May 9, 2011

Mr. Scott Head, Manager
Regulatory Affairs
Nuclear Innovation North America, LLC
P. O. Box 289
Wadsworth, TX 77483

SUBJECT: REQUEST FOR ADDITIONAL INFORMATION LETTER NO. 377 RELATED TO SRP SECTIONS 9.1.2 FOR THE SOUTH TEXAS PROJECT COMBINED LICENSE APPLICATION

Dear Mr. Head:

By letter dated September 20, 2007, STP Nuclear Operating Company (STPNOC) submitted for approval a combined license application pursuant to 10 CFR Part 52. The U. S. Nuclear Regulatory Commission (NRC) staff is performing a detailed review of this application to enable the staff to reach a conclusion on the safety of the proposed application.

The NRC staff has identified that additional information is needed to continue portions of the review. The staff's request for additional information (RAI) is contained in the enclosure to this letter.

To support the review schedule, you are requested to respond within 45 days of the date of this letter. If changes are needed to the safety analysis report, the staff requests that the RAI response include the proposed wording changes.

If you have any questions or comments concerning this matter, I can be reached at 301-415-5787 or by e-mail at Rocky.Foster@nrc.gov or you may contact George Wunder at 301-415-1494 or George.Wunder@nrc.gov.

Sincerely,

/RA Tom Tai for:/

Rocky Foster, Project Manager
ABWR Projects Branch
Division of New Reactor Licensing
Office of New Reactors

Docket Nos. 52-012, 52-013

eRAI Tracking No. 5685

Enclosure:
Request for Additional Information

cc: Mr. William Mookhoek
Mr. James Agles
Loree Elton

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DATE	3/31/11	3/31/11	4/19/11	4/20/11

***Approval captured electronically in the electronic RAI system.**

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Request for Additional Information No. 5685
Revision 4

5/6/2011

South Texas Project Units 3 and 4
South Texas Project Nuclear Operating Co
Docket No. 52-012 and 52-013
SRP Section: 09.01.02 - New and Spent Fuel Storage
Application Section: FSAR 9.1.2

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

09.01.02-2

Summary: Provide more descriptive information on pools, racks and fuel-handling system.

Westinghouse Electric Company LLC, WCAP-17311-P, Rev. 1, "Structural Analysis Report for STP Units 3 & 4 New Fuel Storage Rack Baseline Design," and WCAP-17331-P, Rev. 1, "Structural Analysis Report for STP Units 3 & 4 Spent Fuel Storage Rack Baseline Design" (hereafter referred to as Technical Report(s)), were submitted by the applicant in response to the staff's request, identifying the need for more detail than what was included in Rev. 0 of the reports. While Rev. 1 does provide additional detail, it is still insufficient for the staff to conduct its review in accordance with the guidance in SRP Section 3.8.4, Appendix D (Rev. 3). 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, additional descriptive information, as delineated in SRP 3.8.4, Appendix D, is needed. Also, as indicated in Section I of SRP 3.8.4, Appendix D, the applicant should provide plans and sections showing the racks, pool walls, liner, and details of the fuel-handling system (for the staff's review of the parameters associated with the postulated drop accident).

The staff requests the applicant to provide the following descriptive information, and update the new and spent fuel racks technical reports, as appropriate:

a. Sketches to show all the major structural features with sufficient information to describe the racks, including the cover plate, baseplate, support screws, support plate, pool liner, weights of racks with various sizes, all welds connecting these parts, any other elements in the load path of the racks, water height in the pool, and plans and sections showing the spent fuel pool in relation to other plant structures. These sketches should indicate related information, including the north arrow, cutouts, dimensions, material thicknesses, and weld size/thickness.

b. Provide information about gaps: a) Gaps in both horizontal directions and between racks, rack to wall, and rack to equipment area boundary should be provided in pool plan and cross section views; b) Clarify whether there is any gap between the four racks in the new fuel pit; 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) Explain whether there are any requirements to ensure that the assumed gaps (considering tolerances) will be maintained throughout the licensing period, in particular following a seismic event.

c. In appropriate sections of the Technical Reports, provide ASTM designations, material types and properties for all major components such as support plate, support block, baseplate, cover plate and weld metal material.

d. Are all fuel racks required to be permanently installed in the pool or pit? If not, provide technical justification or additional studies.

e. Figure 3-2 of the new fuel rack Technical Report shows that there is no connection between adjacent cell walls. Confirm this is true, or correct the figure. In the same figure, the enlarged detail at the upper right corner should show wrapper plate. Same questions also apply to Figure 3-3 of the spent fuel rack Technical Report.

f. Section 3 of the new fuel rack Technical Report states that the new fuel racks are anchored to the floor of the new fuel vault at each support foot location. However, Item 2 of Subsection 9.1.1.3.2 of STP 3 & 4 FSAR Rev. 04 states that the new fuel storage racks are supported vertically from a base that is not anchored to the bottom of the fuel vault. Explain the inconsistency. If the Section 3 statement referenced above is true, provide a sketch and description of how the new fuel racks will be anchored down to the pit floor.

g. For the spent fuel racks, clarify and show on related figures the number/locations of support feet of various racks.

h. Figures of rack geometry and isometric view show that some exterior cells of fuel racks are covered by the neutron absorbing material for three sides only. Explain why.

i. Provide types of welds for all weld connections.

09.01.02-3

Summary: Provide additional information on loads and load combinations.

Table 4-1 of both Technical Reports (Rev. 1) lists the loads and load combinations to be used for the structural design of the fuel storage racks. 10 CFR Part 50, Appendix A, GDC 2 requires that the design bases for SSCs important to safety shall reflect appropriate combinations of the effects of normal and accident conditions with the effects of the natural phenomena. The load combinations listed in the reports are consistent with those given in Table 1 of Appendix D to SRP 3.8.4. However, additional information is needed for the staff to conclude that all of the appropriate loads and load combinations have been considered for the new and spent fuel configuration as described in the Technical Reports. Therefore, the applicant is requested to provide the following information and update appropriate sections of the new and/or spent fuel racks technical reports as necessary.

a. Provide a breakdown of forces and stresses for each individual load in each load combination, so that the staff can determine whether all applicable load combinations have been appropriately evaluated.

b. Provide values for T_o and T_a. According to Appendix D to SRP 3.8.4, for the load combination with SSE, the temperature T_a, which is defined as the highest temperature associated with the postulated abnormal design conditions, should be assumed. Explain why material properties at 140 °F were used for the spent fuel rack design evaluation for the load combination with SSE.

c. Table 1 of Appendix D to SRP 3.8.4 identifies that a stuck fuel assembly load case be checked. However, the Technical Reports (Rev. 1) state that a stuck fuel assembly load case does not need to be considered, and reference the COLA Part 2, Tier 2, Section 9.1, (Rev. 4) statement that "the loads experienced under a stuck fuel assembly condition are typically less than those calculated for the seismic conditions." The statement does not provide sufficient technical basis for not considering the stuck fuel assembly load case. Provide analysis detail for the stuck fuel assembly load case and the technical basis for the maximum stuck fuel load that will be used in the analysis.

09.01.02-4

Summary: Provide additional information on fuel drop analyses.

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. Section 8.3 of both Technical Reports addresses fuel drop analysis. However, the staff finds that there is insufficient information for the staff to complete its review in accordance with SRP 3.8.4, Appendix D. Therefore the staff requests the applicant to provide the following additional information, and to update Section 8.3 of the technical reports, as appropriate:

a. For the fuel drop load case, provide details of design checks on baseplate, support plate, as specified in Section I.4 of SRP 3.8.4, Appendix D. Explain whether drop cases producing maximum bending stresses and/or maximum shear stresses in baseplate were considered, and describe the impact locations assumed in the drop cases.

b. Describe the material stress-strain curves used, and identify whether they are “engineering stress-strain” curves or “true stress-strain” curves. Also describe how the curves were adjusted for the ambient temperature. Provide references for the curves used.

c. Explain whether sensitivity studies were performed to confirm the adequacy of the mesh in the finite element model. If no sensitivity studies were performed, provide the technical basis for concluding that the analyzed mesh is sufficiently refined to obtain an accurate solution.

d. Describe how the dropped fuel assembly was modeled. Is it assumed to be infinitely rigid, absorbing no energy by deformation, or is it assumed to be an elastic-plastic member, capable of absorbing energy by deformation? If the latter is assumed, provide figures showing the fuel assembly deformation for both the shallow and deep drop cases, and specify the percent of the initial potential energy that is absorbed by deformation of the fuel assembly.

e. Provide figures showing the deformation shape of cell wall for the controlling shallow drop case and the deformation shape of the baseplate for the controlling deep drop case. Discuss whether baseplate deformation leads to loss of boral shielding of the active fuel zone, and whether this needs to be considered in criticality analysis.

09.01.02-5

Summary: Provide more information on modeling and analysis.

10 CFR 50, Appendix A, GDC 2, requires that safety-related structures be designed to withstand the most severe natural phenomena, such as earthquakes. Acceptable methods for performing seismic analysis of fuel racks are described in SRP 3.8.4, Appendix D. Section 4.2 of both Technical Reports addresses modeling of the fuel storage racks for seismic analysis. The staff finds that the information provided is insufficient to conduct its review of the applicant's seismic analyses in accordance with SRP 3.8.4, Appendix D. Therefore, the staff requests the applicant to provide the following additional information on modeling, and to update Section 4.2 of the technical reports, as appropriate:

a. Section 4.2.2 of the new fuel rack Technical Report states that the bottom of the fuel is also coupled vertically to the baseplate. However, Figure 4-2 (entitled Fuel-to-Cell Connection) of the report does not show the coupling connection between the bottom of the fuel and the baseplate. Provide the physical details of the coupling and explain how this connection was modeled.

b. Explain the darker horizontal line patterns shown in the ANSYS Fuel Rack Model Isometric View of Figure 4-1 of the new fuel Technical Report and Figure 4-6 of the spent fuel Technical Report. Clarify whether they denote a finer element mesh and if so, explain the need for a finer element mesh at those locations.

c. Section 4.2 of the spent fuel rack Technical Report describes the contact elements. Explain whether the contact elements incorporate any impact stiffness. If yes, provide the impact stiffness values for the fuel-to-cell wall contact and the rack-to-floor contact, and explain how those values were determined. Was any sensitivity analysis for impact stiffness performed?

d. Figure 4-7 of the spent fuel rack Technical Report shows that pipe elements were used in the modeling of fuel-to-cell connections. Explain the purpose of those pipe elements. Are they rigid or flexible?

e. Section 4.2 of the spent fuel rack Technical Report describes the modeling of fluid-structure interaction. Explain whether water above and below the racks was also considered in the model. Describe the differences in the hydrodynamic coupling for fuel assembly to cell wall, rack to rack, and rack to pool wall. Describe and justify the assumptions made in the modeling of fluid-structural interaction.

f. Section 4.2 of the spent fuel rack Technical Report indicates that nonlinear time history SSE analysis was performed. Explain what sensitivity studies (e.g., double precision vs. single precision; varying the solution time step; etc.) were conducted to ensure solution convergence and the adequacy of the predicted results.

g. For the modeling of fuel assemblies for both the new and spent fuel rack analyses, explain how the stiffness and damping of the fuel assemblies were determined and provide the corresponding values used.

h. For both the new and spent fuel rack analyses, provide information on the modeling of support legs; for example, the vertical stiffness of the level screw in a support leg and the element type used for the level screw.

i. Section 3 of the spent fuel rack Technical Report states that each spent fuel rack is attached to the neighboring spent fuel rack with tie-bars at the top of the racks, and each side of a rack has a tie-bar. Provide information on the modeling of side-bars. Since Figure 4-9 seems to show more tie-bars at each side of a rack, explain the apparent inconsistency between the statement in Section 3 and Figure 4-9. In addition, since the racks will only be tied together at the top of racks, explain whether any impact between racks at the baseplate level was considered in the modeling and analysis. If not, explain why not.

j. The friction coefficient between the support plate and the pool liner is an important factor affecting the seismic response of the spent fuel racks. Based on its review of prior fuel rack analyses, the staff has concluded that the worst stress condition for all structural elements may not necessarily be associated with one of the bounding values. Provide the technical basis for only considering the two bounding values (0.2 and 0.8) and not other intermediate values.

k. The staff requires clarification of apparent inconsistencies between the technical reports and the FSAR. Section 4.2.3 of both Technical Reports indicates that all three directions of motion are applied simultaneously to the fuel rack models for both the new and spent fuel rack seismic analyses. FSAR Subsections 9.1.1.1.3 and 9.1.2.1.3 indicate that the loads in the three orthogonal directions are combined using the square root of the sum of the squares (SRSS) method. The staff notes that in equivalent static seismic analysis, the method used for new fuel racks, the three directions of motion normally are applied separately so that the response due to each direction of motion can be obtained, and then combined with the responses due to other directions of motions by a combination rule such as SRSS. In time history seismic analysis, the method used for spent fuel racks, the three directions of motion normally are applied simultaneously in a single analysis and the combination of the responses due to the three directions of loading is automatically algebraic. Therefore, clearly describe for both the new fuel racks and for the spent fuel racks, how the three directions of motion are applied, and how the responses due to the three directions of motions are combined.

l. The fabrication of fuel racks relies heavily on the use of intermittent welds, primarily fillet welds. Load transfer between members relies on the adequacy of the welds to transmit the loads. Accurate stress evaluation of the welds is critical in establishing the seismic adequacy of the fuel rack design. There is no information on modeling of welds in the Technical Reports. Provide details on the modeling of welds at all critical locations, in both the new fuel rack and spent fuel rack Technical Reports.

m. Section 4.2.1 of spent fuel rack Technical Report describes detailed rack models and simplified rack models. Describe the benchmarking of simplified rack models using the detailed rack models. For example, compare the major structural frequencies between two models. Explain whether the locations of detailed vs. simplified rack models were varied, and a series of Whole Pool Model (WPM) analyses were performed. If not, provide the technical basis for determining the location representing the worst case scenarios.

n. For both new and spent fuel rack analyses, discuss whether various fuel loading pattern scenarios are considered; i.e., different fill ratios, from partially full to full within a given rack; varying fuel locations within the partially filled rack; varying fill and locations in adjacent racks. Would it ever be possible to have less than all fuel racks in the pool?

o. Section 6 of both the new and spent fuel rack Technical Reports describes computer codes used in the analyses. Explain whether the validation documents for these computer codes are in compliance with SRP 3.8.1, Subsection II.4.E.

09.01.02-6

Summary: Provide more information on design checks.

10 CFR 50, Appendix A, GDC 1, requires that SSCs important to safety be designed to quality standards commensurate with the importance of the safety functions to be performed. Section I.4 of SRP 3.8.4, Appendix D, identifies that the applicant should 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. Although the new and spent fuel racks Technical Reports present some analysis and design information, the staff finds that it is insufficient to conduct its review in accordance with SRP 3.8.4, Appendix D. Therefore, the staff requests the applicant to provide the following additional information, and to include this information in the new and spent fuel racks technical reports, as appropriate.

a. In Section 8.2.2 of the new fuel rack Technical Report, a factor of 0.707 is considered in the calculations for allowable weld stresses. The 0.707 factor is not considered in similar calculations presented in Section 8.2.3 of the spent fuel rack Technical Report. In addition, expand the information in the technical reports to include the code evaluation for all welds.

b. Section 8 of the spent fuel rack Technical Report provides selected results of the seismic analyses. Provide additional seismic analysis results for the spent fuel racks, to include maximum acceleration, maximum rocking angle of a rack, maximum uplift height of a rack support plate, maximum impact force between racks (if any), and maximum impact force on the concrete floor..

c. Section 8.2.1 and 8.2.5 of the spent fuel rack Technical Report indicate that, for the fuel rack cell wall and support plate, respectively, the membrane plus bending stresses exceed the corresponding ASME Code stress limits. The applicant's basis for the acceptability of these exceedances is provided in Note 1 of Table 8-1, Section 8.2.5, and repeated in Notes 1 and 2 of Table 9-1, and identifies that (1) the exceedances are local; (2) structural integrity of the cell wall will be maintained; and (3) the local peak stress in the support plate would redistribute. This is insufficient justification. Provide the ASME Code technical basis for the acceptance of the stress ratios of 1.8 and 1.04 shown in Table 8-1 and Table 9-1, with reference to specific applicable Code paragraphs.

d. Section 8.2.1 of the spent fuel rack Technical Report indicates that the critical buckling stress is 18.9 ksi in the fuel rack cell wall, for level A load combinations. Provide a description of the methodology for the calculation of the critical buckling stress. Was buckling analysis performed for fuel rack cell wall subject to level D load combinations, including seismic analysis and fuel drop analysis? If not, explain why not. If yes, provide a comparison of the calculated compressive stress vs. the allowable compressive stress based on buckling, and the basis (e.g., code limit) for the allowable value.

e. Explain whether punching shear analysis was performed for the part of the baseplate above a support leg, subjected to maximum vertical load under seismic or fuel drop impact loads.

f. Section 8.1.1 "Fuel-to-Cell Wall Impact Loads" of the new fuel rack Technical Report states: "The most significant load on the fuel assembly arises from rattling during the seismic event. The magnitude of the fuel impact force is calculated by pinning both ends of the fuel beam model in the x, y, and z degrees of freedom." Explain the technical basis for pinning both ends of the fuel beam model. Are there lateral constraints at top and bottom?

09.01.02-7

<u>Summary</u>: Provide information regarding quality assurance program, materials control, quality control, and special construction techniques; and discuss provisions for in-service inspection (ISI) of the racks.

10 CFR 50, Appendix B requires that an applicant/licensee have a formal quality assurance program that meets regulatory criteria. All subcontractors and vendors must have a comparable quality assurance program, consistent with that of the applicant/licensee. SRP 3.8.4 identifies that materials control procedures, fabrication/construction quality control procedures, and any special construction techniques should be described, for review by the staff. In addition, SRP 3.8.4 identifies that provisions for in-service inspection should be described, for review by the staff.

Based on its review, the staff determined that the Technical Reports for the new and spent fuel storage racks do not provide information regarding a quality assurance program, materials control, quality control and special construction techniques. In addition, provisions for in-service inspection of the racks are not addressed.

Therefore, the staff requests the applicant to provide information describing its quality assurance program, materials control procedures, fabrication/construction quality control procedures and any special construction techniques. Also explain what provisions are made for performing in-service inspection of the racks, in accordance with 10 CFR 50.55a (g)(3) for ASME Class 3 component supports.

Update the technical reports, as appropriate, to include this information.

09.01.02-8

Summary: Provide information regarding thermal stress evaluation for the spent fuel racks.

Section I.4 of SRP 3.8.4, Appendix D, indicates that the temperature gradient across the spent fuel rack structure that results from the differential heating effect between a full cell (with spent fuel) and an empty cell (no spent fuel) should be evaluated and incorporated in the design of the rack structure. Based on the staff's review, it does not appear that this thermal gradient has been addressed in the spent fuel rack Technical Report. Therefore, the staff requests the applicant to include the design-basis evaluation of the temperature gradient across the rack structure, that results from the differential heating effect between a full and an empty cell, in an appropriate section of the spent fuel rack Technical Report.

09.01.02-9

Summary: Provide additional information about the seismic loading for the nonlinear time history analysis of the spent fuel racks.

Section 4.1 of the spent fuel racks Technical Report describes the time history input for the nonlinear analysis of the spent fuel racks. Quoting from the Technical Report:

> *"The safe shutdown earthquake (SSE) time histories are provided in the Westinghouse calculation note for the generation of artificial seismic time histories [6]. The spent fuel layout drawing in Figure 4-1 details the coordinate system for the seismic inputs from [6]. The x-axis is oriented along plane north, the y-axis is oriented along plane west, and the z-axis is oriented in the vertical direction according to the right-hand rule. The response spectra used for creating the artificial time history are taken from node 100 in the DCD Tier 2, Appendix 3A, Revision 4 [2]. This node corresponds to the reactor building at elevation 77.10 feet (23.5 meters). The base of the spent fuel pool is at 64.96 feet (19.8 meters), and the top of the racks is at 81.36 feet (24.8 meters). Therefore, the developed time history accounts for the wall amplification very near the top of the spent fuel racks."*
>
> *"The acceleration versus time data for the x, y, and z directions are shown in Figure 4-2 through Figure 4-4. Baseline corrected displacement time histories are developed using these accelerations. The displacement versus time data for the x, y, and z directions are shown in Figure 4-5."*

The staff reviewed the single horizontal and vertical response spectra for node 100 in Reference 2 of the Technical Report, and confirmed that the ZPAs of the horizontal and vertical spectra are consistent with the maximum instantaneous accelerations in Figures 4-2 through 4-4 of the Technical Report. However, a considerable amount of information that the staff typically reviews to confirm the adequacy of synthetic time histories to match target spectra is not included in the Technical Report. In addition, the staff's review of Figures 4-2 through 4-5 identified a number of characteristics that require clarification and explanation. Therefore, the staff requests that the applicant provide the following additional information, to assist the staff in making a determination whether the seismic input has been developed in accordance with the guidance specified in SRP 3.7.1, Revision 3:

a. Confirm that the 3 synthetic time histories have been checked against each other to ensure statistical independence. Compare the calculated correlation coefficients to the acceptance criterion of ≤ 0.16. Include this information in the spent fuel racks technical report.

b. Provide figures comparing the 5% damped spectra (2 horizontal, vertical) generated from the synthetic time histories to the 5% damped target spectra (horizontal, vertical) at node 100. Identify the criteria used to verify the adequacy of the match. Include this information in the spent fuel racks technical report.

c. Describe how target PSDs were developed for the Node 100 target spectra, and provide figures comparing the PSDs for the synthetic time histories to the PSDs for the target spectra. Identify the criteria used to verify the adequacy of the PSDs for the synthetic time histories.

d. The plots of the horizontal synthetic time histories presented in Figures 4-2 and 4-3 of the Technical Report exhibit the characteristic that there are many acceleration peaks up to the target spectrum ZPA. It appears that these time histories are derived from traces that had higher acceleration peaks, and all the higher peaks were reduced to the ZPA. Consequently, the synthetic time histories do not look like earthquake time traces. Please explain the process used to develop the horizontal synthetic time histories, and provide the technical basis for their adequacy.

e. The second paragraph quoted above states: "Baseline corrected displacement time histories are developed using these accelerations." Explain the term "baseline corrected" and explain why it is necessary to make this correction in the ANSYS analysis. It is the staff's understanding that ANSYS would automatically remove any drift from the solution. Describe the process used to calculate the baseline correction.

f. The plots of the baseline corrected displacement time histories (x, y, z) presented in Figure 4-5 of the Technical Report exhibit several characteristics that require clarification and explanation: (1) All 3 displacement time histories exhibit a dominant sinusoidal response with a period which is same as the duration of the acceleration time history (2) All 3 displacements are zero at three specific time steps. (3) Although there is only 1 horizontal target spectrum, the peak x displacement is approximately ½ of the peak y displacement. (4) The 2 horizontal displacement histories are completely out-of-phase with each other; the vertical displacement history is perfectly in-phase with y and completely out-of-phase with x. Describe how the displacement time histories are developed from the synthetic acceleration time histories, and provide the technical basis for the adequacy of the generated displacement time histories.