PROPRIETARY

Nuclear Innovation
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June 23, 2011
U7-C-NINA-NRC-110084
10 CFR 2.390

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
One White Flint North
11555 Rockville Pike
Rockville MD 20852-2738

South Texas Project
Units 3 and 4
Docket Nos. 52-012 and 52-013
Response to Requests for Additional Information

Attached are responses to NRC staff questions included in Request for Additional Information (RAI) letter number 377 related to Combined License Application (COLA) Part 2, Tier 2, Section 9.1, "Fuel Storage and Handling." This letter responds in part to RAI letter number 377 for the specific RAIs listed below. Additional responses will be provided on August 5 and September 15, 2011, to complete the response to letter 377. In addition it should be noted that the RAIs in letter 377 related to new fuel racks have been answered by reference to a pending departure deleting the installation and use of new fuel racks. This departure is consistent with the STP Nuclear Operating Company's Unit 1 & 2 practice of storing new fuel in the spent fuel racks. NINA intends to incorporate this departure into Revision 6 of the STP 3 & 4 COLA.

The attachments provide responses to the RAI questions listed below:

09.01.02-2a, 2c, 2d, 2e, 2f, 2g, 2h and 2i	09.01.02-6a and 6f
09.01.02-3b and 3c	09.01.02-7
09.01.02-5a, 5b, 5d, 5e, 5f, 5h, 5j (partial), 5k, 5l and 5o	09.01.02-8
	09.01.02-9

COLA changes will be incorporated in the next routine revision of the COLA following NRC acceptance of the RAI responses.

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Several of the RAI responses provided herein include proprietary information. Therefore this letter transmits proprietary and non-proprietary versions of the applicable RAI responses.

Please note that the information contained in Attachments 9 through 11 is proprietary to Westinghouse Electric Company, LLC. Attachment 8 provides Westinghouse Authorization Letter CAW-11-3182, accompanying affidavit, Proprietary Information Notice, and Copyright Notice. Since Attachments 9 through 11 contain information considered proprietary to Westinghouse, they are supported by an affidavit signed by Westinghouse, the owner of the information. The affidavit sets forth the basis on which the information may be withheld from public disclosure by the Commission and addresses with specificity the considerations listed in paragraph (b) (4) of Section 2.390 of the Commission's regulations. Accordingly, it is respectfully requested that the information which is proprietary to Westinghouse be withheld from public disclosure in accordance with 10 CFR 2.390 of the Commission's regulations. Correspondence with respect to the copyright or proprietary aspects of the items listed above or the supporting Westinghouse Affidavit should reference CAW-11-3182 and should be addressed to J. A. Gresham, Manager, Regulatory Compliance, Westinghouse Electric Company LLC, Suite 428, 1000 Westinghouse Drive, Cranberry Township, Pennsylvania 16066.

Attachments 1 through 7 contain the non-proprietary versions of the RAI responses. When separated from the proprietary material in Attachments 9 through 11, this letter is not proprietary.

There are no commitments in this letter.

If you have any questions regarding these responses, please contact me at (361) 972-7136, or Bill Mookhoek at (361) 972-7274.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on 6/23/11

Scott Head
Manager, Regulatory Affairs
South Texas Project Units 3 & 4

jaa

Attachments:
1. RAI 09.01.02-2 (non-proprietary)
2. RAI 09.01.02-3 (non-proprietary)
3. RAI 09.01.02-5 (non-proprietary)
4. RAI 09.01.02-6 (non-proprietary)
5. RAI 09.01.02-7 (non-proprietary))
6. RAI 09.01.02-8 (non-proprietary)
7. RAI 09.01.02-9 (non-proprietary)
8. CAW-10-2978, Affidavit for Withholding Confidential and Proprietary Information from Public Disclosure under 10 CFR 2.390
9. RAI 09.01.02-2 (proprietary)
10. RAI 09.01.02-5 (proprietary)
11. RAI 09.01.02-9 (proprietary)

cc: w/o attachment except*
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RAI 09.01.02-2

QUESTION:

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.

RESPONSE:

STD DEP 9.1-1 is being revised and will be submitted separately along with a new Tier 1 departure to remove the New Fuel Storage Racks from the New Fuel Vault. This change will eliminate the need for a separate design for New Fuel Storage Racks. The new fuel will be stored in the Spent Fuel Storage Racks located in the Spent Fuel Storage Pool. The Technical Report for the new fuel storage racks, Westinghouse Electric Company LLC, WCAP-17311-P, Rev. 1, "Structural Analysis Report for STP Units 3 & 4 New Fuel Storage Rack Baseline Design," will be withdrawn. The Technical Report, WCAP-17331-P, Rev. 1, "Structural Analysis Report for STP Units 3 & 4 Spent Fuel Storage Rack Baseline Design," will be revised to address issues contained in RAIs 09.01.02-2 through 09.01.02-9 for the spent fuel storage racks located in the Spent Fuel Storage Pool.

WCAP-17331-P, Rev 2 will be submitted by September 15, 2011.

a. The spent fuel storage pool has been reconfigured and now uses [

]a,c

a,c

Sketch 1: Fuel Rack Assembly with Wrapper Details

[ ]a,c

Sketch 2: Isometric View of the Fuel Rack Module

[ ]a,c

a,c

Sketch 3: Spent Fuel Storage Layout

The plan view below shows the detailed layout of the fuel racks in the spent fuel storage area.
[

]a,c

a,c

Sketch 4: Detailed Layout of Fuel Racks in Spent Fuel Area

The following sketches provide details for the spent fuel rack.

a,c

Sketch 5: Spent Fuel Rack Module – Overhead View

a,c

Sketch 6: Spent Fuel Rack Module - Elevation View

a,c

Sketch 7: Typical Interior Full Type Cell Weld, Detail A

a,c

Sketch 8: Typical Edge Cell, Detail B

a,c

Sketch 9: Typical Corner Cell Weld, Detail C

a,c

Sketch 10: Typical Interior Corner Cell Weld (Detail from Sketch 9), Detail M

a,c

Sketch 11: Typical Edge Cell Cover Plate Weld, Detail D

a,c

Sketch 12: Typical Interior Cell Over a Leveling Pad, Detail E

a,c

Sketch 13: Conceptual Rack-To-Rack Linkage

b. Information about gaps, tolerances, etc will be addressed in WCAP-17331-P, Revision 2 to be submitted by September 15, 2011.

c. A table will be included in the Technical Report, WCAP-17331-P, Rev. 2, which will provide all relevant material types, properties, ASTM designations, etc. An example of the table is included as Table 1 in this RAI response.

[ ]a,c

Table 1: Component Properties

d. As stated in the first part of this response, no racks will be located in the New Fuel Vault. All racks for new and spent fuel will be permanently located in the Spent Fuel Storage Pool.

e. As stated in the first part of this response, no racks will be located in the New Fuel Vault.

Regarding the spent fuel racks, there is a connection between adjacent cell walls that was missing from the figures given. [

]a,c

The fillet weld is diagrammed in the following sketch.

a,c

Sketch 14: Fillet Weld for Tie Bars

a,c

Sketch 15: Support Plate Details

a,c

Sketch 16: Support Plates and their Locations on Baseplate

f. As stated in the first part of this response, no racks will be located in the New Fuel Vault. The new fuel will be stored in the Spent Fuel Storage Pool in Spent Fuel Storage Racks.

g. The spent fuel pool layout has been reconfigured. As a result, only one configuration of the fuel rack will be used. [

]a,c This change will be incorporated in the Technical Report.

a,c

Sketch 17: 10 x 10 Fuel Storage Rack Leveling Pad Locations

h. The figures show that some of the of the exterior cells of the fuel racks are only covered by neutron absorbing material on three sides because the fourth side is covered by neutron absorbing material that is located on a neighboring rack cell. Neutron absorbing material is not required on the fourth side if it will be located on the adjacent cell in the next rack. For racks located on the perimeter, the outside facing side of all exterior cells will be covered by neutron absorbing material. This is indicated further on Sketch 2.

i. The small support plate and large support plate are welded onto the baseplate with [
][a,c]

a,c

Sketch 18: Support Plate and Reinforcement Plate Fillet Weld onto Baseplate

All welds connecting the cells to the baseplate are [ ][a,c]

The cells are welded together with[
][a,c]

Corner tie joints are used to join the cells together. Each corner tie joint is [
][a,c]

No changes to the COLA are required by the responses provided above.

RAI 09.01.02-3

QUESTION:

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 To and Ta. According to Appendix D to SRP 3.8.4, for the load combination with SSE, the temperature Ta, 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.

RESPONSE:

a. Response will be addressed in WCAP-17331-P, Revision 2 to be submitted by September 15, 2011.

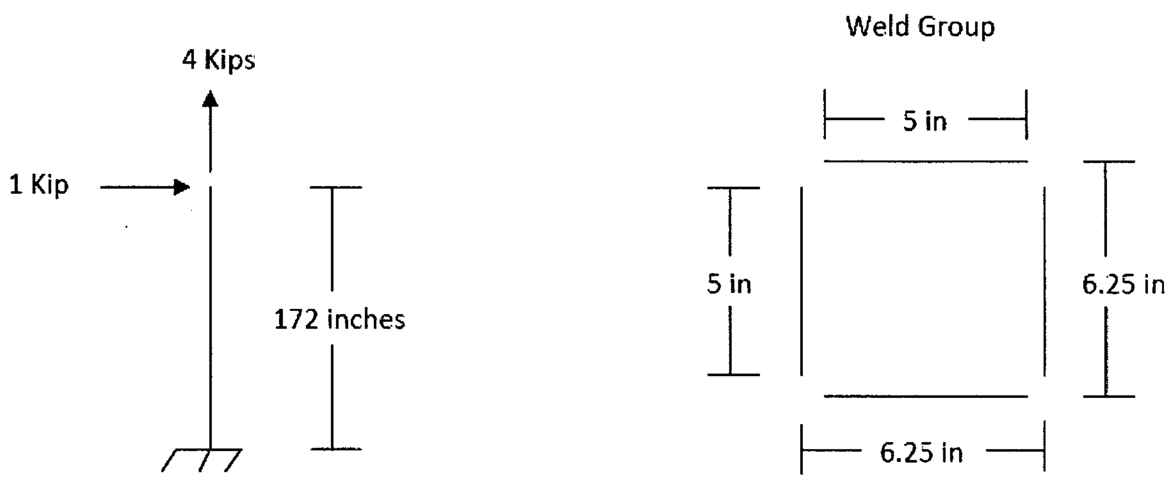
b. The analysis documented in the technical report submitted to the NRC considered an operating temperature (T_o) and an abnormal temperature (T_a) of 140°F for the SFP water temperature. Section 9.1 of the DCD defines a maximum operating temperature of 160°F, and an accident temperature of 212°F. An updated analysis will consider T_o as 160°F and will conservatively consider a maximum abnormal temperature T_a equivalent to the maximum accident temperature of 212°F. Material properties used in the SSE load combinations will be taken at 212°F. The updated analysis will be incorporated into the revised WCAP to be submitted by September 15, 2011.

c. Section 9.1.2.3.2 of the DCD provides the following stuck fuel assembly loads:

17.79 kN Vertical = 4 kips

4.45 kN Horizontal = 1 kip

For the following evaluation, conservatively assume that the vertical load is resisted by a single rack cell in tension. Also assume that the horizontal load is resisted by an axial force couple in only a pair of cells. The horizontal load would actually be resisted by many of the cells, so this assumption is also conservative. The critical section is the weld of the cells to the baseplate, so this weld will be qualified to demonstrate the adequacy of the racks for a stuck fuel assembly. To determine the force couple in the pair of cells, assume that the horizontal force occurs at the very top of the cell, and assume the cells are a cantilevered beam. The welds of the cells to the baseplate are made up of 0.12" fillet welds.



Effective throat of fillet weld

$t_{eff} = 0.12 * 0.707 = 0.085$ in

Determine moment at bottom of cells

M = (1 kip) * (172 inches) = 172 kip-in

Determine force couple in pair of cells due to moment

F = (172 kip-in) / (6.51 inches) = 26.4 kips (cell center-to-center spacing = 6.51 inches)

Total axial force on weld group

F_a = 26.4 kips + 4 kips = 30.4 kips

Total shear force on weld group

$F_v = 1$ kip (assumes entire shear force resisted by one weld group)

Weld Stress

$f_w = [(30.4 \text{ kips})^2 + (1 \text{ kips})^2]^{.5} / (4 * 5 \text{ in})$

$f_w = 1.52$ kip/in

Weld Allowable

$F_W = (0.3)\ (70 \text{ ksi})\ (0.085 \text{ in}) = 1.78 \text{ kip/in} > 1.52 \text{ kip/in} \rightarrow \text{(OK)}$

No changes to the COLA are required by the responses provided above.

RAI 09.01.02-5

QUESTION:

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.

RESPONSE:

a. Refer to response to RAI 09.01.02-2. As stated in the first part of that response, no racks will be located in the New Fuel Vault.

b. The darker horizontal line patterns shown in WCAP-17331-P, Fig 4-6 represent a finer element mesh to accurately model the weld connection between adjacent cells. The weld connections shown in Fig. 4-6 represent an 8x2-inch weld pattern for the cell-to-cell welds. The 8x2-inch weld pattern has been changed to a 4x12-inch weld pattern based on preliminary analysis results. Therefore, Figure 4-6 is outdated and will be updated with a 4x12 pattern in the revision to WCAP-17331-P, which will be submitted in September. All results presented in the Technical Report are based on the 4x12-inch weld pattern for cell-to-cell welds.

c. Response will be addressed in WCAP-17331-P, Revision 2 to be submitted by September 15, 2011.

d. The fuel-to-cell wall connection is modeled by spring elements (ANSYS COMBIN40) connected to a rigid, mass-less pipe element (ANSYS PIPE16). The rigid, mass-less pipes are coupled to the grid outer walls normal to the face of the wall. See Figure 1 (the spring element shown in the Figure 1 inset is an ANSYS COMBIN40 element). This system of connection distributes the fuel lateral loads through the grid structure, but does not over-stiffen the rack. The vertical load of the fuel assembly is also distributed using rigid, mass-less pipe elements (ANSYS PIPE16). These rigid pipes are connected to the baseplate using vertical only ANSYS COMBIN40 spring elements. The pipe model for the vertical load distribution is shown in Figure 2.

e. Rack-to-Rack: The hydrodynamic mass between the racks is calculated from analyses performed using the ANSYS FLUID80 element, considering fluid flow around, below, and above the racks. To evaluate each rack, the rack, its surrounding fluid, and the boundary of the surrounding racks were created. Figure 3 is a typical Rack-to-Rack hydrodynamic mass model. [

]a,c

Fuel-to-Cell Wall: The fuel element-to-cell wall fluid interaction is based on a fluid-structure analysis of the geometry shown in Figure 4. The analysis is performed on a unit length basis using the ANSYS FLUID80 element, and end effects are ignored. The fuel assembly is symmetric relative to the grid structure; therefore, the hydrodynamics are identical for both lateral directions. The unit length hydrodynamic mass is multiplied by the length associated with each fuel element elevation.

Rack-to-Pool Wall: The hydrodynamic mass between the rack and pool wall is calculated from separate analyses performed using the ANSYS FLUID80 element, considering fluid flow around, below, and above the racks. The racks in the Spent Fuel Pool are modeled as a single continuous volume within the pool. The outer fluid boundary is the pool wall, with the minimum gap used to calculate the hydrodynamic coupling. The minimum gap was used because it results in the greatest dynamic input into the rack system. The model was run as a single section. The FEM of the SFR and pool wall boundary is shown in Figure 5. [

]a,c

The hydrodynamic mass is calculated on a per grid cell basis for the x and z directions, and applied to each rack based on the number of edge grid cells.

Verification: The fluid structure interaction methodology uses the theory from Fritz [Fritz, R.J., "The Effect of Liquids on the Dynamic Motions of Immersed Solids," Transactions of the ASME, 1972] and the ANSYS fluid elements. Verification is accomplished by applying the methodology to a test case of a cylinder within a cylinder (Figure 6). The results are shown in Table 1, with very good correlation between the test case and the theory. R_o is the outer cylinder radius and R_i is the inner cylinder radius. Comparing Table 1 to Equations 14 and 15 in Fritz, M_{11} is the term M_H, M_{12} or M_{21} is the term $(M_1 + M_H)$, and M_{22} is the term $(M_1 + M_2 + M_H)$. The calculated hydrodynamic mass matrix is directly input to the rack structural model using ANSYS MATRIX27 elements. The ANSYS MATRIX27 element allows specification of both on and off diagonal mass values.

f. The accuracy of the transient dynamic solution depends on the integration time step. A time step that is too large will affect higher mode responses. Too small a time step will significantly increase ANSYS run times. ANSYS provides guidelines for selecting an integration time step. ANSYS suggests that 20 or more points per cycle for the highest frequency of interest be used. ANSYS also suggests that at least seven points per cycle for contact frequencies (such as the fuel rattling) to minimize energy loss. Using rack, fuel and gap stiffness properties similar to the STP SFR yields a required time step of 0.002 seconds. The STP SFR time history analysis uses a time step of 0.001 seconds and allows for a bi-section down to 0.0001 seconds. Because the time step used satisfies the ANSYS criteria for minimum integration time step size, no additional sensitivity studies were performed.

g. Response will be addressed in WCAP-17331-P, Revision 2 to be submitted by September 15, 2011.

h. The support legs (leveling screw, material ASTM A564, Grade 630) are modeled using the 3-D beam ANSYS BEAM4 element. Figure 7 shows how the leveling screw is connected to the support plate. The vertical stiffness of the leveling screw is determined from its cross sectional area, length, and material properties. See Tables 2 and 3. The contact and friction between the leveling screw and the spent fuel pool floor is modeled using ANSYS CONTAC52 elements.

i. Response will be addressed in WCAP-17331-P, Revision 2 to be submitted by September 15, 2011.

j. In addition to the bounding friction coefficient values of 0.2 and 0.8, an intermediate value (0.5) will be evaluated to demonstrate that an intermediate coefficient of friction does not yield limiting results significantly different from the bounding values of coefficient of friction.
Detailed results will be addressed in WCAP-17331-P, Revision 2 to be submitted by September 15, 2011.

k. The SFR seismic time history analysis applied the three directions of motion simultaneously in a single analysis and the combination of the responses due to the three directions of loading is algebraic.

l. The grid structure is built from long, rectangular sheet metal cells and coverplates that are welded together as shown in figures included in response to RAI 09.01.02-2. Modeling of the welds in ANSYS are as shown in Figure 8 and Figure 9. As noted in RAI response 09.01.02-5(b), 8x2-inch cell-to-cell weld pattern shown in Figure 8 has been changed to a 4x12-inch weld pattern. The grid structure is fully welded to the baseplate, as shown in Figure 10. The support plates are welded along its edges to the baseplate as shown in Figure 7. All welds are modeled using the ANSYS CP coupling command. The SFR weld joints are evaluated by obtaining the loads and moments on the weld joint couples and dividing the maximum calculated weld load by the weld throat area. An explanation of ANSYS modeling of the welds will be added to the Technical Report.

m. Response will be addressed in WCAP-17331-P, Revision 2 to be submitted by September 15, 2011.

n. Response will be addressed in WCAP-17331-P, Revision 2 to be submitted by September 15, 2011.

o. The validation process for computer programs listed in Section 6 of the Technical Report comply with the criteria contained in SRP 3.8.1 Subsection II.4.F, "Computer Programs." (Although SRP 3.8.4 Subsection II.4. D. refers to SRP 3.8.1 Subsection II.4.E it appears that II.4.F is the correct reference.) In addition, the computer program verification and validation process complies with the Westinghouse Quality Program. The specific sections applicable to ANSYS, which is external software acquired from an approved vendor, are Section NSNP 3.6.5, "External Computer Software," and 3.6.2, "Validation of Computer Software." The Westinghouse Quality Program meets customer and regulatory requirements and has been reviewed and approved by the NRC.

No changes to the COLA are required by the responses provided above.

Figure 1: Super Element Rack Model: Fuel Lateral Load Distribution

a,c

Figure 2: Super Element Rack Model: Fuel Vertical Load Distribution

a,c

Figure 3: Rack-to-Rack Hydrodynamic Mass FEM

a,c

Figure 4: Fuel-to Cell Wall Hydrodynamic Mass Finite Element Model

a.c

Figure 5: Rack-to-Pool Hydrodynamic Mass FEM

a,c

Figure 6: Classic Hydrodynamic Mass Calculation FEM

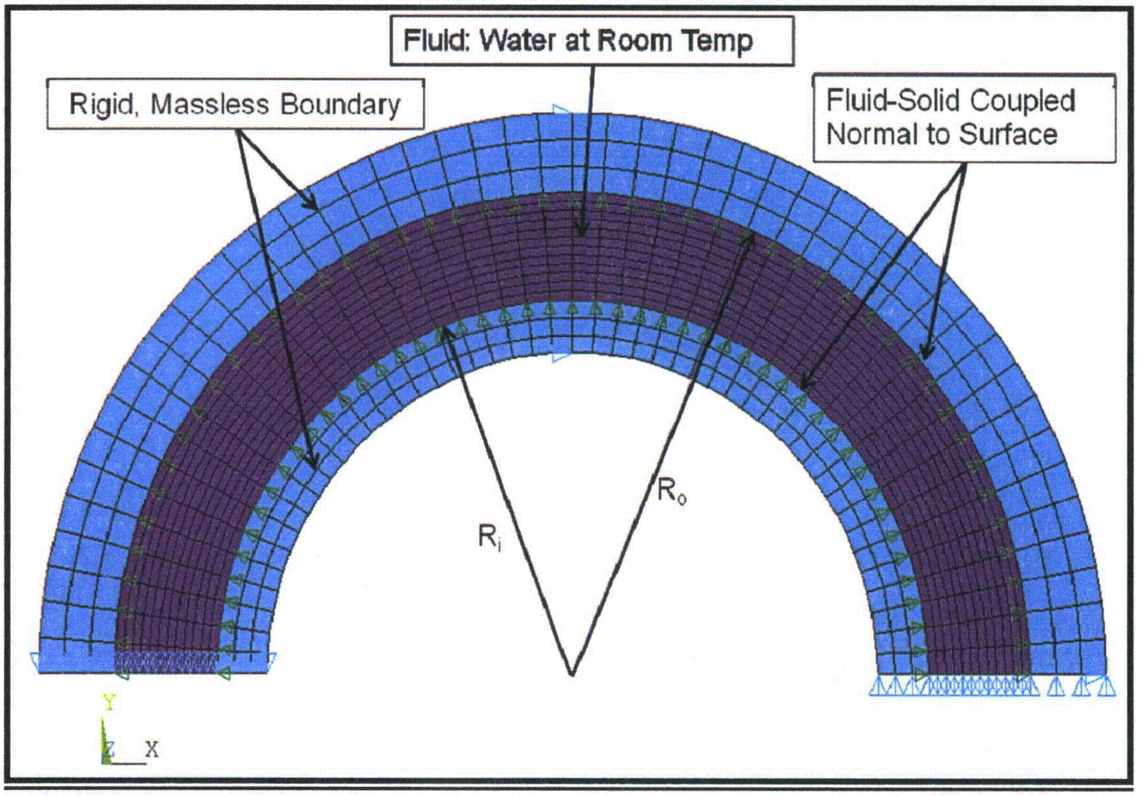


Table 1: Comparison of Classic Case Theory to ANSYS Result

Inputs		
Ri	3.5 in	8.855 cm
Ro	4.5 in	11.385 cm
Cylinder Length	1 in	2.53 cm
Density(3)	0.036 lbs/in^3	1,000 kg/m^3
Modulus(2)	300,000 psi	2.069 GPa
Hydro Term	**Theory(1) - lbs**	**ANSYS Results - lbs**
M11	5.65	5.66
M22	9.33	9.35
M12	-7.04	-7.05
Hydro Term	**Theory(1) - kg**	**ANSYS Results - kg**
M11	2.57	2.57
M22	4.24	4.25
M12	-3.20	-3.20

Notes:

(1) Equations from Fritz.

(2) ANSYS FLUID80 element reference.

(3) There is less than a 2% difference between the room temperature density of water and the 140°F (60°C) density of water. This is not considered a significant difference.

Figure 7: Support Plate and Leveling Screw Details

a,c

Table 2: ASTM A-564, Grade 630 Material Properties

ASTM A-564, Grade 630, English Units			
Temperature (°F)	70	140	200
Yield Strength, S_Y (ksi)	115	110.3	106.3
Ultimate Strength, S_u (ksi)	140	140.0	140
Modulus ($x10^6$ psi)	28.3	27.9	27.5

ASTM A-564, Grade 630, Metric Units			
Temperature (°C)	21.1	60.0	93.3
Yield Strength, S_Y (MPa)	792.9	760.6	732.9
Ultimate Strength, S_u (MPa)	965.3	965.3	965.3
Modulus (GPa)	195.1	192.2	189.6

Table 3: Leveling Screw Dimensions

Location	**Dimensions**	
Level Screw Area[1]	8.807 in^2	56.817 cm^2
Level Screw Inertia[2], Ixx	6.172 in^4	256.90 cm^4
Level Screw Inertia[2], Izz	6.172 in^4	256.90 cm^4
Level Screw Length	3.35 in	85.1 mm

Notes:

(1) The level screw area is calculated from the level screw thread minimum diameter. The thread is a 3.500-8 UN-2 thread. The minimum diameter is 3.3486 inches (85.05 mm). The area is therefore calculated as:
$A = \pi r^2 = \pi(3.3486 \text{ in}/2)^2 = 8.807 \text{ in}^2$ ($5,682 \text{ mm}^2$)

(2) The level screw inertia is based on the minimum thread diameter (see note 1). I_{xx} and I_{zz} are calculated as:
$I_{xx}, I_{zz} = \pi D^4/64 = \pi(3.3486 \text{ in})^4/64 = 6.172 \text{ in}^4$ (256.90 cm^4)

Figure 8: Grid Structure Weld Details

a,c

Figure 9: Cover Plate Weld Details

a,c

Figure 10: Baseplate Weld Details

a,c

RAI 09.01.02-6

QUESTION:

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?

RESPONSE:

a. Regarding the New Fuel Rack (NFR) Technical Report, WCAP-17311-P, please refer to response to RAI 09.01.02-2. As stated in the first part of that response, no racks will be located in the New Fuel Vault.

   The Spent Fuel Rack (SFR) Technical Report, WCAP-17331-P, includes the 0.707 factor in the evaluation of the weld throat length. The SFR weld joints are evaluated by obtaining the loads and moments on the weld joint couples and dividing the maximum calculated weld load by the weld throat area. The following sections detail the cell-to-cell, cover plate, cell-to-baseplate, and baseplate to support plate weld evaluations:

   Weld Allowable Stresses

   Level A allowable based on 1989 ASME Code, NF-3324.5, Table 3324.5(a)-1:
   Fv = 0.3(Suw) = 0.3(68 ksi) = 20.4 ksi @ 140°F weld metal
   Fv = 0.4(Sy) = 0.4(23 ksi) = 9.2 ksi@ 140°F base metal ← governs

   The Level D allowable based on 1989 ASME Code, Appendix F-1332.4:
   Fv = 0.42(Su) = 0.42(68.0 ksi) = 28.6 ksi @ 212°F (Su weld is assumed to be the same as the base metal).

   Cell-to-Cell Weld

   The welds are 12-inch long (L) fillet welds, with a leg length of 0.12 inches. The length of weld throat (T) = 0.12 inches (0.707) = 0.085 inches.

   Service Level A Stresses

   The Service Level A D + L loads are negligible.
   The Service Level A thermal stress, T_o, is 4.45 ksi.
   The total D + L + T_o stress is 4.45 ksi, which is less than the allowable of 9.2 ksi.

Service Level D Stresses

To determine the weld stresses due to the SSE load condition, the forces (F) and moments (M) at the nodes located at the cell-to-cell weld elevations are summed using the ANSYS FSUM command. The stresses are then calculated as:

$$\sigma_x = \frac{F_x}{L} + \frac{M_z}{L^2/6}$$

$$\sigma_y = \frac{F_y}{L}$$

$$\sigma_z = \frac{F_z}{L} + \frac{M_x}{L^2/6}$$

$$\sigma_{Total} = \frac{\left(\sigma_x^{\,2} + \sigma_y^{\,2} + \sigma_z^{\,2}\right)^{0.5}}{T}$$

Where,

$L^2/6 =$ equivalent section modulus for a single line weld

T = 0.085 as calculated above.

For Service Level D, the resulting maximum cell-to-cell D + L + E' weld stress is 13.78 ksi.
This stress is added to the faulted thermal weld stress (Ta), 6.11 ksi.
The total cell-to-cell weld stress is 19.89 ksi, which is less than the weld allowable stress limit of 28.6 ksi.

Summary of Cell-to-Cell Weld Stresses

Combination Equation	Code Level	Summed Actual Stress - ksi	Allowable Stress - ksi	Interaction Ratio (≤ 1.0)
$D + L + T_o$	A	4.45	9.2	0.48
$D + L + T_a + E'$	D	19.89	28.6	0.70

Coverplate Weld

The coverplate weld stress is evaluated in the same manner as the cell-to-cell weld. The coverplate weld is evaluated over a length of 5 inches, even though it is a continuous fillet weld. The Service Level A stress is identical to that calculated for the cell-to-cell weld. The maximum coverplate weld stress for Service Level D is calculated for the maximum fuel impact load. The cover plate weld stress for Level D conditions is evaluated using the same formulation as shown in the RAI response for the Cell-to-Cell weld stress for Level D conditions. It should be noted that for both the Cell-to-Cell weld and coverplate weld Level D stresses, thermal stresses were conservatively added. Thermal stresses are not considered when evaluating Level D conditions. The temperature impact on Level D conditions is considered when evaluating material properties. Material properties are to be evaluated at the maximum Level D temperature. The maximum stress is 11.6 ksi at the fuel impact elevation, which is less than the allowable limit of 28.6 ksi.

Summary of Cell-to-Coverplate Weld Stresses

Combination Equation	Code Level	Summed Actual Stress (ksi)	Allowable Stress (ksi)	Interaction Ratio (≤ 1.0)
D + L + To	*A*	4.45	9.2	0.48
D + L + Ta + E'	*D*	11.60	28.6	0.41

Cell-to-Baseplate Weld

The welds are 5-inch long (L) fillet welds, with a leg length of 0.12 inches. The length of weld throat (T) = 0.12 inches (0.707) = 0.085 inches.

Service Level A Stresses

The Service Level A D + L loads are negligible.
The Service Level A thermal stress, T_{ow}, is 1.71 ksi.
The total D + L + T_{ow} stress is 1.71 ksi, which is less than the allowable of 9.2 ksi.

Service Level D Stresses – Rack-to-Floor Impact

At the mounting pad impact location, the load is compressive and is directly transferred from the baseplate into the grid structure. Therefore, the weld does not experience these loads. Away from the impact point, the forces and moments at the nodes located at the cell-to-baseplate weld locations are summed using the ANSYS FSUM command. The stresses are then calculated as shown here.

For welds running parallel to the x-axis:

$$\sigma_x = \frac{F_x}{L}$$

$$\sigma_y = \frac{F_y}{L} + \frac{M_z}{L^2/6}$$

$$\sigma_z = \frac{F_z}{L} + \frac{M_y}{L^2/6}$$

$$\sigma_{Total} = \frac{\left(\sigma_x^{\ 2} + \sigma_y^{\ 2} + \sigma_z^{\ 2}\right)^{0.5}}{T}$$

For welds running parallel to the z-axis:

$$\sigma_x = \frac{F_x}{L} + \frac{M_y}{L^2/6}$$

$$\sigma_y = \frac{F_y}{L} + \frac{M_x}{L^2/6}$$

$$\sigma_z = \frac{F_z}{L}$$

$$\sigma_{Total} = \frac{\left(\sigma_x^{\ 2} + \sigma_y^{\ 2} + \sigma_z^{\ 2}\right)^{0.5}}{T}$$

Where,

$L^2/6 =$ equivalent section modulus for a single line weld

The resulting maximum D + L + E' baseplate weld stress is 10.1 ksi.
This is added to the faulted thermal weld stress (Taw), 2.34 ksi.
The total D + L + Taw + E' is 12.44 ksi. This is less than the allowable stress of 28.6 ksi..

Summary of Cell-to-Cell Weld Stresses

Combination Equation	Code Level	Summed Actual Stress - ksi	Allowable Stress - ksi (MPa)	Interaction Ratio (≤ 1.0)
$D + L + T_o$	A	1.71	9.2	0.19
$D + L + T_a + E'$	D	12.44	28.6	0.43

<u>Baseplate to Support Plate Weld</u>

The welds are continuous fillet welds, with leg lengths of either 0.31 inches or 0.5 inches. At the mounting pad impact location, the load is compressive and is directly transferred from the support plate to the baseplate through their contact surface. Therefore, the weld does not experience these loads.
Additional detail of the weld stress evaluation will be addressed in WCAP-17331-P, Revision 2 to be submitted by September 15, 2011.

b. Response will be addressed in WCAP-17331-P, Revision 2 to be submitted by September 15, 2011.

c. Response will be addressed in WCAP-17331-P, Revision 2 to be submitted by September 15, 2011.

d. Response will be addressed in WCAP-17331-P, Revision 2 to be submitted by September 15, 2011.

e. Response will be addressed in WCAP-17331-P, Revision 2 to be submitted by September 15, 2011

f. As stated in the first part of this response, no racks will be located in the New Fuel Vault. The Technical Report for the new fuel storage racks, Westinghouse Electric Company LLC, WCAP-17311-P, Rev. 1, "Structural Analysis Report for STP Units 3 & 4 New Fuel Storage Rack Baseline Design," will be withdrawn.

No changes to the COLA are required by the responses provided above.

RAI 09.01.02-7

QUESTION:

Summary: 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.

RESPONSE:

The spent fuel racks are non-nuclear safety- related (NNS). Although 10CFR50 Appendix B only applies to *"activities affecting the safety-related functions of those structures, systems and components..."* elements of 10CFR50, Appendix B are generally applied in accordance with the importance of the equipment's function. The quality requirements applied to the spent fuel racks are established by DCD Table 3.2-1, (F6 Fuel Storage Equipment) and ensure that, in the areas of design, construction and testing, appropriate quality controls are applied. The NINA QAPD, Part III "NonSafety-Related SSC Quality Control" addresses application of quality controls to non-safety related structures. Likewise Toshiba and Westinghouse have submitted Quality Assurance programs that meet regulatory criteria and which would apply as appropriate.

The guidance provided in Appendix D to SRP Section 3.8.4 and associated referenced sections of that SRP outlines the elements that need to be addressed. With respect to materials control procedures, fabrication/construction quality control procedures, and special construction techniques the following discussion is offered.

The "special construction techniques" discussed in SRP 3.8.4 Subsections I.6 and II.6 are a reference to structures that use modular construction methods. This is further elaborated on in NUREG/CR-6486 which is referenced in SRP 3.8.4 Subsection II.4.J.

Regarding guidance contained in NUREG/CR-6486 Section 5.1 and Appendix B, "Modular Construction Review Criteria," it is stated that,

"The scope of this review criteria is limited to structural modules. The type of modules include steel/concrete composite floors, beams, and columns; concrete-filled steel modules; structural steel modules; precast concrete modules; and prefabricated rebar mats, cages, and subassemblies."

While the "modules" discussed in the NUREG include pre-fabricated steel liners for spent fuel storage pools, the guidance does not extend to the level of detail of equipment assemblies composed of individual racks contained within the pool. Therefore, the details provided in response to RAIs 09.01.02-2, -3, -4. -5, -6, -8 and -9 are considered sufficient to determine the adequacy of the rack design as outlined in Appendix D to SRP Section 3.8.4.

Fabrication and installation drawings will be prepared as part of the final design process.

SRP 3.8.4, Section III. 7, "Testing and Inservice Surveillance Requirements," regarding monitoring and maintenance requirements refers to 10 CFR 50.65 and RG 1.160 and falls under the provisions of the maintenance rule. As such, the performance and monitoring of the racks will be evaluated at least every refueling cycle. In addition, DCD Subsection 3.2.5.1 (11) states that the selected requirement commensurate with the specific NNS function is to, *"Ensure reactivity control of stored fuel."* The function of the spent fuel racks as stated in DCD Subsection 9.1.2.1.1 is;

"A full array in the loaded spent-fuel rack is designed to be subcritical, by at least 5% Δk. Neutron-absorbing material, as an integral part of the design, is employed to assure that the calculated k eff, including biases and uncertainties, will not exceed 0.95 under all normal and abnormal conditions."

While reduction in neutron absorbing capacity, observed by the industry, is not a structural issue, it is an operational issue associated with Generic Aging Lessons Learned. As noted in the spent fuel rack criticality analyses, the neutron absorber material is relied on to maintain the fuel subcritical. The in-service inspection program for the spent fuel pool racks will include neutron absorber monitoring coupons, which is typical for a spent fuel rack inspection program. Details of this program will be developed based on the final material and vendor selection.

The in-service inspection program to verify the adequacy of the neutron absorber will be developed as part of the operational procedure development program outlined in Chapter 13.

No change to the COLA is required as part of this response.

RAI 09.01.02-8

QUESTION:

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.

RESPONSE:

The design-basis evaluation of the thermal gradient across the rack structure, that results from the differential heating effect between a full and an empty cell as indicated in SRP 3.8.4, Appendix D, Section I.4, will be included in the revision to the spent fuel rack Technical Report. WCAP-17331-P, Rev 2 will be submitted by September 15, 2011.

No change to the COLA is required by the response provided above.

RAI 09.01.02-9

QUESTION:

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.

RESPONSE:

a. Statistical Independence is shown in the calculation note that generated the artificial time history data.
Below is a copy of the Summary of Horizontal vs. Vertical Cross-Correlation Coefficients:

Comparison	@ 0 Lag (< 0.16)		Strong Motion Duration (< 0.30)
	Excel	DADiSP	
X – Y	-0.087	-0.087	MAX = 0.145, MIN = -0.156
X – Z	-0.056	-0.056	MAX = 0.148, MIN = -0.166
Y – Z	0.061	0.061	MAX = 0.160, MIN = -0.163

The data in the table above was generated using 2 different calculation methods. For the cross-correlation coefficient at a time lag of 0, an excel spreadsheet was used. The Excel data was verified using commercially available software (DADiSP) that can calculate cross correlation coefficients for a 0 time lag as well as for the entire strong motion durations. The above table shows that the 3 synthetic time histories are statistically independent per the requirements of NUREG-0800, Standard Review Plan Section 3.7.1. This information will be included in the spent fuel racks Technical Report.

b. Synthetic time histories were created for 4% damping at Node 100, per the requirements of Reg Guide 1.61, "Damping Values For Seismic Design Of Nuclear Power Plants," as required for welded steel or bolted steel structural material with friction connections (Table 1), not the 5% as requested above.

The following table shows compliance to the NUREG-0800, Standard Review Plan Section 3.7.1 for Response Spectra Comparison (the number of points below the target is less than or equal to 5, and the maximum percent under the target is less than 10%):

Final MathCAD Run Summary

Earthquake	Direction	No. Iterations	No. Points Under (≤5)	Max. % Under (<10%)
DE	Horizontal (x)	89	3	2.48
	Horizontal (y)	53	5	0.90
	Vertical (z)	86	5	1.87

The following Figures 1, 2, and 3 show that the synthetic generated time histories envelope the target response spectra using 4% damping at Node 100 for all three directions. This information will be included in the spent fuel racks Technical Report.

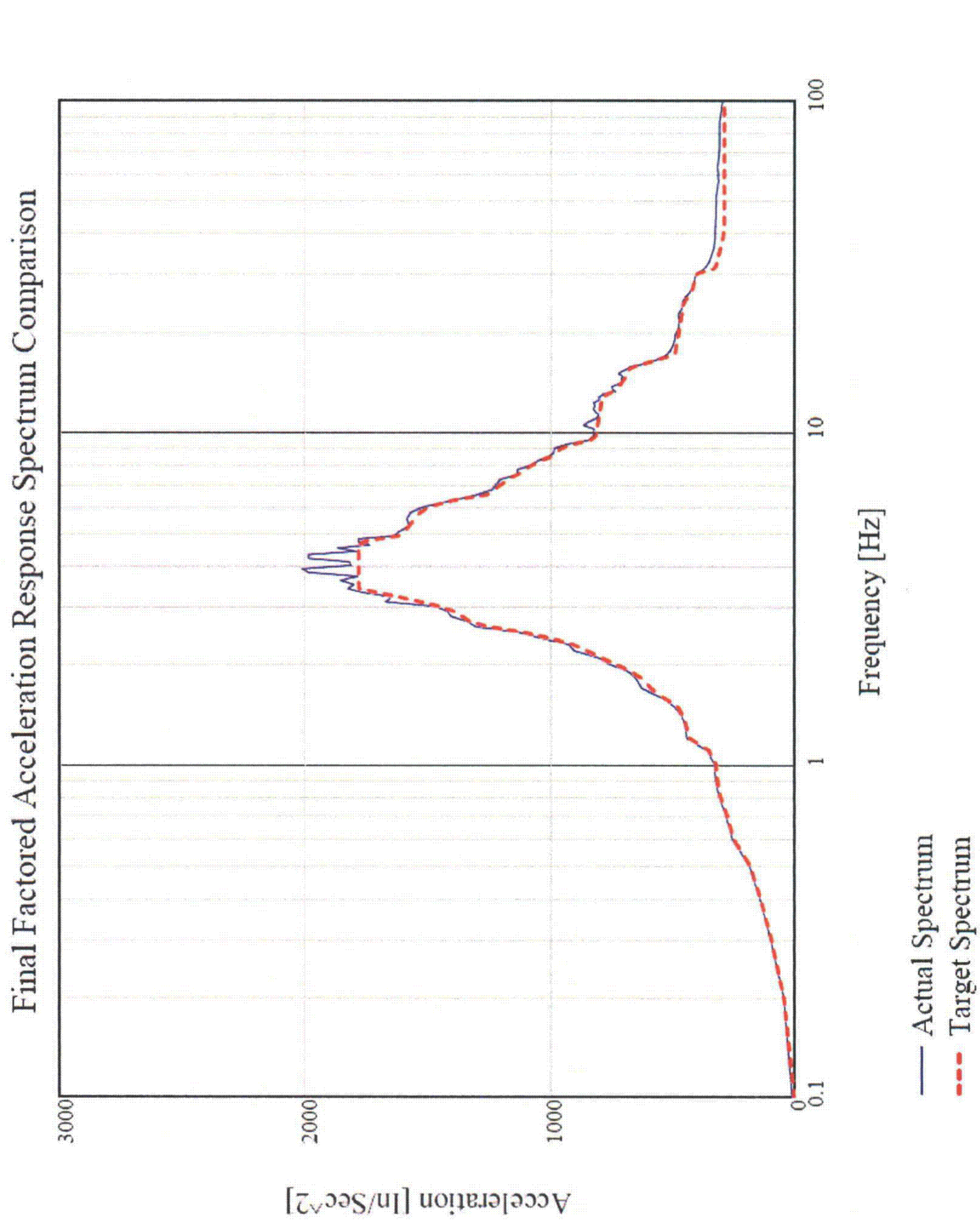


Figure 1 Comparison of Input vs. Calculated Response Spectra, Horizontal (X)

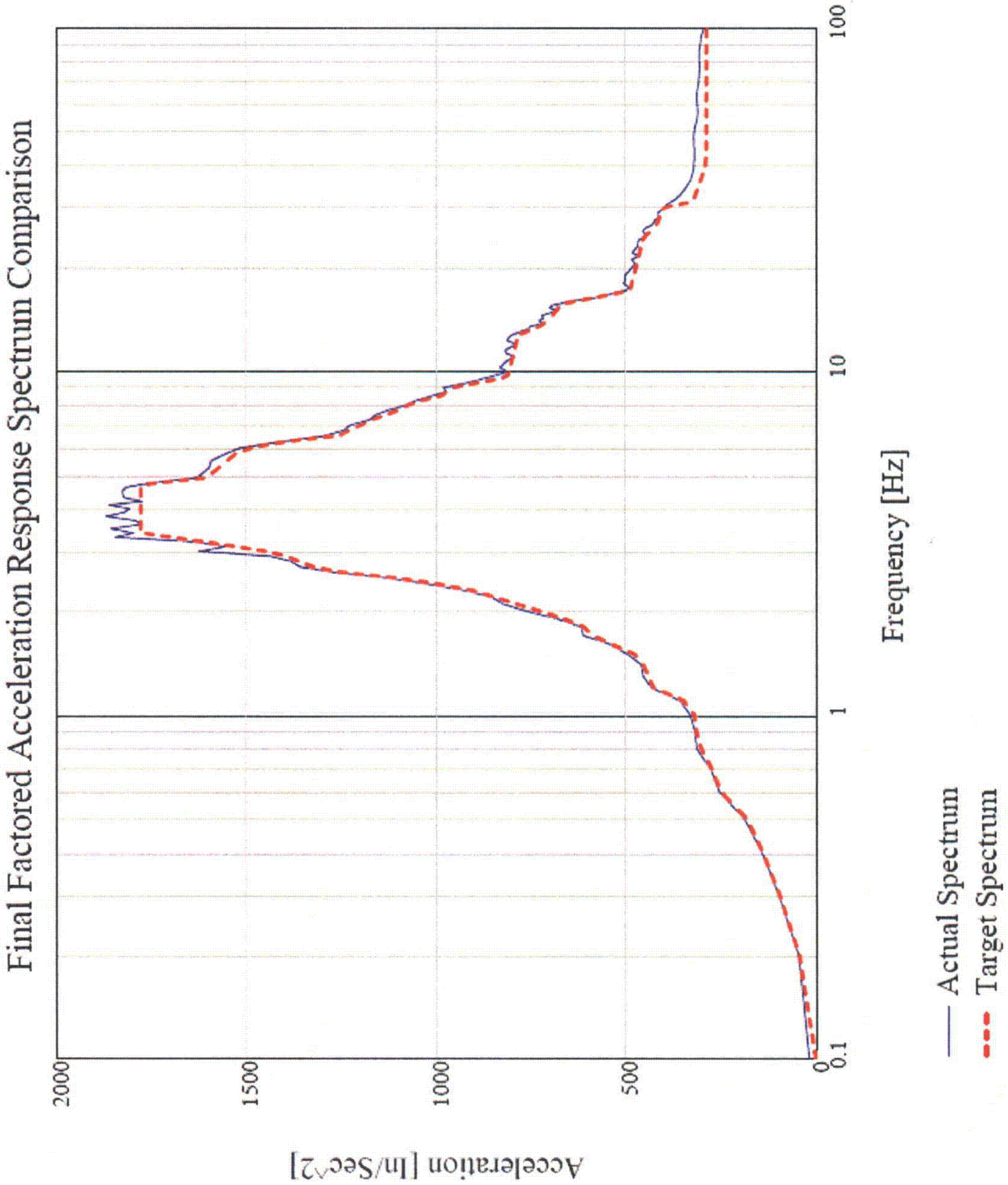


Figure 2 Comparison of Input vs. Calculated Response Spectra, Horizontal (Y)

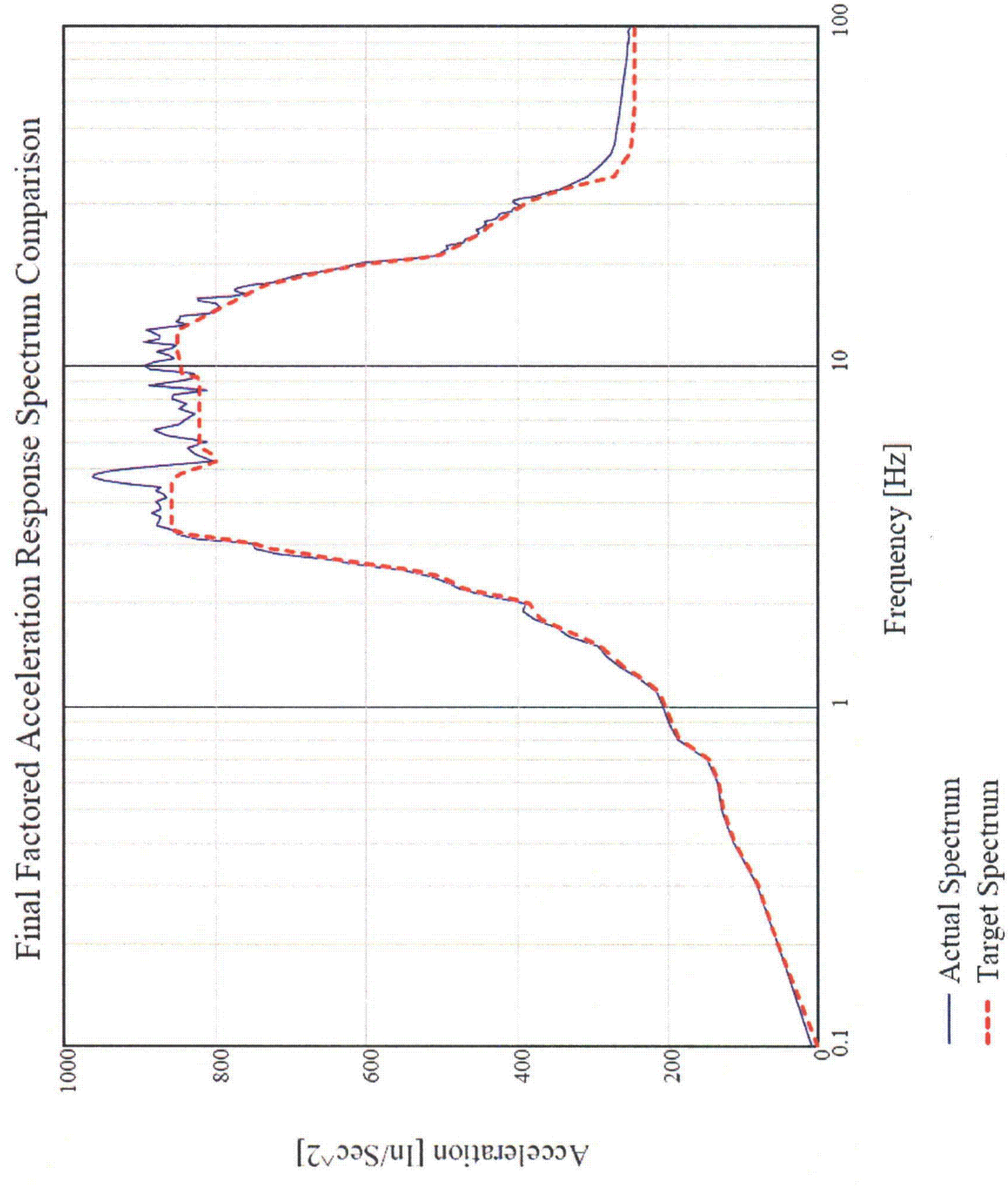


Figure 3 Comparison of Input vs. Calculated Response Spectra, Vertical (Z)

c. Target Power Spectral Density (PSD)s:
The second of the three required steps to confirm the validity of the final time histories is the minimum PSD check. The NRC provides a minimum target PSD function corresponding to a seismic ground response spectra (GRS) that conforms to Reg. Guide 1.60 response spectra; see SRP Section 3.7.1, Appendix A. This minimum target PSD function is provided as normalized to 1.0g peak acceleration (PGA). The normalized target PSD function must be multiplied by the square of the peak acceleration from the input GRS for each curve. For STP, the peak accelerations are 0.742g horizontal and .630g vertical for the Design Earthquake. An Excel spreadsheet was used to compute the normalized NRC target PSD function, multiply the values by the square of the peak acceleration above, and multiply by 80% as required.

Note that the STP input does not meet the minimum GRS specified by Reg. Guide 1.60. The representative motion PSD is expected to be less than the SRP Section 3.7.1 Appendix A target PSD associated with the Reg. Guide 1.60 spectral shape. In such cases, the NRC SRP Section 3.7.1 suggests that a compatible target PSD should be generated.

To develop a site-specific target PSD, the Westinghouse-computer code PowerSpec version 2.0.2, Module 2 was used to generate a PSD from the STP-specific Design Basis Response Spectra (DBRS) at 4% damping. The resulting calculated target horizontal and vertical PSDs was used for comparison to the actual average PSD generated from the artificial time histories.

The Westinghouse-configured code PowerSpec version 2.0.2, Module 8 was then used to generate the actual raw one-sided PSD functions from the final artificial acceleration time histories. PowerSpec produces two output files: which contains the PSD results, and which summarizes the run information including the input and output data.

The SRP 3.7.1 Appendix A requires that "At any frequency f, the average PSD is computed over a frequency band width of ±20% centered on the frequency f." The average of the raw PSDs is computed with the same Excel spreadsheet discussed above.

Figures 4, 5, and 6 are plots of the 80% NRC target PSD function, the actual raw PSD, the actual average PSD, and the site-specific target PSD function for each case.

It can be seen that the actual average PSD curves are above the STP-specific target PSD curves with exceptions as follows:

- X direction, around 15Hz, the actual average is approximately equal to the target.
- Y direction, around 0.32 Hz, the actual average is below the target.

The PSD check that is required by SRP Section 3.7.1 is for synthetic motion generated at the ground level. Since our synthetic motion is at a higher elevation within containment, we have conservatively applied the PSD check at our higher elevation. There are two small frequency ranges (between 0.3-0.4 Hz in the horizontal "Y" direction and between 10-20 Hz in the horizontal "X" direction) where the actual PSD is below the site specific target PSD. The actual PSD is very close to the target PSD within these frequency ranges, and since the input response spectra is at an elevation above ground level, the artificial time history data is deemed acceptable.

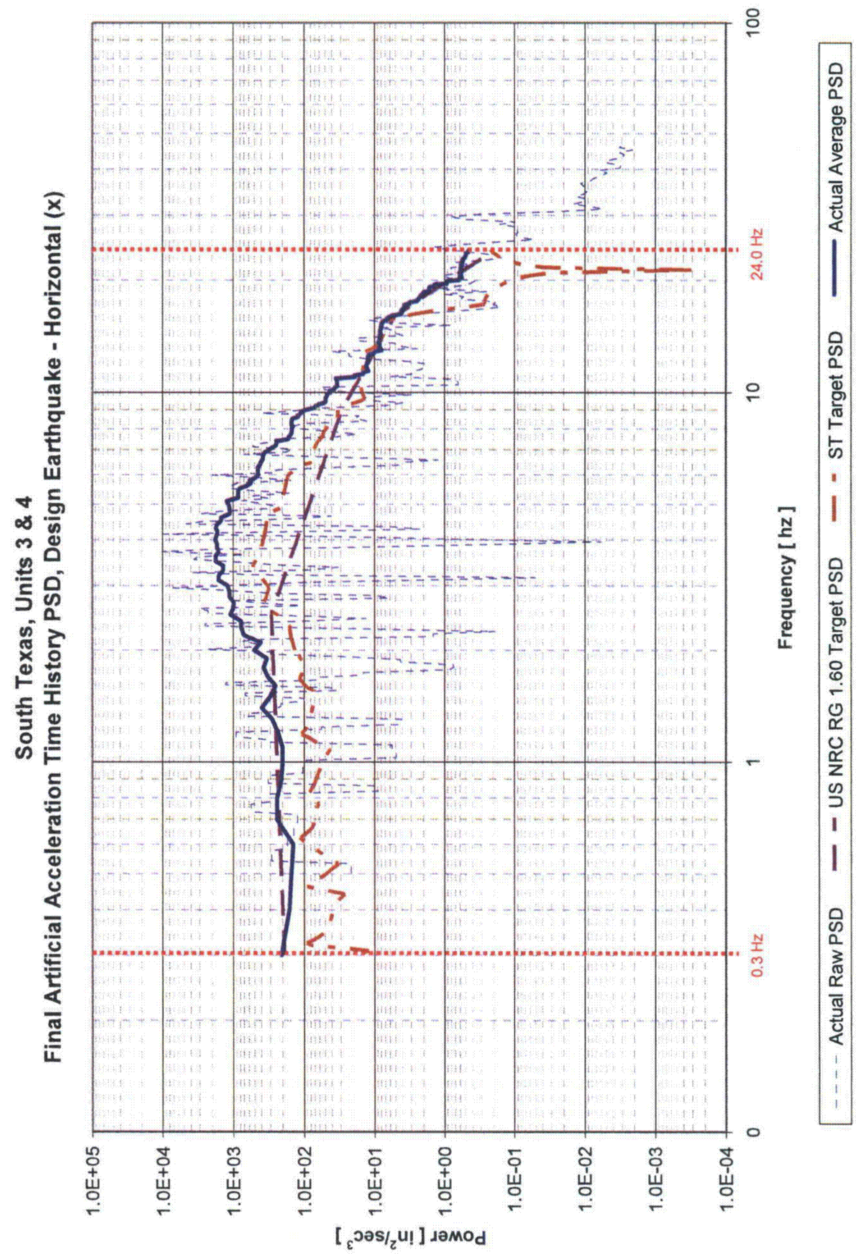


Figure 4 Actual Raw and Average PSD vs. Target – Horizontal (X)

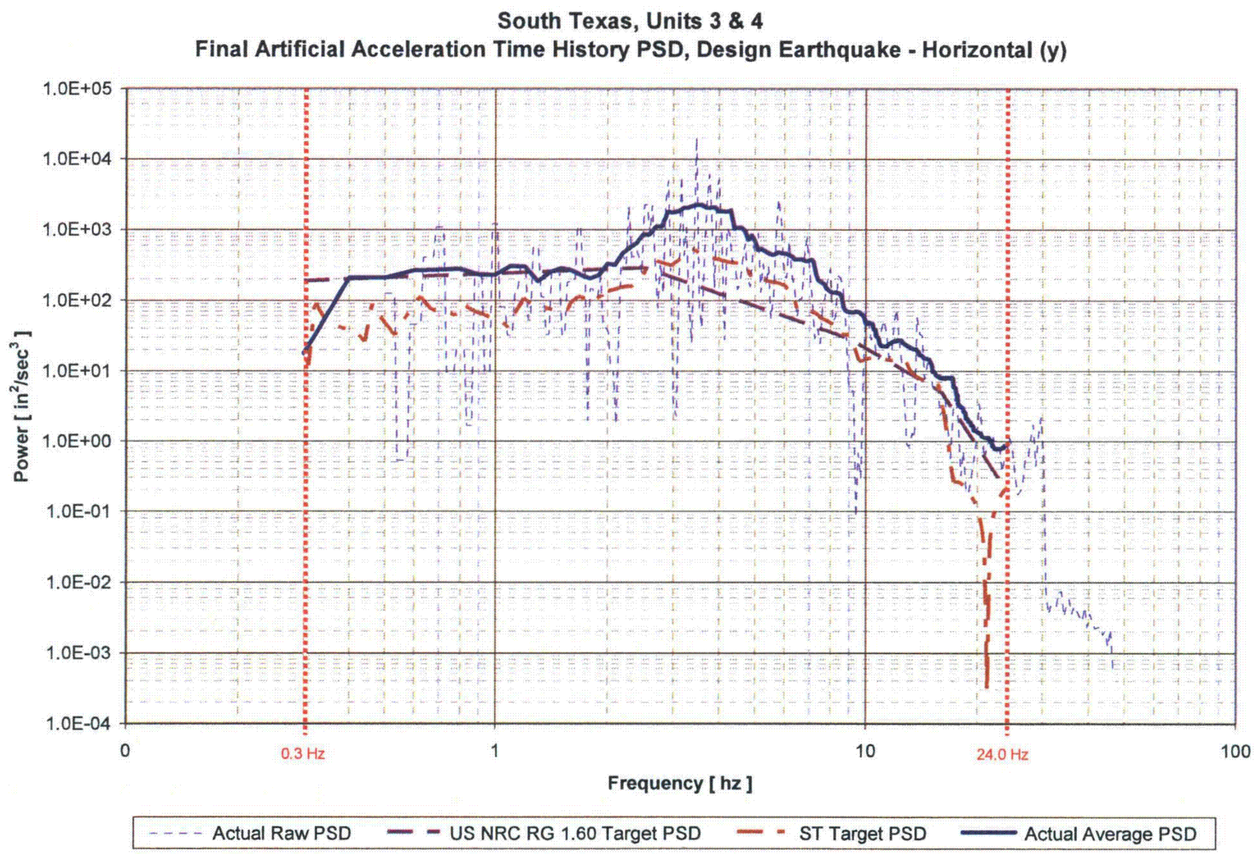


Figure 5 Actual Raw and Average PSD vs. Target – Horizontal (Y)

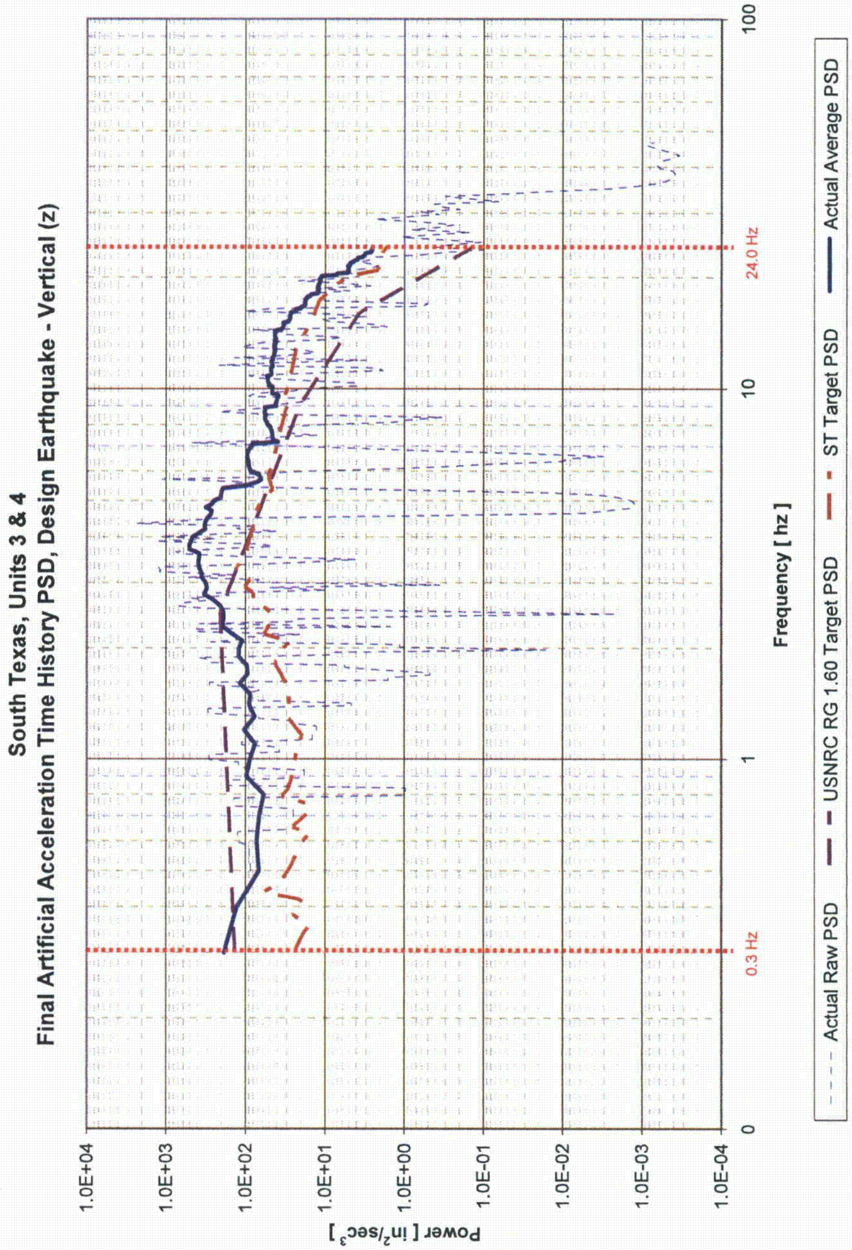


Figure 6 Actual Raw and Average PSD vs. Target PSD – Vertical (Z)

d. Process used to generate synthetic time histories

The approach used meets the requirements of NUREG-0800, SRP 3.7.1. The methodology uses a MathCAD spreadsheet to perform an iterative calculation to convert a starting recorded earthquake ground motion, in this case the El Centro earthquake, to a time history that calculated response spectrum that closely matches the target input seismic response spectrum. This MathCAD approach does not have the ability to adjust the ramp in and out of the strong motion portion of the event. The MathCAD process does perform "clipping" in order to maintain the Zero Period Acceleration (ZPA).

A second method of producing artificial acceleration time histories is a mathematical approach of overlapping sine waves. This approach is available in PowerSpec 2.0 software. This software tool provides limited control of the ramp in and out of the strong motion portion of the event however there is less control over the matching of the calculated response spectrum (results may include overly conservative peaks in acceleration at any number of frequency points within the spectrum). A number of test cases were evaluated. These curves did have the classic appearance (i.e., ramp in and ramp out) and did not require "clipping" to maintain ZPA. Two successive integrations of the artificial acceleration time histories produce velocity and displacement time histories that did not exhibit "drift" and therefore does not require baseline or "drift" correction. This second method produced near identical results as the first MathCAD method.

e. Non-baseline corrected acceleration time histories are generally adequate for linear structures without sliding. When a structure is free to slide under the influence of friction, any residual velocity of the ground can impact slippage. To prevent this the acceleration time histories are "baseline corrected" to eliminate residual displacements and velocities. The following baseline correction methodology has been applied at several spent fuel rack installations.

The acceleration time history (A(t)) is double integrated to determine the residual displacement and velocity at the end of the time history (t_f). These residuals are designated Δs_f and Δv_f, respectively. [

]^{a,c}, that are applied to the original acceleration such that the same residuals will be obtained when the acceleration time history is integrated over time. These factors when subtracted from the original acceleration time history will cancel any residual velocity or displacement at the end of the time history. The "baseline corrected" time history A'(t) is:

[

]^{a,c}

Additional details of the development of the "baseline correction" methodology are provided in the supporting calculation note to the spent fuel rack technical report.

ANSYS does not have the capability of removing drift from the solution.

f. The displacement time history characteristics described in NRC items (1) – (4) are global covering the entire time history duration. The dynamic response of the spent fuel racks are dependent on the local variation of the displacements occurring over small time steps rather than the global variation occurring over the entire time history.

The displacement time histories shown in Technical Report Figure 4-5 are developed from three statistically independent synthesized acceleration time histories (x, y, z), satisfying all the criteria of SRP 3.7.1. The acceleration time histories are "baseline corrected" as described in the response to item e. above. The "baseline corrected" acceleration time histories are numerically double integrated using the following equations:

$A'(t) = A_i + [(A_{i+1} - A_i)/(t_{i+1} - t_i)]*t$

$V(t_{i+1}) = V_i + [(A_i + A_{i+1})/2]*t_{i+1}$

$S(t_{i+1}) = S_i + V_i*t_{i+1} + (2A_i + A_{i+1})*(t_{i+1})^2/6$

Where,

$A'(t)$: Baseline corrected acceleration time history in x, y, z directions

A_i , A_{i+1}: Baseline corrected acceleration time history at two adjacent time points, t_i , t_{i+1}

V_i, S_i: Velocity and displacement, respectively, at time t_i

$V(t_{i+1})$, $S(t_{i+1})$: Velocity and displacement, respectively, at time t_{i+1}

No changes to the COLA are required by the responses provided above.

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CAW-11-3182

June 17, 2011

APPLICATION FOR WITHHOLDING PROPRIETARY
INFORMATION FROM PUBLIC DISCLOSURE

Subject: WEC-NINA-2011-0015 P-Enclosure, "South Texas Project Units 3 & 4 Responses to RAIs 09.01.02-2, 09.01.02-5, and 09.01.02-9 for WCAP-17331-P, Revision 1" (Proprietary)

The proprietary information for which withholding is being requested in the above-referenced report is further identified in Affidavit CAW-11-3182 signed by the owner of the proprietary information, Westinghouse Electric Company LLC. The affidavit, which accompanies this letter, sets forth the basis on which the information may be withheld from public disclosure by the Commission and addresses with specificity the considerations listed in paragraph (b)(4) of 10 CFR Section 2.390 of the Commission's regulations.

Accordingly, this letter authorizes the utilization of the accompanying affidavit by Nuclear Innovation North America (NINA).

Correspondence with respect to the proprietary aspects of this application for withholding or the accompanying affidavit should reference CAW-11-3182 and should be addressed to J. A. Gresham, Manager, Regulatory Compliance, Westinghouse Electric Company LLC, Suite 428, 1000 Westinghouse Drive, Cranberry Township, Pennsylvania 16066.

Very truly yours,

BFMaurer

B. F. Maurer, Manager
ABWR Licensing

Enclosures

cc: R. Foster (NRC TWFN 6 D38M)

AFFIDAVIT

COMMONWEALTH OF PENNSYLVANIA:

ss

COUNTY OF BUTLER:

Before me, the undersigned authority, personally appeared B. F. Maurer, who, being by me duly sworn according to law, deposes and says that he is authorized to execute this Affidavit on behalf of Westinghouse Electric Company LLC (Westinghouse), and that the averments of fact set forth in this Affidavit are true and correct to the best of his knowledge, information, and belief:

B F Maurer

B. F. Maurer, Manager
ABWR Licensing

Sworn to and subscribed before me
this 17th day of June 2011

Cynthia Olesky
Notary Public

COMMONWEALTH OF PENNSYLVANIA
Notarial Seal
Cynthia Olesky, Notary Public
Manor Boro, Westmoreland County
My Commission Expires July 16, 2014
Member, Pennsylvania Association of Notaries

(1) I am Manager, ABWR Licensing, in Nuclear Services, Westinghouse Electric Company LLC (Westinghouse), and as such, I have been specifically delegated the function of reviewing the proprietary information sought to be withheld from public disclosure in connection with nuclear power plant licensing and rule making proceedings, and am authorized to apply for its withholding on behalf of Westinghouse.

(2) I am making this Affidavit in conformance with the provisions of 10 CFR Section 2.390 of the Commission's regulations and in conjunction with the Westinghouse Application for Withholding Proprietary Information from Public Disclosure accompanying this Affidavit.

(3) I have personal knowledge of the criteria and procedures utilized by Westinghouse in designating information as a trade secret, privileged or as confidential commercial or financial information.

(4) Pursuant to the provisions of paragraph (b)(4) of Section 2.390 of the Commission's regulations, the following is furnished for consideration by the Commission in determining whether the information sought to be withheld from public disclosure should be withheld.

(i) The information sought to be withheld from public disclosure is owned and has been held in confidence by Westinghouse.

(ii) The information is of a type customarily held in confidence by Westinghouse and not customarily disclosed to the public. Westinghouse has a rational basis for determining the types of information customarily held in confidence by it and, in that connection, utilizes a system to determine when and whether to hold certain types of information in confidence. The application of that system and the substance of that system constitutes Westinghouse policy and provides the rational basis required.

Under that system, information is held in confidence if it falls in one or more of several types, the release of which might result in the loss of an existing or potential competitive advantage, as follows:

(a) The information reveals the distinguishing aspects of a process (or component, structure, tool, method, etc.) where prevention of its use by any of Westinghouse's competitors without license from Westinghouse constitutes a competitive economic advantage over other companies.

(b) It consists of supporting data, including test data, relative to a process (or component, structure, tool, method, etc.), the application of which data secures a competitive economic advantage, e.g., by optimization or improved marketability.

(c) Its use by a competitor would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing a similar product.

(d) It reveals cost or price information, production capacities, budget levels, or commercial strategies of Westinghouse, its customers or suppliers.

(e) It reveals aspects of past, present, or future Westinghouse or customer funded development plans and programs of potential commercial value to Westinghouse.

(f) It contains patentable ideas, for which patent protection may be desirable.

There are sound policy reasons behind the Westinghouse system which include the following:

(a) The use of such information by Westinghouse gives Westinghouse a competitive advantage over its competitors. It is, therefore, withheld from disclosure to protect the Westinghouse competitive position.

(b) It is information that is marketable in many ways. The extent to which such information is available to competitors diminishes the Westinghouse ability to sell products and services involving the use of the information.

(c) Use by our competitor would put Westinghouse at a competitive disadvantage by reducing his expenditure of resources at our expense.

(d) Each component of proprietary information pertinent to a particular competitive advantage is potentially as valuable as the total competitive advantage. If competitors acquire components of proprietary information, any one component may be the key to the entire puzzle, thereby depriving Westinghouse of a competitive advantage.

(e) Unrestricted disclosure would jeopardize the position of prominence of Westinghouse in the world market, and thereby give a market advantage to the competition of those countries.

(f) The Westinghouse capacity to invest corporate assets in research and development depends upon the success in obtaining and maintaining a competitive advantage.

(iii) The information is being transmitted to the Commission in confidence and, under the provisions of 10 CFR Section 2.390; it is to be received in confidence by the Commission.

(iv) The information sought to be protected is not available in public sources or available information has not been previously employed in the same original manner or method to the best of our knowledge and belief.

(v) The proprietary information sought to be withheld in this submittal is that which is appropriately marked in WEC-NINA-2011-0015 P-Enclosure, "South Texas Project Units 3 & 4 Responses to RAIs 09.01.02-2, 09.01.02-5, and 09.01.02-9 for WCAP-17331-P, Revision 1" (Proprietary) for submittal to the Commission, being transmitted by Nuclear Innovation North America (NINA) letter and Application for Withholding Proprietary Information from Public Disclosure, to the Document Control Desk. The proprietary information as submitted by Westinghouse is that associated with the ABWR spent fuel rack analysis in support of the STP 3&4 COL Application.

This information is part of that which will enable Westinghouse to:

(a) Assist the customer in obtaining NRC review of the Westinghouse spent fuel rack analysis as applied to the STP 3&4 plants.

Further this information has substantial commercial value as follows:

(a) Westinghouse plans to sell the use of this information to its customers for purposes of plant specific spent fuel rack analysis for ABWR licensing basis applications.

(b) Its use by a competitor would improve their competitive position in the design and licensing of a similar product for ABWR plants.

(c) The information requested to be withheld reveals the distinguishing aspects of a methodology which was developed by Westinghouse.

Public disclosure of this proprietary information is likely to cause substantial harm to the competitive position of Westinghouse because it would enhance the ability of competitors to provide similar technical evaluations and licensing defense services for commercial power reactors without commensurate expenses. Also, public disclosure of the information would enable others to use the information to meet NRC requirements for licensing documentation without purchasing the right to use the information.

The development of the technology described in part by the information is the result of applying the results of many years of experience in an intensive Westinghouse effort and the expenditure of a considerable sum of money.

In order for competitors of Westinghouse to duplicate this information, similar technical programs would have to be performed and a significant manpower effort, having the requisite talent and experience, would have to be expended.

Further the deponent sayeth not.

Proprietary Information Notice

Transmitted herewith are proprietary and/or non-proprietary versions of documents furnished to the NRC in connection with requests for generic and/or plant-specific review and approval.

In order to conform to the requirements of 10 CFR 2.390 of the Commission's regulations concerning the protection of proprietary information so submitted to the NRC, the information which is proprietary in the proprietary versions is contained within brackets, and where the proprietary information has been deleted in the non-proprietary versions, only the brackets remain (the information that was contained within the brackets in the proprietary versions having been deleted). The justification for claiming the information so designated as proprietary is indicated in both versions by means of lower case letters (a) through (f) located as a superscript immediately following the brackets enclosing each item of information being identified as proprietary or in the margin opposite such information. These lower case letters refer to the types of information Westinghouse customarily holds in confidence identified in Sections (4)(ii)(a) through (4)(ii)(f) of the affidavit accompanying this transmittal pursuant to 10 CFR 2.390(b)(1).

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