 - b. In Figures 3-1 and 3-3 (APR1400-H-N-NR-14012, Rev.0), dynamic analysis model of new fuel and spent fuel storage racks respectively, rack equivalent element and fuel assembly equivalent element are shown. Please describe the methodology for determining the rack and fuel assembly equivalent element properties including the acceptance criteria for dynamic equivalency. Provide a comparison of natural frequencies and significant modes of vibrations of the equivalent rack-fuel assembly with the actual rack-fuel assembly.
 - c. In Figure 3-4 (APR1400-H-N-NR-14012-P, Rev.0), schematic of spring elements used for SFSR are shown. The applicant is requested to provide the spring values and explain how the different spring stiffness values are determined. Since the impact forces are affected by the impact spring stiffness , the applicant is also requested to explain how is the sensitivity of the impact forces and rack responses to variation in these spring constants is considered in the nonlinear seismic analyses. Provide the results of any sensitivity analysis performed.
 - d. Provide the integration time step used in performing the nonlinear time history analyses for SSE. Please explain the sensitivity of the numerical results to the integration time

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step used in the nonlinear seismic analyses. Provide the results of any sensitivity analysis performed.

- e. The applicant is also requested to explain the methods used to incorporate gaps between the racks, fuel bundles and the guide tubes and how the sensitivity of variation in gaps is considered in the nonlinear seismic analyses. Provide the results of any sensitivity analysis performed.
- f. The applicant is requested to discuss how the effect of the installation tolerances for the nominal gap are considered in the seismic analysis and design of the NFSR and SFSR and provide the results of any sensitivity analysis performed.

The applicant is requested to identify any proposed changes to and provide a mark-up of Subsections in the DCD Tier 2 and the report APR1400-H-N-NR-14012, Rev.0, as appropriate.

09.01.02-21

1. The 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4, 5, 63, and 10CFR 52.80 (a) provide the regulatory requirements for the design of the new and spent fuel storage facilities. Standard Review Plan (SRP) Sections 9.1.2 and 3.8.4, Appendix D describes specific SRP acceptance criteria for the review of the fuel racks that are acceptable to meet the relevant requirements of the Commission's regulations identified above. In DCD Tier 2, Section 9.1.2.2.3, "New and Spent Fuel Storage Rack Design", the applicant stated that "The dynamic and stress analyses are performed as described in report APR1400-H-N-NR-14012-P & NP". In the report APR1400-H-N-NR-14012-P, Rev.0, Section 3.1.2.3 "Hydrodynamic Mass", the staff notes that the Applicant did not describe the hydrodynamic mass under the baseplate of each rack. The SRP 3.8.4 Appendix D section I.5, "Design and analysis Procedure" requires that the effect of effective mass from submergence in water should be quantified. In accordance with SRP 3.8.4 Appendix D section I.5, the Applicant is requested to (1) clarify whether the hydrodynamic mass under the rack baseplate of each rack has been considered in all nonlinear seismic analyses and (2) provide the methodology for calculating this hydrodynamic mass. If the hydrodynamic mass under the base plate of each rack is not considered in the nonlinear dynamic analyses, the applicant is requested to provide the technical basis and justification to show that ignoring the hydrodynamic mass under the baseplate of each rack is conservative. The second part of Subsection 3.1.2.3 states "(2) Hydrodynamic masses between Rack-to-Rack and Rack-to-Pool Wall are calculated based on height of rack, density of fluid and gap of adjacent racks, assuming that the fluid is filled between two objects." The applicant is requested to provide a technical reference to any recognized method for this calculation. Also, describe how changes in the gap during seismic response affect the gap-dependent hydrodynamic mass and the subsequent seismic response due to the revised hydrodynamic mass. This could potentially be significant for low coefficient of friction cases where more sliding is expected.

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09.01.02-22

The 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4, 5, 63, and 10CFR 52.80 (a) provide the regulatory requirements for the design of the new and spent fuel storage facilities. Standard Review Plan (SRP) Sections 9.1.2 and 3.8.4, Appendix D describes specific SRP acceptance criteria for the review of the fuel racks that are acceptable to meet the relevant requirements of the Commission's regulations identified above. In DCD Tier 2, Section 9.1.2.2.3, "New and Spent Fuel Storage Rack Design", the applicant stated that "The dynamic and stress analyses are performed as described in report APR1400-H-N-NR-14012-P & NP". In the report APR1400-H-N-NR-14012-P, Rev.0, Subsection 3.7.3.4 (3) "Secondary Stress by Temperature Effects", it is stated that "a conservative estimate of the weld stresses along the length of an isolated hot cell is obtained by considering a beam strip uniformly heated by 65° F and restrained from growth along one long edge. The Applicant further stated that temperature rise envelops the difference between the maximum local spent fuel pool water temperature (155° F) inside a storage cell and the bulk pool temperature (121° F) based on the thermal-hydraulic analysis of the spent fuel pool". The Applicant is requested to provide appropriate references and the methodology to calculate the maximum local spent fuel pool water temperature inside a storage cell and the bulk pool temperature.

09.01.02-23

1. The 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4, 5, 63, and 10CFR 52.80 (a) provide the regulatory requirements for the design of the new and spent fuel storage facilities. Standard Review Plan (SRP) Sections 9.1.2 and 3.8.4, Appendix D describes specific SRP acceptance criteria for the review of the fuel racks that are acceptable to meet the relevant requirements of the Commission's regulations identified above. In DCD Tier 2, Section 9.1.2.2.3, "New and Spent Fuel Storage Rack Design", the applicant stated that "The dynamic and stress analyses are performed as described in report APR1400-H-N-NR-14012-P & NP". In the report APR1400-H-N-NR-14012-P, Rev.0, Section 4.1 "Description of Mechanical Accident", the applicant considered a drop of fuel assembly in an interior cell away from the support pedestal for one of the 'Straight Deep Drops' scenario. The applicant is requested to provide specific location(s) of the drop on the rack base plate that were considered to maximize the deformation of the rack base plate and whether it also considered a deep drop into a cell along the perimeter and half way between the supports. It is not clear from the description whether the rack baseplate evaluation due to fuel impact assumed that other fuel assemblies are in place when a fuel assembly drops through an empty cell. A full load of fuel assemblies may introduce progressive deformation of the baseplate after a fuel assembly impacts the rack baseplate. The maximum downward deformation of the baseplate may be significant enough to initiate a progressive deformation. Therefore, the applicant is also requested to provide (1) the technical basis and justification for not considering all other fuel assemblies in place when a fuel assembly drops through an empty cell and (2) the design basis for the rack baseplate including the basis for determining the most critical locations of the fuel assembly drop.

The applicant is requested to identify any proposed changes to and provide a mark-up of Subsections in the DCD Tier 2 and the report APR1400-H-N-NR-14012-P, Rev.0, as appropriate.

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09.01.02-24

1. The 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4, 5, 63, and 10CFR 52.80 (a) provide the regulatory requirements for the design of the new and spent fuel storage facilities. Standard Review Plan (SRP) Sections 9.1.2 and 3.8.4, Appendix D describes specific SRP acceptance criteria for the review of the fuel racks that are acceptable to meet the relevant requirements of the Commission's regulations identified above. In DCD Tier 2, Section 9.1.2.2.3, "New and Spent Fuel Storage Rack Design", the applicant stated that "The dynamic and stress analyses are performed as described in report APR1400-H-N-NR-14012-P & NP". In the report APR1400-H-N-NR-14012-P, Rev.0, Section 4.3 "Analysis Method", the applicant presented empirical methodologies to analyze the straight shallow and deep drop accidents. The applicant is requested to provide a validation and verification of the proposed empirical methodologies for nonlinear impact phenomena in order for the staff to evaluate whether the proposed methodologies are conservative in predicting the nonlinear deformations of the rack and the rack baseplate, and the impact force on the rack pedestal that is transmitted to the liner and the concrete structure of the spent fuel pool. A nonlinear dynamic analysis for the impact effects of drop accidents, considering a finite element model of the spent fuel rack, rack base plate, a fuel assembly and the pedestal support using appropriate shell, beam, and solid body elements is one approach acceptable to the staff.

09.01.02-25

1. The 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4, 5, 63, and 10CFR 52.80 (a) provide the regulatory requirements for the design of the new and spent fuel storage facilities. Standard Review Plan (SRP) Sections 9.1.2 and 3.8.4, Appendix D describes specific SRP acceptance criteria for the review of the fuel racks that are acceptable to meet the relevant requirements of the Commission's regulations identified above. In DCD Tier 2, Section 9.1.2.2.3, "New and Spent Fuel Storage Rack Design", the applicant stated that "The dynamic and stress analyses are performed as described in report APR1400-H-N-NR-14012-P & NP". In the report APR1400-H-N-NR-14012-P, Rev.0, Section 4.5 "Results of Analyses", the applicant provided the results of fuel assembly drop analyses but did not provide the structural assessment of the dropped fuel assemblies due to impact with the rack and the rack baseplate. The staff notes that the applicant in Subsection 3.7.2 of the report provided structural evaluation of the fuel for the lateral impact loads on the fuel assembly due to fuel-to-cell wall impact. The applicant is requested to provide the results of its structural evaluation of the fuel assembly from the mechanical drop accident scenarios described in Section 4.1 of the report.

The applicant is requested to identify any proposed changes to and provide a mark-up of Subsections in the DCD Tier 2 and the report APR1400-H-N-NR-14012-P, Rev.0, as appropriate.

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09.01.02-26

1. The 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4, 5, 63, and 10CFR 52.80 (a) provide the regulatory requirements for the design of the new and spent fuel storage facilities. Standard Review Plan (SRP) Sections 9.1.2 and 3.8.4, Appendix D describes specific SRP acceptance criteria for the review of the fuel racks that are acceptable to meet the relevant requirements of the Commission's regulations identified above. In DCD Tier 2, Section 9.1.2.2.3, "New and Spent Fuel Storage Rack Design", the applicant stated that "The dynamic and stress analyses are performed as described in report APR1400-H-N-NR-14012-P & NP". The staff noted that APR1400-H-N-NR-14012-P, Rev.0 did not consider seismic-induced sloshing effects in the nonlinear seismic analyses of the rack structure. The SRP 3.8.4 Appendix D, Section I.5 requires that the effect of sloshing water be quantified. In accordance with SRP 3.8.4 Appendix D, Section I.5, the applicant is requested to quantify the effect of sloshing water or provide the technical basis and justification for not considering the seismic sloshing effect on the dynamic response of the spent fuel racks. The applicant is requested to identify any proposed changes to and provide a mark-up of Subsections in the DCD Tier 2 and the report APR1400-H-N-NR-14012-P, Rev.0, as appropriate.

09.01.02-27

The 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4, 5, 63, and 10CFR 52.80 (a) provide the regulatory requirements for the design of the new and spent fuel storage facilities. Standard Review Plan (SRP) Sections 9.1.2 and 3.8.4, Appendix D describes specific SRP acceptance criteria for the review of the fuel racks that are acceptable to meet the relevant requirements of the Commission's regulations identified above. In DCD Tier 2, Section 9.1.2.2.3, "New and Spent Fuel Storage Rack Design", the applicant stated that "The dynamic and stress analyses are performed as described in report APR1400-H-N-NR-14012-P & NP". In the technical report APR1400-H-N-NR-14012-P, Rev 0, Section 4.5 "Results of Analyses" for the case of the straight deep drop accident over a pedestal, the staff needs additional information to perform the safety evaluation of support of the spent fuel racks. The applicant, in accordance with SRP 3.8.4 Appendix D I.1A, "Support of the Spent Fuel Racks", is requested to provide (1) a detailed description of the model and the methodology used for evaluating the spent fuel pool concrete and the liner for local impact effects, (2) the concrete strength and the thickness of the fuel pool floor and the stainless steel liner, and (3) evaluation results including the integrity of the spent fuel stainless steel liner. The applicant is requested to identify any proposed changes to and provide a mark-up of Subsections in the DCD Tier 2 and the report APR1400-H-N-NR-14012-P, Rev.0, as appropriate.

09.01.02-28

1. The 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4, 5, 63, and 10CFR 52.80 (a) provide the regulatory requirements for the design of the new and spent fuel storage facilities. Standard Review Plan (SRP) Sections 9.1.2 and 3.8.4, Appendix D describes specific SRP acceptance criteria for the review of the fuel racks that are acceptable to meet the relevant requirements of the Commission's regulations identified above. In DCD Tier 2, Section 9.1.2.2.3, "New and Spent Fuel Storage Rack Design", the applicant stated that "The dynamic and stress analyses are performed as described in report APR1400-H-N-NR-14012-P & NP". In the technical report APR1400-H-N-NR-14012-P, Rev

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0, Subsection 3.7.3.3, "Stresses on Welds", the applicant evaluated stresses in cell-to-baseplate and baseplate-to-pedestal welds but did not calculate the base metal shear stress. The safety factor (ratio of allowable to actual shear stress) for the base metal may be lower than that for the weld. This reduction is noted in safety factors in Table 3-13 "Stress Evaluation for Fuel Racks. The staff notes that the safety factor for the cell-to cell weld stress is 5.42 that is reduced to 3.68 for the base metal shear. The applicant is requested to provide the base metal shear stress and corresponding safety factor for the cell-to-baseplate and baseplate-to-pedestal weld connections so the staff can make safety conclusions related to the rack welded connections.

09.01.02-29

1. The 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4, 5, 63, and 10CFR 52.80 (a) provide the regulatory requirements for the design of the new and spent fuel storage facilities. Standard Review Plan (SRP) Sections 9.1.2 and 3.8.4, Appendix D describes specific SRP acceptance criteria for the review of the fuel racks that are acceptable to meet the relevant requirements of the Commission's regulations identified above. In DCD Tier 2, Section 9.1.2.2.3, "New and Spent Fuel Storage Rack Design", the applicant stated that "The dynamic and stress analyses are performed as described in report APR1400-H-N-NR-14012-P & NP". In the technical report APR1400-H-N-NR-14012-P, Rev 0, Subsection 3.7.3.3, "Stresses on Welds", the applicant evaluated stresses in cell-to-cell welds. An underlying assumption in the modeling of the rack as a single beam using the overall bending stiffness of the entire rack is that the cell-to-cell welds are intact and can carry the internal forces necessary to validate this assumption. This is not addressed in the report. The applicant is requested to provide a quantitative evaluation demonstrating that this loading in conjunction with the other loadings discussed in the report does not create an overstress condition in the cell-to-cell welds.

09.01.02-30

1. The 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4, 5, 63, and 10CFR 52.80 (a) provide the regulatory requirements for the design of the new and spent fuel storage facilities. Standard Review Plan (SRP) Sections 9.1.2 and 3.8.4, Appendix D describes specific SRP acceptance criteria for the review of the fuel racks that are acceptable to meet the relevant requirements of the Commission's regulations identified above. SRP 3.8.4 Appendix D I (5) states that "Details of the mathematical model, including a description of how the important parameters are obtained, should be provided". In DCD Tier 2, Section 9.1.2.2.3, "New and Spent Fuel Storage Rack Design", the applicant stated that "The dynamic and stress analyses are performed as described in report APR1400-H-N-NR-14012-P & NP". In the technical report APR1400-H-N-NR-14012-P, Rev 0, Subsection 3.1.2.2, "Details of Rack and Fuel Assembly" the staff finds that the information of the rack and fuel assembly mathematical model and the computer program used for the nonlinear seismic analysis is insufficient. The applicant is requested to provide the following additional information so that the staff can perform its safety evaluation of the seismic analysis of the rack and fuel assembly.
 - a. The applicant stated that "There are three nodes for rack cells and fuel assemblies". The applicant did not provide any technical basis to show that the three node model of the fuel assembly adequately represents the dynamic characteristics of the fuel assembly.

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The applicant is requested to provide the fuel frequencies of the three lumped mass fuel model along with a comparison with frequency of the fuel assuming the fuel assembly as a simply supported beam, and with any physical test measurements of a PWR fuel assembly.

- b. The applicant stated that “All the fuel assemblies in each storage rack module are modeled as one beam of which the mass equals the sum of the masses of all the fuel assemblies in a rack”. The applicant is requested to discuss and provide the details of how the stiffness properties of the beam that represents all the fuel assemblies in a rack are calculated to capture the dynamic characteristics of the free standing racks under seismic loading. The applicant is also requested to provide the assumptions and computational details of the contact stiffness between the fuel and the rack’s cell wall that is used to predict the maximum fuel-to-cell impact loads.
- c. The applicant used ANSYS, Version 10 finite element program for the nonlinear dynamic analysis. The applicant is requested to provide reference to operating or new nuclear power plants free standing fuel racks that have been licensed using ANSYS Version 10. The applicant is also requested to provide the details of benchmarking, validation and verification of ANSYS commuter program for the specific application to the nonlinear seismic analysis of the free standing submerged fuel rack structures that includes nonlinear springs.

The applicant is requested to identify any proposed changes to and provide a mark-up of Subsections in the DCD Tier 2 and the report APR1400-H-N-NR-14012-P, Rev.0, as appropriate.

09.01.02-31

1. The 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4, 5, 63, and 10CFR 52.80 (a) provide the regulatory requirements for the design of the new and spent fuel storage facilities. Standard Review Plan (SRP) Sections 9.1.2 and 3.8.4, Appendix D describes specific SRP acceptance criteria for the review of the fuel racks that are acceptable to meet the relevant requirements of the Commission's regulations identified above. In DCD Tier 2, Section 9.1.2.2.3, “New and Spent Fuel Storage Rack Design”, the applicant stated that “The dynamic and stress analyses are performed as described in report APR1400-H-N-NR-14012-P & NP”. In the technical report APR1400-H-N-NR-14012-P, Rev 0, Subsection 3.7.1.3, “Impact Loads”, for the case of rack-to-rack impacts, states that “The prominent baseplate of the fuel storage rack for the APR1400 design is installed almost in contact with the adjacent baseplate. According to the analysis result, the impact occurs not between the pool wall and the upper part of the rack, but between the baseplate of racks. SRP 3.8.4 Appendix D I(5) states that ” Details of the mathematical model, including a description of how the important parameters are obtained, should be provided” .In order for the staff to conclude that the applicant has adequately evaluated the rack-to-rack impact effects using a reasonable estimate of the impact spring rate, the applicant is requested to provide in accordance with the SRP 3.8.4 Appendix D I(5) the technical basis for calculating the impact spring constant for the rack-to-rack and rack baseplate-to-rack baseplate impact analysis in order to maximize the impact force. The applicant is also requested to address how the sensitivity of the impact force to the impact spring constant was considered in the analysis and design.

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The applicant is requested to identify any proposed changes to and provide a mark-up of Subsections in the DCD Tier 2 and the report APR1400-H-N-NR-14012-P, Rev.0, as appropriate.

09.01.02-32

The 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4, 5, 63, and 10CFR 52.80 (a) provide the regulatory requirements for the design of the new and spent fuel storage facilities. Standard Review Plan (SRP) Sections 9.1.2 and 3.8.4, Appendix D describes specific SRP acceptance criteria for the review of the fuel racks that are acceptable to meet the relevant requirements of the Commission's regulations identified above. In DCD Tier 2, Section 9.1.2.2.3, "New and Spent Fuel Storage Rack Design", the applicant stated that "The dynamic and stress analyses are performed as described in report APR1400-H-N-NR-14012-P & NP". In the technical report APR1400-H-N-NR-14012-P, Rev 0, Subsection 3.1.2.1 (2) "General Considerations" the applicant included the pedestal-to-bearing pad interface in the dynamic model of the rack for the impact loads. However, the staff did not find any acceptance criteria for the bearing pad. In order for the staff to perform its safety evaluation of the rack supports, the applicant in accordance with SRP 3.8.4 Appendix D I (3), is requested to provide a sketch showing the bearing pad dimensions and a layout of bearing pad with respect to the rack pedestal and the pool floor and acceptance criteria for the bearing pads including the maximum calculated and allowable bearing stress. The applicant is requested to identify any proposed changes to and provide a mark-up of Subsections in the DCD Tier 2 and the report APR1400-H-N-NR-14012-P, Rev.0, as appropriate.

09.01.02-33

1. The 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4, 5, 63, and 10CFR 52.80 (a) provide the regulatory requirements for the design of the new and spent fuel storage facilities. Standard Review Plan (SRP) Sections 9.1.2 and 3.8.4, Appendix D describes specific SRP acceptance criteria for the review of the fuel racks that are acceptable to meet the relevant requirements of the Commission's regulations identified above. In DCD Tier 2, Section 9.1.2.2.3, "New and Spent Fuel Storage Rack Design", the applicant stated that "The dynamic and stress analyses are performed as described in report APR1400-H-N-NR-14012-P & NP". In the technical report APR1400-H-N-NR-14012-P, Rev 0, Section 4, "MECHANICAL ACCIDENTS ANALYSIS", Subsection 4.3, "Analysis Method", states that "This calculation covers the new fuel storage racks in NFP and the spent fuel storage racks of Region I and Region II in SFP. Region I racks are structurally stronger than Region II racks. To conservatively estimate the damage of the racks due to the postulated drop accidents, the calculation is performed for Region II racks. Since the new fuel storage rack is held down by firmly attached to the embedment plates of NFP using a stud bolt and is supported by additional intermediate plate, and has no "poison zone", the drop accident evaluation is performed only for the case of drop (away from pedestal) on baseplate of the fuel rack". The applicant is requested to provide the technical basis for concluding that the spent fuel storage racks of Region I are structurally stronger than the Region II racks and also provide a technical justification that the dynamic response and the design safety factors for the Region II racks will bound the Region I racks and the design stress limits for region I racks will not be exceeded under the required load combinations in the Table 3-1. The applicant is requested to identify any proposed changes to and provide a mark-up of Subsections in the DCD Tier 2 and the report APR1400-H-N-NR-14012-P, Rev.0, as appropriate.

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09.01.02-34

The 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4, 5, 63, and 10CFR 52.80 (a) provide the regulatory requirements for the design of the new and spent fuel storage facilities. Standard Review Plan (SRP) Sections 9.1.2 and 3.8.4, Appendix D describes specific SRP acceptance criteria for the review of the fuel racks that are acceptable to meet the relevant requirements of the Commission's regulations identified above. In DCD Tier 2, Section 9.1.2.2.3, "New and Spent Fuel Storage Rack Design", the applicant stated that "The dynamic and stress analyses are performed as described in report APR1400-H-N-NR-14012-P & NP". In the technical report APR1400-H-N-NR-14012-P, Rev 0, Subsections 3.2.2.1 and 3.2.2.2, the applicant provided the acceptance criteria for normal and upset conditions, Service Level A and Service Level B respectively, but did not discuss or provide the evaluation results for the normal and upset conditions. In accordance with SRP 3.8.4 Appendix D I (6), the applicant is requested to provide its evaluation results for the normal and upset conditions. The applicant is requested to identify any proposed changes to and provide a mark-up of Subsections in the DCD Tier 2 and the report APR1400-H-N-NR-14012-P, Rev.0, as appropriate.

09.01.02-35

The 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4, 5, 63, and 10CFR 52.80 (a) provide the regulatory requirements for the design of the new and spent fuel storage facilities. Standard Review Plan (SRP) Sections 9.1.2 and 3.8.4, Appendix D describes specific SRP acceptance criteria for the review of the fuel racks that are acceptable to meet the relevant requirements of the Commission's regulations identified above. In DCD Tier 2, Section 9.1.2.2.3, "New and Spent Fuel Storage Rack Design", the applicant stated that "The dynamic and stress analyses are performed as described in report APR1400-H-N-NR-14012-P & NP". In the technical report APR1400-H-N-NR-14012-P, Rev 0, Subsection 3.2.2.2, "Upset Conditions (Level B)", the Service Level B acceptance criteria states that "allowable stress of Level A is used for Level B for conservatism". The staff notes that in Section 4.3.5, "Methodology for Stuck Fuel Accident", the applicant did not use the allowable stress of Level A but instead increased the Service Level A allowable in shear to Service Level B allowable. In accordance with SRP 3.8.4 Appendix D I (6), the applicant is requested to clarify the apparent inconsistency in the implementation of its Service Level B acceptance criteria for the stuck fuel assembly scenario. The applicant is also requested to provide the results of its evaluation and safety factors for the cell wall tensile stress, cell to cell weld shear stress, and the base metal shear stress for this accident scenario. The applicant is requested to identify any proposed changes to and provide a mark-up of Subsections in the DCD Tier 2 and the report APR1400-H-N-NR-14012-P, Rev.0, as appropriate.

09.01.02-36

1. The 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4, 5, 63, and 10CFR 52.80 (a) provide the regulatory requirements for the design of the new and spent fuel storage facilities. Standard Review Plan (SRP) Sections 9.1.2 and 3.8.4, Appendix D describes specific SRP acceptance criteria for the review of the fuel racks that are acceptable to meet the relevant requirements of the Commission's regulations identified above. In DCD Tier 2, Section 9.1.2.2.3, "New and Spent Fuel Storage Rack Design", the applicant stated that "The dynamic and stress analyses are performed as described in report APR1400-H-N-NR-14012-P & NP". In the technical report APR1400-H-N-NR-14012-P, Rev

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0, Subsection 3.7.1.1, “Displacements of Rack”, it is stated that “Actually, impact on rack-to-rack occurs at baseplate of the SFSTRs because the installed racks are in contact with each other. The maximum impact loads generated at the NFSTRs and the SFSTRs are summarized in Table 3-10.” In Subsection 3.7.1.3 (2), “Impact Loads”, it is stated that “The prominent baseplate of the fuel storage rack for the APR1400 design is installed almost in contact with the adjacent baseplate.”

In accordance with SRP 3.8.4 Appendix D I (3, 5), the applicant is requested to provide the following information so that the staff can perform its safety evaluation of the seismic analysis of new and spent fuel storage racks (NFSTR and SFSTR).

- a. For NFSTR and SFSTR, provide the baseplate dimensions and layout and plan view clearly showing gap or no gap between the adjacent baseplates; the gaps between the baseplates and the spent fuel pool walls; and the rack-to-rack gaps at midheight and at the top of the racks. Identify the elevation of the gaps shown in Figure 2-4.
- b. Discuss how the effect of adjacent baseplates that are in contact is modeled in the non-linear dynamic models.
- c. The pool multi-rack dynamic analysis model in Figure 3-2 shows gaps between the adjacent base plates of all 29 racks. Describe how the contact between the baseplates is modeled in the whole pool multi-rack model. If the racks are installed such that their baseplates are in contact, provide the technical basis why the whole pool multi-rack model, with gaps, shown in Figure 3-2, predicts conservative dynamic responses for the racks and SFP walls.
- d. Discuss how the thermal load effects are considered for the installed racks that are in contact (no gap) with each other at the baseplate. Also discuss the effect on the design forces at the pedestal due to the thermal expansion of the installed racks.
- e. The applicant is requested to provide COL information items that include the development of post seismic event inspection procedures to measure gaps between the new and spent fuel storage racks.

The applicant is requested to identify any proposed changes to and provide a mark-up of Subsections in the DCD Tier 2 and the report APR1400-H-N-NR-14012-P, Rev.0, as appropriate.

09.01.02-37

1. The 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4, 5, 63, and 10CFR 52.80 (a) provide the regulatory requirements for the design of the new and spent fuel storage facilities. Standard Review Plan (SRP) Sections 9.1.2 and 3.8.4, Appendix D describes specific SRP acceptance criteria for the review of the fuel racks that are acceptable to meet the relevant requirements of the Commission's regulations identified above. In DCD Tier 2, Section 9.1.2.2.3, “New and Spent Fuel Storage Rack Design”, the applicant stated that “The dynamic and stress analyses are performed as described in report APR1400-H-N-NR-14012-P & NP”. In the technical report APR1400-H-N-NR-14012-P, Rev 0, Table 3-9, “Maximum Loads on single Pedestal”, the applicant provided the pedestal forces for the new and spent fuel racks. In accordance with SRP 3.8.4 Appendix D I (5), the

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applicant is requested to provide the details how the pedestal forces were converted to the bending moment and shear force at the bottom baseplate-to-pedestal interface. The applicant is requested to identify any proposed changes to and provide a mark-up of Subsections in the DCD Tier 2 and the report APR1400-H-N-NR-14012-P, Rev.0, as appropriate.

09.01.02-38

The 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4, 5, 63, and 10CFR 52.80 (a) provide the regulatory requirements for the design of the new and spent fuel storage facilities. Standard Review Plan (SRP) Sections 9.1.2 and 3.8.4, Appendix D describes specific SRP acceptance criteria for the review of the fuel racks that are acceptable to meet the relevant requirements of the Commission's regulations identified above. In DCD Tier 2, Section 9.1.2.2.3, "New and Spent Fuel Storage Rack Design", the applicant stated that "The dynamic and stress analyses are performed as described in report APR1400-H-N-NR-14012-P & NP". In the technical report APR1400-H-N-NR-14012-P, Rev 0, Subsection 3.7.3.3 (3) "Cell-to-Cell Weld" provides a general description of the forces considered in the evaluation of cell-to-cell welds but did not provide any descriptions of how the stresses in the weld were calculated. In accordance with SRP 3.8.4 Appendix D I (3, 4, 5, 6), the applicant is requested to provide details of how the stresses in the cell-to-cell welds were determined, including a free-body diagram explaining how the loads were transferred and used to evaluate the cell-to-cell welds. The applicant is requested to identify any proposed changes to and provide a mark-up of Subsections in the DCD Tier 2 and the report APR1400-H-N-NR-14012-P, Rev.0, as appropriate.

09.01.02-39

1. The 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4, 5, 63, and 10CFR 52.80 (a) provide the regulatory requirements for the design of the new and spent fuel storage facilities. Standard Review Plan (SRP) Sections 9.1.2 and 3.8.4, Appendix D describes specific SRP acceptance criteria for the review of the fuel racks that are acceptable to meet the relevant requirements of the Commission's regulations identified above. In DCD Tier 2, Section 9.1.2.2.3, "New and Spent Fuel Storage Rack Design", the applicant stated that "The dynamic and stress analyses are performed as described in report APR1400-H-N-NR-14012-P & NP". In the technical report APR1400-H-N-NR-14012-P, Rev 0, Subsection 3.7.3.3(2) "Baseplate-to-Pedestal Weld", it is stated that "The weld between baseplate and support pedestal is checked using finite element analysis to determine that the maximum stress is 124.1 MPa (17,992 psi) under a Level D condition". In accordance with SRP 3.8.4 Appendix D I (3, 4, 5, 6), the applicant is requested to provide details of the finite element analysis performed, including the finite element computer program, the computer model, and the loads considered in the weld stress analysis. The applicant is requested to identify any proposed changes to and provide a mark-up of Subsections in the DCD Tier 2 and the report APR1400-H-N-NR-14012-P, Rev.0, as appropriate.

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09.01.02-40

1. The 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4, 5, 63, and 10CFR 52.80 (a) provide the regulatory requirements for the design of the new and spent fuel storage facilities. Standard Review Plan (SRP) Sections 9.1.2 and 3.8.4, Appendix D describes specific SRP acceptance criteria for the review of the fuel racks that are acceptable to meet the relevant requirements of the Commission's regulations identified above. In DCD Tier 2, Section 9.1.2.2.3, "New and Spent Fuel Storage Rack Design", the applicant stated that "The dynamic and stress analyses are performed as described in report APR1400-H-N-NR-14012-P & NP". In the technical report APR1400-H-N-NR-14012-P, Rev 0, the applicant in Subsection 3.2.2.3 "Faulted (Abnormal) Conditions (Level D)", specified the allowable compressive stress as two-thirds of the critical buckling stress for the stress limit criteria for combined axial compression + bending loads,. However, in subsection 3.7.3.4(2), "Local Stress Evaluation", the applicant calculated the critical buckling stress of 12,731 psi but did not reduce it to two-thirds to obtain allowable compressive stress for the rack cell wall. In accordance with SRP 3.8.4 Appendix D I (3), the applicant is requested to provide the technical justification for using the calculated critical buckling stress as the limit under Service Level D condition, instead of the two-thirds of the critical buckling stress as stated in the Level D stress limit criteria. Also, in the calculation of critical buckling stress, BETA (value of coefficient) = 4.0 is used. The applicant is requested to explain what boundary conditions are assumed on the long edges of the simplified cell wall buckling model, and provide the technical basis for this designation. The applicant is requested to identify any proposed changes to and provide a mark-up of Subsections in the DCD Tier 2 and the report APR1400-H-N-NR-14012-P, Rev.0, as appropriate.

09.01.02-41

1. The 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4, 5, 63, and 10CFR 52.80 (a) provide the regulatory requirements for the design of the new and spent fuel storage facilities. Standard Review Plan (SRP) Sections 9.1.2 and 3.8.4, Appendix D describes specific SRP acceptance criteria for the review of the fuel racks that are acceptable to meet the relevant requirements of the Commission's regulations identified above. In DCD Tier 2, Section 9.1.2.2.3, "New and Spent Fuel Storage Rack Design", the applicant stated that "The dynamic and stress analyses are performed as described in report APR1400-H-N-NR-14012-P & NP". In accordance with SRP 3.8.4 Appendix D I (3, 4, 5, 6), the applicant is requested to provide the following additional information in the technical report.
 - (a) In the technical report APR1400-H-N-NR-14012-P, Rev 0, Subsection 3.7.2, "Fuel structural Evaluation", the applicant did not discuss the location of the impact on the fuel where the maximum impact force occurs. The applicant is requested to provide the impact load for both the top and at the mid height of the fuel assembly. The staff notes in Subsection 3.1.2.2, "Details for Rack and Fuel Assembly", that "The mass of the upper, the central and the lower nodes is 1/4, 1/2 and 1/4 of the total mass, respectively". Since only 25 percent of the mass is assumed at the ends of the fuel assembly, there is a potential for a higher g-load on the fuel assembly at the top compared to that at the mid height if the impact load at the top of the fuel assembly is more than half the impact load calculated at the mid height. The applicant is requested to provide a technical justification for not determining the g-load on the fuel assembly at

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the top and at the mid-height and then using the maximum of the g-load in subsequent fuel assembly structural integrity evaluations.

- (b) The staff in reviewing Table 3-10, "Impact Loads on Rack", notes that the impact load on the fuel assembly in the East-West and North-South directions is 25000 lbf and 18,594 lbf respectively. In subsection 3.7.2, "Fuel structural Evaluation", the applicant considered only the 25000 lbf load in evaluation the fuel assembly. The applicant is requested to provide the technical basis for not combining the impact load on the fuel assembly in the north-south and east-west directions simultaneously to obtain the total lateral impact load for use in evaluating the structural integrity of the fuel assembly.
- (c) The applicant is also requested to provide the general criteria used for combining the seismic responses in the design and analysis of the fuel assembly, rack structure, welded connections, and the rack supports of NFSR and SFSR due to the SSE excitation along the three orthogonal directions (2 horizontal and vertical) imposed simultaneously.

The applicant is requested to identify any proposed changes to and provide a mark-up of Subsections in the DCD Tier 2 and the report APR1400-H-N-NR-14012-P, Rev.0, as appropriate.

09.01.02-42

The 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4, 5, 63, and 10CFR 52.80 (a) provide the regulatory requirements for the design of the new and spent fuel storage facilities. Standard Review Plan (SRP) Sections 9.1.2 and 3.8.4, Appendix D describes specific SRP acceptance criteria for the review of the fuel racks that are acceptable to meet the relevant requirements of the Commission's regulations identified above. In DCD Tier 2, Section 9.1.2.2.3, "New and Spent Fuel Storage Rack Design", the applicant stated that "The dynamic and stress analyses are performed as described in report APR1400-H-N-NR-14012-P & NP". In the technical report APR1400-H-N-NR-14012-P, Rev 0, Table 3-11, "Stress Evaluation for Fuel Assembly", the applicant provides allowable limit for fuel grid spacer and fuel rod cladding. The staff did not find the basis for the bending stress calculation in the fuel rod cladding reported in the Table 3-11. In order for the staff to perform its safety evaluation of the fuel assembly, the applicant in accordance with SRP 3.8.4 Appendix D I (6) is requested to provide the technical basis for calculating the bending stress and the acceptance criteria used for the evaluation the fuel cladding. The applicant is also requested to provide the stress/strain evaluation of fuel cladding and an evaluation of the fuel channel. The applicant is requested to identify any proposed changes to and provide a mark-up of Subsections in the DCD Tier 2 and the report APR1400-H-N-NR-14012-P, Rev.0, as appropriate.

09.01.02-43

1. The 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4, 5, 63, and 10CFR 52.80 (a) provide the regulatory requirements for the design of the new and spent fuel storage facilities. Standard Review Plan (SRP) Sections 9.1.2 and 3.8.4, Appendix D describes specific SRP acceptance criteria for the review of the fuel racks that are acceptable to meet the relevant requirements of the Commission's regulations identified above. In DCD Tier 2, Section 9.1.2.2.3, "New and Spent Fuel Storage Rack Design", the

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applicant stated that “The dynamic and stress analyses are performed as described in report APR1400-H-N-NR-14012-P & NP”. In the technical report APR1400-H-N-NR-14012-P, Rev 0, Subsection 3.7.3, “Rack structural evaluation”, the staff did not find the punching shear evaluation of the baseplate against the rack pedestal impact loads. The credible failure mode for the rack baseplate is a punching shear failure due to the concentrated load transmitted by a support pedestal under SSE conditions and impact load on the rack baseplate due to an accidental drop of a fuel assembly. In order for the staff to perform its safety evaluation of the rack supports, the applicant in accordance with SRP 3.8.4 Appendix D I (3) is requested to demonstrate that the capacity of the baseplate against the punching is larger than the calculated rack pedestal impact load. The applicant is requested to identify any proposed changes to and provide a mark-up of Subsections in the DCD Tier 2 and the report APR1400-H-N-NR-14012-P, Rev.0, as appropriate.

09.01.02-44

1. The 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4, 5, 63, and 10CFR 52.80 (a) provide the regulatory requirements for the design of the new and spent fuel storage facilities. Standard Review Plan (SRP) Sections 9.1.2 and 3.8.4, Appendix D describes specific SRP acceptance criteria for the review of the fuel racks that are acceptable to meet the relevant requirements of the Commission's regulations identified above. SRP Section 3.8.4, “Other Seismic Category I Structures,” Appendix D (7) in parts requires that the applicant should describe materials, quality control procedures, and any special construction techniques. In DCD Tier 2, Section 9.1.2, the staff did not find the governing quality control requirements and procedure for design and construction for the spent fuel storage racks. The staff also did not find the manufacturing process; special fabrication techniques; and the sequences used for constructing the fuel storage racks to reduce fabrication distortions and to provide accessibility for inspection. In accordance with SRP 3.8.4 Appendix D, and Appendix A to 10 CFR Part 50, General Design Criteria 1, 2, 4, 5, 61, 63, the applicant is requested to provide governing quality control requirements and procedure and any special fabrication and construction techniques used for constructing the fuel storage racks.

09.01.02-45

1. The 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4, 5, 63, and 10CFR 50.68 provide the regulatory requirements for the design of the new and spent fuel storage facilities. Standard Review Plan (SRP) Section 3.8.4, Appendix D, and Section 9.1.2 describes specific SRP acceptance criteria for the review of the fuel racks that are acceptable to meet the relevant requirements of the Commission's regulations identified above. In SRP Section 9.1.2 III.6, “The reviewer should also consider the appropriateness of identified COL action items. The reviewer may identify additional COL action items; however, to ensure these COL action items are addressed during a COL application, they should be added to the DC FSAR”. In DCD Tier 2, Section 9.1.2, the staff did not find any Combined License Information items identified for the dynamic and structural analyses of the new and spent fuel storage racks. In accordance with the SRP Section 9.1.2 III.6, the applicant is requested to provide a justification for not including any Combined License Information items. The structural, dynamic, and impact analysis of the fuel racks is highly dependent on the specific rack design. The COL applicant is required to perform a

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confirmatory structural dynamic and stress analysis for the spent fuel rack including reconciliation of loads imposed by the spent fuel rack on the spent fuel pool structure.

09.01.02-46

The 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4, 5, 63, and 10CFR 52.80 (a) provide the regulatory requirements for the design of the new and spent fuel storage facilities. Standard Review Plan (SRP) Sections 9.1.2 and 3.8.4, Appendix D describes specific SRP acceptance criteria for the review of the fuel racks that are acceptable to meet the relevant requirements of the Commission's regulations identified above. The staff reviewed DCD Tier 1, Table 2.7.4.1-1 and Table 2.7.4.2-1 that specify the inspections, tests, analyses, and associated acceptance criteria for the new and spent fuel storage racks respectively. In DCD Tier 1 Subsections 2.7.4.1.1 and 2.7.4.2.1, the design commitment for the new and spent fuel storage rack respectively, states that "The (new) spent fuel storage racks are designed and constructed to accommodate design basis load and load combinations including impact due to postulated fuel handling accidents in a subcritical configuration". In accordance with SRP 3.8.4 Appendix D, and Appendix A to 10 CFR Part 50, General Design Criteria 1, 2, 4, 5, 61, 63, and 10CFR 52.80(a), the applicant is requested to clarify and include in Table 2.7.4.1-1 and Table 2.7.4.2-1, the design commitment "The (new)spent fuel storage racks are designed and constructed to accommodate design basis load and load combinations including impact due to postulated fuel handling accidents in a subcritical configuration" and specify the "Inspections, Tests, Analyses" that will be performed and provide the 'Acceptance Criteria" to meet the design commitment.

The applicant is requested to identify any proposed changes to and provide a mark-up of Subsections in the DCD Tier 1 and 2 and the report APR1400-H-N-NR-14012-P, Rev.0, as appropriate.

09.01.02-47

The 10 CFR Part 50, Appendix A, General Design Criteria (GDC) 1, 2, 4, 5, 63, and 10CFR 52.80(a) provide the regulatory requirements for the design of the new and spent fuel storage facilities. Standard Review Plan (SRP) Sections 9.1.2 and 3.8.4, Appendix D describes specific SRP acceptance criteria for the review of the fuel racks that are acceptable to meet the relevant requirements of the Commission's regulations identified above. In DCD Tier 1 Subsections 2.7.4.1.1 and 2.7.4.2.1, the new and the spent fuel racks respectively, are stated as "non-safety related, but seismic Category I for integrity of the spent fuel assemblies". SRP Section 3.8.4, Appendix D states that "The Regulatory Guide 1.29, "Seismic Design Classification" classifies spent fuel pool racks as seismic Category I structures. Spent fuel pool racks should be treated as safety-related components for determining Quality Assurance requirements (10 CFR Part 50, Appendix B) and periodic condition monitoring requirements (10 CFR 50.65 "Maintenance Rule")". In accordance with SRP 3.8.4 Appendix D, and Appendix A to 10 CFR Part 50, General Design Criteria 1, 2, 4, 5, 61, 63, the applicant is requested to provide justification for treating the racks as non-safety related components and provide the basis for determining the Quality Assurance requirements (10 CFR Part 50, Appendix B) and periodic condition monitoring requirements (10 CFR 50.65 "Maintenance Rule")" for the racks.

The applicant is requested to identify any proposed changes to and provide a mark-up of Subsections in the DCD Tier 1 and 2 and the report APR1400-H-N-NR-14012-P, Rev.0, as appropriate.