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Sent: Friday, October 01, 2010 10:05 AM
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Subject: U.S. EPR Design Certification Application RAI No. 445 (5083), FSAR Ch. 3
Attachments: RAI_445_SEB2_5083.doc

Attached please find the subject requests for additional information (RAI). A draft of the RAI was provided to you on September 16, 2010, and on September 30, 2010, you informed us that the RAI is clear and no further clarification is needed. You also pointed out that the staff has inadvertently included proprietary information in some of the questions. As a result, Draft RAI Questions 03.08.04-17, 03.08.04-18, 03.08.04-19, 03.08.04-20, and 03.08.04-26 were modified. The schedule we have established for review of your application assumes technically correct and complete responses within 30 days of receipt of RAIs. For any RAIs that cannot be answered within 30 days, it is expected that a date for receipt of this information will be provided to the staff within the 30 day period so that the staff can assess how this information will impact the published schedule.

Thanks,
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U. S. EPR Standard Design Certification
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Docket No. 52-020
SRP Section: 03.08.04 - Other Seismic Category I Structures
Application Section: 3.8.4

QUESTIONS for Structural Engineering Branch 2 (ESBWR/ABWR Projects) (SEB2)

03.08.04-15

Transnuclear Inc., Report TN-Rack.0101, Rev.0, "U.S. EPR New and Spent Fuel Storage Rack Technical Report" (hereafter referred to as Technical Report), provides some figures and descriptive information for the fuel racks. However, to ensure compliance with 10 CFR 50, Appendix A, General Design Criterion (GDC) 2, as it relates to the design of safety-related structures being able to withstand the most severe natural phenomena such as earthquakes and as described in SRP 3.8.4, Appendix D, additional descriptive information is needed. As indicated in Section I of SRP 3.8.4, Appendix D, the applicant should provide descriptive information including plans and sections showing the racks, pool walls, liner, and details of the fuel-handling system (for review of the parameters associated with the postulated drop accident).

To conduct an adequate review of the structural/seismic analysis of the fuel racks, provide the following items:

a. Sketches to show all the major structural features with sufficient information to describe the racks, including the steel crates, rack cell (tube) walls, base plate, support legs, bearing pads, pool liner, vertical angles, bottom bands, grid assemblies, neutron absorber sheathing, all welds connecting these parts, and any other elements in the load path of the racks. These sketches should indicate related information, including the north arrow, cutouts, dimensions, material thicknesses, weld size/thickness and gaps between the fuel to cell walls, rack to rack, rack to pool walls, rack to equipment area in both horizontal directions and between the tubes to steel crate in the horizontal and vertical directions.

b. Explain why three support legs along one edge of the main assembly are shown in Figure 1-5, while the plan view shown on Figure 1-2 does not show these supports along the edge.

c. Horizontal support details for the new fuel racks at the top are not described and should be provided.

d. Provide more information about gaps: a) Gaps between racks, rack to wall, and rack to equipment area boundary should be provided in Figure 9.1.2-7 of the markups for Section 9.1 of the EPR FSAR; b) Clarify whether there is any gap between the two racks in the new fuel bunker, and what is the basis for concluding that the anchorage of these racks eliminates amplification of the seismic response as stated in Section 2.2.1 of the Technical Report; c) Identify

the gap tolerances for each of the gaps between the fuel to cell wall, rack to rack, rack to equipment area, and rack to wall; d) Explain whether any studies were done for different initial gap conditions considering the potential tolerances, and if not, explain why; and e) What are the COLA requirements in the FSAR to ensure that the assumed gaps (considering tolerances) will be maintained throughout the licensing period, especially after a major earthquake.

e. A figure similar to Figure 9.1.2-4 for the spent fuel storage rack should also be provided for the new fuel storage rack in Section 9.1 of the markups for the EPR FSAR.

f. A figure should be provided to show the locations and cross section (with dimensions) of the leak chase channels to assess the potential loadings imposed by the rack legs onto these channels.

g. A sketch and details of the fuel-handling system should be provided to facilitate the review of the postulated drop accident parameters and the lifting analysis contained in section 3A.3 of the Technical Report. This information should include the maximum height of the bottom of the fuel assembly during fuel handling over the racks and a sketch of the structural elements (including materials, dimensions, and welds) in the load path of the fuel handling system including the sling or lifting beam when handling the racks.

h. Provide description on non-connection of the tube assemblies to the fuel racks;

i. Item 3 in Section 2.2 of the Technical Report states that "All submerged parts of the fuel store racks are fabricated from Type 304/304L stainless steel (Dual Certified), aluminum or metal matrix composites (MMC)." Clarify whether the materials mentioned above include the materials for the support legs, and whether the aluminum is for tube assemblies as part of a rack. Explain why "or" is used in the sentence instead of "and."

j. Are all fuel racks required to be permanently installed in the pool? Where in FSAR is the information? If not, provide technical justification or additional studies.

03.08.04-16

Tables 3-1 and 3-2 of the Technical Report summarize allowable stresses. To ensure compliance with 10 CFR 50.55a, as it relates to codes and standards, and as described in SRP 3.8.4, Appendix D, the staff finds that some of the allowable stresses given in the two tables need to be verified and corrected as described below.

As stated in Section I.2 of SRP 3.8.4, Appendix D, "Design, fabrication, and installation of spent fuel racks of stainless steel material may be performed based on ASME Code, Section III, Division 1, Subsection NF requirements for Class 3 component supports." Therefore, verify the following contents in the two tables and make corrections where applicable:

a. In Table 3-1, the allowable stress for tension from elastic analysis under accident conditions is given as the lesser of 1.2Sy or Su. However, article F-1334.1 of Appendix F to ASME Code, Section III, Division 1, Subsection NF, states: "The tensile stress on the net section, except at pin holes and in the through-plate thickness direction, shall not exceed the lesser of 1.2Sy and 0.7Su."

b. Explain what is meant by "elastic plastic analysis" in Note 2 of Table 3-1 since Appendix F to Section III of the ASME Code has separate provisions for elastic and plastic analysis. Also, explain the basis for the limits specified in the tables since they do not seem to match the limits specified for austenitic steels in Appendix F to Section III of the ASME Code.

c. In Table 3-2, explain the basis for the allowable stresses for PL and (Pm or PL) + Pb + Q under normal conditions, which are given as 1.5Sm and 3.0Sm, respectively.

d. In Table 3-2, the allowable stresses given for elastic analysis under accident conditions seem to follow article F-1331 of Appendix F to ASME Code, Section III, Division 1, Subsection NF, instead of article F-1332. Explain why.

e. In view of the above questions, the applicant is requested to review and confirm that all stress limits are utilized in accordance with the ASME Code Section III, Division 1, Subsection NF and Appendix F as appropriate.

03.08.04-17

Section 3.2 of the Technical Report lists the loads and load combinations used in the structural design of the fuel racks. In this regard, 10 CFR Part 50, Appendix A, GDC 2, requires that design bases for SSCs important to safety reflect appropriate combinations of the effects of normal and accident conditions with the effects of natural phenomena. Although the load combinations listed in the Technical Report are consistent with those given in Table 1 of SRP 3.8.4, Appendix D, the following additional information is needed for a complete review of the structural analysis of the fuel storage racks:

a. Breakdown of forces and stresses are either not given or not clearly indicated in Appendices 3A through 3C of the Technical Report, especially for dead, live, and temperature loads, which should be included in most of the load combinations. Provide a breakdown of forces and stresses for all applicable load combinations.

b. In Section 3.2 of the Technical Report, the values of To and Ta are given as 150 ˚F and 212 ˚F, respectively. Explain why, in Appendix 3C of the Technical Report, service level D allowable stresses are checked at 200 ˚F instead of at 212 ˚F.

c. Section I.4 of SRP 3.8.4, Appendix D, specifies that maximum uplift forces available from the crane should be indicated, and consideration of these forces be included in the design of the racks and in the analysis of the existing pool floor, if applicable. In the Technical Report, a bounding weight is used for the lifting analysis. However, Subsection 2.2.1, Item 13, of the Technical Report states: "The empty weight of the fuel storage rack modules is limited to 22 ton (20 tonne) including the lifting rig to meet the available crane capacity." Therefore, explain which is the correct weight to use for the lifting analysis of the racks and whether the difference between these two values is due only to the weight of the lifting rig.

03.08.04-18

Appendix 3B of the Technical Report addresses two fuel drop analysis cases. However, the staff finds that insufficient information is provided. In this regard, 10 CFR Part 50,

Appendix A, GDC 1, requires that SSCs important to safety be designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety functions to be performed. In addition, Section I.4 of SRP 3.8.4, Appendix D, specifies that the fuel pool racks and the fuel pool structure should be evaluated for accident load combinations. The following additional information is needed for a complete review of the structural analysis of the fuel storage racks:

a. Clarify how many support legs were assumed in the fuel drop analysis. For the case of deep drop in the middle of the rack, if the impact spot was assumed right at the base plate geometry center, confirm that it is the critical impact spot producing bounding responses of the base plate, considering that there are two support legs close to the center of the base plate when a total of 6 support legs are assumed. Section 3B.2 of the Technical Report states that racks have a significant unsupported span relative to the other rack sizes. However, Figures 1-2, 3C-28 and 3C-29 show that those others racks are larger in size (in plan view).

b. Clarify whether a shallow drop in the closest vicinity of a vertical support angle was considered. It may produce the maximum compression force in the vertical support angle.

c. Provide the technical basis for the failure strain value used to model the failure of the elements.

d. Clarify which stress-strain curve (i.e., "engineering stress-strain curve" or "true stress-strain curve") was used, and whether the temperature effect on the curve was considered. To quantify the ductility ratios, provide the values of yield and ultimate strains for all materials used. Provide references for the curve used. Clarify whether the same curve was used in the seismic analysis presented in the Technical Report;

e. The mesh sizes of the finite element model seem coarse. Explain if sensitivity studies were performed to confirm the adequacy of the mesh sizes. The staff notes that, in such studies, adequacy should be determined by plotting hourglass energy together with the kinetic energy, internal energy and total energy.

f. Correct page number typos on the reference and figure pages in Appendix 3B of the Technical Report.

03.08.04-19

Appendix 3C of the Technical Report addresses the seismic analysis of the spent fuel racks. To ensure compliance with 10 CFR 50, Appendix A, GDC 2, as it relates to the design of safety-related structures being able to withstand the most several natural phenomena such as earthquakes, the following additional information on seismic modeling is needed:

a. Provide more detailed descriptions of the Arbitrary-Lagrangian-Eulerian (ALE) analysis algorithms; for example, explain how the important parameters were obtained and how ALE analysis algorithms compare with traditional potential theory-based added mass/damping method. Clarify whether water in the aluminum tube cells and water below the racks were also modeled with fluid elements, and whether hydrodynamic coupling was taken into account in the stress analysis using the detailed single rack model. If not, provide the technical basis for not doing so.

b. Subsection 3C.3.4 of the Technical Report does not mention how grid assemblies were modeled. Provide an explanation of how these assemblies were modeled.

c. Subsection 3C.3.5.1 of the Technical Report describes contact force definitions. Clarify whether those contact definitions consider impact stiffness. If yes, provide the impact stiffness values for rack to rack, fuel to fuel cell, rack to wall and rack to floor. Explain how those values were determined, including the value of effective stiffness given in Section 3C.3.6 of the Technical Report for spacer grids between fuel cells and fuel assemblies. Also clarify whether any sensitivity analysis for impact stiffness was performed.

d. Provide the technical basis for the use for the friction coefficient value and the coefficient of restitution value, and values for other important parameters in the models used.

e. As indicated in Section I.3 of SRP 3.8.4, Appendix D, loads generated by the impact of fuel assemblies during a postulated seismic excitation should be considered for local as well as overall effect. Section 3C.3.6 of the Technical Report discusses the modeling of the fuel rattling inside the tube of cells for the detailed single rack model. Clarify whether assumptions were made on fuel motions. In addition, clarify whether fuel assembly rattling was also considered in the seismic analysis for the whole pool analysis. If yes, provide detailed descriptive information on the modeling. If not, provide the technical basis.

f. Provide information on the modeling of support legs, for example, the vertical stiffness of the tube (screw jack) in a support leg and the element type of the tube. Confirm that the design check on support legs has been done.

g. Section 2.2.1, Item 1, of the Technical Report mentions that underwater fuel storage rack modules may be interconnected to provide additional seismic restraint. However, the Technical Report does not present any analysis that includes these interconnections. Explain why not.

h. As indicated in Section I.5 of SRP 3.8.4, Appendix D, details of the methods used to account for the effect of sloshing water on the pool walls should be provided. Provide the detailed information.

i. Explain how the dead weight mass was treated for submerged rack structures and how the effective damping of the fuel assemblies and water damping were considered.

j. The friction coefficient between the bearing pads and the pool liner is an important factor affecting the seismic response of the racks. Provide the technical basis for only considering the two bounding values and not other intermediate values for the fully loaded configuration. For the cases of partially loaded configuration, several runs may be needed in order to adequately consider the randomness of the friction coefficient and the configuration of loaded cells. Therefore, provide the number of runs for each of the two cases of partially loaded configuration and the technical basis for the determination of the number.

03.08.04-20

Appendix 3C of the Technical Report addresses seismic analysis of the spent fuel racks. To ensure compliance with 10 CFR 50, Appendix A, GDC 2, as it relates to the design of safety-related structures being able to withstand the most several natural phenomena

such as earthquakes, the following additional information on seismic loads, analysis, and design is needed:

a. Explain why only input time history set 1, which produces the bounding response for the fully loaded cases, was used to analyze the partially loaded cases. The staff notes that input time histories that yield the bounding response for the fully loaded cases may not yield the bounding response for the partially loaded cases. Explain why the seismic input developed for the U.S. EPR Fuel Building analysis/design (given in Section 3.7 of the U.S. EPR FSAR) was not used. Clarify whether an envelope of the spectra at the pool floor and along the height of the pool wall was used. Explain why 5% damping was used considering that SSE damping should be 4% according to RG 1.61, Rev.1.

b. The stress analysis discussed in Section 3C.3.6 of the Technical Report does not address load combinations, nor does it include stress evaluations for welds and bearing pads. Clarify whether these have been done.

c. Provide the technical basis showing that one of the racks provides bounding stresses in the stress evaluations.

d. For the time history analysis, clarify: (i) whether single precision was used; and (ii) whether any check was done on the effects of double precision and/or smaller time steps on convergence.

03.08.04-21

The Technical Report presents analysis and design of the fuel storage racks. However, the staff finds that insufficient information on design checks has been included in the Technical Report. In this regard, 10 CFR 50, Appendix A, GDC 1, requires that SSCs important to safety shall be designed to quality standards commensurate with the importance of the safety functions to be performed. In addition, Section I.4 of SRP 3.8.4, Appendix D, requires the applicant to demonstrate that the functional capability and/or the structural integrity of each component is maintained. Also, as indicated in Section I.3 of SRP 3.8.4, Appendix D, loads generated by the impact of fuel assemblies during a postulated seismic excitation should be considered for local as well as overall effects, and it should be demonstrated that the consequent loads on the fuel assembly do not lead to damage of the fuel. Therefore, for a complete review of the structural analysis of the fuel storage racks, provide additional information on the following design checks:

a. Buckling analysis for the components, such as aluminum tube walls and rack vertical angles, subject to significant compression forces.

b. Retrieveability of fuel assemblies inside the tubes when the rack is impacted by the postulated fuel drop case.

c. Punching shear analysis for the part of a base plate above a support leg under seismic or impact loads.

d. Complete weld checks for all welds except full penetration welds.

e. Explain why fuel assembly check was not performed. Describe how the responses of the racks were used to demonstrate that the existing dynamic qualification of the fuel assemblies is maintained.

f. Explain why analysis of the dry new fuel storage racks is not presented in the Technical Report.

03.08.04-22

The Technical Report presents the analysis and design of the fuel storage racks. However, to ensure compliance with 10 CFR 50, Appendix A, GDC 2, which requires appropriate consideration of the most severe of the natural phenomena, and GDC 4, which requires appropriate consideration of postulated accidents, the load effects from the fuel storage racks and water should be considered in the design of the fuel pool. In addition, SRP 3.8.4, Appendix D, describes minimum requirements and criteria for the review of spent fuel pool racks and the associated structures; Section I.6 of Structural Acceptance Criteria states that "The fuel pool structure should be designed for the increased loads that stem from the new and/or expanded high density racks. The fuel pool liner leak-tight integrity should be maintained, or the functional capability of the fuel pool should be demonstrated." Describe the resulting fuel rack loads on the pool walls and floor, and explain whether these loads were used directly in the design of the pool structure, or whether a comparison of these loads was made with the loads assumed previously in the design of the pool structure. The aforementioned description should include local and overall effects (for example, impact loads from rack support legs for pool floor bending check), and loads from spent fuel racks and dry new fuel racks. Explain whether there is any restriction on bearing pad locations relative to leak chase channels in the pool floor, and whether locations of leak chase channels were taken into account for pool liner design. Explain whether sliding would occur between the bearing pad and pool liner. If it does, explain how damage to the pool liner due to horizontal sliding forces is avoided.

03.08.04-23

The Technical Report follows the guidance provided by SRP 3.8.4 (Reference 1) for the analysis and design of the fuel storage racks. Subsection II.4 of SRP 3.8.4 indicates that the validity of any computer programs used in the design and analysis of structures should be verified in accordance with the procedures in Subsection II.4.E of SRP Section 3.8.1. The Technical Report states that most of the analyses were done utilizing commercial computer codes. To ensure compliance with 10 CFR 50, Appendix A, GDC 1, as it relates to SSCs being designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety functions to be performed, and with the guidance in SRP 3.8.4, identify all computer codes used in the analyses and clarify whether the validation documents for these computer codes are in compliance with SRP 3.8.1, Subsection II.4.E.

03.08.04-24

10 CFR 50, Appendix A, GDC 1, requires that SSCs important to safety shall be designed to quality standards commensurate with the importance of the safety functions to be performed. In addition, Section I.2 of SRP 3.8.4, Appendix D, specifies that for spent fuel racks: "Construction materials should conform to American Society of Mechanical Engineers, (ASME), Boiler and Pressure Vessel Code, (Code), Section III, Division 1, Subsection NF." In this regard, the FSAR needs to clarify the application of the ASME Code to New and Spent Fuel Storage Racks, and the Technical Report needs to provide more information on compliance with Regulatory Guide (RG) 1.124 and the use of RG 1.60 when utilizing the ASME Code, as discussed below.

a. Table 2.2.8-1 of the FSAR indicates that Section III of the ASME Code does not apply to New and Spent Fuel Storage Racks. Explain why not.

b. When utilizing the ASME Code, Section III, Subsection NF, are all of the applicable provisions in NRC Regulatory Guide, 1.124, Rev. 1, also satisfied? This should be clearly stated in the Technical Report and the FSAR. Also, since RG 1.60 was included as a reference, explain how it was used and correct the published year of RG 1.13, Rev. 2 in Section 1.3 of the Technical Report.

03.08.04-25

The Technical Report presents the analysis and design of the fuel storage racks. However, there is insufficient information regarding materials, quality control, and special construction techniques, as well as in-service examination of the racks. The staff notes that 10 CFR 50, Appendix B requires compliance with quality assurance criteria for nuclear power plants. In addition, Section I.7 of SRP 3.8.4, Appendix D, states that "The applicant should describe materials, quality control procedures, and any special construction techniques; the sequence of installation of the new fuel racks (…)." Therefore:

a. Provide the information regarding materials, quality control procedures, any special construction techniques, and the sequence of installation of the new fuel racks.

b. Explain what provisions are given for performing the in-service examination of the rack, as indicated in 10 CFR 50.55a(g)(3) for ASME Class 3 component supports.

03.08.04-26

a. Last paragraph of page 3A-1 states that "the membrane (Pm) and membrane plus bending (Pm+Pb) stress intensity is (...)." Clarify which structural component is being evaluated.

b. In the calculations included in page 3A-5 of Appendix 3A of the Technical Report, there is reference to allowable elongations in the axial and lateral directions respectively. Explain what these limits represent.

03.08.04-27

Appendix 3A, Section 3A.4, of the Technical Report presents design checks of support grid and aluminum tubes subject to differential heating effect between a full and an empty cell. In this regard, 10 CFR Part 50, Appendix A, GDC 1 requires that SSCs important to safety be designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety functions to be performed. In addition, Section I.4 of SRP 3.8.4, Appendix D, indicates that the temperature gradient across the rack structure that results from the differential heating effect between a full and an empty cell should be indicated and incorporated in the design of the rack structure. Therefore, the following additional information is needed for a complete review of the structural analysis of the fuel storage racks:

a. Provide the technical basis supporting the statement: "An isolated fuel assembly stored in a fuel compartment will produce the maximum thermal gradient in top and bottom support grids." What if two adjacent cells are heated?

b. For the check of support grids, only thermal expansion in the horizontal direction is considered. Explain why thermal expansion in the vertical direction is not also considered.

c. For the check of aluminum tubes, explain the source of the coefficient of thermal expansion for aluminum at 250F, since the properties given in Table 3-4 of the Technical Report are only for temperatures of 75F and 200F.

d. In Appendix 3A, Section 3A.4, of the Technical Report, a lower bound temperature of 70˚ F is used for temperature change calculations. Provide the technical basis for the use of 70 ˚F as the lower bound temperature.