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Your ref: Docket No. 52-006
Our ref: DCP_NRC_002690

November 11, 2009

Subject: AP1000 Response to Request for Additional Information (SRP 9)

Westinghouse is submitting a response to the NRC request for additional information (RAI) on SRP Section 9. This RAI response is submitted in support of the AP1000 Design Certification Amendment Application (Docket No. 52-006). The information included in this response is generic and is expected to apply to all COL applications referencing the AP1000 Design Certification and the AP1000 Design Certification Amendment Application.

Enclosure 1 provides the response for the following RAI(s):

RAI-SRP 9.1.2-SEB1-05 R1
RAI-SRP 9.1.2-SEB1-06 R1
RAI-SRP 9.1.2-SEB1-07 R1
RAI-SRP9.1.5-SBPB-01 R2

Questions or requests for additional information related to the content and preparation of this response should be directed to Westinghouse. Please send copies of such questions or requests to the prospective applicants for combined licenses referencing the AP1000 Design Certification. A representative for each applicant is included on the cc: list of this letter.

Very truly yours,

Robert Sisk, Manager
Licensing and Customer Interface
Regulatory Affairs and Standardization

/Enclosure

1. Response to Request for Additional Information on SRP Section 9

D063
NRO

0344ljb.doc

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	A. Monroe	-	SCANA	1E
	P. Jacobs	-	Florida Power & Light	1E
	C. Pierce	-	Southern Company	1E
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ENCLOSURE 1

Response to Request for Additional Information on SRP Section 9

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-SRP 9.1.2-SEB1-05
Revision: 1

Question:

Section 2.4 "Assumptions" was revised in TR 54 Rev. 2 to state that "Modeling the total effect of n individual fuel assemblies rattling inside the storage cells in a horizontal plane as one lumped mass at each of five levels in the fuel rack is a conservative assumption. Thus, the effects of chaotic fuel mass movement are incorporated into the analysis by introducing a fuel ratio factor of 0.75 (75% of the fuel weight is used in the analysis)."

The staff notes that the use of a 0.75 fuel ratio factor appears to be a departure from prior revisions of TR 54, where 100% fill was used to conservatively represent "fully loaded" cases. The new "mixed loading case" was intended to address the potential for partial fill loading. The staff's understanding was that in the current set of analyses reported in TR 54, Rev. 2, for fully loaded and mixed loading cases, all fuel assemblies that are considered in each loading case are assumed to move in phase (i.e., fuel ratio factor of 1.0). The staff requests Westinghouse to provide a detailed technical basis for utilizing a fuel ratio factor of 0.75, in these analyses.

Westinghouse Response: (Revision 0)

The Holtec dynamic analyses performed for the AP1000 spent fuel racks apply an attenuation factor to the rattling mass to compensate for the fact that the fuel assemblies within a spent fuel rack are assumed to move in unison throughout the seismic event. In reality, each fuel mass has 2 degrees of freedom (in the x and y directions), which are independent of other fuel assemblies. To account for the mitigating effect on the response of the rack-fuel assemblage, a reduced horizontal rattling mass is defined for use in the dynamic rack analyses, where the totality of fuel in a rack is modeled by five lumped masses at elevations 0, 0.25H, 0.5H, 0.75H, and H (H is the cell height above the baseplate). The lumped masses are assumed centrally located with nominal fuel assembly-to-storage cell gap. The purpose of the attenuation factor is not to simulate a partially loaded rack; rather it serves to simulate the effect of non-coherent fuel assembly movements within a spent fuel rack on the overall response of the spent fuel rack.

In TR 54 Rev. 2, an attenuation factor of 0.75 was assumed based on prior analyses performed by Holtec for similar rack designs. However, this assumption should be revised to assume an attenuation factor of 0.79 based on a detailed analysis of the AP1000 spent fuel rack geometry and seismic loading, which is described below. The details of the evaluation which justifies the use of a 0.79 fuel attenuation factor are included in the attachment to this RAI.

To quantify the level of conservatism associated with a centrally positioned single moving mass representing the rattling motion of all of the fuel assembly mass in a spent fuel rack requires a comparative analysis. The purpose of the analysis is to study the dynamic response of a two dimensional non-coherent rack model versus a two-dimensional coherent model of exact geometrical configuration when subjected to the full strength seismic excitation specific to the AP1000 design and hence derive an attenuation factor based on a comparison of the results. To reach the objective, a 12 x 11 non-coherent rack module with 132 fuel assembly independent masses is simulated. For the coherent model, the same rack is also simulated with a centrally positioned lumped fuel mass (equal to the sum of 132 individual fuel assembly masses). This modeling approach was previously used by Holtec for the design analysis of the cask pit racks at Diablo Canyon Power Plant (Reference 1), which were approved by the NRC in 2005. Based on a comparison of the net impact force on the non-coherent and coherent rack models, an attenuation factor of 0.79 has been set and utilized to re-evaluate the whole pool multi-rack (WPMR) analyses involving the AP1000 spent fuel racks.

The difference in the results between the two attenuation factors is insignificant, except for the maximum fuel to cell wall impact load, which increased by roughly 12%; however, all calculated safety factors remain greater than 1.0. Additionally, the rack-to-wall impact load increased and has no impact on the structural integrity of the spent fuel racks; but the effect on the spent fuel pool wall will be evaluated in the response to RAI-SRP-9.1.2-SEB1-06.

The models and analyses are described, appropriate input data set down, and the results discussed in the following paragraphs.

Westinghouse Additional Response: (Revision 1)

After the submittal of the Revision 0 response to this RAI, and following the August 2009 NRC audit and subsequent discussions, Westinghouse has determined that an attenuation factor less than 1.0 cannot be justified. Westinghouse is updating the spent fuel rack seismic analyses to use a fuel ratio factor of 1.0. The results will be included in a revision to Technical Report 54, which will be available with all supporting documentation, at the end of November, 2009.

Reference(s):

1) "Diablo Canyon Unit 1 and 2, Issuance of Amendments 183/185 Re: Revision to Technical Specifications 3.7.17 and 4.3 for a Temporary Cask Pit Spent Fuel Storage Rack for Cycles 14 to 16," ML052970270, 11/21/2005.

Design Control Document (DCD) Revision:
None.

PRA Revision:
None.

Technical Report (TR) Revision: (Revision 0, 1)

The results of the updated analysis using an attenuation factor of 1.0 will be included in TR-54 Rev. 3, which will be available near the end of November. The TR revisions that were included in the Revision 0 response to this RAI will be superseded by the TR-54, Revision 3.

The following changes should be made to TR-54 to incorporate the resulting changes discussed above; however, these changes do not necessitate a subsequent submittal of TR-54 to the NRC for review as the detailed information is provided directly in this RAI response.

Change the last sentence of Section 2.4 of TR-54, Rev. 2 as follows:

Thus, the effects of chaotic fuel mass movement are incorporated into the analysis by introducing a fuel ratio factor of ~~0.75~~ 0.79 (~~75%~~ 79% of the fuel weight is used in the analysis).

Change Section 2.8.1.3 of TR-54, Rev. 2 as follows:

Run number 4 8 provides the maximum shear loads; the value is used as an input loading to evaluate the female pedestal-to-baseplate weld.

Change Section 2.8.1.4, subsection "Fuel-to-Cell Wall Impact Loads" of TR-54, Rev. 2 as follows:

$$\sout{a = \frac{4F}{w} = 2.38 \cdot g} \quad \boxed{a = \frac{4F}{w} = 2.66 \cdot g}$$

F = maximum fuel-to-cell wall impact force (= ~~1,030~~ 1,150 lbf)

Change Section 2.8.1.4, subsection "Rack-to-Rack and Rack-to-Wall Impacts" of TR-54, Rev. 2 as follows:

The solver summary result files from Reference 13 in all of the simulations were manually scanned to determine the maximum impact on each side of the rack. Rack-to-wall impacts occur twice – in Run 5 rack A1 impacts the west wall at a force of ~~45,690~~ 81,580 lb and in Run 4 rack B4 impacts the north wall at a force of ~~67,800~~ 38,340 lb. Rack-to-rack impacts do occur at the top of rack elevation between adjacent Region 2 racks and also at the baseplate elevation of all racks. The maximum rack-to-rack impact load at the top of the rack elevation is ~~269,700~~ 260,600 lb which results from Run 2. In order to ensure that fuel retrievability is maintained, the impact loads at the rack top elevation are compared against two-thirds of the critical buckling load for the cell walls required by Table NF-3523(b)-1 of the ASME Code for primary plus secondary stresses. The resulting stress factor is ~~1.11~~ 1.72; therefore, these impact loads do not result in damage to the racks that would prevent fuel retrievability.

Change Section 2.8.2.2 of TR-54, Rev. 2 as follows:

- For ASB99 Simulation

  $\{[R6 * (1.2)]^2 + [R2 * (0.72)]^2 + [R7 * (0.72)]^2\}^{1/2} * S_y * \text{Ratio} =$

  {[~~0.499~~ 0.480 * (1.2)]^2 + [~~0.054~~ 0.081 * (0.72)]^2 + [~~0.057~~ 0.067 * (0.72)]^2}$^{1/2}$ * (21,300) * 2.1516 = ~~27,564~~ 26,624 psi

Change Section 2.8.2.3 of TR-54, Rev. 2 as follows:

Table 2-15 provides the limiting thread stresses under faulted conditions. The maximum average shear stress in the engagement region is ~~16,617~~ 16,202 psi, which occurs during run number ~~5~~ 4. This computed stress is applicable to both the male and female pedestal threads.

Change Section 2.8.3 of TR-54, Rev. 2 as follows:

This load will induce low stress levels in the neighborhood of the pedestal, compared with the load levels that exist under the SSE load condition (that is, on the order of ~~393,000~~ 374,000 lb for this rack). Therefore, there are no primary shear loads on the pedestal and since the Level A loads are approximately 20% of the Level D loads, while the Level A limits exceed 50% of the Level D limits, the SSE load condition bounds the dead load condition and no further evaluation is performed for dead load only.

Change Section 2.8.4.1 of TR-54, Rev. 2 (as previously modified by Rev. 0 of RAI-SRP 9.1.2-SEB1-07) as follows:

2.8.4.1 Cell Wall Buckling Evaluation

The allowable local buckling stresses in the fuel rack cell walls (from vertical loading) are obtained by using classical plate buckling analysis on the lower portion of the cell walls. The following formula for the critical stress has been used:

$$\sigma_{cr} = K \cdot \frac{E}{1-\upsilon^2} \cdot \left(\frac{t}{b}\right)^2$$

Where E = 27.6 x 10^6 psi, υ is Poison's ratio = 0.3, t = 0.075", b = 8.8". The *K* factor varies depending on the plate length/width ratio and the boundary support conditions at the sides of the plate. At the base of the rack, the cell wall acts alone in compression for a length of about 6 inches up to the point where the ~~poison~~ neutron absorber sheathing is attached. Above this level, the sheathing provides additional strength against buckling, which is not considered here. Therefore, the length/width ratio for the 8.8" wide cell wall is taken as 0.68. Per Table 35 of Reference 25, the value of *K* is taken as 5.81, which is the average value for all sides simply supported and all sides clamped.

For the given data $\sigma_{cr} < 12{,}800$ psi

It is conservative to apply the above equation to the rack cell wall if σ_{cr} is compared with the maximum compressive stress anywhere in the cell wall. This local buckling stress limit is not violated anywhere in the body of the rack modules since the maximum compressive stress in the outermost cell is σ = (1.2)(21,300) * R6 (which is ~~0.499~~ 0.480) = ~~12,754~~ 12,269 psi, which is less than 12,800 psi. Therefore, rack cell wall buckling is not a concern.

Change Table 2-9 of TR-54, Rev. 2 as follows:

Table 2-9 Results Summary

Run No.	Coefficient of Friction	Max. Stress Factor	Max. Vertical Load (lbf)	Max. Shear Load (lbf) (X or Y)	Max. Fuel-to-Cell Wall Impact (lbf)
1	0.8	~~0.475~~ 0.455	~~364,000~~ 347,000	~~159,000~~ 202,000	~~912~~ 967
2	0.5	~~0.446~~ 0.480	~~333,000~~ 336,000	~~139,000~~ 157,000	~~924~~ 955
3	0.2	0.430	~~321,000~~ 316,000	~~58,800~~ 53,200	~~826~~ 994
4	0.8	~~0.499 (+5.1%)~~ 0.459 (+0.9%)	~~393,000 (+8.0%)~~ 374,000 (+7.8%)	~~210,000 (+32%)~~ 179,000 (-11.4%)	~~909 (-0.4%)~~ 879 (-9.1%)
5	0.8	~~0.411 (-13.5%)~~ 0.407 (-10.5%)	~~306,000 (-15.9%)~~ 320,000 (-7.8%)	~~169,000 (+6.3%)~~ 127,000 (-37.1%)	~~1,008 (+10.5%)~~ 932 (-3.6%)
6	0.8	~~0.462 (-2.7%)~~ 0.450 (-1.1%)	~~343,000 (-5.8%)~~ 347,000 (+0.0%)	~~163,000 (+2.5%)~~ 177,000 (-12.4%)	~~811 (-11.2%)~~ 913 (-5.6%)
7	0.8	~~0.467 (-1.7%)~~ 0.470 (+3.3%)	~~371,000 (+1.9%)~~ 356,000 (+2.6%)	~~176,000 (+10.7%)~~ 164,000 (-18.8%)	~~1,030 (+12.9%)~~ 1,150 (+18.9%)
8	0.8	~~0.439 (-7.6%)~~ 0.440 (-3.3%)	~~326,000 (-10.4%)~~ 334,000 (-3.7%)	~~162,000 (+1.9%)~~ 210,000 (+4.0%)	~~931 (+2.0%)~~ 947 (-2.1%)
9	0.8	0.074	34,300	19,200	0

Change Table 2-10 of TR-54, Rev. 2 as follows:

Table 2-10 Time History Post-Processor Results

Location on Rack	Maximum Rack Displacement Relative to Floor (in)	Run Number
Base Plate	~~0.354~~ 2.73	~~1~~ 5
Top of Rack	~~1.486~~ 3.50	~~3~~ 7

Change Table 2-11 of TR-54, Rev. 2 as follows:

Table 2-11 Maximum Stress Factors

Run Number	Pedestal Stress Factor	Cell Wall Stress Factor
1	~~0.083~~ 0.092	~~0.475~~ 0.455 ~~$\left(0.475 \times \frac{1}{0.567}\right) = 0.837$ *~~ $\left(0.455 \times \frac{1}{0.580}\right) = 0.784$ *
2	~~0.079~~ 0.093	~~0.446~~ 0.480 ~~$\left(0.446 \times \frac{1}{0.567}\right) = 0.786$ *~~ $\left(0.480 \times \frac{1}{0.577}\right) = 0.832$ *
3	~~0.074~~ 0.073	0.430 ~~$\left(0.430 \times \frac{1}{0.567}\right) = 0.758$ *~~ $\left(0.430 \times \frac{1}{0.580}\right) = 0.741$ *
4	~~0.092~~ 0.094	~~0.499~~ 0.459

		~~$\left(0.499 \times \frac{1}{0.567}\right) = 0.880*$~~ $\boxed{\left(0.459 \times \frac{1}{0.580}\right) = 0.791*}$
5	~~0.069~~ 0.071	~~0.411~~ 0.407 ~~$\left(0.411 \times \frac{1}{0.567}\right) = 0.724*$~~ $\boxed{\left(0.407 \times \frac{1}{0.580}\right) = 0.702*}$
6	~~0.087~~ 0.083	~~0.462~~ 0.450 ~~$\left(0.462 \times \frac{1}{0.585}\right) = 0.789*$~~ $\boxed{\left(0.450 \times \frac{1}{0.580}\right) = 0.776*}$
7	~~0.089~~ 0.103	~~0.467~~ 0.470 ~~$\left(0.467 \times \frac{1}{0.567}\right) = 0.823*$~~ $\boxed{\left(0.470 \times \frac{1}{0.580}\right) = 0.810*}$
8	~~0.083~~ 0.088	~~0.439~~ 0.440 ~~$\left(0.439 \times \frac{1}{0.567}\right) = 0.774*$~~ $\boxed{\left(0.440 \times \frac{1}{0.580}\right) = 0.759*}$
9	0.008	0.040 ~~$\left(0.040 \times \frac{1}{0.567}\right) = 0.0705*$~~

		$\left(0.040 \times \frac{1}{0.580}\right) = 0.069\,*$
Note: * Adjustment factor accounting for ASME Code Slenderness Ratio		

Change Table 2-12 of TR-54, Rev. 2 as follows:

Table 2-12 Baseplate-to-Cell Maximum Weld Stress

Weld Stress (psi)	Allowable Stress (psi)	Safety Factor
~~27,564~~ 26,624	35,748	~~1.296~~ 1.343

Change Table 2-13 of TR-54, Rev. 2 as follows:

Table 2-13 Base Metal Shear Stress at Baseplate-to-Cell Weld Location

Base Metal Shear Stress (psi)	Allowable Stress (psi)	Safety Factor
~~17,028~~ 18,826	~~18,000~~ 19,224*	~~1.06~~ 1.02

Note:
* Based on yield strength of SA240-304 at ~~200~~ 150°F (0.72 x ~~25,000~~ 26,700 psi = ~~18,000~~ 19,224 psi). Considering the material properties at 150°F is a conservative assumption because this bounds both the normal and abnormal (i.e., emergency core offload) design conditions; the limiting temperature in both cases is 140°F.

Change Table 2-14 of TR-54, Rev. 2 as follows:

Table 2-14 Baseplate-to-Pedestal Welds

Weld Stress (psi)	Run No.	Allowable Stress (psi)	Safety Factor
~~11,670~~ 11,680	~~7~~ 8	35,748	3.06

Change Table 2-15 of TR-54, Rev. 2 as follows:

Table 2-15 Pedestal Thread Shear Stress		
Base Metal Shear Stress (psi)	**Allowable Stress (psi)**	**Safety Factor**
~~17,028~~ 16,202	18,000*	~~1.06~~ 1.11
Note: * Based on yield strength of SA240-304 at 200°F (0.72 x 25,000 psi = 18,000 psi).		

Change Table 2-16 of TR-54, Rev. 2 as follows:

Table 2-16 Maximum Cell-to-Cell Weld Stress		
Weld Stress (psi)	**Allowable Stress (psi)**	**Safety Factor**
~~10,591~~ 11,158	35,748	~~3.38~~ 3.20

Change Table 2-17 of TR-54, Rev. 2 as follows:

Table 2-17 Maximum Base Metal Shear Stress at Cell-to-Cell Weld Location		
Base Metal Shear Stress (psi)	**Allowable Stress (psi)**	**Safety Factor**
~~7,489~~ 7,890	18,000*	~~2.40~~ 2.28
Note: * Based on yield strength of SA240-304 at 200°F (0.72 x 25,000 psi = 18,000 psi).		

Note: The proprietary attachment in Revision 0 of this RAI response provided details of the evaluation which justifies the use of a 0.79 fuel attenuation factor. Since Westinghouse has determined that an attenuation factor less than 1.0 cannot be justified, this attachment is removed in its entirety.

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-SRP 9.1.2-SEB1-06
Revision: 1

Question:

Section 2.8.1.4 "Rack-to-Rack and Rack-to-Wall Impacts" was revised in TR 54 Rev. 2 to state: "Rack-to-wall impacts occur twice – in Run 5 rack A1 impacts the west wall at a force of 45,690 lb and in Run 4 rack B4 impacts the north wall at a force of 67,800 lb."

Since the revised analyses now indicate that impacts occur between the racks and the pool walls, the staff requests Westinghouse to describe in detail how these additional impact loads have been considered in the design of the fuel pool structure (including the liner) and the design of the fuel racks, and also to identify where this is/will be described in the AP1000 DCD.

Westinghouse Response: (Revision 0)

Consideration of Impact on Spent Fuel Racks:

The maximum rack-to-wall impact force on the spent fuel racks of 67,800 lbs (and also as increased to 81,580 lbs as a result of the re-evaluation of the fuel attenuation factor per RAI-SRP9.1.2-SEB1-05) is bounded by the maximum rack-to-rack impact, which is 269,700 lbs as discussed in Section 2.8.1.4 of TR54 (this value decreased to 260,600 lbs in the RAI-SRP9.1.2-SEB1-05 re-evaluation).

The spent fuel racks have been analyzed to show that the force required to buckle the cell walls at the top of the rack is greater than the calculated maximum impact force (260,600 lbs in the updated analysis, or 269,700 without considering the RAI-SRP-9.1.2-SEB1-05 changes) by more than factor of 1.5. Specifically, the Westinghouse/Holtec proprietary version of the calculation concludes that the Safety Factor is 1.66 (in the old version, and updated to 1.72 in the reanalysis), and therefore will not buckle under the maximum calculated impact loads, including the maximum rack-to-wall impacts.

In conclusion, the effect on the spent fuel racks due to their impact with the spent fuel pool walls is bounded by the impact that the spent fuel racks have with other spent fuel racks, and this larger impact was considered in TR54 when evaluating the structural integrity of the spent fuel racks and shown to result in a safety factor greater than 1.5.

Consideration of Impact on Spent Fuel Pool Structure:

An additional analysis was performed to evaluate the impact of the resultant spent fuel rack loads imparted on the spent fuel pool structure during a seismic event. The analysis considers the updated maximum impact load of 81,580 lbs from the RAI-SRP-9.1.2-SEB1-05 response.

The conclusion of the analysis is that the rack impact load is much lower than other conventional loads that were previously considered and do not result in a significant impact. The required steel thickness of the liner to account for accident conditions changed from 0.465" to 0.467" and remains below the 0.5" design plate thickness.

The details of the evaluation of the impacts on the spent fuel pool structure are documented in Reference 1. No DCD changes are proposed, as this level of detail is not typically provided in the DCD.

Westinghouse Additional Response: (Revision 1)

After the submittal of the Revision 0 response to this RAI, and following the August 2009 NRC audit and subsequent discussions, Westinghouse is redesigning the Spent Fuel Racks to improve their resistance to buckling.

The following design changes are being implemented. Specific details will be included in the supporting documentation to be provided at the end of November, 2009:

- The cell wall thickness of the Region 1 and Region 2 racks as well as the 5 defective cells is being increased from 0.075" to 0.090".
- The upper supports (bumper bars) on the Region 2 racks are being increased in thickness from 0.25" to 0.50" and in length from 12" to 15". And identical bumper bars (0.50" thick and 15" long) are being added to the Region 1 racks as well as the defective cells.
- Localized reinforcement is being added near the top of the Region 2 cell walls. 0.105" thick plates (about 8.5" wide by 20" long) are being added above each Metamic® poison panel to stiffen this area of the rack structure where the highest impact loads occur.
- The placement of the racks within the spent fuel pool is being modified to account for the aforementioned changes and to optimize the gaps such that the impacts (both rack-to-rack and rack-to-wall) are minimized. The slightly modified pool layout is shown in the markup of DCD Figure 9.1-4 on the following page.

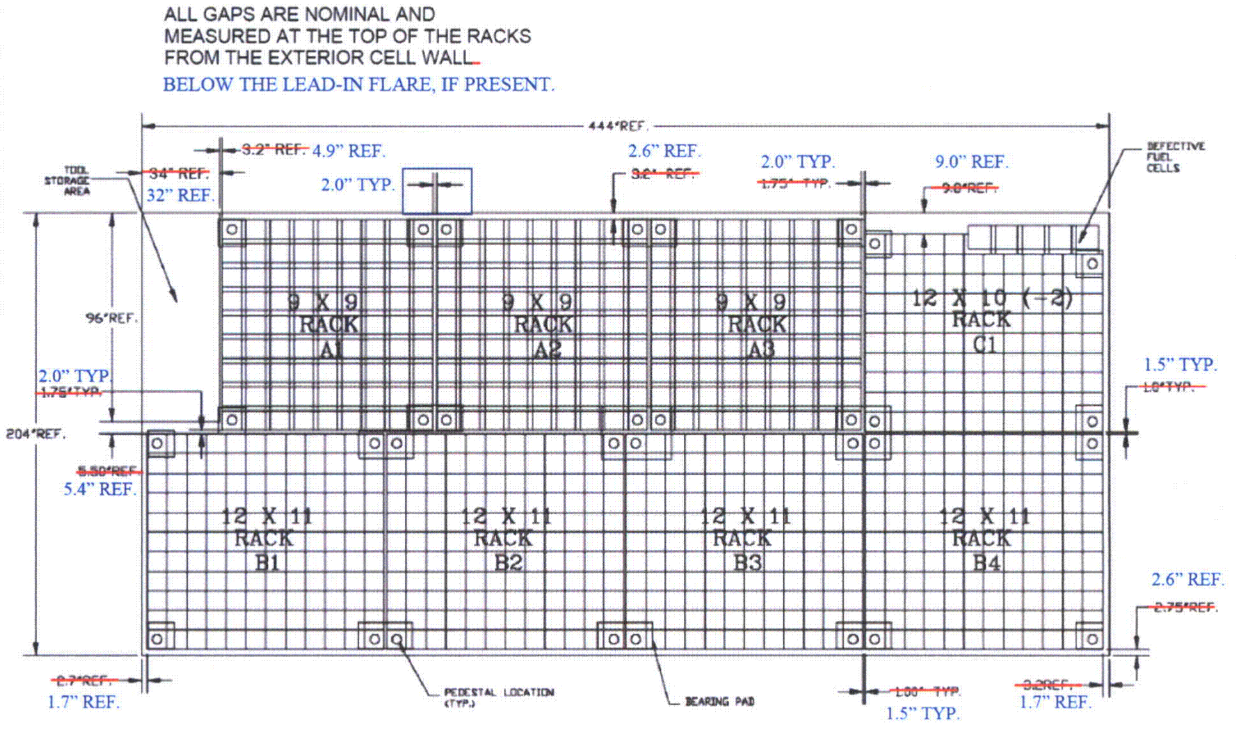

Figure 9.1-4

Spent Fuel Storage Pool Layout (889 Storage Locations)

As a result of the design changes listed above, the Spent Fuel Racks are able to maintain at least a 1.5 factor of safety against buckling near the top of the racks, consistent with the requirements of the ASME Code for Level D conditions. An LS-DYNA analysis was used to evaluate the buckling capacity near the top of the rack structure. The detailed results of the analysis will be contained in Revision 3 of TR-54, which will be available at the end of November.

As a result of the redesign of the Spent Fuel Racks, the impact load from the racks to the spent fuel pool walls/liner has increased (in the Revision 0 response the load evaluated was 81,580 lbs; the loads have now increased to less than 363,600 lbs). An additional analysis, as documented in Reference 2, was performed and it demonstrated the SFP liner, as currently designed, is able to withstand the additional loads without a significant impact (1.5% increase in required wall thickness). The required wall thickness increases from 0.465" to 0.472" (it was 0.467" in the Revision 0 response), but remains below the actual plate thickness of 0.500 inches. Therefore the impact on the spent fuel pool wall/liner is acceptable.

References:

1. Westinghouse Proprietary Letter OBY/DCP0434, "Impact Evaluation due to Spent Fuel Rack Reaction during a Seismic Event", 5/29/09

2. Westinghouse Proprietary Letter OBY DCP 000469, "Impact Evaluation due to Spent Fuel Rack Reaction during a Seismic Event (Revise of OBY/DCP0434)", 11/2/09

Design Control Document (DCD) Revision: ~~None.~~

The following DCD changes are required as a result of the Spent Fuel Rack design changes.

- The first paragraph under item A in Section 9.1.2.2.1 of Rev. 17 of the DCD should be modified as follows:
  - o 10.9 should be changed to *10.93*
  - o 9.03 should be changed to *9.04*

The spent fuel pool rack layout contains both Region 1 rack modules with a center-to-center spacing of nominally ~~10.9~~ 10.93 inches and Region 2 rack modules with a center-to-center spacing of nominally ~~9.03~~ 9.04 inches. Both of these rack module configurations provide adequate separation between adjacent fuel assemblies with neutron absorbing material to maintain a subcritical array.

- The twelfth paragraph under item A in Section 9.1.2.2.1 of Rev. 17 of the DCD should be modified as follows:
  - o The last sentence that says, "The racks rest on the pool floor and are evaluated to determine that under loading conditions they do not impact each other nor do they impact the pool walls", should be changed to read, "The racks rest on the pool floor and are evaluated to determine that under loading conditions *the rack-to-rack and rack-to-wall impacts are acceptable on both the racks and the pool walls*".

The seismic and stress analyses of the spent fuel racks consider the various conditions of full, partially filled, and empty fuel assembly loadings. The racks are evaluated for the safe shutdown earthquake condition and seismic Category I requirements. A detailed stress analysis is performed to verify the acceptability of the critical load components and paths under normal and faulted conditions. The racks rest on the pool floor and are evaluated to determine that under loading conditions ~~they do not impact each other nor do they impact the pool walls~~ the rack-to-rack and rack-to-wall impacts are acceptable on both the racks and the pool walls.

- Figure 9.1-2 (Sheet 1 of 2) of Rev. 17 of the DCD should be modified as follows:
  - o The 4.4" dimension should be deleted, as it can be calculated from the other 2 dimensions provided, and it is inconsistent with the format of Figure 9.1-3.
  - o 8x10.9CTC=87.2" SQUARE should be changed to *8 x 10.93 CTC = 87.4" SQUARE*
  - o 8' - 0.2" SQUARE should be changed to *8' - 0.8" SQUARE*

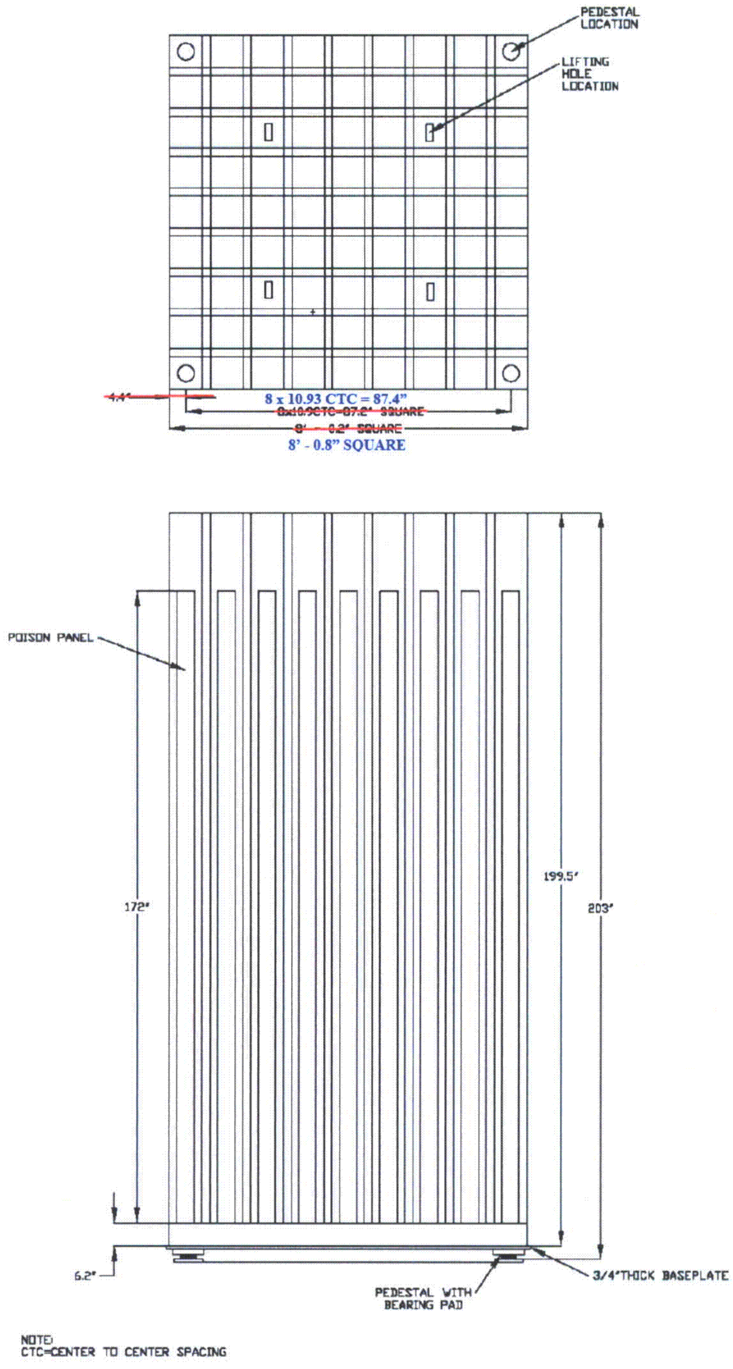

Figure 9.1-2 (Sheet 1 of 2)

Region 1 Spent Fuel Storage Rack Layout

- Figure 9.1-2 (Sheet 2 of 2) of Rev. 17 of the DCD should be modified as follows:
    - 10.9" TYP. should be changed to *10.93" TYP.*

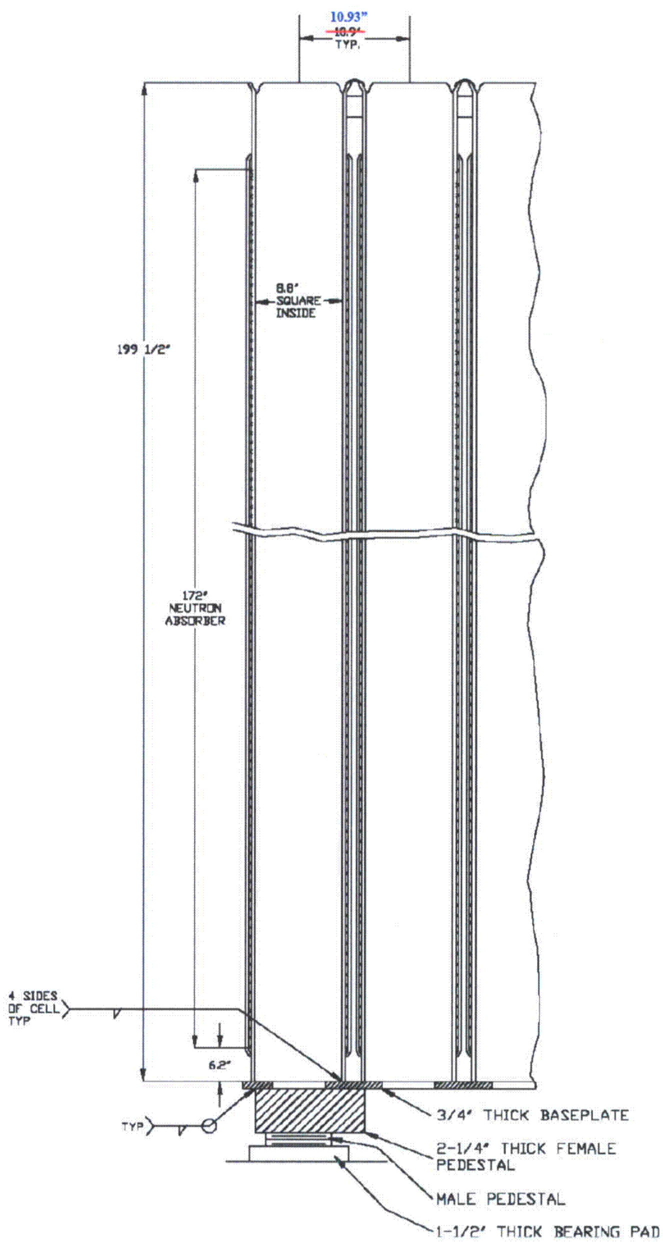

Figure 9.1-2 (Sheet 2 of 2)

Region 1 Spent Fuel Storage Rack Cross Section

• Figure 9.1-3 (Sheet 1 of 2) of Rev. 17 of the DCD should be modified as follows:
  - o 10 x 9.03 CTC=90.3" should be changed to *10 x 9.04 CTC = 90.4"*
  - o 8' - 3.3" should be changed to *8' - 4"*
  - o 11 x 9.03 CTC=99.3" should be changed to *11 x 9.04 CTC = 99.4"*
  - o 9' - 0.3" should be changed to *9' - 1"*

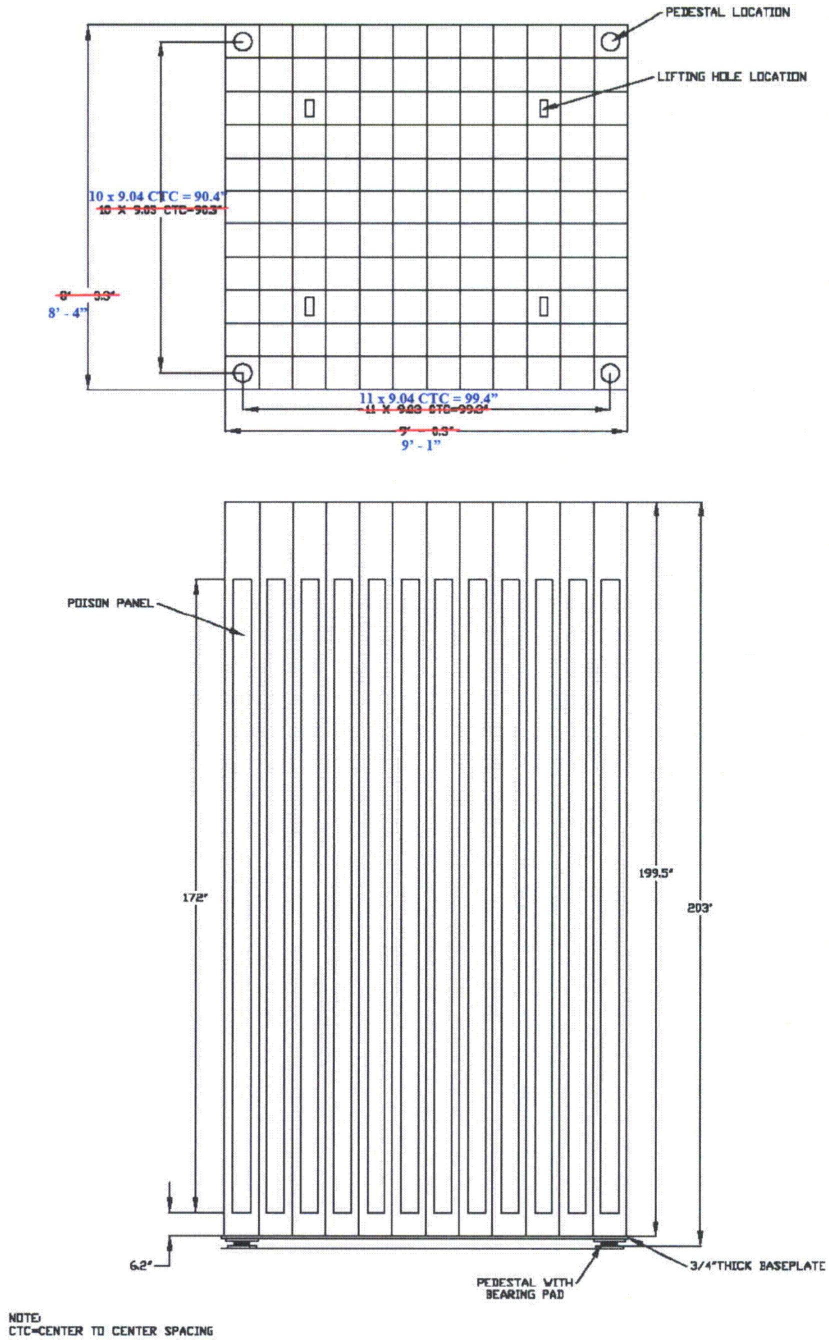

Figure 9.1-3 (Sheet 1 of 2)

Region 2 Spent Fuel Storage Rack Layout

- Figure 9.1-3 (Sheet 2 of 2) of Rev. 17 of the DCD should be modified as follows:
  - 9.03" TYP. should be changed to *9.04" TYP*.

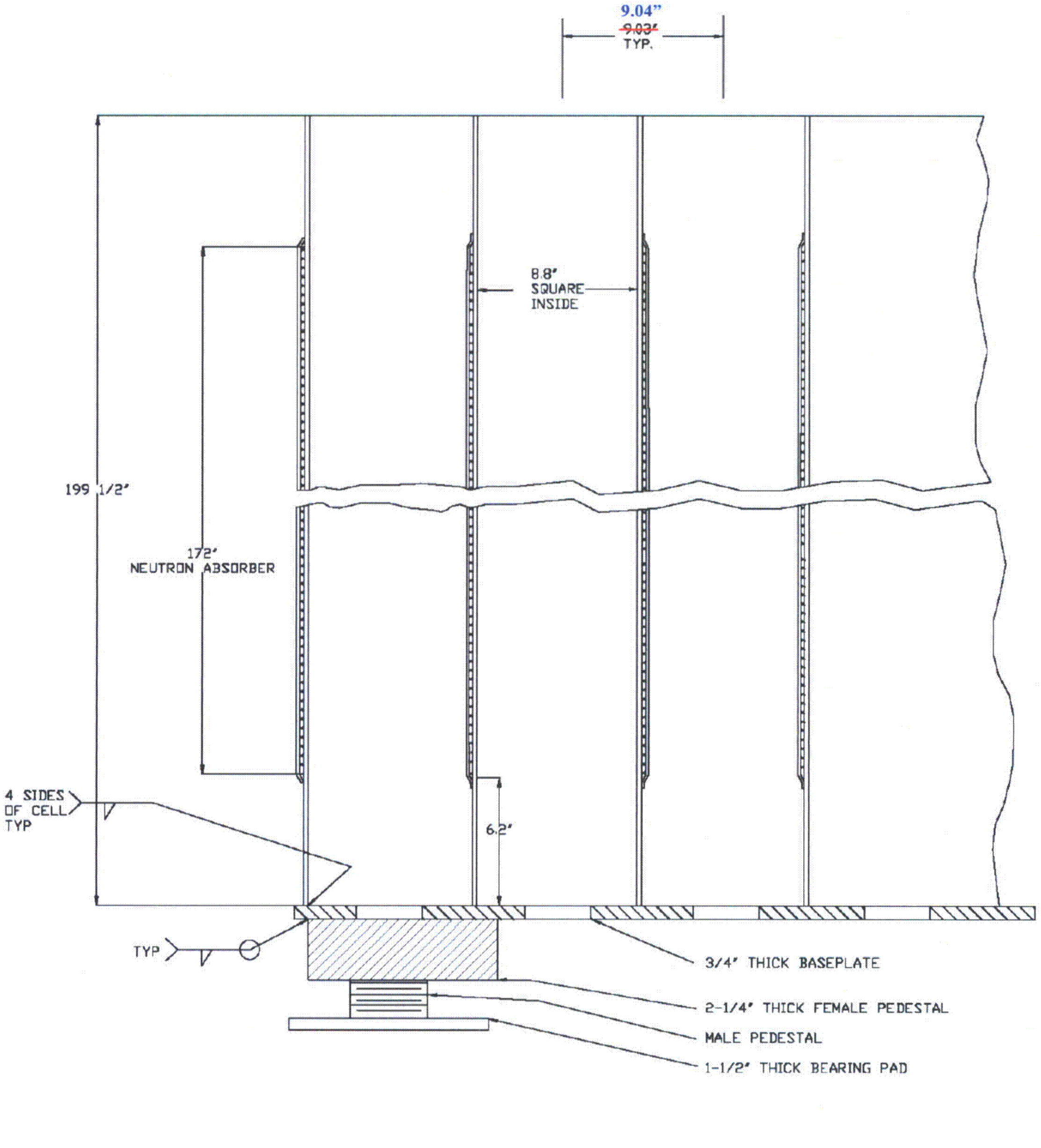

Figure 9.1-3 (Sheet 2 of 2)

Region 2 Spent Fuel Storage Rack Cross Section

- Figure 9.1-4 and Technical Specification Figure 4.3-1 of Rev. 17 of the DCD should both be modified as follows:
  - Details are included in the marked-up figure.
  - (Note that a previous Westinghouse approved design change modified this figure to change the 34" tool storage area and corresponding 3.2" gap to Rack A1 to 33" with a 4.2" gap.) These dimensions are now changed to make the tool storage area width 32" and the gap to Rack A1 distance 4.9".

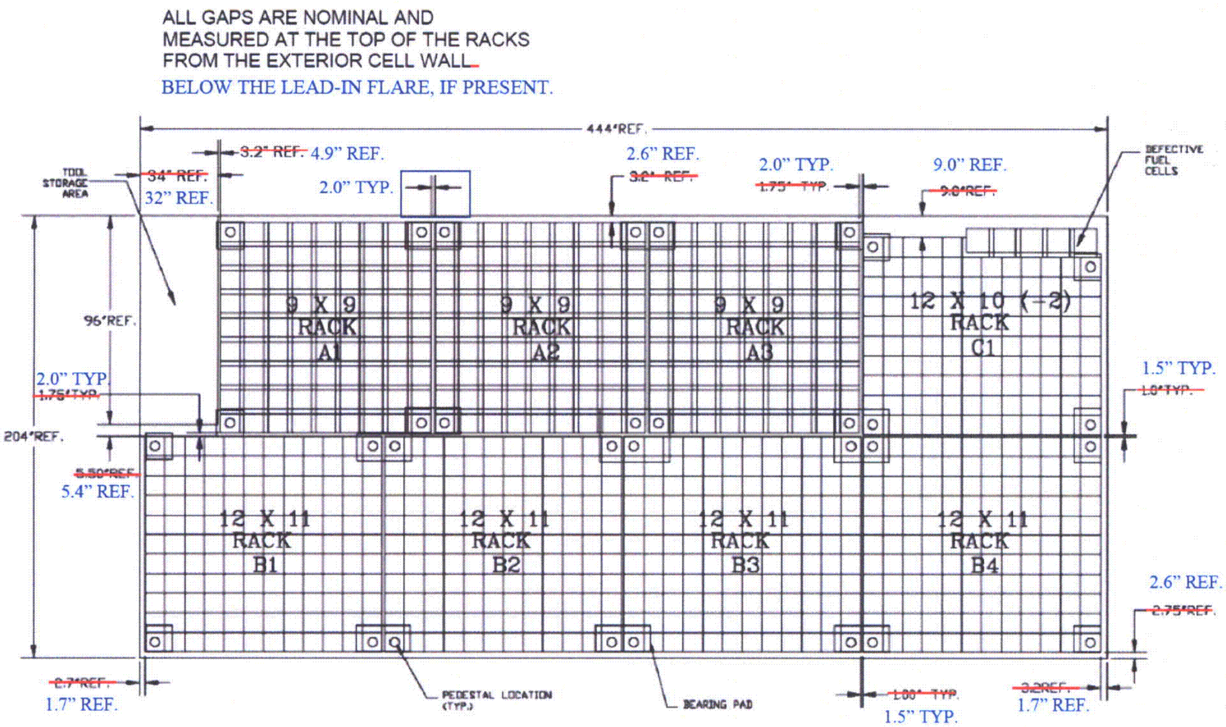

Figure 9.1-4

Spent Fuel Storage Pool Layout (889 Storage Locations)

PRA Revision: None.

Technical Report (TR) Revision: ~~None~~.

The results of the spent fuel rack design change will be included in Revision 3 of TR-54, available at the end of November, 2009.

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-SRP 9.1.2-SEB1-07
Revision: 1

Question:

Section 2.8.4.1 "Cell Wall Buckling Evaluation" was revised in TR 54 Rev. 2. A different buckling equation and different boundary conditions are indicated. The rectangular flat plate model representing the lower cell wall region is now assumed to be clamped on all 4 edges. Even with the assumption of clamped on all 4 edges, a very small safety margin against buckling is indicated in Rev. 2.

Considering that only 1 edge can truly be treated as clamped, and the other 3 edges can rotate somewhat due to the flexibility of the adjacent sections, the staff requests Westinghouse to provide the technical basis for changing the boundary conditions to clamped on all 4 edges. Also, identify the minimum acceptable factor of safety and the technical basis for its selection.

Westinghouse Response: (Revision 0)

1) Provide technical basis for changing the buckling equation and boundary conditions:

The change was made because the buckling equation and boundary conditions used in TR54 Rev. 1 were overly conservative. In the previous equation, the factor β was set equal to 4.0, which applies to simply supported rectangular plates whose length is 3 times greater than its width. Although the cell length is more than 3 times the cell width, the compressive load is not uniform over the entire length of the cell. The maximum compressive stress occurs at the very base of the cell wall where the maximum bending moment occurs. Moreover, approximately 6" above the rack base plate, the cell wall is reinforced by the 0.075" thick boundary sheathing, which is welded in place. For these reasons, the buckling capacity of the perimeter cell wall was recalculated in TR-54 Rev. 2 for the lowermost 6" of the cell wall (below the boundary sheathing).

The boundary conditions for the cell wall section were also changed in TR54 Rev. 2 from simply supported on all 4 sides to clamped on all 4 sides since the adjacent sections restrict the rotation of the cell wall along its boundary edges. The reality is that the boundary conditions for the cell wall lie somewhere between simply supported and clamped.

Considering the average of these boundary conditions results in the following changes to Section 2.8.4.1 of TR-54:

Westinghouse

2.8.4.1 Cell Wall Buckling Evaluation

The allowable local buckling stresses in the fuel rack cell walls (from vertical loading) are obtained by using classical plate buckling analysis on the lower portion of the cell walls. The following formula for the critical stress has been used:

$$\sigma_{cr} = K \cdot \frac{E}{1-\upsilon^2} \cdot \left(\frac{t}{b}\right)^2$$

Where E = 27.6 x 10^6 psi, υ is Poison's ratio = 0.3, t = 0.075", b = 8.8". The *K* factor varies depending on the plate length/width ratio and the boundary support conditions at the sides of the plate. At the base of the rack, the cell wall acts alone in compression for a length of about 6 inches up to the point where the poison sheathing is attached. Above this level, the sheathing provides additional strength against buckling, which is not considered here. Therefore, the length/width ratio for the 8.8" wide cell wall is ~~1.46~~ taken as 0.68. ~~For all slides clamped, the *K* value is given by Table 35 of Reference 25 to be 7.23.~~ Per Table 35 of Reference 25, the value of *K* is taken as 5.81, which is the average value for all sides simply supported and all sides clamped.

For the given data σ_{cr} < ~~13,100~~ 12,800 psi

~~It should be noted that this calculation is based on the applied vertical stress being uniform along the entire length of the cell wall. In the actual fuel rack, the compressive vertical stress comes from consideration of overall bending of the rack structures during a seismic event and as such is negligible at the rack top and maximum at the rack bottom.~~ It is conservative to apply the above equation to the rack cell wall if σ_{cr} is compared with the maximum compressive stress anywhere in the cell wall. This local buckling stress limit is not violated anywhere in the body of the rack modules since the maximum compressive stress in the outermost cell is σ = (1.2)(21,300) * R6 (which is 0.499) = 12,754 psi, which is less than ~~31,100~~ 12,800 psi. Therefore, rack cell wall buckling is not a concern.

2) Identify the minimum acceptable safety factor:

The AP1000 spent fuel racks are analyzed in accordance with the NRC Guidance document entitled "Review and Acceptance of Spent Fuel Storage and Handling Applications" (dated April 14, 1978 with January 18, 1979 amendment thereto). Accordingly, the rack cellular structure is treated as a multi-flange beam, whose area and moment of inertia properties are equal to that of the gross cellular cross section, and it is subject to the requirements of ASME Subsection NF for Class 3 components. Strictly speaking, the above referenced NRC document does not require a local buckling evaluation of a perimeter cell wall near the base of the rack, so there is no specific minimum acceptable safety factor. However, for defense in depth, a local cell wall buckling evaluation has been performed and documented in TR-54 Rev. 2. For this local buckling evaluation, the cell wall is considered as a thin plate structure, rather than a beam type member, and the critical buckling load is calculated based on the buckling solutions for a rectangular plate given in Roark's Formulas for Stress & Strain (6th Edition). The fuel rack design is acceptable if the maximum compressive stress in the cell wall is less than the critical buckling stress (SF > 1.0).

Note: This RAI and response is similar to RAI-SRP9.1.2-SEB1-03, which applies to the new fuel rack.

Westinghouse Additional Response: (Revision 1)

Following the Revision 0 RAI response and subsequent discussions with the NRC, Westinghouse has re-evaluated the buckling capacity of the Spent Fuel Storage Rack cells at the base of the rack using an ANSYS finite element analysis. The results show that the spent fuel rack cells remain in a stable configuration when subjected to 1.5 times the maximum seismic load without any gross yielding of the storage cell; therefore, the ASME Code requirements for Level D conditions in this area are satisfied.

The finalized ANSYS analysis and results will be included in a revision to Technical Report 54, which will be available with all supporting documentation, at the end of November, 2009.

Reference(s):

1) NRC Guidance document "OT Position for Review and Acceptance of Spent Fuel Storage and Handling Applications", dated April 14, 1978 with January 18, 1979 amendment.
2) "Roark's Formulas for Stress and Strain", 6th Edition, Warren C. Young, 1989.

Design Control Document (DCD) Revision:
None.

PRA Revision:
None.

Technical Report (TR) Revision: (Revision 0, 1)

The changes to Section 2.8.4.1 indicated above in response to item 1 should be made to TR-54; however, these changes do not necessitate a subsequent submittal of TR-54 to the NRC for review as the detailed information is provided in this RAI response.

The results of the ANSYS analysis of cell wall buckling at the base of the racks will be included in TR-54 Rev. 3, which will be available at the end of November, 2009.

RAI Response Number: RAI-SRP9.1.5-SBPB-01
Revision: 2

Question: ***(Revision 0)***

In AP1000 DCD Revision 16 it is stated on page 9.1-38 under section 9.1.5.1.2, "Codes and Standards," that the polar crane and cask handling cranes are designed according to NUREG-0554 supplemented by ASME NOG-1 for a Type I single failure proof (SFP) crane. This complies with SRP 9.1.5. Detailed descriptions of the polar crane and cask handling crane are also given in DCD Revision 16 section 9.1.5.

On page 9.1-37 of DCD Revision 16 under section 9.1.5.1.1, "Safety Design Basis," it is stated that the containment equipment hatch hoist and containment maintenance hatch hoist are SFP systems and are classified as seismic Category I. It is also stated that the components of SFP systems necessary to prevent uncontrolled lowering of a critical load are classified as safety-related. On page 9.1-38 of DCD Revision 16 under section 9.1.5.2, "System Description," it is stated that the containment equipment hatch hoist and maintenance hatch hoist incorporate SFP features based on NUREG-0612 guidelines. Additionally, Section 9.1.5.1.2 states that hoists are designed according to ASME NOG-1 and to the applicable ANSI standard. Table 3.2-3 lists the principle design code for MHS-MH-06 and 06 as manufacturers' standard. Unlike the polar crane and cask handling crane, there are no detailed descriptions of the containment equipment hatch hoist and maintenance hatch hoist in DCD Section 9.1.5, nor are the design requirements as explicit as they are for the polar and cask handling cranes. Since the equipment and maintenance hatch hoists are SFP, they should have more specific design criteria similar to what is specified for the polar crane and cask handling cranes.

A) ASME NOG-1 for Type I cranes describes design details for SFP hoists. Explain why the DCD does not require the design requirements that are specified for single failure hoists in ASME NOG 1 for a Type 1 cranes to be implemented for the single failure proof equipment and maintenance hatch hoists.

B) Describe the design of the containment equipment hatch hoist and maintenance hatch hoist and the single failure proof features that make them single failure proof systems. Explain if any and which components of these two single failure proof systems prevent uncontrolled lowering of a critical load and are classified safety-related.

Additional Question (Revision 2)

Use one of several approaches (matrix, TR revision, DCD update) to clarify exactly what parts of which documents (NOG-1, CMAA 70, NUREG 0554) are used to assure that the Equipment Hatch Hoists and Maintenance Hatch Hoists are single failure proof.

Westinghouse Response: (Revision 0)

A) The Design Specification of the Maintenance Hatch Hoist system and Equipment Hatch Hoist system will follow the guidelines of NUREG-0554 supplemented by ASME NOG-1. The AP1000 DCD Revision 16, Table 3.2-3 will be revised to reflect this change.

B) The Maintenance Hatch Hoist system and Equipment Hatch Hoist system will adhere to NUREG-0554 supplemented by ASME NOG-1 by the detailed designs following these standards.

Additional Westinghouse Response based on NRC comments at 3/18/09 meeting: (Revision 1)

Westinghouse noted that the ASME NOG-1, Type I designation is not applicable for Equipment Hatch Hoists and Maintenance Hatch Hoists, as it applies to the design of overhead and gantry cranes (i.e., cranes that run on top of rails) from the rails to the load hook.

Single failure proof hatch hoists are designed, fabricated, examined, and tested in accordance with CMAA 70 and the guidelines of NUREG 0554, supplemented by provisions of ASME NOG-1 as it relates to single failure proof hoists.

Hatch hoist components that are necessary to prevent uncontrolled lowering of a critical load following a single credible failure will be classified as safety related.

References:

i) NUREG-0554, "Single Failure Proof Cranes For Nuclear Power Plants"
ii) ASME NOG-1, "Rules for Construction of Overhead and Gantry Cranes (Top Running Bridge, Multiple Girder)"

Additional Westinghouse Response based on NRC comments at 3/18/09 meeting: (Revision 2)

The Equipment Hatch Hoist and Maintenance Hatch Hoist are designed as single failure proof systems. A detailed description of these hoists is provided in new DCD sections 9.1.5.2.3 and 9.1.5.2.4 below. These provide specific design criteria similar to what is specified for the polar crane and cask handling cranes. Subsection 9.1.5.2.3.2, "Component Descriptions," describes how the code requirements are implemented in the design of key safety related components.

Design Control Document (DCD) Revision: (Revision 0) ***(this is already incorporated into DCD R17)***
See below for Revision 2 changes

Revise DCD Rev.16 Table 3.2-3 as follows:

MHS-MH-05	Equipment Hatch Hoist	C	I	~~Manufacturer Std.~~ NUREG-0554 supplemented by ASME NOG-1	
MHS-MH-06	Maintenance Hatch Hoist	C	I	~~Manufacturer Std.~~ NUREG-0554 supplemented by ASME NOG-1	

Design Control Document (DCD) Revision: (Revision 2)

Update the DCD as indicated below (Sections 9.1.5.2.3 and higher are new)

9.1.5.1.1 Safety Design Basis

Section 3.2 identifies safety and seismic classifications for mechanical handling system equipment. Heavy load handling systems are generally classified as nonsafety-related, nonseismic systems. The components of single-failure-proof systems necessary to prevent uncontrolled lowering of a critical load are classified as safety-related.

The polar crane, cask handling crane, containment equipment hatch hoist, and containment maintenance hatch hoist are single-failure-proof systems and are classified as seismic Category I. They are designed to support a critical load during and after a safe shutdown earthquake. The equipment and maintenance ~~hatches~~ hatch hoist systems are required to be operational after a safe shutdown earthquake.

9.1.5.2 System Description

Table 9.1-5 lists the heavy load handling systems located ~~in the nuclear island~~ in the safety-related areas of the plant, specifically the nuclear island. The polar crane and cask handling crane are designed according to the requirements of NUREG-0554 supplemented by ASME NOG-1 for a Type I, single-failure-proof crane. A description of these cranes is provided in this subsection. The containment equipment hatch hoist and maintenance hatch hoist incorporate single failure proof features based on NUREG 0612 guidelines are designed according to the requirements of NUREG-0554 supplemented by ASME NOG-1 for a Type I, single-failure-proof hoist.

9.1.5.2.3 Equipment Hatch Hoist General Description

The equipment hatch hoist is a hoist that is foot mounted on a platform supported by the containment structure.

The hoist is electrically powered and raises and lowers loads by reeving wire rope through sheaves that are an integral part of the load block. A hook or lifting lug is attached to the load block.

9.1.5.2.3.1 System Operation

The equipment hatch hoist lifts the equipment hatch. The hoist is designed to withstand the containment environmental conditions during all modes of plant operation, including pressurization and depressurization of the containment. The hoist is designed to operate only during shutdown periods.

Movements of the hoist can be controlled from a wall mounted pushbutton control station. The pushbutton control station includes a main power control switch. Motion control push buttons on the control station return to the OFF position when released.

Hoist speed is in accordance with ASME NOG-1.

9.1.5.2.3.2 Component Descriptions

The equipment hatch hoist is designed according to NUREG-0554 supplemented by ASME NOG-1. Table 9.1.5-4 lists the design characteristics of this hoist. This subsection describes how the code requirements are implemented in the design of key safety-related components.

Hoist System

The hoisting rope is wound around the drum in a single layer. If the rope becomes dislodged from its proper groove, the hoist drive is automatically shut down and the holding brakes are set. Features are also provided to contain the drum and prevent disengagement of the gearing in the event of drum shaft or bearing failure. Hoist motor regenerative braking, two holding brakes, and a third brake on the wire rope drum are provided.

Two separate, redundant reeving systems are used, so that a single rope failure will not result in the dropping of the load. Two wire ropes are reeved side-by-side through the sheave blocks. Each rope connects to an equalizer that adjusts for unequal rope length. The equalizer is also a load transfer safety system, eliminating sudden load displacement and shock to the hoist in the unlikely event of a rope break. Overtravel protection is provided (see subsection 9.1.5.2.3.3); however, even in the event of hook overtravel in the raising direction to the point the load block contacts the hoist structure, the ropes cannot be cut or crushed.

The load block provides a load attachment point that has double the normal design factor in lieu of redundancy.

Special Lifting Devices

Special lifting devices shall not be used with the equipment hatch hoist

Lifting Devices Not Specially Designed

Slings or other lifting devices not specially designed are selected in accordance with ANSI B30.9 (Reference 15), except that the load rating is based on the combined maximum static and dynamic loads that could be imparted to the sling.

For the handling of critical loads, dual or redundant slings are used, or a sling having a load rating twice that required for a non-critical load is used and shall be constructed of metallic material (chain or wire rope) per NRC Regulatory Issue Summary 2005-25, Supplement 1 (Reference 23).

Load Lift Points

The design stress safety factors for heavy load lift points, such as lifting lugs, are consistent with the safety factors used for special lifting devices. The design of lift points for critical loads is in accordance with NUREG-0612, Paragraph 5.1.6.(3).

9.1.5.2.3.3 Instrumentation Applications

Limit switches are used to initiate protective responses to:

- Hoist overtravel.
- Hoist overspeed.
- Hoist overload or unbalanced load.
- Improper winding of hoist rope on the drum.

Redundant limit switches are used with the hoist to limit the extent of travel in both the hoisting and lowering directions. The primary protection for the hoist in each direction is a limit switch which interrupts power to the hoist motor via the control circuitry. Interruption of power to the hoist motor causes the hoist brakes to set. The hoist may be operated in the safe direction to back out of the overtravel condition.

The secondary protection for the hoist in the raising direction is a block-actuated limit switch, which is mechanically and electrically independent of the primary limit switch and interrupts power to the hoist motor and causes the brake(s) to set. The secondary protection for the hoist in the lowering direction is a limit switch, which is mechanically and electrically independent of the primary switch, but also interrupts power to the hoist motor via the control circuitry. Actuation of the secondary limit switches prevents further hoisting or lowering until specific corrective action is taken.

A centrifugal-type limit switch, located on the drum shaft, provides overspeed protection for the hoist. Hoist speeds in excess of 125 percent of the rated lowering speed for a critical load causes the hoist motor to stop and the holding brakes to set.

A load-sensing system is used to detect overloading of the hoists. Hoisting motion is stopped when the overload setpoint is exceeded. Similarly, an unbalanced load is detected by a system that stops the hoist motion when there is excessive movement of the equalizer mechanism.

A level wind limit switch is provided to detect improper threading of the hoist rope in the drum grooves. This switch stops crane drive motors and sets the brakes. Further hoisting or lowering is prevented until specific corrective action is taken.

9.1.5.2.4 Maintenance Hatch Hoist General Description

The maintenance hatch hoist system is the same as that of the equipment hatch hoist system.

Add new Table 9.1.5-4 as shown:

Table 9.1.5-4

EQUIPMENT HATCH HOIST COMPONENT DATA

Hoist	
Approximate capacity	See Table 9.1-5.

Hook speed	See Note 1.
Approximate hook travel (elevation)	To hatch (lowered position)
Main hoist braking system (diverse systems)	
Control brakes (type and number)	Hoist motor regenerative braking
Holding brakes (type and number)	Friction (two)
Emergency drum brake (type and number)	Friction (one)

Note:

1. Hoist speed is within the recommended range of ASME NOG-1.

PRA Revision:
None

Technical Report (TR) Revision:
None