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Your ref: Docket No. 52-006
Our ref: DCP_NRC_003023

August 25, 2010

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-SEB1-06 R3

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 Strategy

/Enclosure

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

D063
NRD

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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-SEB1-06
Revision: 3

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.

Additional Question: (Revision 2)

Specific questions are clarified as follows:

1. Indicate how the tri-axial state of stress in the impacted faceplate has been addressed in determining the minimum required plate thickness when considering the impact load in addition to other concurrent loadings.

2. Provide the design basis loads (for the governing load combination that includes seismic loads) for the location evaluated on Wall L2. This will provide a comparison between the "Rack impact load" and the "design basis loads"; and confirm that the impact load is insignificant.

Additional Question: (Revision 3)

Specific questions are re-clarified as follows:

Item 1. Westinghouse will calculate the third principal stress in the surface faceplate and determine the tri-axial state of stress in the surface faceplate. The first two principal stresses will be obtained from the shell stresses of the NI05 model. The third principal stress will be obtained by hand calculation in which the impact force will be spread over a contact surface.

If the calculated stress intensity for the steel plate is close to the allowable stress intensity, the sensitivity of the result to the assumed contact area for the impact load should be addressed. Westinghouse should confirm with Holtec the location of impact and whether there may be multiple impacts at the same instant in time, based on Holtec's nonlinear analysis results. The in-plane principal stresses in the steel plate should be taken from the layered shell re-analysis of wall L-2 for the seismic plus impact load combination discussed in question 2.

Item 2. Westinghouse will determine the element member forces at several critical locations on wall L-2 for both the load combination with seismic only and by adding the rack impact to the seismic load combination. A comparison between the two cases will be provided.

Confirm that the hydrostatic pressure is included in the load combinations; confirm that a layered shell model, with separate layer for the steel plate, will be used at least for the impact area; and address whether the increase in member forces in wall L-2, obtained for the seismic plus impact load combination, still fall within the available design margin.

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.

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.

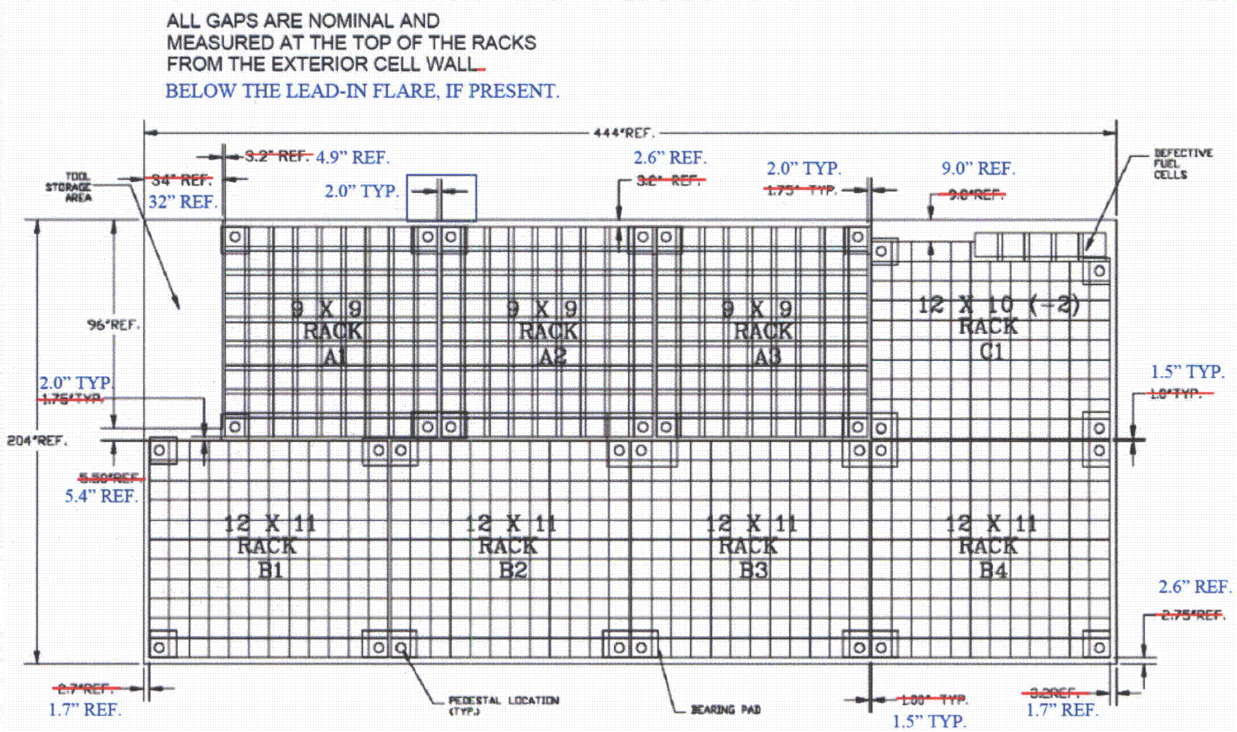

Figure 9.1-4

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:

DCD Changes: (Revision 1)

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:
  - 10.9 should be changed to *10.93*
  - 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~~ <u>10.93</u> inches and Region 2 rack modules with a center-to-center spacing of nominally ~~9.03~~ <u>9.04</u> 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:
  - 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~~ <u>the rack-to-rack and rack-to-wall impacts are acceptable on both the racks and the pool walls</u>.

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

- Figure 9.1-2 (Sheet 1 of 2) of Rev. 17 of the DCD should be modified as follows:
  - 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.
  - 8x10.9CTC=87.2" SQUARE should be changed to *8 x 10.93 CTC = 87.4" SQUARE*
  - 8' - 0.2" SQUARE should be changed to *8' - 0.8" SQUARE*

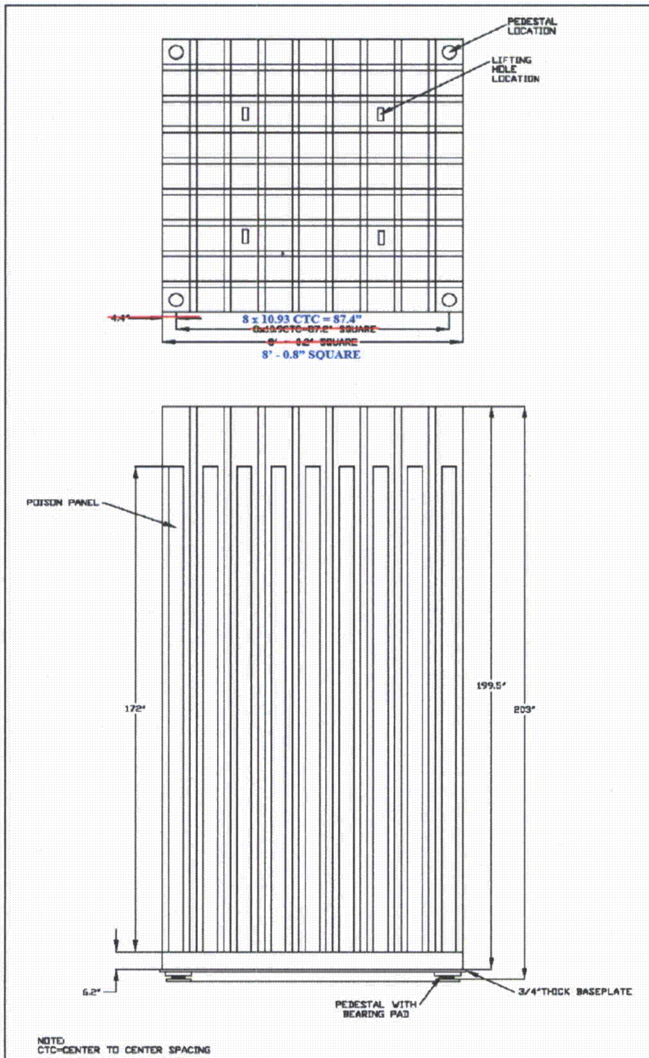

Figure 9.1-2 (Sheet 1 of 2)

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.*

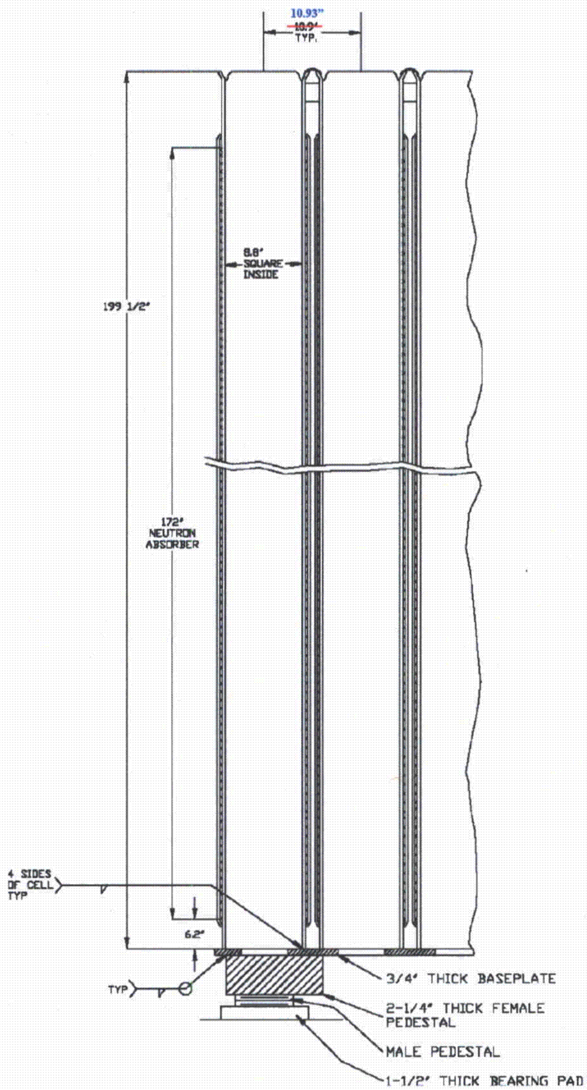

Figure 9.1-2 (Sheet 2 of 2)

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:
  - 10 x 9.03 CTC=90.3" should be changed to *10 x 9.04 CTC = 90.4"*
  - 8' - 3.3" should be changed to *8' - 4"*
  - 11 x 9.03 CTC=99.3" should be changed to *11 x 9.04 CTC = 99.4"*
  - 9' - 0.3" should be changed to *9' - 1"*

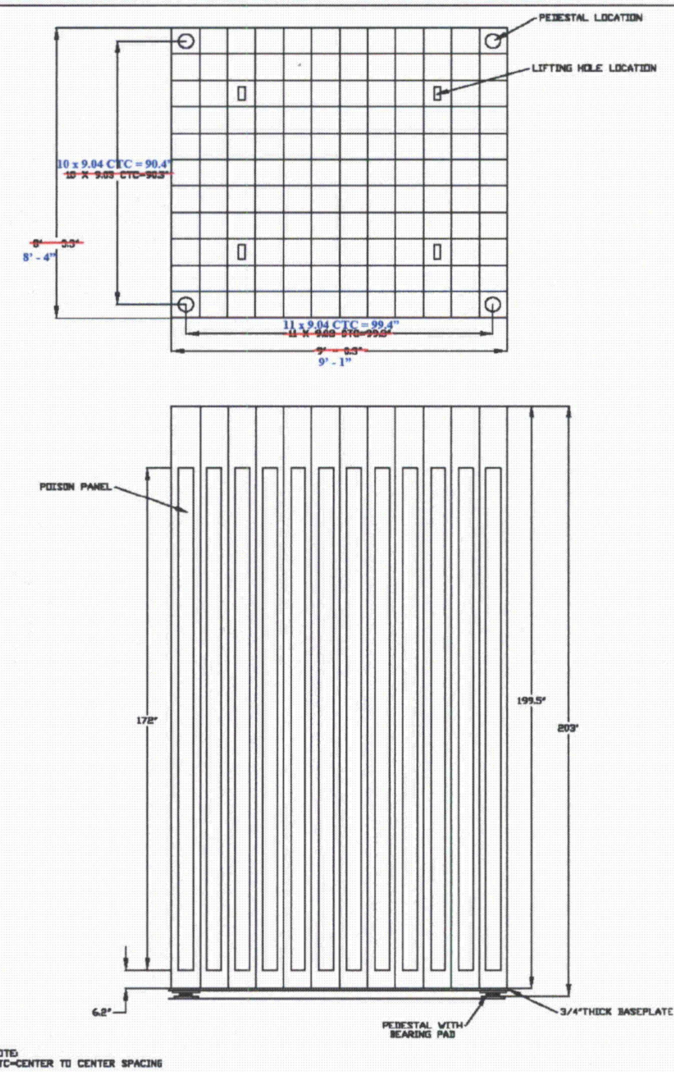

Figure 9.1-3 (Sheet 1 of 2)

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:
  - o 9.03" TYP. should be changed to *9.04" TYP.*

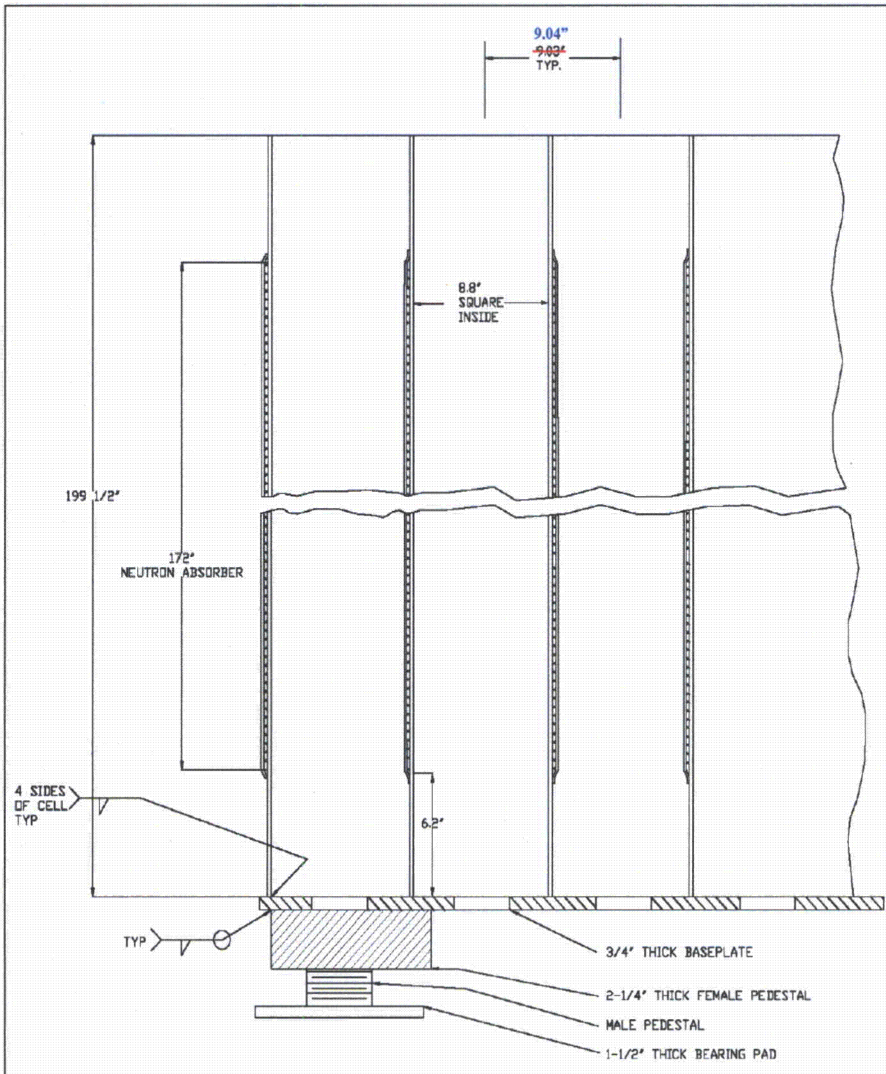

Figure 9.1-3 (Sheet 2 of 2)

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".

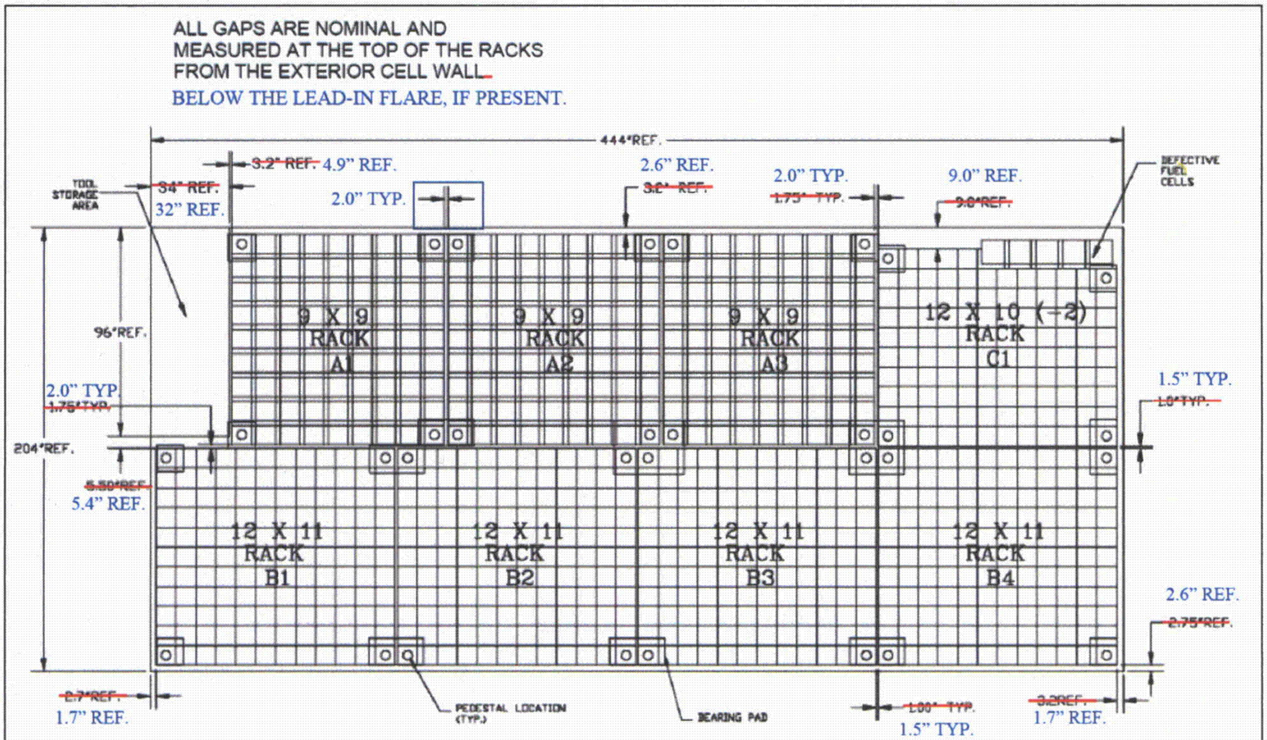

Figure 9.1-4

Spent Fuel Storage Pool Layout (889 Storage Locations)

Additional Response: (Revision 2)

1. The spent fuel pool walls were idealized in the analysis model NI05 as made up of shell elements. Since the principal stress sigma 3 is zero for shell elements, the NI05 analysis results did not include sigma 3 in the analysis results; however, the other two principal stresses were available. This is generally the way civil structures are evaluated.

As provided in the loads information below (question 2 of this response), the rack impact load is quite insignificant compared to the original design basis loads for this Wall L-2. The analysis done for civil structures is adequate.

2. The most significant design basis load is the seismic load.

At the Wall L-2 location, the seismic spectral acceleration in the E-W direction, for 5% damping, is 4.5g. The total weight of this wall is approximately 950 kip. Therefore, the wall may experience a seismic load of approximately 4275 kip.

Two rack impact analyses were performed; for impact loads of 83 kip and 363 kip. These loads are quite insignificant compared to the seismic load. The plate thickness was shown to be adequate to withstand this impact load. The information provided is supported by calculations that are available for review.

Additional Response: (Revision 3)

Item 1. The third principal stress σ_3 in the surface faceplate was calculated and the tri-axial state of stress in the surface faceplate determined. The calculation of the third principal stress was based on a contact surface area of rectangular shape of 96 inch by 1 inch. Where the 96 inch is the width of the rack and the 1 inch is the effective height of contact between the rack and the wall.

The third principal stress σ_3 was calculated using the following formula:

σ_3 = contact force / Area (96 x 1.0), (σ_3 = 3.78 ksi)
where the contact force = 363 kips

The new stress intensity values were calculated using the third principal stress σ_3 and the previously calculated first two principal stressed σ_1 and σ_2 values to assess the impact of σ_3. The effect of σ_3 was evaluated for load combinations 15, 20 and 21. Load combinations 20 and 21 have accidental thermal loading that imposes the highest element design forces. Load combinations 2 and 15 control the plate thickness design for non-thermal loading. The calculation results are provided in Table RAI-SRP9.1.2-SEB1-06-01 for the effect of the tri-axial state of stress in the faceplate of wall L-2 for load combinations 20 and 21. These results demonstrate that the third principal stress σ_3 has a negligible effect on the state of stress.

The calculation results are provided in Table RAI-SRP9.1.2-SEB1-06-02 for the effect of the tri-axial state of stress in the faceplate of wall L-2 for element 10529 with load combination 15 and for elements 20450 and 20451 with load combination 2. The table compares the tri-axial stress state with and without rack impact loading. Tables RAI-SRP9.1.2-SEB1-06-01 and RAI-SRP9.1.2-SEB1-06-02 show that the effect of tri-axial state of stress is dependent on the stress level of the faceplate.

Westinghouse evaluated the location of impact and whether there may be multiple impacts based on the information from Holtec. It was determined that a force greater than the maximum value provided by Holtec was used in the evaluation that showed the design to be adequate. In addition, the calculated stress intensity for the steel plate is not close to the allowable stress intensity and therefore, the sensitivity of the result was not addressed.

It is noted that in Table RAI-SRP9.1.2-SEB1-06-01, that S_b is the total equivalent concrete section modulus of cracked section of the tension side in in^3 and S_t is the total equivalent concrete section modulus of cracked section of the compression side in in^3. In addition, it is noted that LC20 and LC21 do not include SSE because a thermal accident causes secondary stress and secondary stress calculations are not required for a load combination that includes SSE. Also, LC20 and LC21 do not include rack impact forces as Table RAI-SRP9.1.2-SEB1-06-03 shows the effect of impact on element forces is not significant and Table RAI-SRP9.1.2-SEB1-06-01 shows that the stress ratio has a significant factor of safety.

Item 2. The element member forces at several critical locations on wall L-2 for load combinations 2 and 15 were evaluated with and without rack impact loading. Table RAI-SRP9.1.2-SEB1-06-03 provides results of the effect of rack loads on element forces for an impact lead of 363 kips. Elements 20450 and 20451 are in the vicinity of the applied rack loads as shown in Figure RAI-SRP9.1.2-SEB1-06-1. Element 10529 is further away from rack load locations as shown in Figure RAI-SRP9.1.2-SEB1-06-2. The plate thickness is adequate to withstand this impact load. It is noted that the hydrostatic pressure is included in the load combinations.

It is shown in Table RAI-SRP9.1.2-SEB1-06-01 and Table RAI-SRP9.1.2-SEB1-06-02 that the impact of σ_3 on the tri-axial state of stress will not cause a significant stress increase in the elements. Most elements have a large factor of safety for stress ratio (MAX/2Fy). Also, Table RAI-SRP9.1.2-SEB1-06-03 shows that the impact load does not cause over stressing, even in the elements adjacent to loading line. Therefore, with the impact loading, these plate wall elements fall within the available design margin. The pool walls are constructed using structural modules (steel faceplates and concrete). The design of these modules considers the calculated member forces through the entire module section. The calculation results show that these member forces with impact forces fall within the available design margin.

PRA Revision: None.

Technical Report (TR) Revision:

TR Changes: (Revision 1)

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.

TR Changes: (Revision 2 and 3)

The results of the spent fuel rack design changes and impacts have been included in ~~APP-GW-GLR-026, Revision 3, November 2009 (TR44).~~APP-GW-GLR-033, Revision 4, November 2009 (TR54).

Section				Elem. LC	Design Force		Steel Plate					
Wall	h t In	A_e I_{cr} in²/ft 10⁴in⁴/ft	S_t S_b in³/ft		TX TY TXY Kips /ft	MX MY MXY Kips ft/ft	σ_x σ_y τ_{xy} ksi	σ_1 σ_2 σ_3 ksi	Stress intensity $\lvert(\sigma_1-\sigma_2)_{max}\rvert$ $\lvert(\sigma_2-\sigma_3)_{max}\rvert$ $\lvert(\sigma_3-\sigma_1)_{max}\rvert$ ksi	MAX ksi	$2F_y$ ksi	MAX/$2F_y$
L2	48' 0.5"	660.5 73881	5473 2141	10524 21	-741.7 -755.2 398.9	19.9 125 -70.3	-8.14 -3.56 36.2	30.42 -42.12 3.78	72.54 45.90 26.64	72.54	130	0.558
				10544 21	-267 -805.6 -503.5	51.4 -38.6 -8	-0.94 -8.07 42.3	37.94 -46.95 3.78	84.89 50.73 34.16	84.89	130	0.653
				20477 20	-574.5 -288.1 -121.5	-977.5 -297 -195.8	37.07 9.88 18.37	46.33 0.62 -3.78	45.71 4.40 50.11	50.11	130	0.385
				20473 20	-415.6 -320.1 -58.6	-621.6 -292.2 -150.5	22.96 9.27 11.22	29.26 2.97 -3.78	26.29 6.75 33.04	33.04	130	0.253

Table RAI-SRP9.1.2-SEB1-06-01:
Results for Tri-axial State of Stress in the Surface Faceplate for LC20 and LC21

Elem. LC	Design Force		Steel Plate					
	TX TY TXY kips /ft	MX MY MXY kips ft/ft	σ_x σ_y τ_{xy} ksi	σ_1 σ_2 σ_3 ksi	Stress intensity $\lvert(\sigma_1-\sigma_2)_{max}\rvert$ $\lvert(\sigma_2-\sigma_3)_{max}\rvert$ $\lvert(\sigma_3-\sigma_1)_{max}\rvert$ ksi	MAX ksi	F_y ksi	MAX/F_y
10529 15 No Rack	102.6 240.8 -105.7	-8.4 -198.7 -40.3	8.93 29.02 10.51	33.51 4.44 0.0	29.07 4.44 33.51	33.51	65	0.515
10529 15 W/Rack	101.1 237.4 -107	6.2 -234 -38	8.75 30.33 10.52	34.61 4.47 -3.78	30.14 8.25 38.39	38.39	65	0.590
20450 2 No Rack	39.4 14 19.2	49.4 30.8 75.1	5.51 2.56 4.76	9.02 -0.95 0.0	9.97 0.95 9.02	9.97	65	0.153
20450 2 W/Rack	40.3 12.6 19.2	72.9 32.7 105.7	6.64 2.52 6.05	10.98 -1.81 -3.78	12.79 1.97 14.76	14.76	65	0.227
20451 2 No Rack	28.3 15.6 15	2.8 83.4 68.6	2.48 5.06 4.14	8.11 -0.56 0.0	8.67 0.56 8.11	8.67	65	0.133
20451 2 W/Rack	27.1 13.8 13.6	8.3 118.3 101.3	2.63 6.48 5.4	10.29 -1.17 -3.78	11.46 2.61 14.07	14.07	65	0.216

Table RAI-SRP9.1.2-SEB1-06-02: Results for Tri-axial State of Stress in the Surface Faceplate with and without Rack Impact Loading for LC2 and LC15

	No Rack	Rack	No Rack	Rack	No Rack	Rack
Elem #	20450 LC 2		20451 LC 2		10529 LC 15	
TX	39.4	40.3	28.3	27.1	102.6	101.1
TY	14.0	12.6	15.6	13.8	240.8	237.4
TXY	19.2	19.2	15.0	13.6	-105.7	-107.0
MX	49.4	72.9	2.8	8.3	-8.4	6.2
MY	30.8	32.7	83.4	118.3	-198.7	-234.0
MXY	75.1	105.7	68.6	101.3	-40.3	-38.0
NX	-6.3	-11.4	0.0	0.2	1.3	9.8
NY	5.0	2.6	-6.7	-17.1	-7.2	5.4

Table RAI-SRP9.1.2-SEB1-06-03: Examples of the Effect of Rack Loads on Element Forces for LC2 and LC15

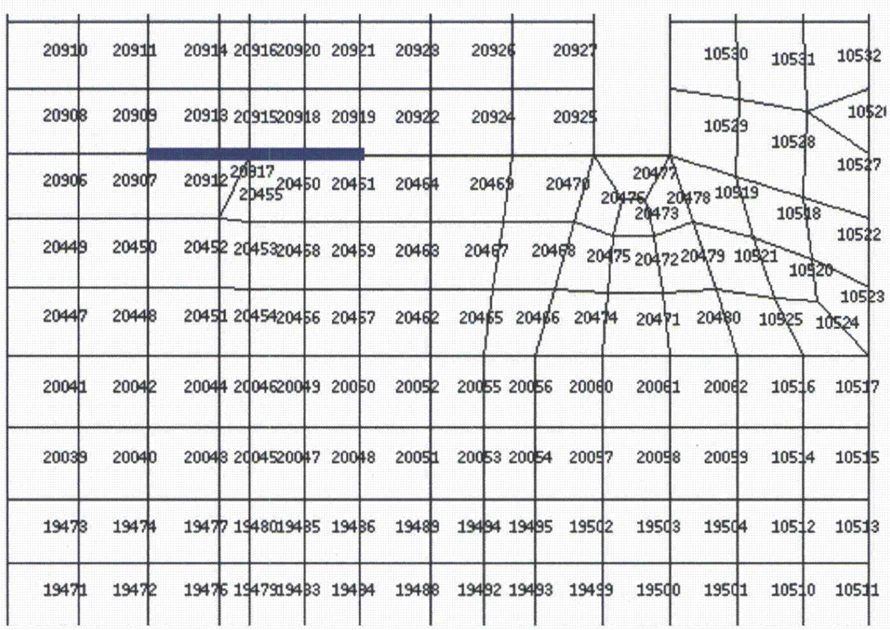

Figure RAI-SRP9.1.2-SEB1-06-01: Node/Element Number and Applied Load

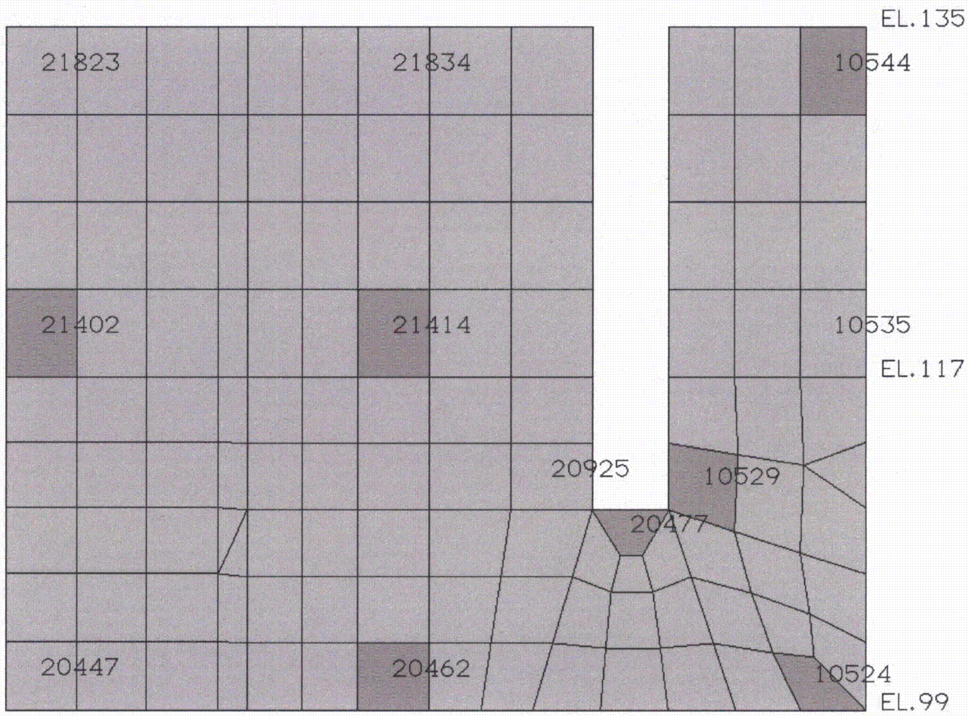

Figure RAI-SRP9.1.2-SEB1-06-02: Node/Element Number