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Your ref: Docket No. 52-006
Our ref: DCP/NRC2203

July 15, 2008

Subject: AP1000 Response to Requests for Additional Information (TR 44)

Westinghouse is submitting a revised response to the NRC requests for additional information (RAIs) on AP1000 Standard Combined License Technical Report (TR) 44, APP-GW-GLR-026, "New Fuel Storage Rack Structural/Seismic Analysis." This RAI response is submitted in support of the AP1000 Design Certification Amendment Application (Docket No. 52-006). The information included in the response is generic and is expected to apply to all COL applications referencing the AP1000 Design Certification and the AP1000 Design Certification Amendment Application.

A revised response is provided for RAI-TR44-002,-003,-005 through -012,-014 through -017,-019,-020,-021,-024,-025 and -026. This response completes all requests received to date for Technical Report 44. A revision 0 response for RAI-TR44-005,-009,-012,-017,-019 and -024 was provided under letter DCP/NRC1953 dated July 5, 2007. A revision 0 response for RAI-TR44-007,-008,-015,-016,-020,-021 and -026 was provided under letter DCP/NRC1924 dated June 7, 2007. A revision 0 response for RAI-TR44-011 was provided under letter DCP/NRC1875 dated May 3, 2007. A revision 0 response for RAI-TR44-002,-003,-006,-010,-014 and -025 was provided under letter DCP/NRC1866 dated April 13, 2007.

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,

John DeBlasio

for/

Robert Sisk, Manager
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00442psa.doc

D063
NRO

/Enclosure

1. Response to Requests for Additional Information on Technical Report 44

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ENCLOSURE 1

Response to Requests for Additional Information on Technical Report 44

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-TR44-002
Revision: 1

Question:

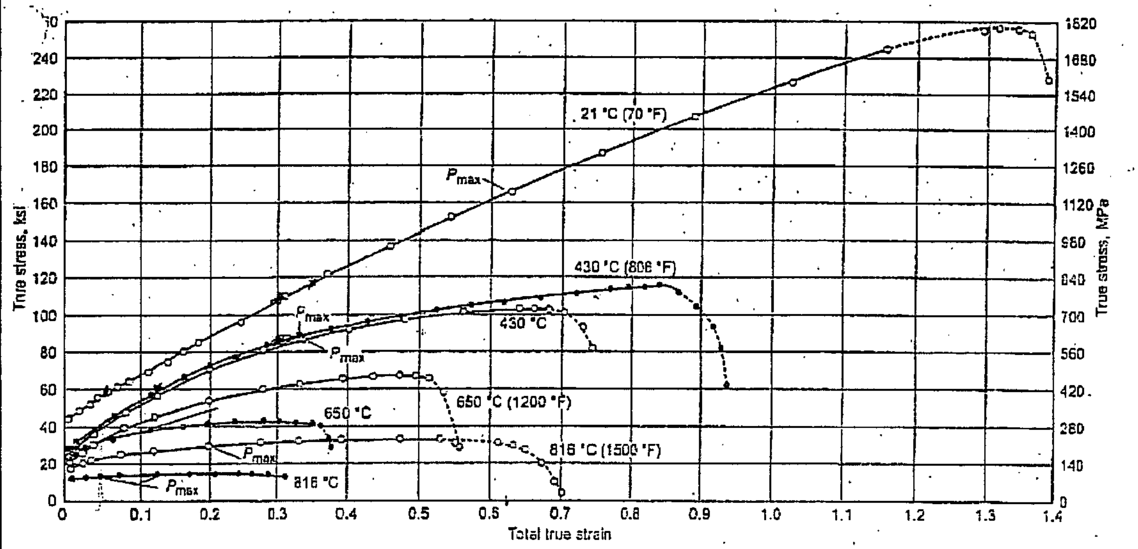
Section 2.8.5 states that appropriate non-linear material properties have been applied to the rack components to permit yielding and permanent deformation. Table 2-6 only provides Young's modulus, yield strength, and ultimate strength, which are not sufficient to define an engineering stress-strain curve. In addition, LYDYNA requires true stress-strain relation for its nonlinear materials. Therefore, provide the following: (1) a complete description of the material stress-strain curve and confirm that a true stress-strain curve was used in these impact analyses and (2) a description of the fuel assembly model, including the element properties and material properties for the dropped fuel assembly.

<u>**Staff Assessment**: Response same as for spent fuel racks. See RAI-TR54-05.</u>

<u>As a result of the October 8-12, 2007 audit, **confirmatory** pending submittal of supplemental response and the application of the same resolution as noted in TR54-05, to the new fuel rack.</u>

Westinghouse Response:

1) The new fuel racks are fabricated from SA240-304 and SA564-630 stainless steel. For the impact analyses, a true-stress strain curve, which is obtained from <u>Atlas of Stress Strain Curves</u> (2nd Edition, ASM International) and reproduced below as Figure TR44-2.1, is used to define the strength properties of SA240-304 stainless steel.



S5.044 304 annealed stainless steel bar, true stress-strain curves at room and elevated temperatures

Figure 44-2.1 Stress Strain Curve for SA240-304 Stainless Steel

The properties of SA564-630, which is used to fabricate the adjustable support pedestals, are input in terms of engineering stress/strain based on material data taken from the ASME Boiler and Pressure Vessel Code. Also, the welds that connect the rack components are modeled as a bi-linear elasto-plastic material having the engineering stress/strain properties of the adjoining base metal (i.e., SA240-304). The material property values, which are used to define the engineering stress-strain curves for SA564-630 stainless steel and the structural welds, are summarized in the table below.

Material Properties	Material Types	
	SA240-304 (Welds)	SA564-630
Young's Modulus ($10^6 \times$ psi)	27.87	28.77
Yield Stress (ksi)	26.7	109.2
Ultimate Stress (ksi)	73.0	140.0
Failure Strain (in/in)	0.4	0.14

2) The fuel assembly is modeled by a rigid bottom end fitting and a mass at the top (representing the weight of lifting tool) connected by an elastic beam (with a Young's modulus of 1.04×10^7

psi and a Poisson's ratio of 0.3 for typical rod material) that has an equivalent mass and total cross-sectional area of all fuel rods in an AP1000 fuel assembly. In addition, a very thin rigid shell is attached to the bottom end fitting to represent the side surfaces of the fuel assembly that might be in contact with rack cell walls in a shallow drop event. To maximize the damage in the rack, the fuel assembly is only allowed to move in the vertical direction.

Westinghouse Supplemental Response following May 21 and 22, 2008 Technical Review:

(1) The similar spent fuel rack RAI-TR54-05 was resolved during the October 8-12, 2007 audit. During the audit Westinghouse demonstrated that the true stress-strain curve for the SS material at the appropriate temperature is derived by manual interpolation of the true stress-strain curves, which are provided in Atlas of Stress Strain Curves (2nd Edition, ASM International) for Type 304 stainless. The properties were linearly interpolated to obtain the values at 150°F. Using data from the ASME Code Section II, Part D, Westinghouse demonstrated that the temperature versus yield stress and ultimate stress for stainless steel materials are not linear resulting is a slight overestimation of these values in the LS-DYNA drop analyses. Using the nonlinear curves based on the ASME Code, the overestimation was less than 4% for the ultimate strength and less than 10% for the yield. Therefore, the results would not vary significantly. The staff reviewed the two curves and agreed with Westinghouse's assessment. Westinghouse appliedd this same approach for the new fuel racks; therefore, Westinghouse considers this item to be resolved for the new fuel racks as well.

(2) For spent fuel rack RAI-TR54-05, Section 2.8.5 of TR54, Rev. 1 was revised to include a more complete description of the fuel assembly model. The staff reviewed Rev. 1 of TR-54 (Section 2.8.5) and found that the stiffness and mass representation is acceptable, and this item was resolved in the May 21 and 22, 2008 technical review. For the new fuel racks, Section 2.8.5 of TR44 was revised to include the equivalent information; see the Technical Report Revision section.

References:

1. APP-GW-GLR-026, Revision 0, "New Fuel Storage Rack Structural/Seismic Analysis," (Technical Report Number 44)
2. APP-FS02-Z0C-001, Revision 0, "Analysis of AP1000 Fuel Storage Racks Subjected to Fuel Drop Accidents"

Design Control Document (DCD) Revision:
None

PRA Revision:
None

Technical Report (TR) Revision:
Yes - Section 2.8.5 of TR44 was revised as follows:

Both analyses are performed using the dynamic simulation code LS-DYNA (Reference 22). A finite element model of one-quarter of the AP1000 New Fuel Storage Rack plus a single fuel assembly is modeled using appropriate shell and solid body elements available in LS-DYNA. The fuel assembly model, which is shown in Figure 2-8, consists of four parts: a rigid bottom end fitting, an elastic beam representing the fuel rods, a lumped mass at the top end of the beam representing the handling tool, and a thin rigid shell that defines the enveloping size and shape of the fuel assembly. The mass and cross-sectional area properties of the elastic beam are based on the entire array of fuel rods (cladding material only). The fuel mass is lumped with the bottom end fitting. Appropriate non-linear material properties have been assigned to the rack components to permit yielding and permanent deformation to occur. Figure 2-9 shows the details of the finite element model in the area where the impacts occur.

Figure 2-8 was added to TR44:

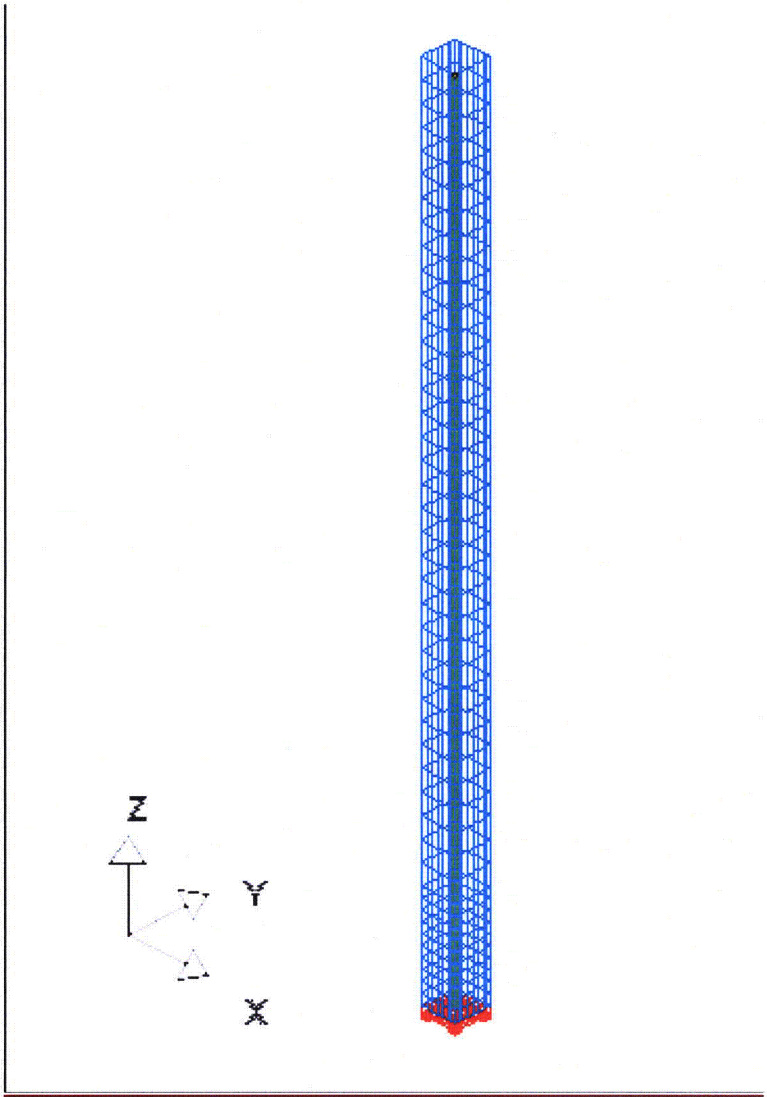


Figure 2-8 LS-DYNA Model of Dropped Fuel Assembly

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-TR44-003
Revision: 1

Question:

The baseplate in Figure 2-8 appears to have only one layer of 8 node brick element through its thickness. It is not clear if a solid or a thick shell element is used. Clarify the type of element used for the baseplate.

Staff Assessment: Response same as for spent fuel racks. See RAI-TR54-06.

As a result of the October 8-12, 2007 audit, **confirmatory** pending submittal of supplemental response and the application of the same resolution as noted in TR54-06, to the new fuel rack.

Westinghouse Response:

The baseplate is modeled using 8-noded solid elements arranged in a single layer.

Westinghouse Supplemental Response following May 21 and 22, 2008 Technical Review:

The similar spent fuel rack RAI-TR54-06 was resolved during the May 21 and 22, 2008 technical review. During the technical review, Westinghouse demonstrated that the rack baseplate model was revised to utilize thick shell elements in Revision 1 of APP-FS02-Z0C-001, "Analysis of AP1000 Fuel Storage Racks Subjected to Fuel Drop Accidents". Westinghouse also demonstrated that the model to use strain rate effects for the material properties was revised. The net effect of both improvements resulted in lower deformations. The staff found that the use of the thick shell element representation of the baseplate rather than one row of solid brick elements is acceptable and the use of strain rate effects is appropriate because it more closely simulates the true material behavior under dynamic impact loadings.

Westinghouse applied this same approach for the new fuel racks. Because the NRC staff has already reviewed and accepted Revision 1 of APP-FS02-Z0C-001, which also applies to the new fuel rack, Westinghouse considers this item to be resolved for the new fuel rack as well.

References:

1. APP-GW-GLR-026, Revision 0, "New Fuel Storage Rack Structural/Seismic Analysis," (Technical Report Number 44)
2. APP-FS02-Z0C-001, Revision 1, "Analysis of AP1000 Fuel Storage Racks Subjected to Fuel Drop Accidents"

Design Control Document (DCD) Revision:
None

PRA Revision:
None

Technical Report (TR) Revision:
None

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-TR44-005
Revision: 1

Question:

Section 2.8.5 does not indicate whether other fuel assemblies are in place, when a fuel assembly drops through an empty cell and impacts the baseplate at its center. Depending on how the baseplate is designed, a full load of fuel assemblies may introduce progressive deformation after a fuel assembly impacts at the center of the baseplate. The maximum downward deformation of the baseplate is about 3.8 inches, as shown in Figure 2-10. This may be significant enough to initiate a progressive deformation. Therefore, provide: (1) the assumption on the existing fuel assemblies when the impact occurs, (2) the design basis for the baseplate, and (3) a figure similar to Figure 2-10, that shows the cells together with the severely deformed baseplate.

Staff Assessment: Response similar to response for spent fuel racks. See RAI-TR54-09.

As a result of the October 8-12, 2007 audit, **confirmatory** pending submittal of supplemental response and the application of the same resolution as noted in TR54-09, to the new fuel rack.

Westinghouse Response:

1) The new fuel storage rack is assumed to be empty (i.e., no fuel assemblies in place) when a fuel assembly drops through an empty cell and impacts the baseplate at its center. This is a simplifying assumption, which is reasonable considering the degree of conservatism associated with the postulated 36" drop height. Note that the response to RAI TR44-001 indicates that it is unlikely that the drop height will ever be 36 inches, as the top of the rack is less than 6 inches below the floor elevation. Based on a realistic carry height above the floor of 12 inches, the drop height above the new fuel storage rack is not likely to exceed 18 inches.

2) The design basis for the baseplate is to provide vertical support for the stored fuel assemblies and to protect the New Fuel Storage Pit from a fuel assembly strike. In other words, a dropped fuel assembly should not pierce the baseplate and result in a direct impact with the reinforced concrete floor of the New Fuel Storage Pit.

(3) Figure TR44-005.1 below shows the cells together with the severely deformed baseplate for the same LS-DYNA solution as shown in Figure 2-10. Note that the deformation of the cells is not significant compared to the baseplate. This is because the cell-to-baseplate weld connections break as a result of the postulated fuel impact load before the cell walls are permanently deformed.

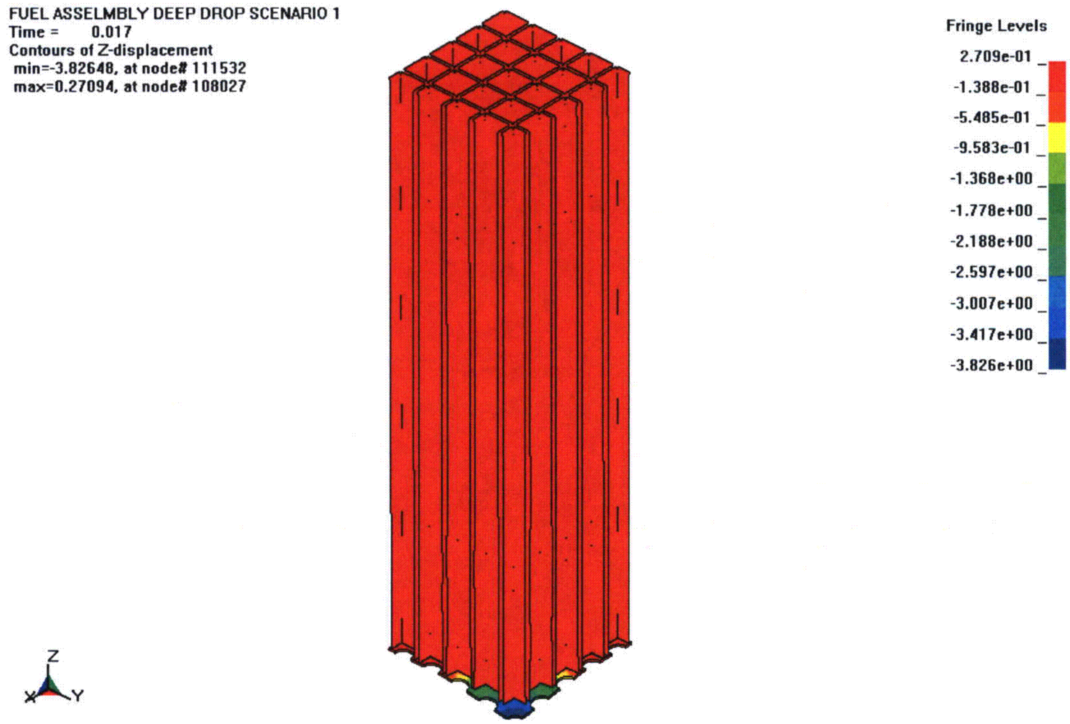


Figure TR44-05.1 Fuel Assembly Deep Drop Scenario 1 for New Fuel Rack

Westinghouse Supplemental Response following May 21 and 22, 2008 Technical Review:

Item 1: During the May 21 and 22, 2008 technical review of spent fuel rack RAI-TR54-09, Westinghouse demonstrated to the NRC staff that the model was revised to consider the effects of all of the stored fuel assemblies in the rack by modifying the density of the rack baseplate in Revision 1 of APP-FS02-Z0C-001, "Analysis of AP1000 Fuel Storage Racks Subjected to Fuel Drop Accidents". This revision to the model was made along with the use of thick shell elements for the baseplate and the inclusion of strain rate effects. The staff reviewed the calculation and confirmed that the approach utilizes the mass effect of all of the fuel assemblies by increasing the baseplate density. The staff concluded that the consideration of the rest of the fuel assemblies (excluding the single dropped fuel assembly) by increasing the mass of the baseplate is an acceptable approach to simulate the dynamic effects of the other fuel assemblies. Following the May 21 and 22, 2008 technical review this item was considered resolved. Westinghouse applied the same approach for the new fuel racks. Because the NRC staff has already reviewed and accepted Revision 1 of APP-FS02-Z0C-001, which also applies to the new fuel rack, Westinghouse considers this item to be resolved for the new fuel rack as well.

Item 2: The equivalent item for spent fuel rack RAI-TR54-09 was resolved as originally submitted. Therefore, no supplemental response is required.

Item 3: The equivalent item for spent fuel rack RAI-TR54-09 was resolved as originally submitted (in Revision 1 of RAI-TR54-09). Therefore, no supplemental response is required. Note: The concern of the large vertical deformation is being addressed under RAI TR44-06.

References:

1. APP-GW-GLR-026, Revision 0, "New Fuel Storage Rack Structural/Seismic Analysis," (Technical Report Number 44)
2. APP-FS02-Z0C-001, Revision 1, "Analysis of AP1000 Fuel Storage Racks Subjected to Fuel Drop Accidents"

Design Control Document (DCD) Revision:
None

PRA Revision:
None

Technical Report (TR) Revision:
None

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-TR44-006
Revision: 1

Question:

A vertical movement of 2 inches of a fuel assembly is defined as the criticality limit in Section 2.8.5, and the impact analysis shows that quite a number of fuel assemblies will have more than 2 inches displacement. It appears that a rack design with only a 2 inches space between the bottom of the baseplate and the top of the floor would eliminate this risk. Please explain why the design has a space larger than 2 inches.

Staff Assessment: Response similar to response for spent fuel racks. See RAI-TR54-10.

As a result of the October 8-12, 2007 audit, **confirmatory** pending submittal of supplemental response and the application of the same resolution as noted in TR54-10, to the new fuel rack.

Westinghouse Response:

Each storage cell is 193.5 inches in length and rests on top of a base plate whose top is 5 inches above the concrete floor. Note that each Metamic poison panel is 172 inches long and has a bottom elevation that is 6.23 inches above the top of the base plate. The active fuel region of each fuel assembly begins at an elevation 8.23 inches above the base plate. Therefore, the bottom elevation of the Metamic poison panel is positioned to be two inches lower than the bottom elevation of the active fuel.

Therefore, the results of the criticality analyses are bounding even if the fuel assembly is vertically displaced downward by up to two inches as a result of the hypothetical fuel assembly drop. The two inch vertical displacement of the fuel assemblies, mentioned in Technical Report 44 is not a criticality limit.

The criticality analyses summarized in COL Technical Report APP-GW-GLR-030 Rev.0 "New Fuel Storage Rack Criticality Analysis" addressed the hypothetical fuel assembly drop in subsection 2.4.2 as follows:

"The resulting deformation on the base plate following a drop of fuel assembly straight through an empty cell impacting the rack baseplate is discussed in subsection 2.8.5 of Reference 4. To conservatively bound the deformation results for the base plate, the bottom elevations of 25 fuel assemblies were lowered by 5 inches. (Note that the base plate is 3/4 inches thick and is normally 4.25 inches above the floor.) This is a five-by-five array of fuel assemblies centered on the empty cell impacted by the dropped fuel assembly (refer to Figure 2-10 of Reference 4). Even with the bottom elevation of the active fuel in 25 fuel assemblies lowered by 5 inches, the criticality design limits given in Section 2.1 are still met."

Since the criticality analysis demonstrates that the stored fuel assemblies remain subcritical following a hypothetical fuel assembly drop, the space between the bottom of the baseplate and the new fuel storage vault floor is not designed to control criticality, but to prevent the new fuel vault floor from an impact strike. In other words, the rack baseplate is raised high enough above the new fuel storage vault floor (4.25") to prevent the baseplate from contacting the floor when it deforms under impact.

Westinghouse Supplemental Response following May 21 and 22, 2008 Technical Review:

The hypothetical drop, wherein a fuel assembly travels downward through an empty storage cell and impacts the baseplate was re-analyzed in Revision 1 of APP-FS02-Z0C-001, "Analysis of AP1000 Fuel Storage Racks Subjected to Fuel Drop Accidents" for the new fuel rack. The new analysis model incorporates the following changes (as discussed in the RAI responses to TR44-03, TR44-05, and TR44-07): (1) the baseplate is modeled with thick shell elements, (2) the effect of the stored fuel assemblies is accounted for by increasing the mass density of the baseplate, and (3) strain rate effects are considered for the welds only. Based on the re-analyses, the maximum vertical displacement of the new fuel rack baseplate is 2.41", which is less than the 5" displacement considered in the criticality analysis. Therefore, the existing criticality analysis remains bounding.

These improvements were reviewed in Revision 1 of APP-FS02-Z0C-001 by the NRC staff and found to be technically acceptable for the similar spent fuel RAI-TR54-10 during the May 21 and 22 technical review. As a result of that technical review, this item was resolved for the spent fuel racks. Because Westinghouse applied the same approach for the new fuel racks and obtained conservative results and the NRC staff has already reviewed and accepted Revision 1 of APP-FS02-Z0C-001, which also applies to the new fuel rack, Westinghouse considers this item to be resolved for the new fuel rack as well.

Figure 2-10 of TR44 was revised to reflect the updated results of the drop analysis; see the Technical Report Revision section for details.

References:

1. APP-GW-GLR-026, Revision 0, "New Fuel Storage Rack Structural/Seismic Analysis," (Technical Report Number 44)
2. APP-FS02-Z0C-001, Revision 1,"Analysis of AP1000 Fuel Storage Racks Subjected to Fuel Drop Accidents"
3. APP-GW-GLR-030 Revision 0, "New Fuel Storage Rack Criticality Analysis," (Technical Report Number 67)

Design Control Document (DCD) Revision:
None

PRA Revision:
None

Technical Report (TR) Revision:
Yes - Figure 2-10 was replaced by the following figure:

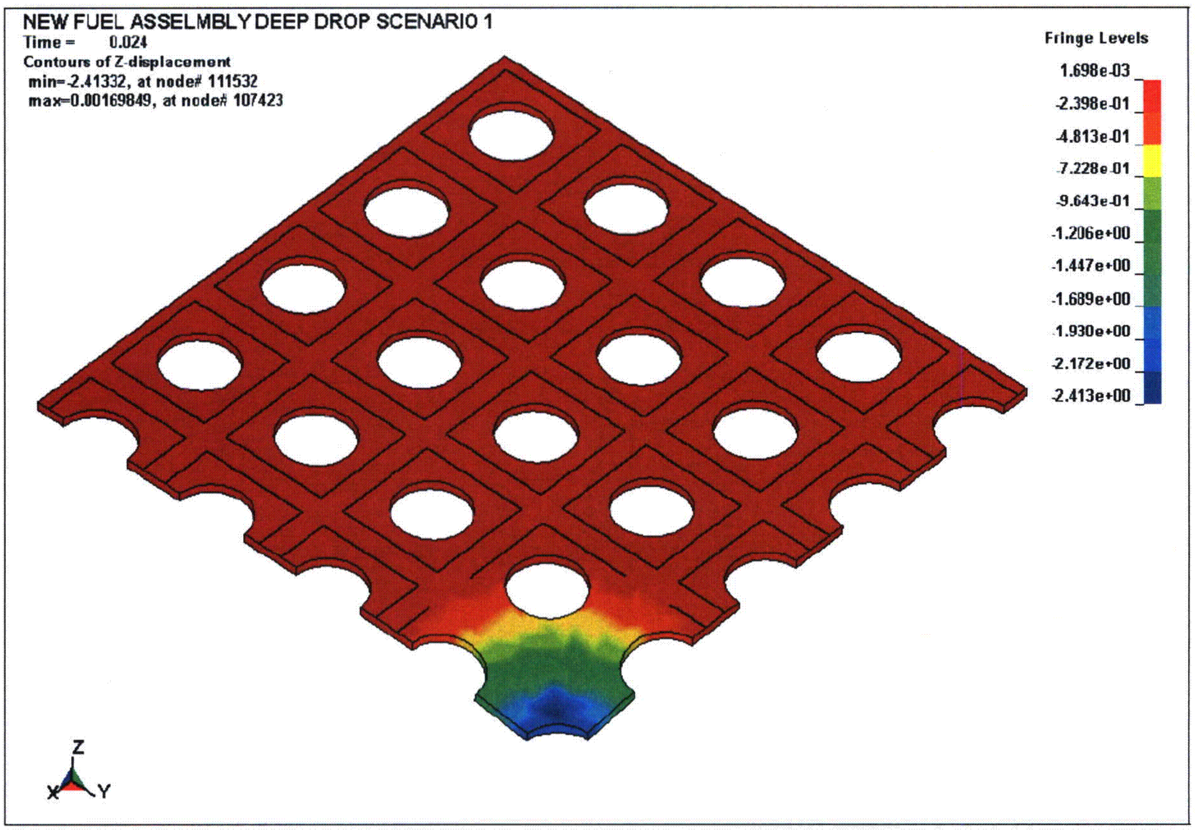


Figure 2-10 Baseplate Deformation Resulting from Fuel Assembly Drop onto Baseplate (2.41 inch Maximum Displacement Directly under Impact Location

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-TR44-007
Revision: 1

Question:

Figure 2-9 of this report shows the permanent deformation at the top of a cell wall. The permanent deformation is measured as 10.26 inches, which is smaller than the limit of 14 inches. However, the figure also shows indications of nontrivial hourglassing, which may significantly affect the accuracy of the analysis result. The mesh at the impact location should be locally refined, to ensure convergence with mesh size. Therefore, an additional analysis with a finer mesh at the impact region should be performed to confirm that the model is suitable.

Staff Assessment: Response similar to response for spent fuel racks. See RAI-TR54-11.

As a result of the October 8-12, 2007 audit, **confirmatory** pending submittal of supplemental response and the application of the same resolution as noted in TR54-11, to the new fuel rack.

Westinghouse Response:

The general acceptance criterion for the 36 inch fuel assembly drop onto the top of a new fuel storage rack is to maintain the stored fuel assemblies in a subcritical configuration. In measurable terms, the permanent deformation of the rack (measured downward from the top of rack) is limited to 15.27 inches, which is the distance from the top of the rack to the top of the neutron absorber panel. This limit is conservative because the active fuel region begins two inches below the top of the neutron absorber panels. Therefore, more margin exists than Technical Report APP-GW-GLR-026 indicates, and a mesh convergence study is not required.

Westinghouse Supplemental Response following May 21 and 22, 2008 Technical Review:

The 36" fuel assembly drop onto the top of the new fuel rack was re-analyzed in Revision 1 of APP-FS02-Z0C-001, "Analysis of AP1000 Fuel Storage Racks Subjected to Fuel Drop Accidents", with consideration of strain rate effects for the welds. The new analysis shows that the maximum permanent deformation of the rack cell wall is 12.75" (measured from the top of rack) versus the allowable limit of 20.83". This allowable limit is the distance from the top of the rack to the top of the poison panel, which is 2 inches above the top of the active fuel. Note the height of the new fuel rack cell was increased by 6 inches. Since the active fuel region is surrounded by an undamaged cell wall, there is no longer a need to demonstrate that the refinement of the model is adequate in the localized region of the impact zone.

For the similar RAI related to the spent fuel racks, RAI-TR54-11, the NRC staff requested Westinghouse to also confirm the adequacy of the rack model in the crushed zone region by providing curves that compare the hourglass energy to the kinetic, internal, and/or total energy.

Westinghouse provided these curves which demonstrated that the hourglass energy was essentially negligible in comparison to the internal energy of the cell structure and impact bar that were being plastically deformed during these drop accident cases. For the spent fuel racks, the NRC staff found the response to be technically acceptable in view of the much larger margins in the extent of plastic deformation in the new revised model, and the comparison of the hour glass energy. Following the May 21 and 22, 2008 technical review, this item was considered resolved for the spent fuel racks. Westinghouse applied this same approach for the new fuel racks; therefore, Westinghouse considers this additional item to be resolved for the new fuel racks as well.

References:
1. APP-GW-GLR-026, Revision 0, "New Fuel Storage Rack Structural/Seismic Analysis," (Technical Report Number 44)
2. APP-FS02-Z0C-001, Revision 1, "Analysis of AP1000 Fuel Storage Racks Subjected to Fuel Drop Accidents"

Design Control Document (DCD) Revision:
None

PRA Revision:
None

Technical Report (TR) Revision:
Paragraph three, Subsection 2.8.5, Hypothetical Fuel Assembly Drop Accidents was revised as follows:

For the drop to the top of the AP1000 New fuel Storage Rack, the fuel assembly is assumed to strike the edge of an exterior cell at a speed corresponding to a 36-inch drop in air and to remain vertical as it is brought to a stop by the resisting members of the rack. The objective is to demonstrate that the extent of permanent damage to the impacted rack does not extend to the beginning of the active fuel region. For the AP1000 fuel, the top of the active fuel begins ~~17.27~~22.83 inches below the top of the rack.

Paragraph five, Subsection 2.8.5, Hypothetical Fuel Assembly Drop Accidents ~~will be~~was revised as follows:

The results from the analyses are shown in Figures 2-9 and 2-10. For the drop to the top of the AP1000 New Fuel Storage Rack, the extent of the permanent damage is limited to a depth of ~~10.26~~12.75 inches. The tops of the poison panels are located ~~15.27~~20.83 inches below the top of the rack. The poison panels overlap the active fuel by two inches at the top and bottom. The top of the active fuel begins ~~17.27~~22.83 inches below the top of the rack, therefore, the active fuel region is surrounded by an undamaged cell wall and no further criticality analysis is required.

Figure 2-9 was replaced with the following figure:

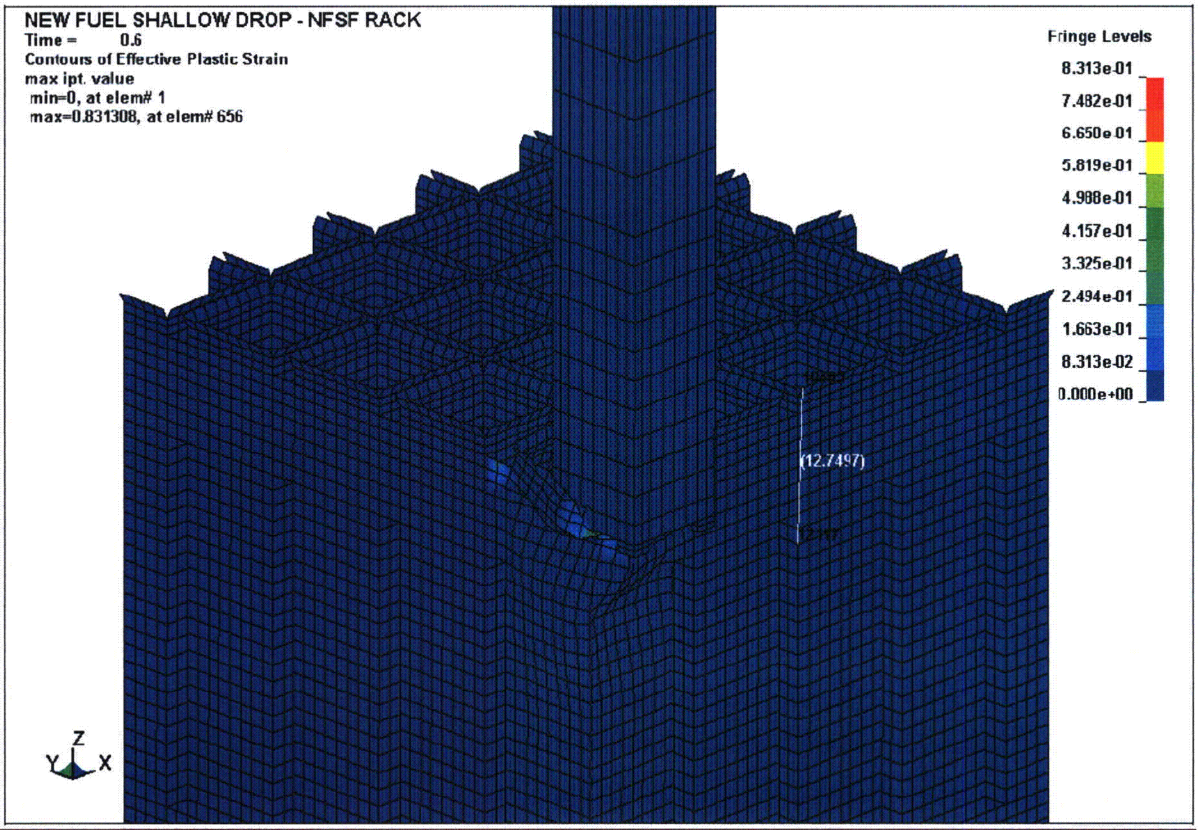


Figure 2-9 Results from Drop on AP1000 New Fuel Storage Rack

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-TR44-008
Revision: 1

Question:

As indicated in Table 2-3 of the report and the markup for DCD Table 9.1-1, one of the fuel handling accident loads that need to be considered is uplift force on the rack caused by a postulated stuck fuel assembly. Section 2.8.3 of the report states: "An evaluation of a stuck fuel assembly, leading to an upward load of 2,000 lb has been performed. The results from the evaluation show that this is not a bounding condition because the local stresses do not exceed 2,500 psi." The information provided is not sufficient for the staff to reach a conclusion that this load has been adequately considered. Please provide a detailed description of the assumptions, the analyses conducted, the results obtained, and the basis for the conclusion that this is not a bounding condition.

Staff Assessment: Response similar to response for spent fuel racks. See RAI-TR54-14.

Following the submittal of the Westinghouse Revision 1 response to RAI-TR54-14, the NRC staff requested additional information:

The following information is needed to ensure that the calculation in Westinghouse's response is adequate:

(1) Explain how the effective b_e and t_e are determined.

(2) Provide a calculation on the adequacy of the vertical welds along the height between adjoining cells and the horizontal welds at the base (cell walls to baseplate). If the stress levels are higher than those currently presented in the response, then revise the Technical Report accordingly.

(3) The two sentence description of the stuck fuel assembly is presented in Section 2.8.3- "Dead Load Evaluation" of the Technical Report. A more detailed description comparable to the information given in the RAI response should be included in a more appropriate section of the Technical Report since this loading is a fuel handling accident condition not a dead load evaluation.

(4) Explain why the Technical Report and the response describes the uplift force equal to 2,000 pounds is used, while DCD Section 9.1.2.2.1 indicates that an uplift force of 5,000 pounds is used in the analysis.

Westinghouse Response:

A nearly empty rack with one corner cell occupied is subject to an upward load of 2000 lbf, which is assumed to be caused by the fuel sticking while being removed. The ramification of the loading is two-fold:

1) The upward load creates a force and a moment at the base of the rack;

2) The loading induces a local tension in the cell wall.

The following calculation determines the maximum stress in the rack cell structure due to a postulated stuck fuel assembly. The terms p, Nx, Ny, Ixx2, and Iyy2 are defined as the cell pitch, the number of storage cells in the horizontal x-direction, the number of storage cells in the horizontal y-direction, the moment of inertia of the rack cell structure about the x-axis, and the moment of inertia of the rack cell structure about the y-axis, respectively.

Calculation of the Effect of a Stuck Fuel Assembly

$P_{stuck} := 2000 \cdot lbf$ Per Westinghouse design input

Compute maximum stress at base of rack cell structure assuming rack behaves as a cantilever beam

$X := N_x \cdot \frac{p}{2}$ $X = 4.087\,ft$ $I_{xx2} = 6.653 \times 10^4 \, in^4$

$Y := N_y \cdot \frac{p}{2}$ $Y = 3.633\,ft$

$\sigma_{grid} := P_{stuck} \cdot \frac{X^2}{I_{xx2}} + P_{stuck} \cdot \frac{Y^2}{I_{yy2}}$ $\sigma_{grid} = 118.032\,psi$

It is clear that the global stress due to a stuck fuel assembly is insignificant. Now, check local stress in cell in tension. Conservatively using the effective width

$A_{celllocal} := 4 \cdot b_e \cdot t_e$ $A_{celllocal} = 0.991\,in^2$

$\sigma_{local} := \frac{P_{stuck}}{A_{celllocal}}$ $\sigma_{local} = 2.018 \times 10^3\,psi$

This local stress is well below the yield stress of the cell wall material (i.e., 30,000 psi per Table 2-5.)

Westinghouse Supplemental Response from May 21 and 22, 2008 Technical Review:

Item 1: During the October 8-12, 2007 audit, Westinghouse showed the NRC staff Appendix D (pg. D-13) of the equivalent structural/seismic calculation for the spent fuel racks, APP-FS02-S3C-002, Rev. 0, where the calculation of b_e and t_e was performed. The equations for the calculation of the effective width were taken from the ASME Code, Section III, Subsection NF, NF-3222.2, and the methodology used in the new fuel rack structural/seismic analysis is the same.

The effective thickness for a spent fuel rack cell uses one-half the actual thickness because each cell wall is shared by the adjacent two cells. During the May 21 and 22, 2008 technical review the NRC staff reviewed Revision 1 of APP-FS02-S3C-002, and determined that the calculation for the effective width is based on the provisions in the ASME Code, Section III, Subsection NF, and the effective wall thickness corresponds to one-half of the true wall thickness. Therefore, item 1 of RAI-TR54-14 for the spent fuel racks was found to be technically acceptable by the NRC staff.

The same approach was used in the new fuel rack structural/seismic analysis, APP-FS01-S3C-001, Revision 1; therefore, Westinghouse considers this item to be technically acceptable for the new fuel rack as well.

Item 2: The following calculations demonstrate the adequacy of the vertical welds along the height between adjoining cells and the horizontal welds at the base (cell walls to baseplate) to resist the stuck fuel assembly load.

Cell to cell welds

Each storage cell in the new fuel rack is welded vertically along its height to the adjoining cells by a combination of 3" and 6" long intermittent fillet welds. The minimum length of weld over the height of a storage cell, along one corner of the cell, is 6". Therefore, for conservatism, the entire stuck fuel assembly load is assumed to be resisted by only two 3" long fillet welds at the very top of the rack. Based on this approach, the stress in the cell to cell welds is calculated as follows:

Stuck fuel assembly load	$P_{stuck} := 4000 \cdot \mathrm{lbf}$
Length of intermittent fillet weld	$L_{weld} := 3 \cdot \mathrm{in}$
Size of intermittent fillet weld	$t_{weld} := \frac{1}{16} \cdot \mathrm{in}$
Number of fillet welds that resist load	$N := 2$
Effective throat area of fillet welds	$A_{weld} := N \cdot L_{weld} \cdot \frac{t_{weld}}{\sqrt{2}}$
	$A_{weld} = 0.265\ \mathrm{in}^2$
Shear stress in fillet welds	$\tau := \frac{P_{stuck}}{A_{weld}}$
	$\tau = 15085\ \mathrm{psi}$

Per Section 2.3.4.1 of TR-44, the allowable weld stress under normal conditions is 0.3 times the material ultimate strength. From Table 2-5 of TR-44, the ultimate strength of SA240-304 material at 100F is 75,000 psi. Therefore, the allowable weld stress under normal conditions is 0.3 x 75,000 psi = 22,500 psi, which is greater than the weld stress calculated above.

Cell to baseplate welds

Each storage cell in the new fuel rack is welded to the base plate by four 7" (min.) long fillet welds. Since the total length of weld associated with cell to baseplate connection (28") is greater than the length considered in the above cell to cell weld evaluation (6"), and the weld size is the same (1/16"), the stress in the cell to baseplate welds is bounded by the preceding stress calculation for the cell to cell welds.

Item 3: The description of the stuck fuel assembly evaluation will be deleted from Section 2.8.3 of the Technical Report and will be replaced by a more detailed description in the newly added Section 2.8.6 (Stuck Fuel Assembly Evaluation). See the Technical Report Revision section below.

Item 4: This item is not directly applicable to the new fuel racks as it is currently worded; however, in the TR an uplift force of 2,000 pounds was stated, but in Section 9.1.1.2.1 of the DCD it is stated that an uplift force of 2,027 will be evaluated. The uplift force was reevaluated in Revision 1 of the new fuel rack structural/seismic analysis, APP-FS01-S3C-001, for 4,000 pound because the hoist on the fuel handling machine is rated at 4,000 pounds. The resultant stress on the rack is within the allowable; the max stress is 4,046 psi (see below calculation) compared to an allowable stress of 30,000 psi. The consideration of a 4,000 lbf uplift force will be reflected revised in TR44 and the DCD; see the Technical Report and DCD Revision sections below.

Calculation of the Effect of a Stuck Fuel Assembly

$P_{stuck} := 4000 \cdot lbf$ Per Westinghouse design input

Compute maximum stress at base of rack cell structure assuming rack behaves as a cantilever beam

$X := N_x \cdot \frac{p}{2}$ $X = 4.087\ ft$ $I_{xx2} = 6.644 \times 10^4\ in^4$

$Y := N_y \cdot \frac{p}{2}$ $Y = 3.633\ ft$ $I_{yy2} = 8.306 \times 10^4\ in^4$

$\sigma_{grid} := P_{stuck} \cdot \frac{X^2}{I_{xx2}} + P_{stuck} \cdot \frac{Y^2}{I_{yy2}}$ $\sigma_{grid} = 236.391\ psi$

It is clear that the global stress due to a stuck fuel assembly is insignificant. Now, check local stress in cell in tension. Conservatively using the effective width

$A_{celllocal} := 4 \cdot b_e \cdot t_e$ $A_{celllocal} = 0.989\ in^2$

$\sigma_{local} := \frac{P_{stuck}}{A_{celllocal}}$ $\sigma_{local} = 4045.588\ psi$

<u>This local stress is well below the yield stress of the cell wall material (i.e., 30,000 psi per Table 2-5 of TR44.)</u>

References:

1. APP-GW-GLR-026, Revision 0, "New Fuel Storage Rack Structural/Seismic Analysis," (Technical Report Number 44)
2. <u>APP-FS02-S3C-002, Revision 1, "Spent Fuel Storage Rack Structural/Seismic Analysis"</u>
3. <u>APP-FS01-S3C-001, Revision 1, "New Fuel Storage Rack Structural/Seismic Analysis"</u>

Design Control Document (DCD) Revision:

Item B, "New Fuel Handling Crane Uplift Analysis", of Section 9.1.1.2.1, "New Fuel Rack Design", is revised as follows:

An analysis is performed to demonstrate that the rack can withstand a maximum uplift load of 4000 pounds. This load is applied to a postulated stuck fuel assembly. Resultant rack stresses are evaluated against the stress limits and are demonstrated to be acceptable. It is demonstrated that there is no change in rack geometry of a magnitude which causes the criticality criterion to be violated.

Section 9.1.1.3, "Safety Evaluation", is revised as follows:

The rack is also designed with adequate energy absorption capabilities to withstand the impact of a dropped fuel assembly from the maximum lift height of the new fuel handling crane. Handling equipment (cask handling crane) capable of carrying loads heavier than fuel components is prevented from traveling over the fuel storage area. The fuel storage rack can withstand an uplift force greater than or equal to the uplift capability of the new fuel handling crane (4000 pounds).

Item Q, "New Fuel Handling Crane", of Section 9.1.4.2.4, "Component Description", is revised as follows:

The new fuel handling crane is located in the fuel handling area. It is a standard commercial crane with an "L" shaped frame and an electric operated hoist. It is used to move the new fuel from the new fuel storage position to the new fuel elevator. The crane is positioned so that it cannot reach the spent fuel storage positions. The crane capacity is limited to a 4000 pound load.

PRA Revision:

None

Technical Report (TR) Revision:

The two sentence description of the stuck fuel assembly evaluation in Section 2.8.3 of the Technical Report was replaced by the following newly added section:

2.8.6 Stuck Fuel Assembly Evaluation

A nearly empty rack with one corner cell occupied is subject to an upward load of 4,000 lbf, which is assumed to be caused by the fuel sticking while being removed. The ramification of the loading is two-fold:

1. The upward load creates a force and a moment at the base of the rack;
2. The loading induces a local tension in the cell wall and shear stresses in the adjacent welds.

Strength of materials calculations have been performed to determine the maximum stress in the rack cell structure due to a postulated stuck fuel assembly. The results are summarized in Table 2-16.

Table 2-16 was added to the Technical Report:

Table 2-16 Results from Stuck Fuel Assembly Evaluation

Item	Calculated Stress (psi)	Allowable Stress (psi)	Safety Factor
Tensile Stress in Cell Wall	4,046	30,000	7.41
Shear Stress in Cell-to-Cell Weld	15,085	22,500	1.49

RAI Response Number: RAI-TR44-009
Revision: 1

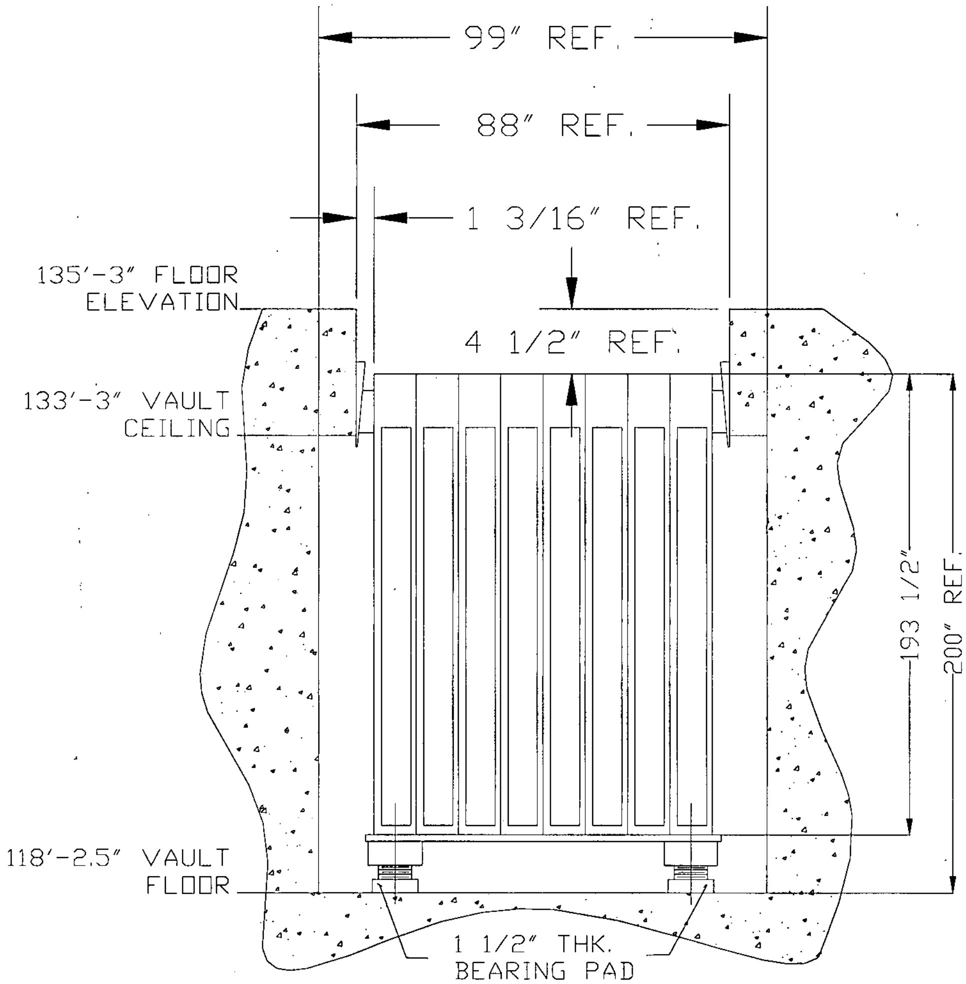
Question:

Insufficient descriptive information has been included in the new fuel report to permit an adequate review of the structural/seismic analysis of the new fuel rack. Please provide descriptive information including plans and sections showing the new fuel rack and vault walls. All of the major features of the rack including the cell walls, baseplate, pedestals, bearing pads, neutron absorber sheathing, any impact bars, welds connecting these parts, and any other elements in the load path of the rack should be shown on one or several sketches. These sketches should also indicate related information which includes key: cutouts, dimensions, material thicknesses, and gaps (fuel to cell, rack to walls). In addition to the above, for review of postulated fuel handling drop accident and quantification of the drop parameters, sketches with sufficient details for the fuel handling system should be provided.

Staff Assessment: Response similar to response for spent fuel racks. See RAI -TR54-15.

Westinghouse Response:

Figures TR44-9.1 through TR-44-9.5 provide additional descriptive information on the new fuel rack and New Fuel Storage Pit floor and walls. The new fuel handling system is still in final design and no sketches are available. The quantification of the drop parameters has been established and analyzed in Technical Report Number 44. A conservative drop height of 36 inches has been assumed even though the most likely drop height will not exceed 18 inch above the new fuel rack. The total drop weight is 2,027 pounds, which consist of a new fuel assembly, control assembly and new fuel handling tool.



ELEVATION VIEW OF NEW FUEL STORAGE RACK
(EAST WALL VIEW LOOKING WEST)

FIGURE TR44-9.1

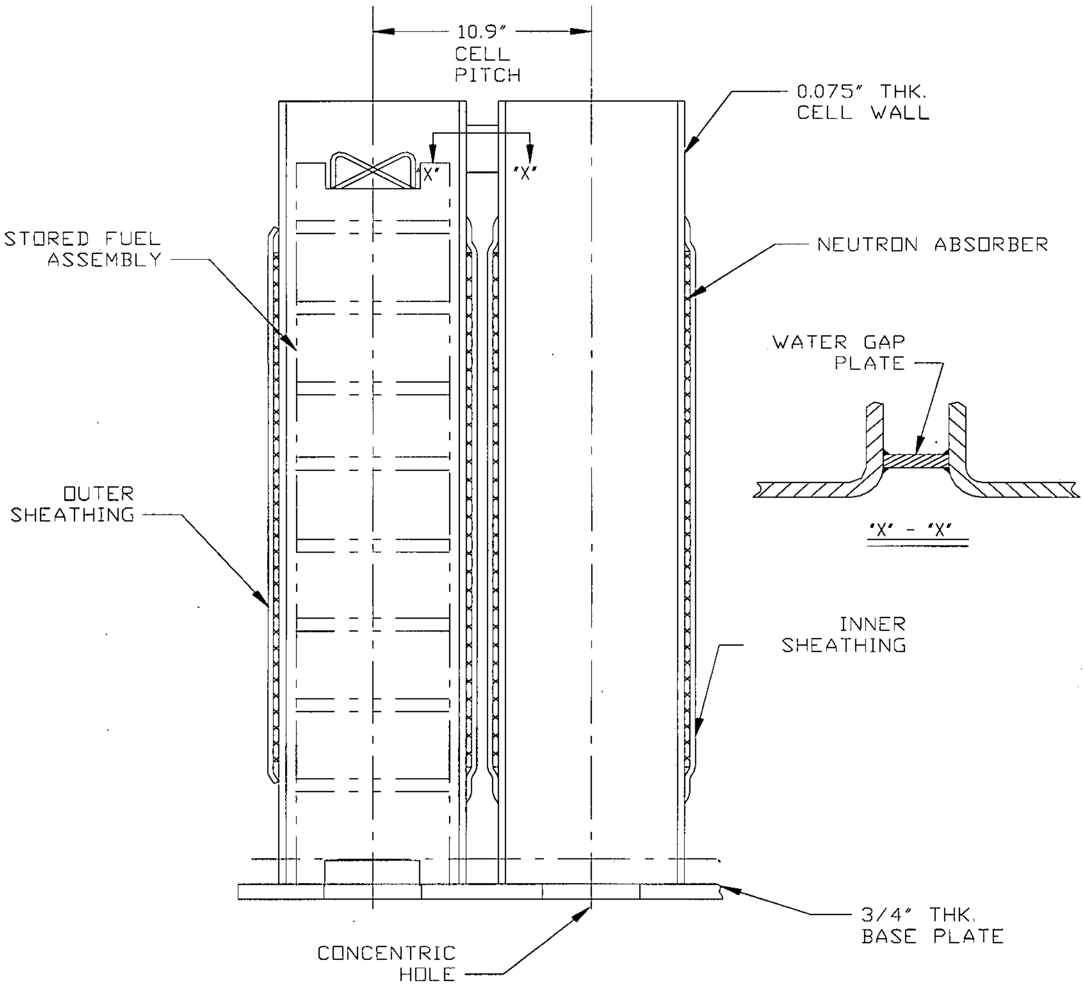


FIGURE TR44-9.2; ELEVATION VIEW OF NEW STORAGE RACK CELLS

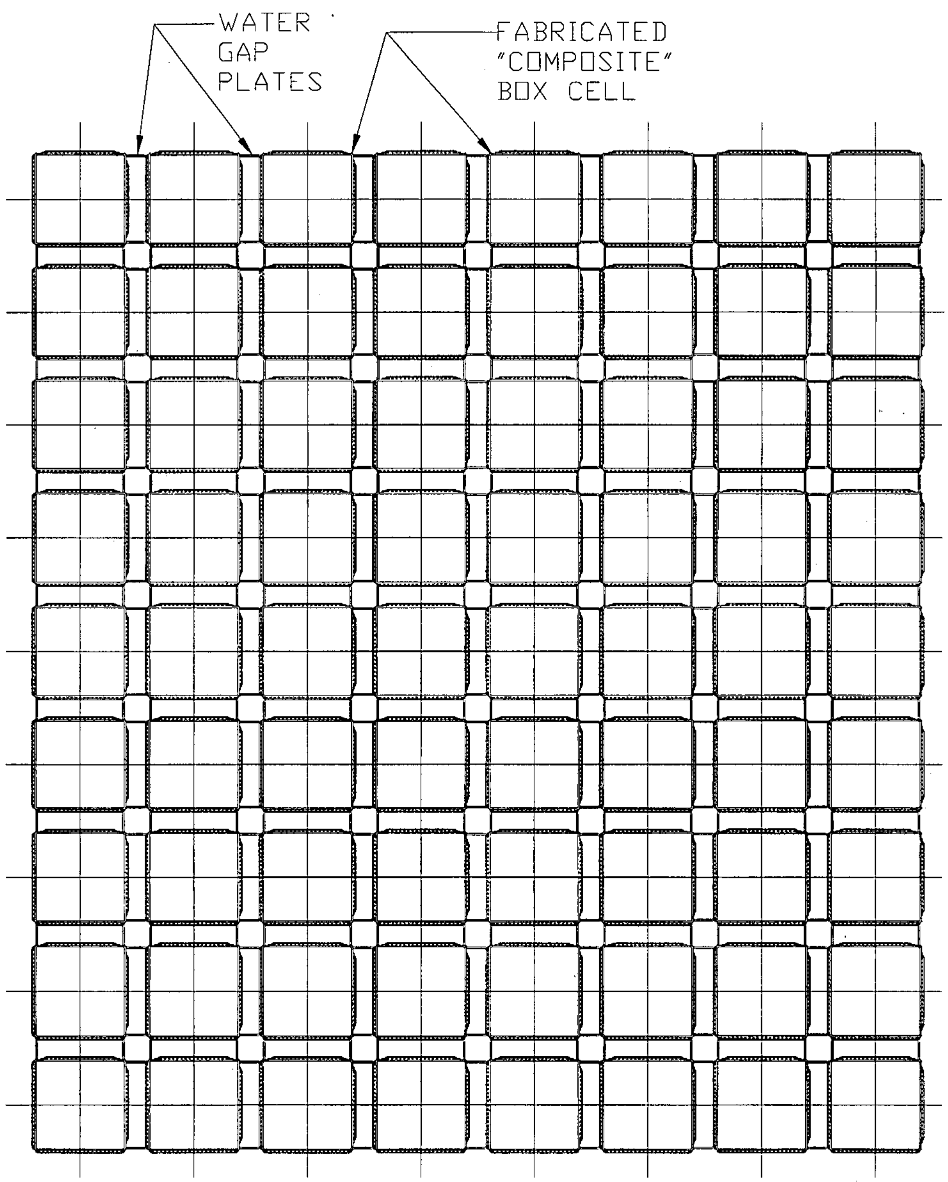


FIGURE TR44-9.3; STORAGE CELL ARRAY
FOR NEW FUEL STORAGE RACK

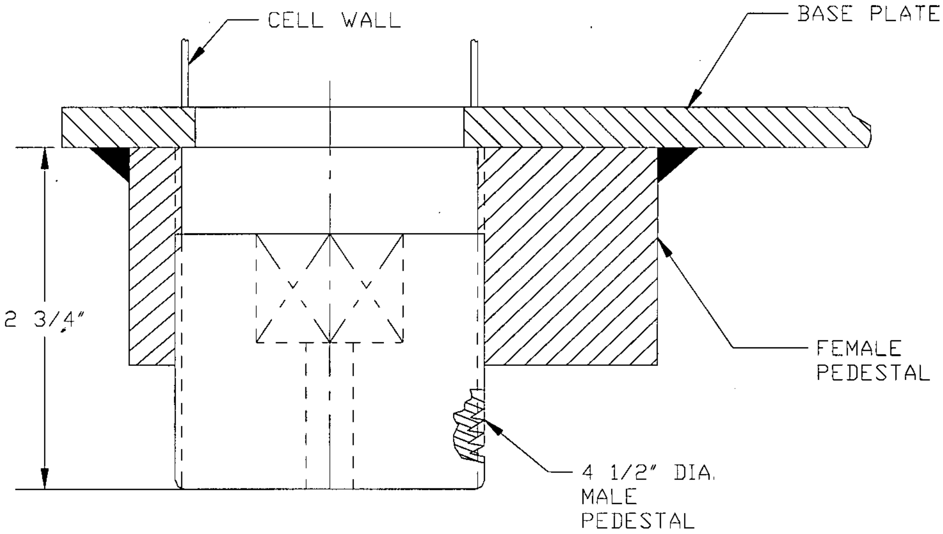


FIGURE TR44-9.4; CROSS SECTION OF ADJUSTABLE SUPPORT

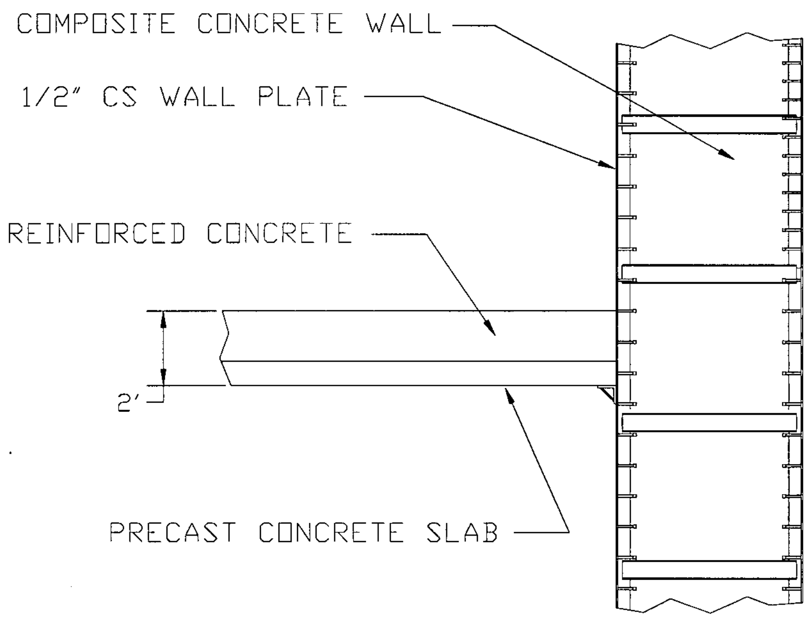


Figure TR44-9.5 New Fuel Pit Floor and Wall Detail

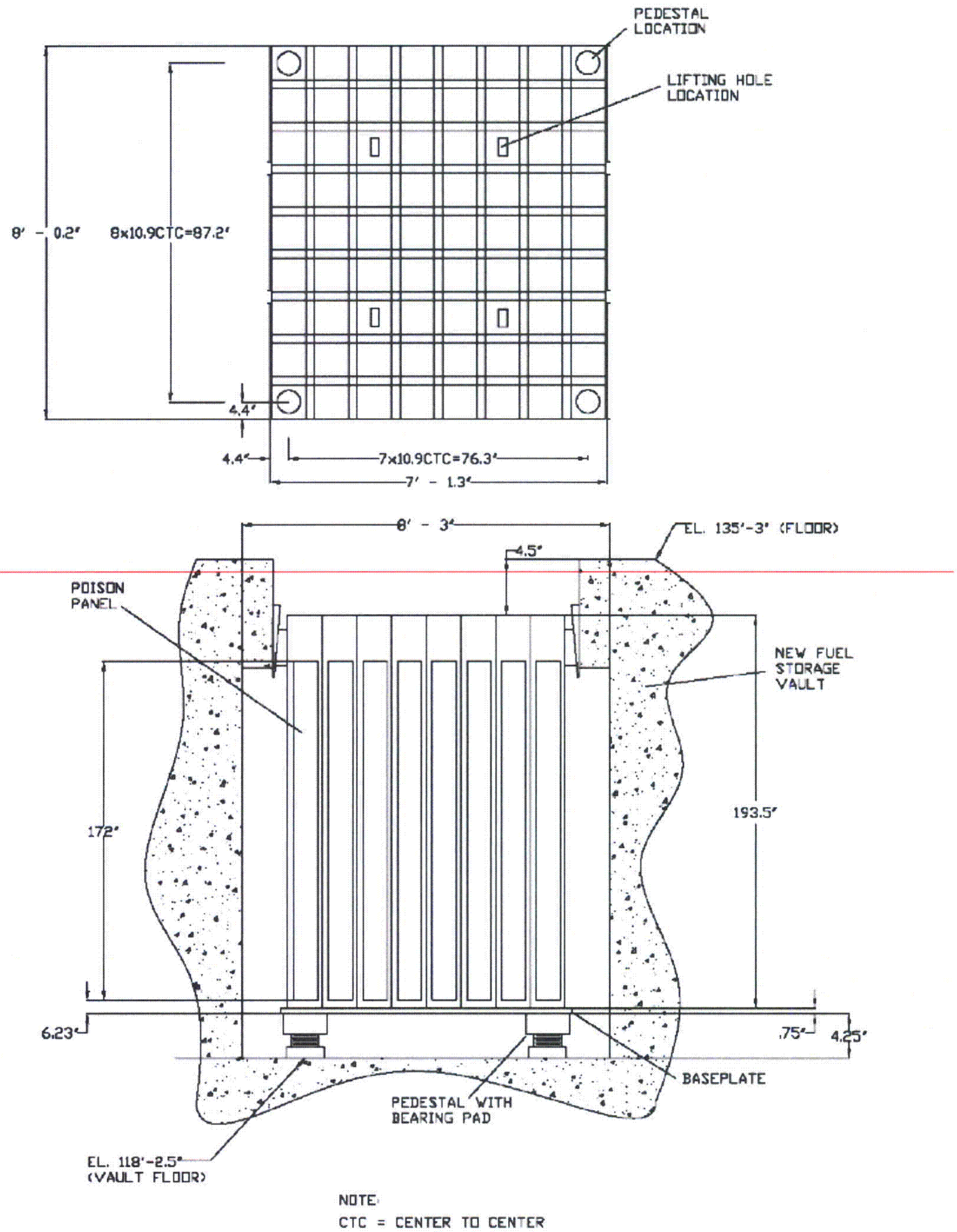
Westinghouse Supplemental Response following May 21 and 22, 2008 Technical Review:

The two figures shown in the DCD and TR markup sections provide updates of the layout and cross section of the new fuel storage rack. The figures replaced Figure 2-1 of TR44 and DCD Figure 9.1-1, Sheets 1 and 2; see the DCD and TR markup sections for details.

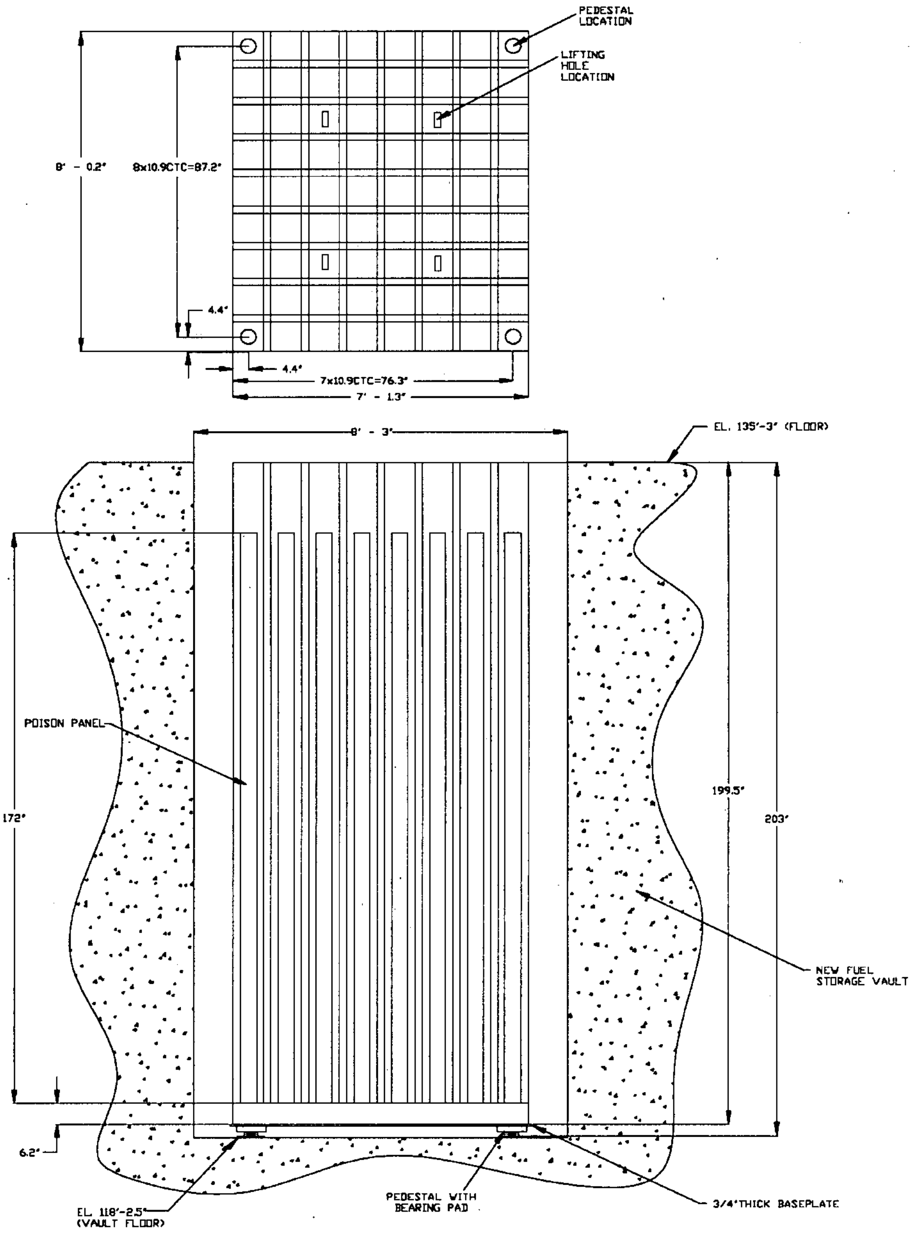
Reference:

1. APP-GW-GLR-026, Revision 0, "New Fuel Storage Rack Structural/Seismic Analysis," (Technical Report Number 44)

Design Control Document (DCD) Revision:
Revise Figure 9.1-1, Sheets 1 and 2, as follows:

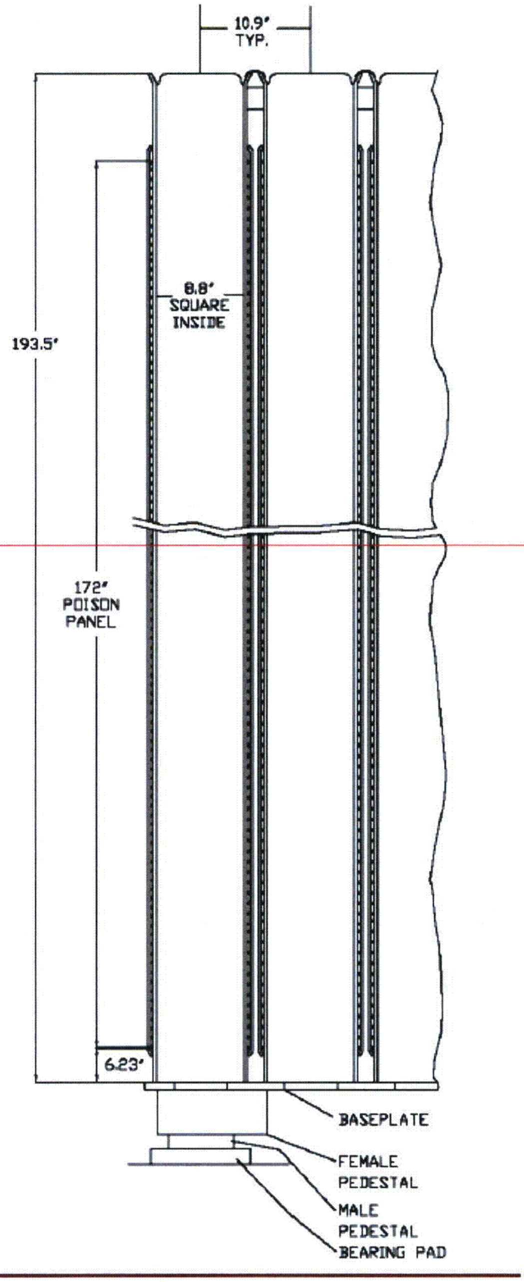


~~Figure 9.1-1 (Sheet 1 of 2)~~
~~**New Fuel Storage Rack Layout (72 Storage Location)**~~



NOTE:
CTC=CENTER TO CENTER SPACING

Figure 9.1-1 (Sheet 1 of 2)
New Fuel Storage Rack Layout (72 Storage Location)



~~Figure 9.1-1 (Sheet 2 of 2)~~
~~**New Fuel Storage Rack Cross Section**~~

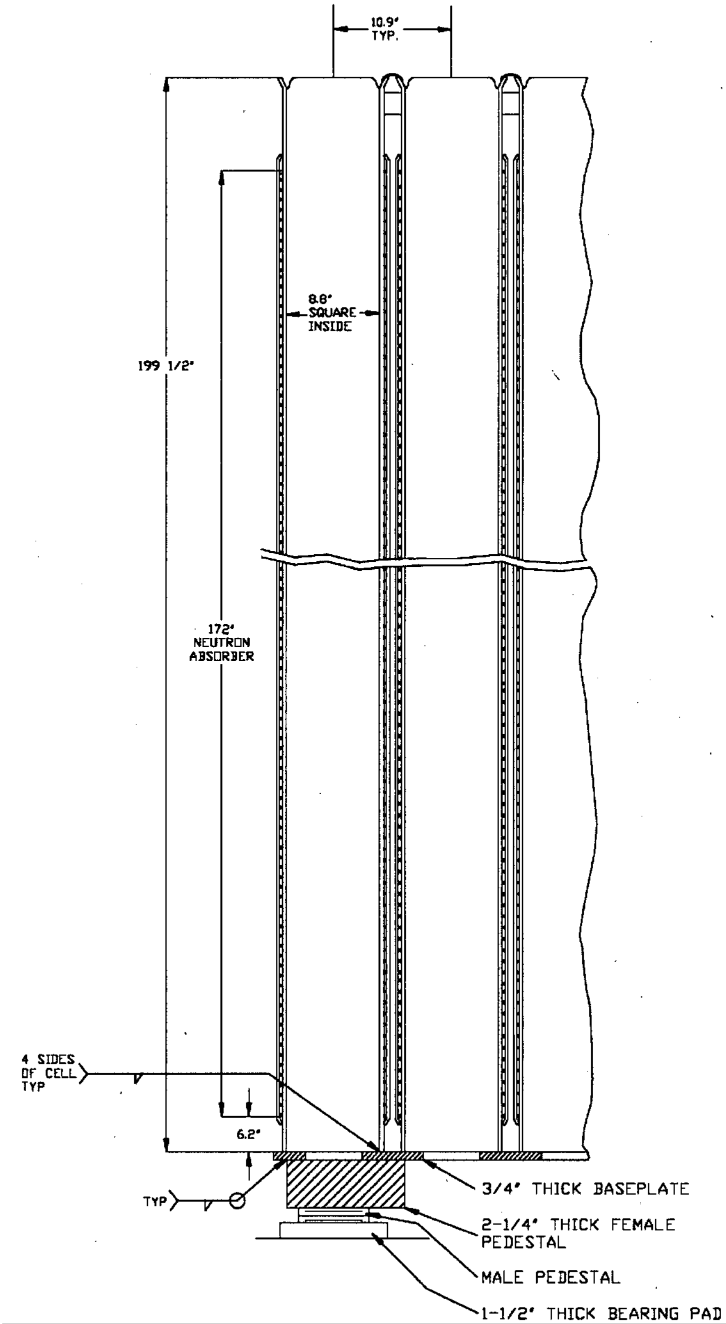
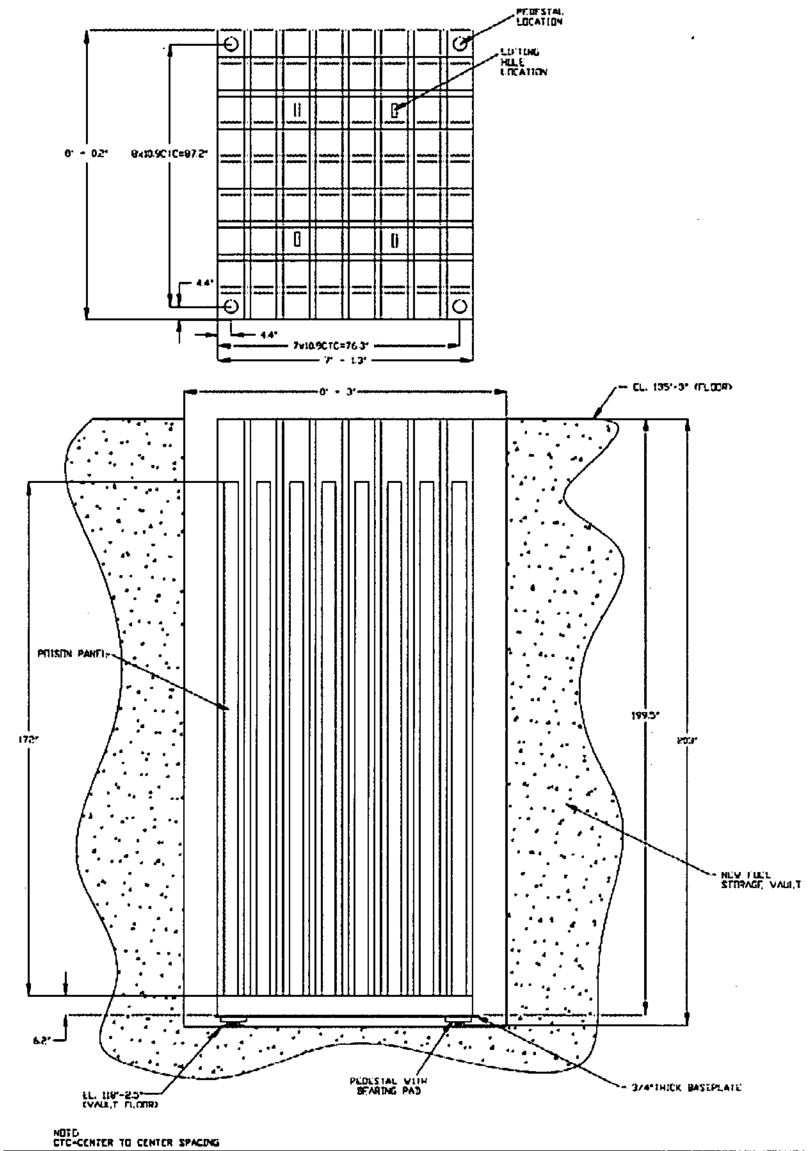


Figure 9.1-1 (Sheet 2 of 2)
New Fuel Storage Rack Cross Section

PRA Revision:
None

Technical Report (TR) Revision:
<u>Figure 2-1 was renamed and replaced by the following 2-sheet figure:</u>



<u>Figure 2-1 New Fuel Storage Rack Layout (72 Storage Location) (Sheet 1 of 2)</u>

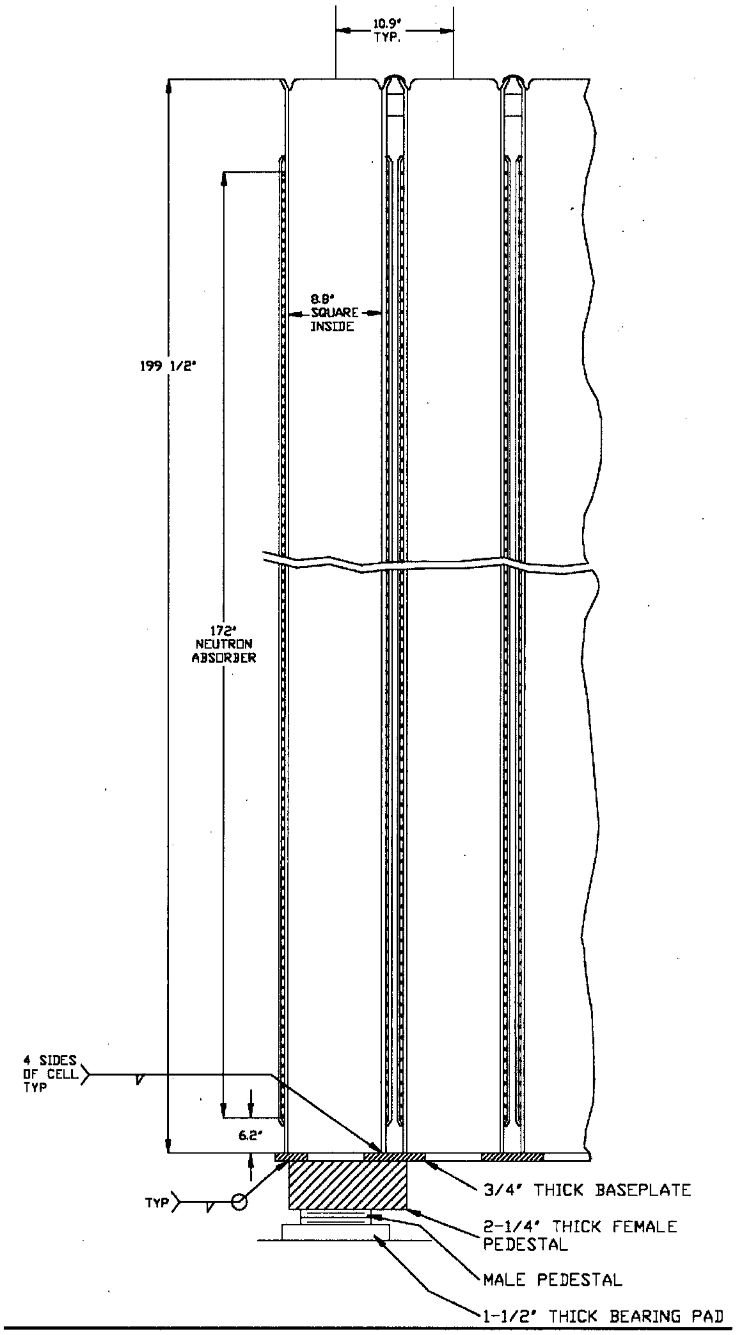


Figure 2-1 New Fuel Storage Rack Cross Section (Sheet 2 of 2)

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-TR44-010
Revision: 1

Question:

The Westinghouse Report APP-GW-GLR-026, Revision 0, appears to be a summary type report. However, to adequately perform a technical review of the analysis and design of the new fuel rack, a more detailed report should be submitted. Therefore, provide a detailed new fuel storage rack report/calculation for review.

Staff Assessment: The staff needs to review References 2 and 3 at the next audit, either at Westinghouse Energy Center, or at Westinghouse's office in Rockville, MD. Response similar to response for spent fuel racks. See RAI-TR54-16.

Westinghouse Response:

The Westinghouse Report APP-GW-GLR-026, Revision 0, is a summary type report. This report is based on the calculations APP-FS01-S3C-001, Revision 0 "New Fuel Storage Rack Structural/Seismic Analysis" and APP-FS02-Z0C-001, Revision 0, "Analysis of AP1000 Fuel Storage Racks subjected to Fuel Drop Accidents." These calculations can be reviewed in the Westinghouse Energy Center or Westinghouse Rockville Office prior to the NRC mid-April audit. Please advise Westinghouse of your plan for review of these documents.

Westinghouse Supplemental Response following May 21 and 22, 2008 Technical Review:

Revision 0 of Westinghouse Report APP-GW-GLR-026 is a summary type report based on Revision 0 of APP-FS01-S3C-001 and Revision 0 of APP-FS02-Z0C-001. These two calculations have been revised to incorporate the new seismic spectra and the change in cell height. Revision 1 of TR44 incorporates the changes made in Revision 1 of APP-FS01-S3C-001, "New Fuel Storage Rack Structural/Seismic Analysis" and Revision 1 of APP-FS02-Z0C-001, "Analysis of AP1000 Fuel Storage Racks Subjected to Fuel Drop Accidents".

In the May 21 and 22, 2008 technical review, the NRC staff reviewed Revision 1 of APP-FS02-Z0C-001, "Analysis of AP1000 Fuel Storage Racks Subjected to Fuel Drop Accidents" and the equivalent structural/seismic analysis for the spent fuel racks, APP-FS02-S3C-002, "Spent Fuel Storage Racks Structural/Seismic Analysis" and found them to be technically acceptable.

Westinghouse applied the same approach for the new fuel rack design. In addition, the NRC staff has already reviewed and accepted Revision 1 of APP-FS02-Z0C-001, which also applies to the new fuel rack. Therefore, Westinghouse considers this item to be technically acceptable for the new fuel rack as well.

References:

1. APP-GW-GLR-026, Revision 0, "New Fuel Storage Rack Structural/Seismic Analysis," (Technical Report Number 44)
2. APP-FS01-S3C-001, Revision 1, "New Fuel Storage Rack Structural/Seismic Analysis"
3. APP-FS02-Z0C-001, Revision 1, "Analysis of AP1000 Fuel Storage Racks subjected to Fuel Drop Accidents"
4. APP-FS02-S3C-002, Revision 1, "Spent Fuel Storage Racks Structural/Seismic Analysis"

Design Control Document (DCD) Revision:
None

PRA Revision:
None

Technical Report (TR) Revision:
None

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-TR44-011
Revision: 1

Question:

Insufficient data is provided regarding the input loads used for the seismic analysis of the new fuel rack. The following information is requested:

(a) Floor response spectra (X, Y, and Z - vertical directions) at or the near the elevation of the top of the fuel rack and near the bottom of the fuel rack or vault floor corresponding to the damping value used for the analysis.

(b) Explain why the envelope of these two sets of spectra was not used.

(c) The current DCD is applicable for the hard rock site. Therefore, provide further explanation for the range of soil and rock properties used in enveloping the seismic floor spectra. Where are these ranges of soil/rock properties specified for confirmation by future COL applicant?

(d) For the synthetic time histories, provide plots of the three time histories, the cross correlation coefficients, the comparisons of the spectra from the synthetic time histories to the enveloped target response spectra, and the comparisons of the power spectral density plots to the target power spectral density function associated with the target response spectra.

(e) Which time history was used (displacement, velocity, or acceleration)? Were all three directions input simultaneously? Was gravity included in the time history analysis?

Staff Assessment: Response similar to response for spent fuel racks. See RAI-TR54-17.

Westinghouse Response:

a) Floor response spectra (X, Y, and Z - vertical directions) near the elevation of the bottom of the new fuel storage vault corresponding to the damping value used for the analysis are provided in the PDF attachment RAI TR44-11a. No floor response spectra are provided near or at the elevation of the top of the new fuel rack (See response to TR44-11b).

The ASB99 floor response spectra (FRS) represents the enveloping response spectra for the auxiliary and shield building (ASB) at elevation 99 feet for a range of soil/rock condition. FRS of various soil/rock analyses were first enveloped for various locations of the ASB. All of the ASB locations at elevation 99 were then grouped and enveloped to develop the ASB99 floor response spectra.

b) It is probable that the floor response spectra will be revised for various reasons and that a revision to the new fuel storage rack structural/seismic analysis will be required. The methodology of developing the spectra is described in RAI-TR-44-011 a, d and e responses.

c) The range of soil and rock conditions for which the seismic floor spectra applies is described in Westinghouse Technical Report 03, APP-GW- S2R-010 Revision 0, "Extension of NI Structures Seismic Analysis to Soil Sites."

d) The synthetic time histories, the response spectrum curves, and the power spectral density plots for the Auxiliary and Shielding Building (ASB) at Elevation 99 feet are provided in Figures TR44-11.1 through TR44-11.9. The cross correlation coefficients for the three orthogonal components (East-West, North-South, and Vertical) of the ASB99 synthetic time histories are summarized in the table below.

Description	Cross Correlation Coefficient
East-West to North-South	-0.0414
East-West to Vertical	0.0088
North-South to Vertical	0.0536

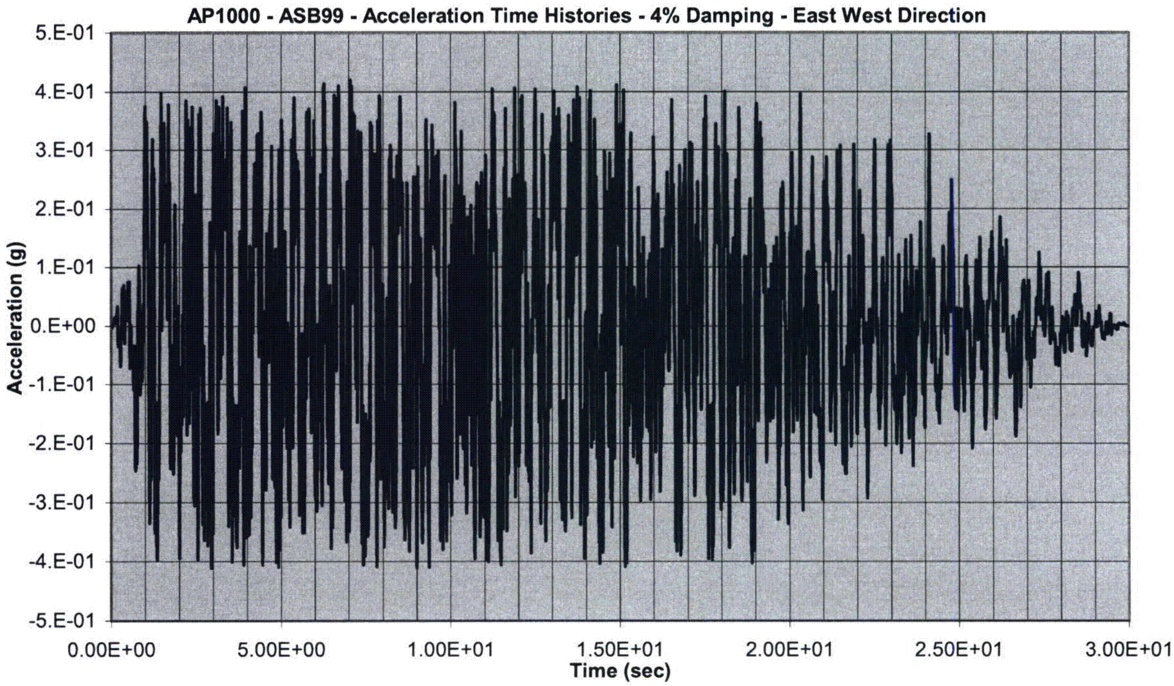


Figure TR44-11.1 ASB99 Acceleration Time History for EW Direction

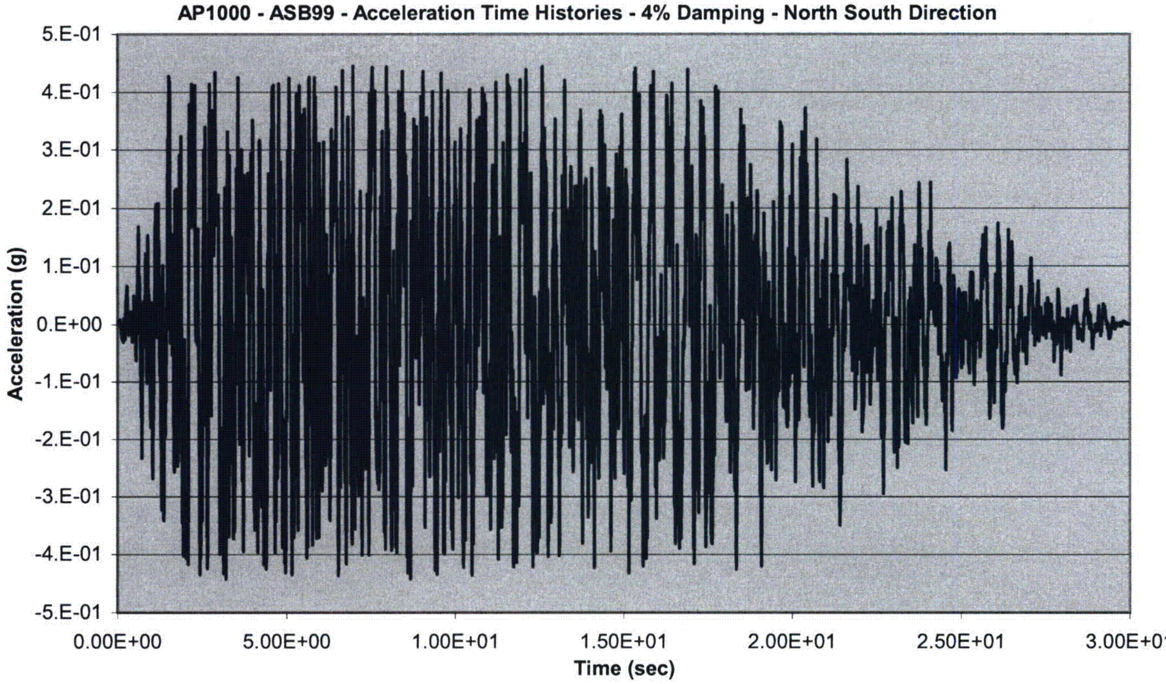


Figure TR44-11.2 ASB99 Acceleration Time History for NS Direction

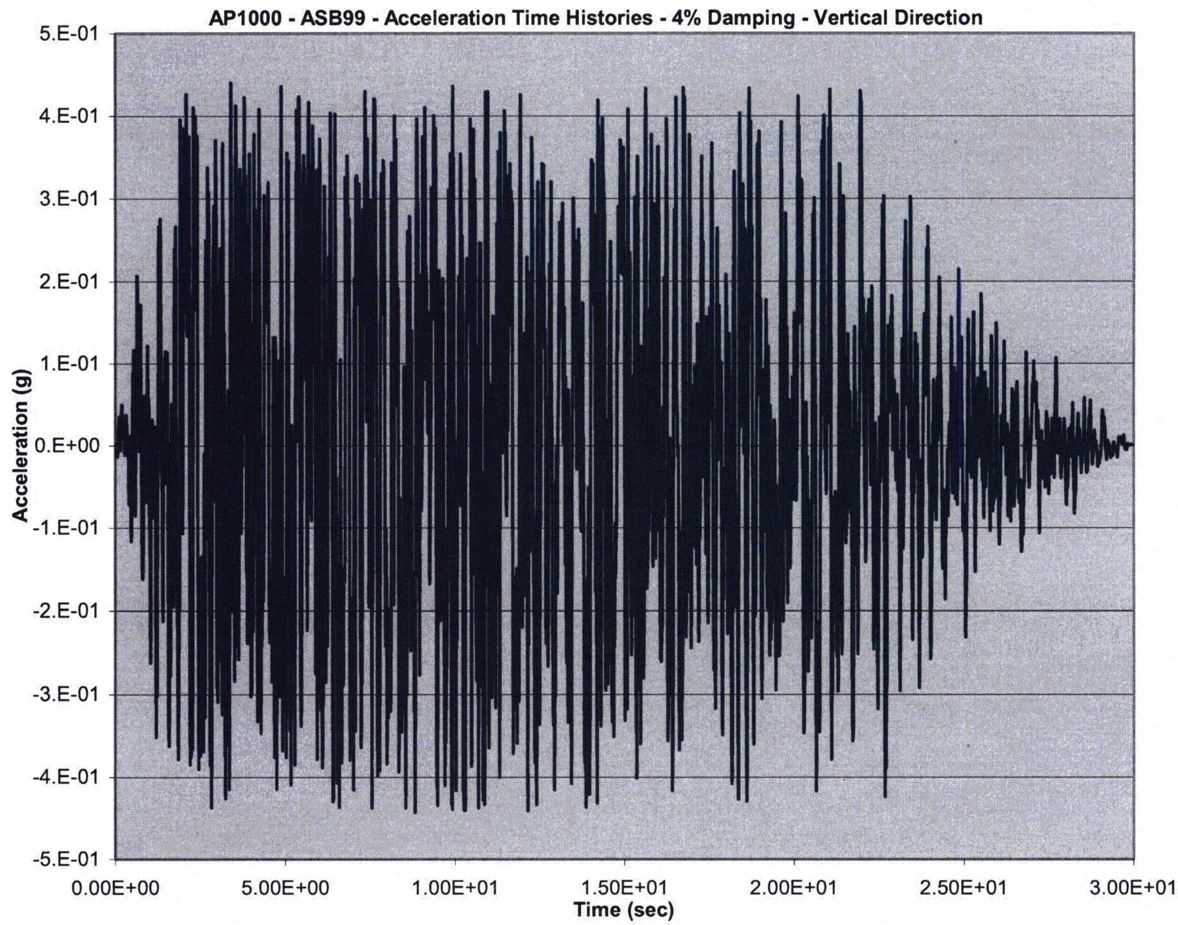


Figure TR44-11.3 ASB99 Acceleration Time History for VT Direction

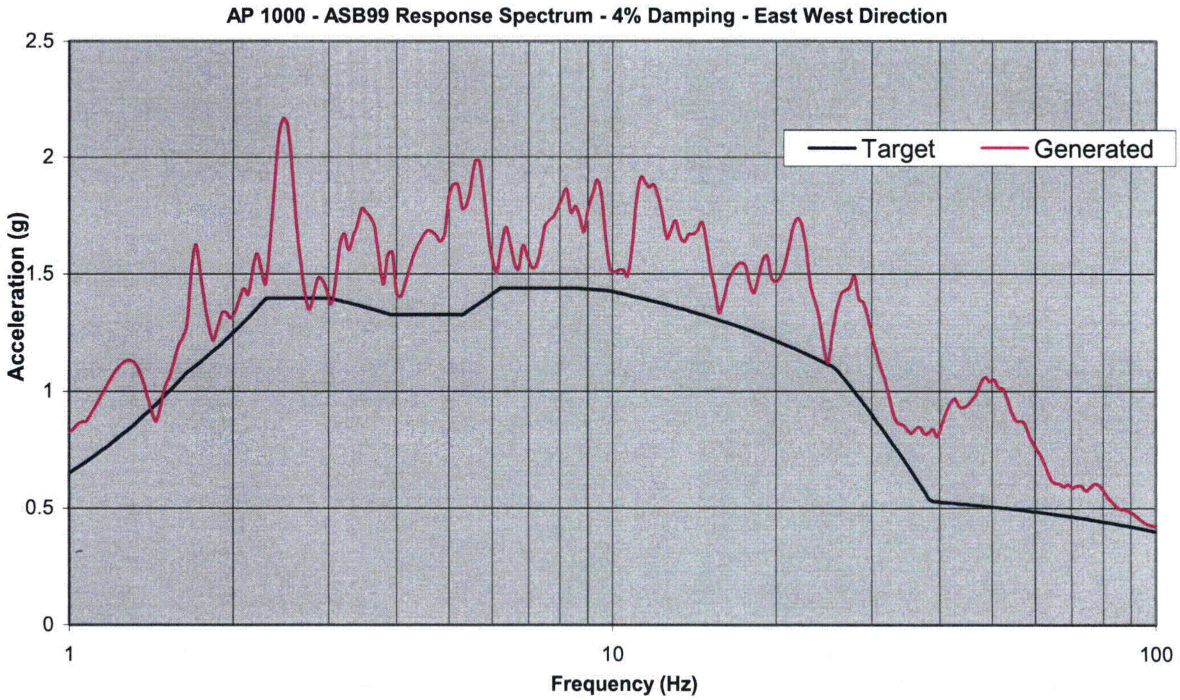


Figure TR44-11.4 ASB99 Response Spectrum for EW Direction

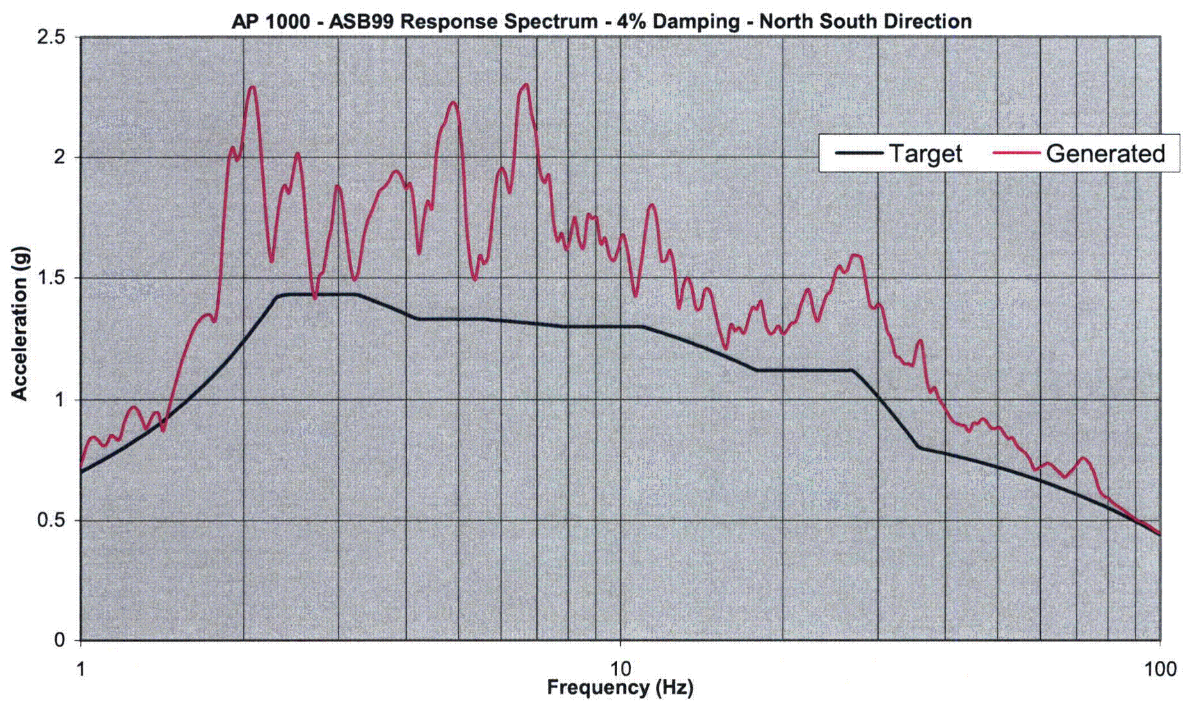


Figure TR44-11.5 ASB99 Response Spectrum for NS Direction

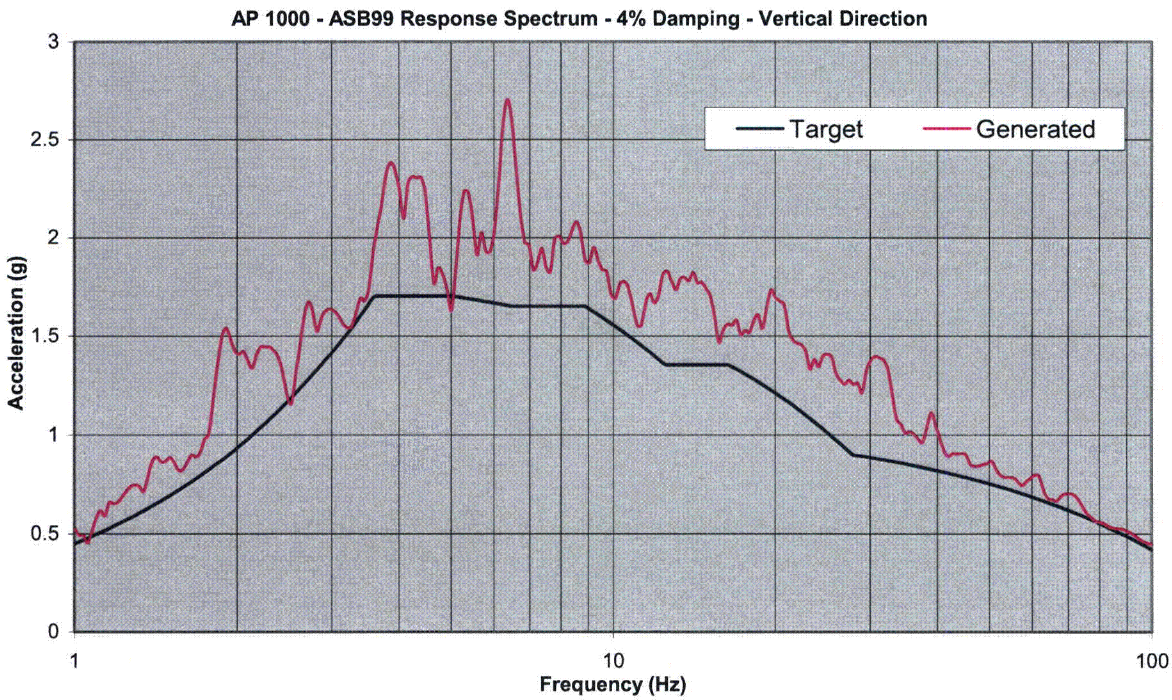


Figure TR44-11.6 ASB99 Response Spectrum for VT Direction

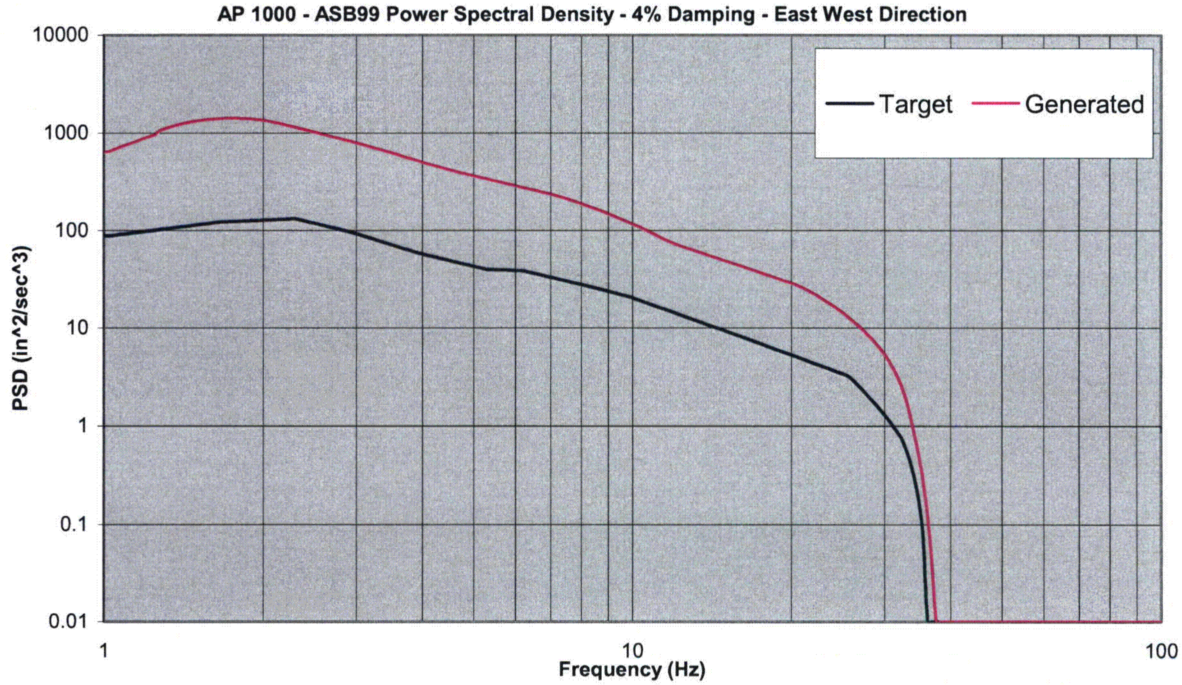


Figure TR44-11.7 ASB99 Power Spectral Density for EW Direction

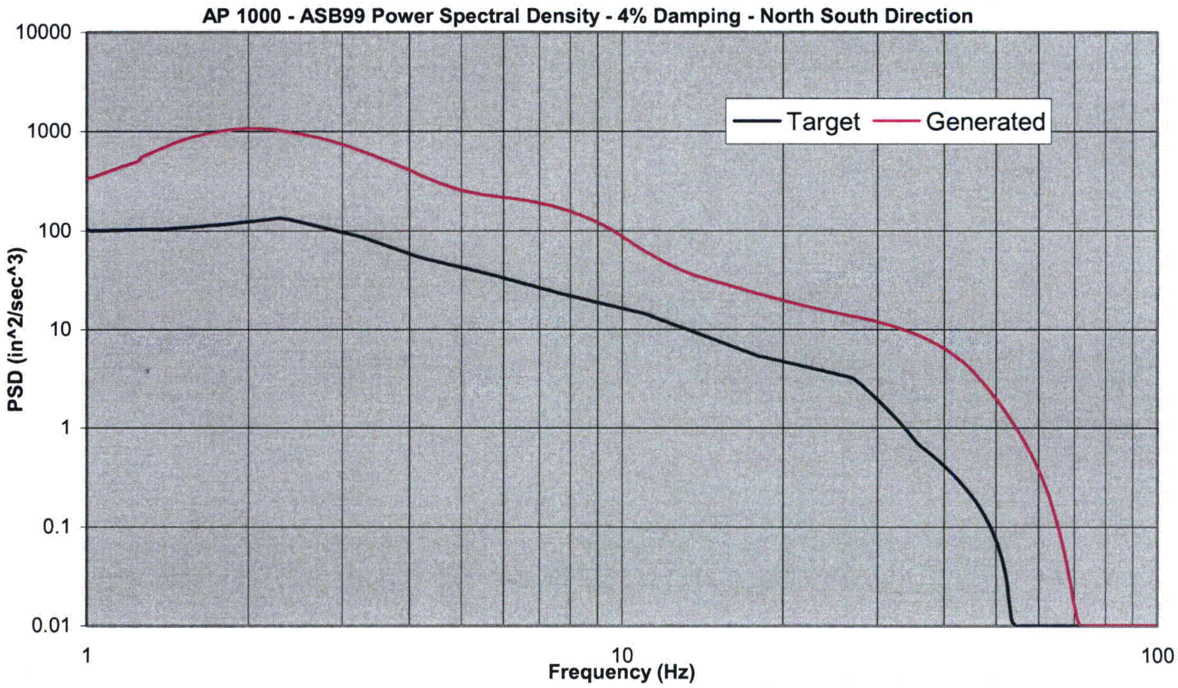


Figure TR44-11.8 ASB99 Power Spectral Density for NS Direction

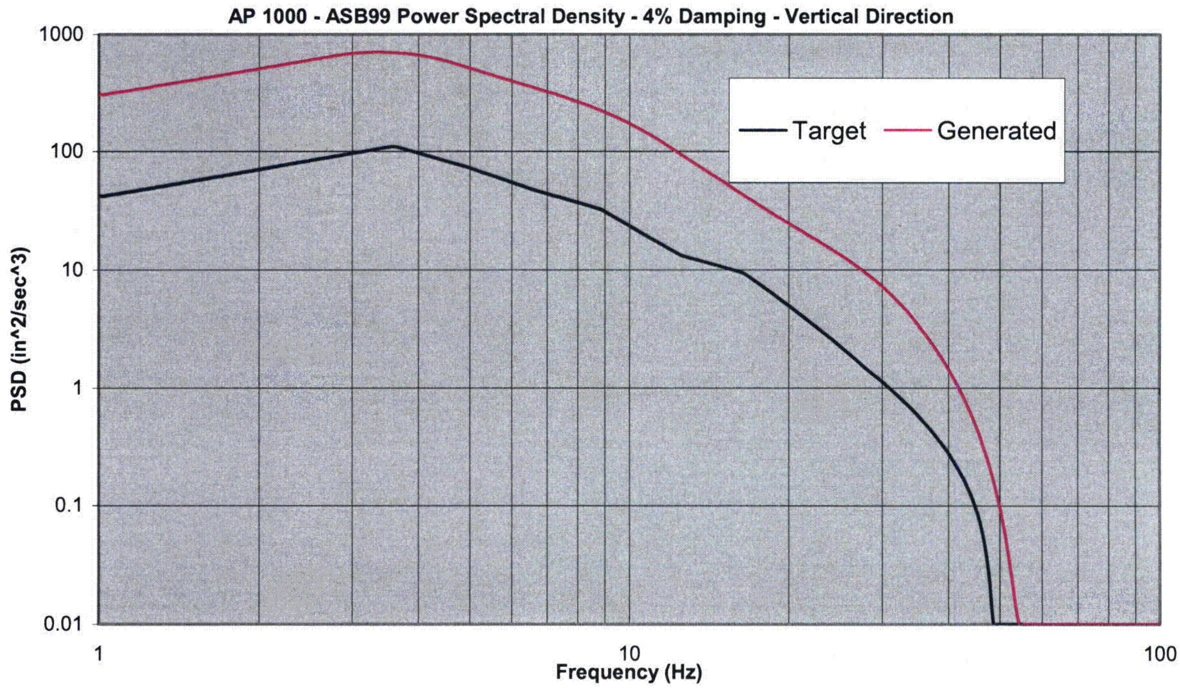


Figure TR44-11.9 ASB99 Power Spectral Density for VT Direction

e) Acceleration time histories are used as the input motion for the seismic analysis of the spent fuel racks. The acceleration input is defined by three orthogonal components, which are input and solved simultaneously. Gravity is also included in the time history analysis.

Westinghouse Supplemental Response following May 21 and 22, 2008 Technical Review:

For the similar spent fuel racks RAI-TR54-017, items A, B, and D were considered technically acceptable following the April 16-19, 2007 audit. Item C had a typographical error that was corrected in Revision 1 of RAI-TR54-017, and following the May 21 and 22, 2008 technical review, item C was considered technically acceptable. That typo did not occur in this RAI for the new fuel rack; therefore Westinghouse considers item C of this RAI to be technically resolved for the new fuel rack as well. For spent fuel rack RAI-TR54-017, item E was considered technically acceptable, and it was requested that the words in the response be included in a revision to TR54. Similar words to those used to resolve this item for the spent fuel racks will be included in a revision to TR44, see the Technical Report Revision section below for a mark-up of TR44.

Therefore Westinghouse considers all of the responses submitted in Rev. 0 of this RAI for the new fuel rack to be technically acceptable as well; however, the input floor response spectra was revised since Rev. 0 was submitted. Following are updated responses to account for those changes.

a) The "New Fuel" floor response spectra (FRS) represents the enveloping response spectra for the new fuel storage vault inside the Auxiliary and Shield Building (ASB) at an elevation close to the bottom of the new fuel vault floor for a range of soil/rock condition.

d) The synthetic time histories, the response spectrum curves, and the power spectral density plots for the new fuel storage vault inside the Auxiliary and Shielding Building (ASB) at Elevation 116' - 6" (the bottom of the new fuel vault is at Elevation 118' - 2.5") are provided in Figures TR44-11.1 through TR44-11.9. The cross correlation coefficients for the three orthogonal components (East-West, North-South, and Vertical) of the "New Fuel" synthetic time histories are summarized in the table below.

Description	**Cross Correlation Coefficient**
East-West to North-South	0.0152
East-West to Vertical	-0.0537
North-South to Vertical	0.0031

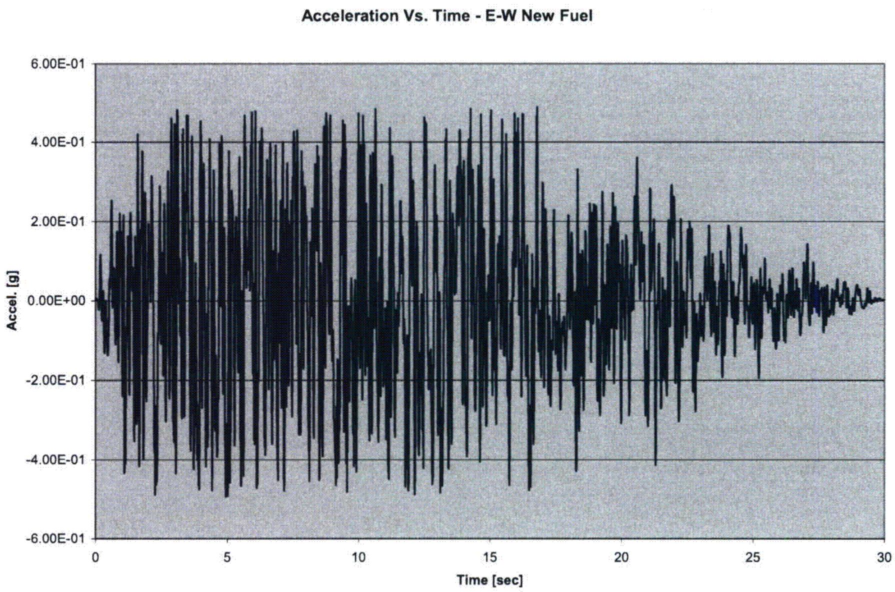


Figure TR44-11.1 New Fuel Acceleration Time History for EW Direction

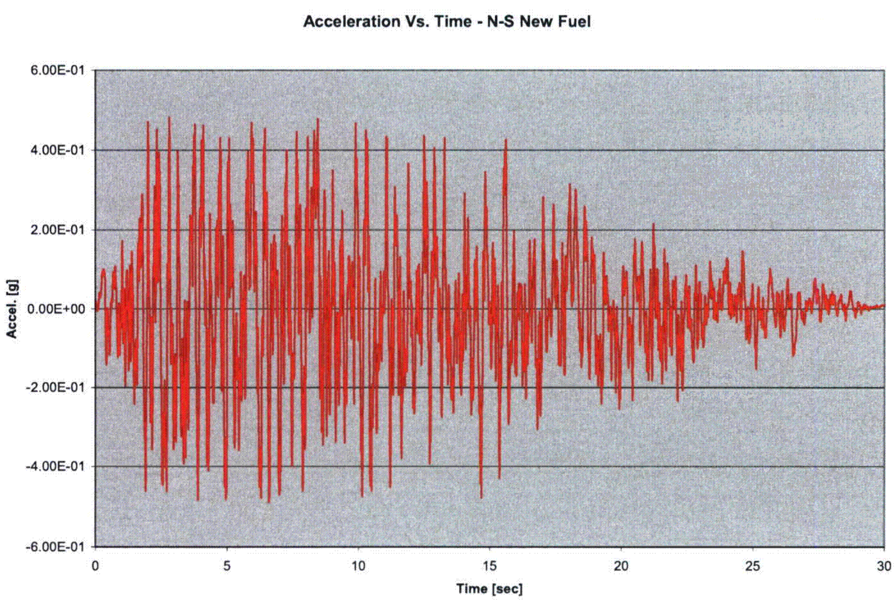


Figure TR44-11.2 New Fuel Acceleration Time History for NS Direction

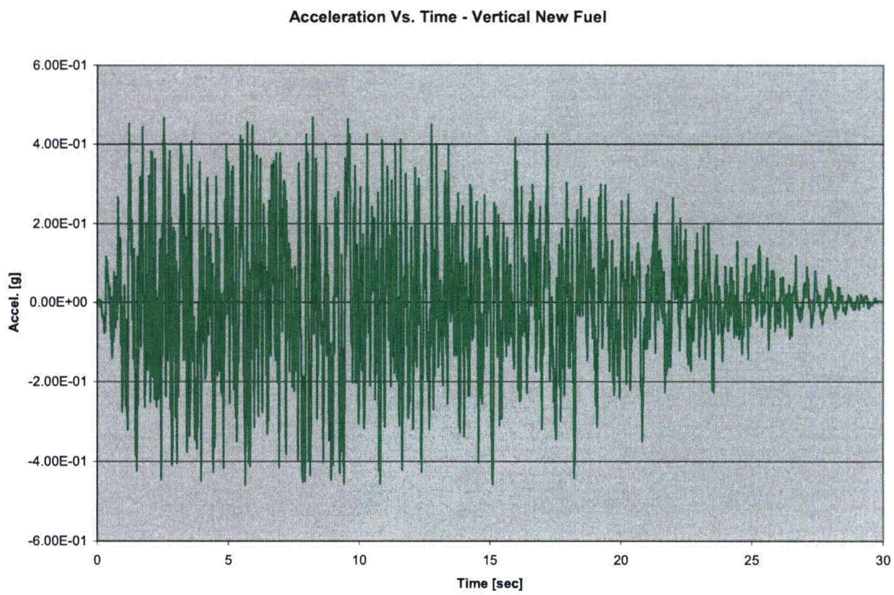


Figure TR44-11.3 New Fuel Acceleration Time History for VT Direction

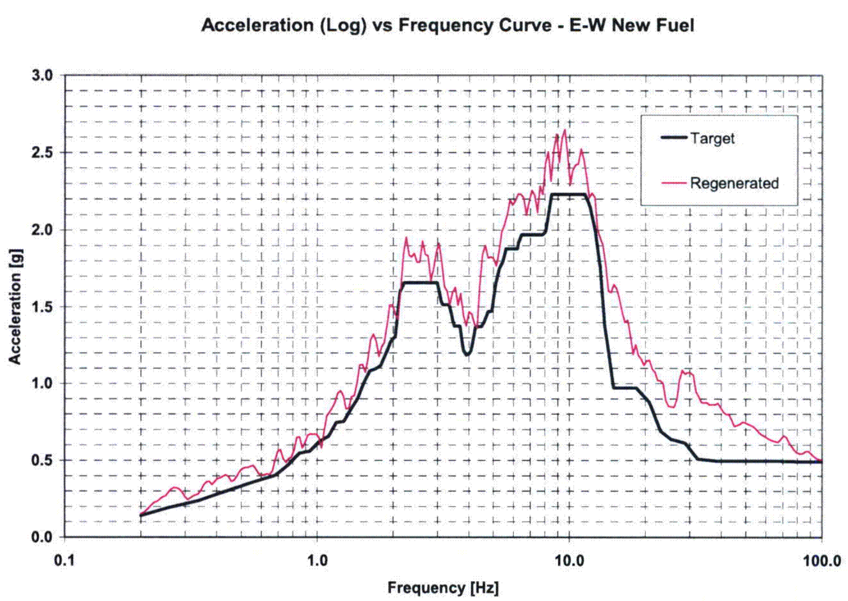


Figure TR44-11.4 New Fuel Response Spectrum for EW Direction

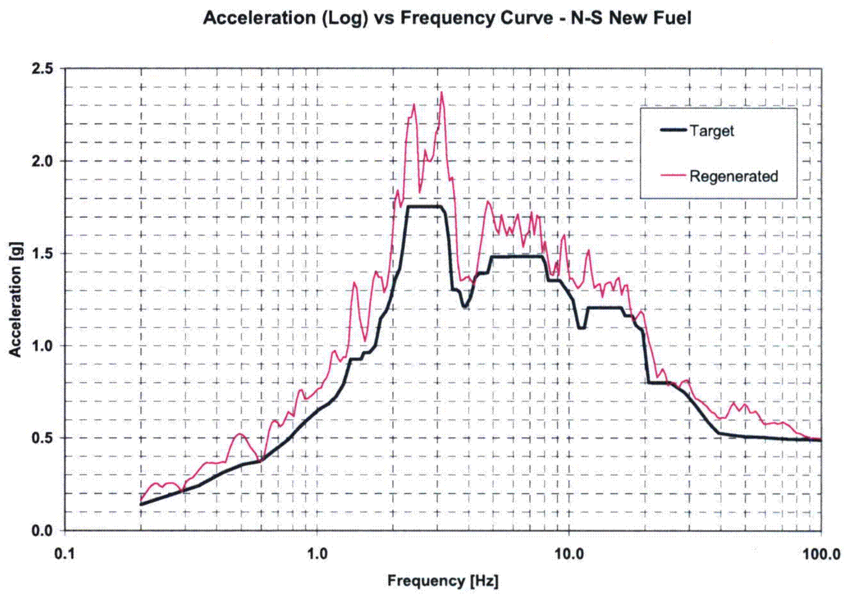


Figure TR44-11.5 New Fuel Response Spectrum for NS Direction

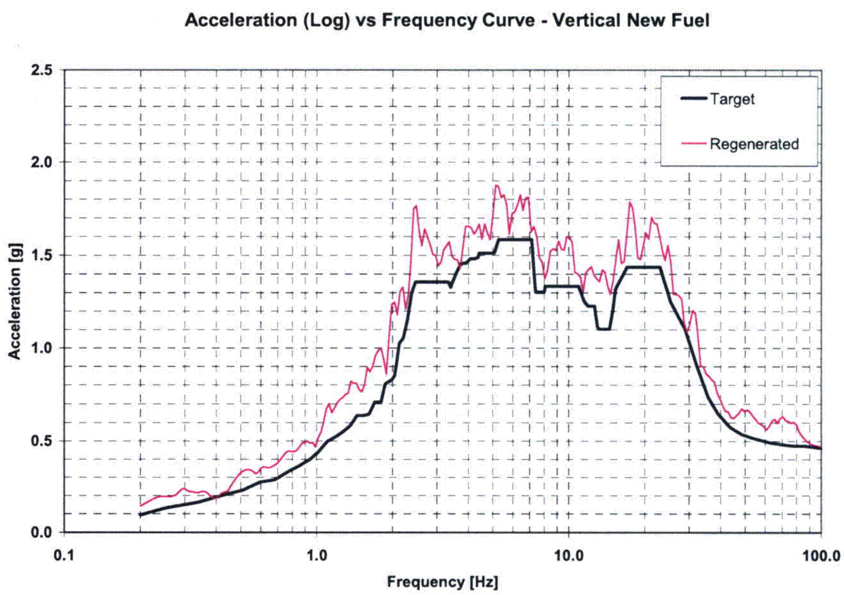


Figure TR44-11.6 New Fuel Response Spectrum for VT Direction

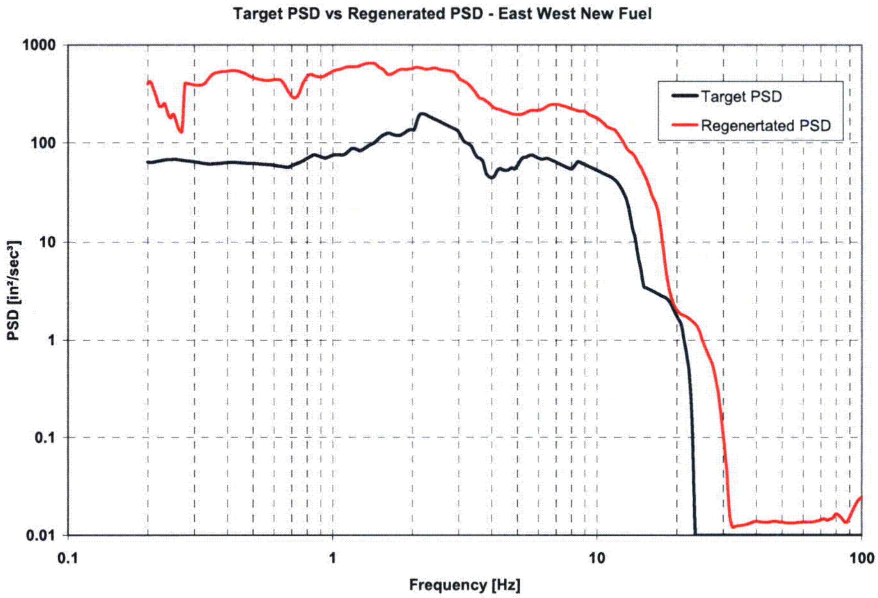


Figure TR44-11.7 New Fuel Power Spectral Density for EW Direction

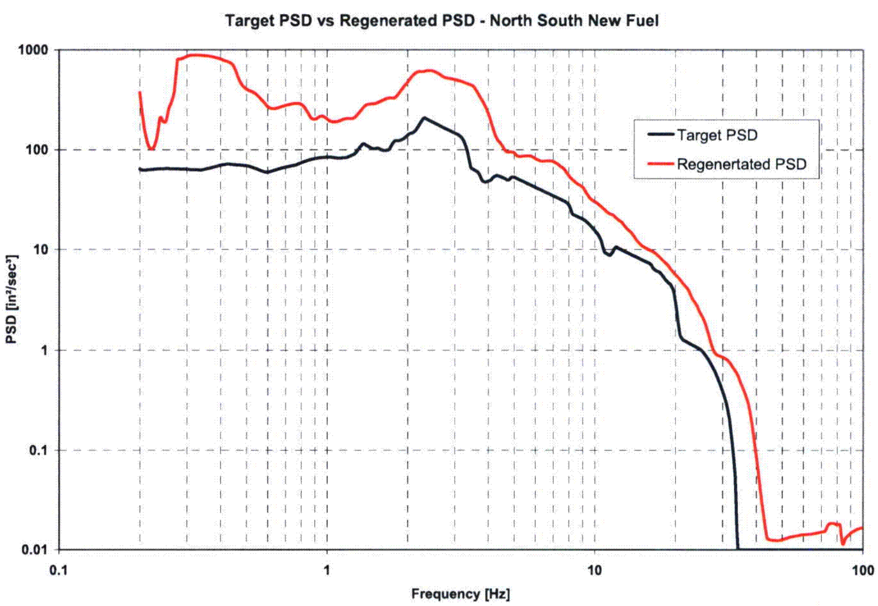


Figure TR44-11.8 New Fuel Power Spectral Density for NS Direction

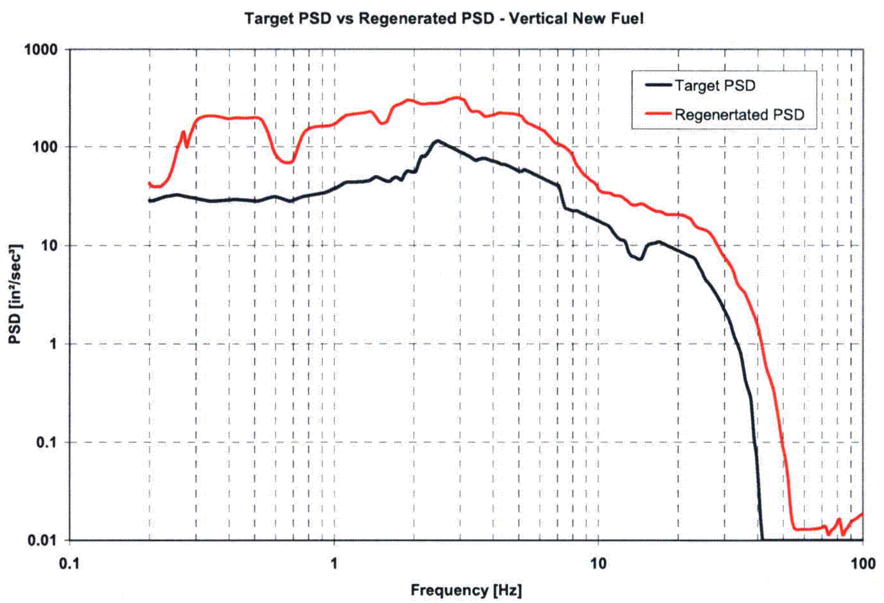


Figure TR44-11.9 New Fuel Power Spectral Density for VT Direction

e) Acceleration time histories are used as the input motion for the seismic analysis of the new fuel rack. The acceleration input is defined by three orthogonal components, which are input and solved simultaneously. Gravity is also included in the time history analysis.

References:

1. APP-GW-GLR-026, Revision 0, "New Fuel Storage Rack Structural/Seismic Analysis," (Technical Report Number 44)
2. Westinghouse Calculation APP-GW-S2R-010, Revision 2, "Extension of NI Structures Seismic Analysis to Soil Sites"

Design Control Document (DCD) Revision:
None

PRA Revision:
None

Technical Report (TR) Revision:
Technical Report Number 44 ~~(APP-GW-GLR-026, Revision 0 will be~~has been revised to reflect the ~~probable~~ change in floor response spectra.

Section 2.2.1 was revised to include the following paragraph:
"The acceleration time histories for the New Fuel FRS are used as the input motion for the seismic analysis of the new fuel rack. The three orthogonal components are input and solved simultaneously together with a constant 1-g gravity acceleration."

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-TR44-012
Revision: 1

Question:

How are the different impact stiffness values determined for the fuel assembly-to- cell wall, rack to wall, and pedestal-to-bearing pad? Since the impact forces can be greatly affected by the impact spring constant, what is the sensitivity of the impact forces and rack responses to variation in these spring constants? Are impact forces imparted directly onto the cell walls or are there impact bars?

Staff Assessment: Response similar to response for spent fuel racks. See RAI-TR54-021.

Following the submittal of the Westinghouse Revision 1 response to RAI-TR54-021, the NRC staff requested additional information:

(1) Explain why the fuel to cell wall impact stiffness is determined based on the solution of a simply supported circular plate under a concentrated load applied at its center. If the impact between the fuel assembly and the cell wall occurs at the fuel rod spacer grids, which extend beyond the fuel rods, then wouldn't the cross section of the grids define the loading on the cell wall for determining the impact stiffness? Could impact also occur between the individual outer row of fuel rods and the cell walls away from the spacer grids? If so, then shouldn't this loading pattern also be considered?

(2) As requested in the original RAI, describe how the impact stiffness values are determined for the rack to rack and rack to wall impacts. This description should include the approach used for the impacts at the bottom and the top of the racks, which are expected to be different.

(3) For the rack to floor impact spring, provide an explanation/derivation of the equation presented for the spring constant of the cellular structure and E_{eff}, which appear to govern the total rack to floor impact spring constant.

Westinghouse Response:

The impact stiffness values for the rack to wall and pedestal to bearing pad (concrete floor) are calculated as shown in Attachment 1 to this RAI response. The fuel to cell wall impact stiffness is determined based on the solution for a simply supported circular plate under a concentrated load applied at its center, where the plate diameter is equal to the cell inner dimension and the plate thickness is equal to the cell wall thickness. The stiffness of the annular plate is then multiplied by the number of loaded storage cells for the new fuel storage rack, since the stored fuel assemblies are assumed to rattle in unison. A sensitivity study has not been performed specifically for the AP1000 new fuel rack to quantify the effect of variations in the impact stiffness values. However, sensitivity studies have been performed in the past for similar spent fuel rack applications submitted by Holtec, which employed the same method of computing the impact stiffness values, and the impact forces were found to be insensitive to small variations in the stiffness values provided that the integration time step was sufficiently small. There are no impact bars at the top of the new fuel storage rack. However, the new fuel storage rack is braced against the north and south walls of the New Fuel Storage Pit by inserting stainless steel wedges in the interstitial space between the top of the new fuel storage rack and the pit opening. Figure TR44-9.1, which is part of the response to RAI TR44-09, provides a sketch of the new fuel storage rack inside the New Fuel Storage Pit with the wedges installed.

Westinghouse Supplemental Response following May 21 and 22, 2008 Technical Review:

Since the Westinghouse submittal of the Revision 0 response to this RAI, the design of the new fuel storage pit was changed to remove the concrete corbels at the top of the pit and the stainless steel wedges that were to be welded in the interstitial space between the top of the new fuel storage rack and the pit opening following installation of the rack.

Westinghouse provided responses to items (1), (2), and (3) above as part of RAI-TR54-021, and following the May 21 and 22, 2008 technical review the RAI was considered resolved for the spent fuel racks. Since the impact stiffness values for the new and spent fuel racks are determined using the same method and assumptions, Westinghouse considers this RAI to be resolved for the new fuel rack also.

Reference:

1. APP-GW-GLR-026, Revision 0, "New Fuel Storage Rack Structural/Seismic Analysis," (Technical Report Number 44)

Design Control Document (DCD) Revision:
None

PRA Revision:
None

Technical Report (TR) Revision:
None

RAI Response Number: RAI-TR44-014
Revision: 1

Question:

Section 2.2.2.2 of the report describes the modeling of a single rack. It indicates that the rack cellular structure elasticity is modeled by a 3-D beam having three translational and three rotational degrees-of-freedom (DOFs) at each end so that two-plane bending, tension/compression, and twist of the rack are accommodated. Explain why shear stiffness/deformation is not also included. Provide more detailed information about how the beam model of the rack was developed, considering that it is an assembly of many square-celled structures welded at discrete locations.

Staff Assessment: Response similar to response for spent fuel racks. See RAI-TR54-023.

As a result of the October 8-12, 2007 audit, **confirmatory** pending submittal of supplemental response and the application of the same resolution as noted in TR54-23, to the new fuel rack.

Westinghouse Response:

Shear deformation is included in the rack dynamic model. The beam model of the rack was developed based on the applicable Codes, Standards and Specifications given in Section IV(2) of the NRC guidance on spent fuel pool modifications entitled, "Review and Acceptance of Spent Fuel Storage and Handling Applications," dated April 14, 1978, which states that "Design ... may be performed based upon the AISC specification or Subsection NF requirements of Section III of the ASME B&PV Code for Class 3 component supports." The rack modeling technique is consistent with the linear support beam-element type members covered by these codes.

Westinghouse Supplemental Response following May 21 and 22, 2008 Technical Review:

For spent fuel racks RAI-TR54-023, Section 2.2.2.2 of TR-54 was revised to clarify that shear stiffness/deformation is also included in the rack model. Following the May 21 and 22, 2008 technical review this item was resolved for the spent fuel racks. Section 2.2.2.2 of TR-44 was revised similarly for the new fuel rack; see the Technical Report Revision section below for details.

For spent fuel racks RAI-TR54-023, the staff found that the methodology for the development of the beam properties of the rack based on Reference 10 of TR-54, as applicable for the honeycomb construction case cited in the paper, and the use of this approach in prior licensing applications was acceptable and therefore this item was considered resolved. For the new fuel rack, this paper is listed as Reference 9 in TR-44. Since this is the same reference, Westinghouse considers this item to be resolved for the new fuel rack as well.

Reference:

1. APP-GW-GLR-026, Revision 0, “New Fuel Storage Rack Structural/Seismic Analysis,” (Technical Report Number 44)
2. NRC Letter Guidance on spent fuel pool modifications, Section IV(2) “Review and Acceptance of Spent Fuel Storage and Handling Applications,” April 14,1978.

Design Control Document (DCD) Revision:
None

PRA Revision:
None

Technical Report (TR) Revision:
TR44 will be revised to include the discussion on shear deformation presented in the RAI-TR44-014 response.

Section 2.2.2.2 of TR44 was revised as follows:

Finally, Figure 2-6 provides a schematic diagram of the coordinates and the beam springs used to simulate the elastic bending behavior and shear deformation of the rack cellular structure in two-plane bending. Not shown are the linear springs modeling the extension, compression, and twisting behavior of the cellular structure.

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-TR44-015
Revision: 1

Question:

Section 2.2.2.2 refers to Figure 2-2 for the dynamic beam model of a single rack. The text and figure do not adequately describe the model. Therefore, explain the following:

(a) Define what each series of nodal DOFs correspond to (i.e., nodes 1,2; P1, P2, ...; q4, q5, ..., 1*, 2*, ...). While some of these may be deduced by judgement, the report should clearly define all of these.

(b) Explain whether there are 5 nodes and 4 beams along the rack beam model to coincide with the 5 nodes and 4 elements of the fuel assemblies.

Staff Assessment: Response similar to response for spent fuel racks. See RAI-TR54-024.

As a result of the October 8-12, 2007 audit, confirmatory pending submittal of supplemental response and the application of the same resolution as noted in TR54-24, to the new fuel rack.

Westinghouse Response:

a. The following table defines the nodal DOFs for the dynamic beam model of a single rack as depicted in Figure 2-2 of the Technical Report.

<table>
<tr><th>LOCATION (Node)</th><th colspan="3">DISPLACEMENT</th><th colspan="3">ROTATION</th></tr>
<tr><td></td><td>U_x</td><td>U_y</td><td>U_z</td><td>θ_x</td><td>θ_y</td><td>θ_z</td></tr>
<tr><td>1</td><td>p_1</td><td>p_2</td><td>p_3</td><td>q_4</td><td>q_5</td><td>q_6</td></tr>
<tr><td>2</td><td>p_7</td><td>p_8</td><td>p_9</td><td>q_{10}</td><td>q_{11}</td><td>q_{12}</td></tr>
<tr><td colspan="7">Node 1 is assumed to be attached to the rack at the bottom most point.
Node 2 is assumed to be attached to the rack at the top most point.
Refer to Figure 2-2 of COLA Technical Report APP-GW-GLR-026 for node identification.</td></tr>
<tr><td>2^*</td><td>p_{13}</td><td>p_{14}</td><td colspan="4" rowspan="4"></td></tr>
<tr><td>3^*</td><td>p_{15}</td><td>p_{16}</td></tr>
<tr><td>4^*</td><td>p_{17}</td><td>p_{18}</td></tr>
<tr><td>5^*</td><td>p_{19}</td><td>p_{20}</td></tr>
</table>

1*	p_{21}	p_{22}

where the relative displacement variables q_i are defined as:

$p_i = q_i(t) + U_x(t)$ $i = 1,7,13,15,17,19,21$

$= q_i(t) + U_y(t)$ $i = 2,8,14,16,18,20,22$

$= q_i(t) + U_z(t)$ $i = 3,9$

$= q_i(t)$ $i = 4,5,6,10,11,12$

p_i denotes absolute displacement (or rotation) with respect to inertial space

q_i denotes relative displacement (or rotation) with respect to the floor slab

* denotes fuel mass nodes

U(t) are the three known earthquake displacements

b. The rack cell structure is modeled as a single beam between two nodes, which are located at the top of the rack and at the baseplate elevation. This is consistent with Holtec's standard model for seismic analysis of spent fuel racks, which has been reviewed and approved by the NRC on numerous dockets. Although there is not a one-to-one correspondence between beam nodes and fuel assembly nodes, fuel-to-cell wall impact loads, which can occur at elevation 0, 0.25H, 0.5H, 0.75H, and H (where H is the height of the cell structure), are properly transmitted to the rack beam in accordance with the methodology outlined in Reference 10 in COLA Technical Report APP-GW-GLR-026, Revision 0.

Westinghouse Supplemental Response following May 21 and 22, 2008 Technical Review:

a. For the resolution to spent fuel racks RAI-TR54-024, Westinghouse added the equivalent table as shown above in the Revision 0 response of Item A to Revision 1 of TR54 as Table 2-18. The staff reviewed Section 2.2.2.2 and Table 2-18, and following the May 21 and 22, 2008 technical review this item was resolved. The equivalent table is added to TR44, Rev. 1 for the new fuel rack; see the Technical Report Revision section.

b. For the resolution to spent fuel racks RAI-TR54-024, the NRC staff reviewed the approach described in Reference 11 of Technical Report APP-GW-GLR-033, Revision 0, for the use of the coupling terms to relate the internal deformations of the fuel nodes to the external deformations of the fuel rack beam nodes at the two ends. Based on this review and the use of this method in prior licensing submittals to the NRC, the staff found this approach to be acceptable and considered this item resolved. For the new fuel rack, this paper is listed as Reference 10 in TR-44. Since this is the same reference which has already been reviewed and accepted, Westinghouse considers this item to be resolved for the new fuel rack as well.

References:

1. APP-GW-GLR-026, Revision 0, "New Fuel Storage Rack Structural/Seismic Analysis," (Technical Report Number 44)
2. Levy, S., and Wilkinson, John, "The Component Element Method in Dynamics," McGraw Hill, 1976.

Design Control Document (DCD) Revision:
None

PRA Revision:
None

Technical Report (TR) Revision:
Table 2-16 is added to Section 2.2.2.2:

Table 2-16 Degrees of Freedom for Single Rack Dynamic Model

Location (Node)	Displacement			Rotation		
	U_x	U_y	U_z	θ_x	θ_y	θ_z
1	p_1	p_2	p_3	q_4	q_5	q_6
2	p_7	p_8	p_9	q_{10}	q_{11}	q_{12}

Node 1 is assumed to be attached to the rack at the bottom most point.

Node 2 is assumed to be attached to the rack at the top most point.

Refer to Figure 2-2 for node identification.

2*	p_{13}	p_{14}
3*	p_{15}	p_{16}
4*	p_{17}	p_{18}
5*	p_{19}	p_{20}
1*	p_{21}	p_{22}

where the relative displacement variables q_i are defined as:

$p_i = q_i(t) + U_x(t)$ $i = 1,7,13,15,17,19,21$
$\quad = q_i(t) + U_y(t)$ $i = 2,8,14,16,18,20,22$
$\quad = q_i(t) + U_z(t)$ $i = 3,9$
$\quad = q_i(t)$ $i = 4,5,6,10,11,12$

p_i denotes absolute displacement (or rotation) with respect to inertial space
q_i denotes relative displacement (or rotation) with respect to the floor slab

* denotes fuel mass nodes
U(t) are the three known earthquake displacements

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-TR44-016
Revision: 1

Question:

Explain whether only a full fuel rack is considered in the simulation, or if several scenarios are considered; i. e., different fill ratios, from empty to full. Provide the technical justification if only a full rack is considered.

Staff Assessment: Response similar to response for spent fuel racks. See RAI-TR54-025.

Westinghouse Response:

The new fuel rack is assumed to be fully loaded with maximum weight fuel assemblies in all three simulations. This scenario bounds any partially loaded configuration since it (1) maximizes the vertical compression and lateral friction loads on the support pedestals and (2) produces the maximum rack displacements and fuel-to-cell wall impacts. The displacements are larger for a fully loaded rack, as opposed to a partially filled rack, because the dynamic model conservatively assumes that all stored fuel assemblies rattle in unison. Hence, the momentum transferred between the rattling fuel mass and the spent fuel rack is maximum for a fully loaded rack. For a partially filled rack, the decrease in rattling fuel mass outstrips the destabilizing effect of an eccentric fuel loading pattern.

Westinghouse Supplemental Response following May 21 and 22, 2008 Technical Review:

For the similar spent fuel racks RAI-TR54-025, the NRC found that the Westinghouse response "does appear to support the conclusion that generally the fully loaded racks would be expected to maximize impact forces and displacements." The NRC reviewer also concluded that "the use of the maximum weight for the fuel assemblies, the analysis assumption that all stored fuel assemblies rattle in unison, and consideration of the upper and lower bound coefficient of friction at all support legs provide added conservatism to bound the results from the other possible variations." Therefore, Westinghouse considers the above response to RAI-TR44-016 to be resolved for the new fuel rack.

Section 9.1.1.2.1 of the DCD will be revised to eliminate the reference to performing seismic and stress analyses that evaluate partially full and empty fuel assembly loadings of the new fuel rack.

Reference:

1. APP-GW-GLR-026, Revision 0, "New Fuel Storage Rack Structural/Seismic Analysis," (Technical Report Number 44)

Design Control Document (DCD) Revision:

The first paragraph under Item A of Section 9.1.1.2.1 is revised as follows:

~~The new fuel storage racks are purchased equipment.~~ The rack array center-to-center spacing of nominally 10.9 inches provides a minimum separation between adjacent fuel assemblies sufficient with neutron absorbing material to maintain a subcritical array. ~~The purchase specification for the new fuel storage racks will require the vendor to perform confirmatory dynamic and stress analyses.~~ The seismic and stress analyses of the new fuel rack considers the ~~various~~ conditions of full~~, partially filled, and empty~~ fuel assembly loadings. The rack is evaluated for the safe shutdown earthquake condition against the seismic Category I requirements. A stress analysis is performed to verify the acceptability of the critical load components and paths under normal and faulted conditions. The rack rests on the pit floor ~~and is braced as required to the pit wall structures~~.

PRA Revision:

None

Technical Report (TR) Revision:

None

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-TR44-017
Revision: 1

Question:

What are the gaps and tolerances for each of the gaps between the fuel assembly and cell wall, and between the rack and vault wall? What are the assumed initial locations of the various components (fuel assemblies and rack) and what is the technical basis for this assumption. Were any studies done for different initial conditions (considering tolerances); if not, explain why it was not necessary. Are there requirements in the DCD to ensure that the assumed gaps (considering tolerances) are maintained throughout the operating license period?

Staff Assessment: Response similar to response for spent fuel racks. See RAI-TR54-026.

Westinghouse Response:

All gaps between fuel assemblies and cell walls and between the rack and vault walls are set to match the nominal gaps provided on the layout drawing. Table TR44-017.1 summarizes the gap information used in the dynamic analyses.

	Fuel-to-Cell Wall	Rack-to-Wall
Nominal Gap (inch)	(8.8"-8.404")/2 = 0.198"	North – 0" (see note 1) East – 28.7" South – 0" (see note 1) West – 28.7"

Table TR44-017.1 Gap Information used in the Dynamic Analysis of the New Fuel Rack

Note:
1. The new fuel storage rack is braced against the north and south walls of the New Fuel Storage Pit by inserting stainless steel wedges in the interstitial space between the top of the new fuel storage rack and the New Fuel Storage Pit opening (see TR44-009 RAI Response Figure TR44-9.1).

Fuel is assumed centrally located in cell. This is conservative since minimizing gap on one or two walls will generally produce a larger hydrodynamic coupling effect.

Some numerical studies were done on other rack projects; the results generally showed a small influence on results. A larger influence occurs if the gaps are assumed to be displacement dependent, rather than always being held constant at their initial value. The neglect of this effect is conservative.

Once the new fuel rack is installed, the "as-built" gaps are reconciled with the gaps initially used for analysis by evaluation of the numerical results and the predicted motions. The new fuel rack will be positioned in the New Fuel Storage Pit per the gap information provided in Table TR44-017.1. The only way the gaps would change over time would be by the action of a seismic event. Combined License applicants will have a procedure in place to address measurement of the post design-basis seismic event gaps, and to evaluate the acceptability of the configuration showing it is acceptable, or to take appropriate corrective actions. A statement will be added to the Technical Report addressing the design-basis seismic event potential change in gaps between the new fuel rack and New Fuel Storage Pit walls.

Westinghouse Supplemental Response following May 21 and 22, 2008 Technical Review:

Since the Westinghouse submittal of the Revision 0 response to this RAI, the design of the new fuel storage pit was changed to remove the concrete corbels at the top of the pit and the stainless steel wedges that were to be welded in the interstitial space between the top of the new fuel storage rack and the pit opening following installation of the rack. As a result of the changes to the new fuel storage pit, the updated gap information is provided in the table below and was used in the dynamic analyses. Note that a conservative gap size was used for the fuel-to-cell wall gap in the dynamic analysis based on the smallest fuel assembly cross-section of 8.404 inches. The largest fuel assembly cross-section is 8.426 inches which equates to a 0.187 inch fuel-to-cell wall gap.

	Fuel-to-Cell Wall	Rack-to-Wall
Nominal Gap (inch)	(8.8"-8.404")/2 = 0.198"	North – 6.88" East – 28.93" South – 6.88" West – 28.93"

Per the structural/seismic calculation for the new fuel rack, APP-FS01-S3C-001, Revision 1, the maximum displacement at the top of the new fuel rack is 6.35". Therefore, the minimum gap between the new fuel rack and the pit walls (at the top of rack elevation) will be specified on Rev. 1 of Drawing APP-FS01-V2-002 as 6-3/8".

References:

1. APP-GW-GLR-026, Revision 0, "New Fuel Storage Rack Structural/Seismic Analysis," (Technical Report Number 44)
2. APP-FS01-S3C-001, Revision 1, "New Fuel Storage Rack Structural/Seismic Analysis"
3. Westinghouse Drawing APP-FS01-V2-002, Revision 1, "New Fuel Storage Rack Layout"

Design Control Document (DCD) Revision:
None

PRA Revision:
None

Technical Report (TR) Revision:
The following statement will be added to Technical Report 44 addressing the design-basis seismic event potential changes in gaps between the new fuel rack and walls of the new fuel storage pit:

"Per DCD subsection 3.7.5.2, Combined License applicants will prepare site-specific procedures for activities following an earthquake. These procedures will be used to accurately determine both the response spectrum and cumulative absolute velocity of the recorded earthquake ground motion from the seismic instrumentation system. An activity will be to address measurement of the post-seismic event gaps between the new fuel rack and walls of the new fuel storage pit and to take appropriate corrective actions."

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-TR44-019
Revision: 1

Question:

The load combinations specified in Table 2-3 of the subject report and Table 9.1-1 (markup version of the DCD provided in Section 5 of the subject report) do not appear to be consistent. Therefore, please explain the apparent inconsistencies and/or modify these tables to be consistent.

Staff Assessment: Acceptable, pending staff review of DCD Rev. 16, and staff review of the formally submitted Technical Report revision (TR44 Rev. 1). **Therefore, this RAI is confirmatory.**

Westinghouse Response:

Table 2-3 of Technical Report Number 44 will be revised as follows (which is derived from Appendix D to SRP Section 3.8.4):

Table 2-3 Loading Combinations for AP1000 New Fuel Storage Rack

Loading Combination	Service Level
$D + L$ $D + L + T_o$	Level A
$D + L + T_o + P_f$	Level B
$D + L + T_a + E'$	Level D
$D + L + F_d$	The functional capability of the fuel rack should be demonstrated.

Notes:

1. There is no operating basis earthquake (OBE) for the AP1000 plant.
2. The fuel rack is freestanding; thus, there is minimal or no restraint against free thermal expansion at the base of the rack. As a result, thermal loads applied to the rack (T_o and T_a) produce only local (secondary) stresses.

Abbreviations are those used in Reference 6:

D	=	Dead weight induced loads (including fuel assembly weight)
L	=	Live load (not applicable to fuel racks since there are no moving objects in the rack load path)
F_d	=	Force caused by the accidental drop of the heaviest load from the maximum possible height
P_f	=	Upward force on the racks caused by postulated stuck fuel assembly
E'	=	Safe Shutdown Earthquake (SSE)
T_o	=	Differential temperature induced loads based on the most critical transient or steady state condition under normal operation or shutdown conditions
T_a	=	Differential temperature induced loads based on the postulated abnormal design conditions

DCD Table 9.1-1 Loads and Load Combinations for Fuel Racks has been revised as follows:

Table 9.1-1

LOADS AND LOAD COMBINATIONS FOR FUEL RACKS

Load Combination	Service Level
$D + L$ $D + L + T_o$	Level A
$D + L + T_o + P_f$	Level B
$D + L + T_a + E'$	Level D
$D + L + F_d$	The functional capability of the fuel racks should be demonstrated.

Notes:

1. There is no operating basis earthquake (OBE) for the AP1000 plant.
2. The fuel racks are freestanding; thus, there is minimal or no restraint against free thermal expansion at the base of the rack. As a result, thermal loads applied to the rack (T_o and T_a) produce only local (secondary) stresses.

Abbreviations are those used in NUREG-0800, Section 3.8.4 (including Appendix D) of the Standard Review Plan (SRP):

- D = Dead weight induced loads (including fuel assembly weight)
- L = Live load (not applicable to fuel racks since there are no moving objects in the rack load path)
- F_d = Force caused by the accidental drop of the heaviest load from the maximum possible height
- P_f = Upward force on the racks caused by postulated stuck fuel assembly
- E' = Safe Shutdown Earthquake (SSE)
- T_o = Differential temperature induced loads based on the most critical transient or steady state condition under normal operation or shutdown conditions
- T_a = Differential temperature induced loads based on the postulated abnormal design conditions

Westinghouse Supplemental Response following May 21 and 22, 2008 Technical Review:

This response has already been assessed by the NRC staff and determined to be acceptable. However, for the similar spent fuel racks RAI-TR54-029, the NRC staff had additional comments; the same resolution of these comments applies to the new fuel rack as well:

Reference 5 in TR44 Revision 1 has been eliminated. Reference 6 is the basis for the analysis and evaluation. Analysis and evaluation follow the U.S. NRC Standard Review Plan 3.8.4, Revision 1. A statement has been added to Section 2.0, "Technical Background" and Subsection 2.3.1, "Introduction", stating: Analyses and evaluations follow the U.S. NRC Standard Review Plan 3.8.4 Revision 1 (Reference 6). Although the licensing basis for the AP1000 design invokes NRC SRP 3.8.4, Revision 1, an evaluation has been performed to confirm that the stress analysis of the new fuel rack also satisfies the applicable provisions of NRC SRP 3.8.4, Revision 2 (Reference 24).

Westinghouse has reviewed Revisions 1 and 2 of SRP 3.8.4 (Appendix D). The only difference between the two is the following paragraph (which appears in Rev. 2 only):

"If the spent fuel racks are designed to be free standing (i.e., without connections to the pool walls/floor), then their response involves a complex combination of motions that includes sliding, rocking, and twisting and involves impacts between the fuel assemblies and the fuel cell walls, rack-to-rack, and rack-to-wall. In view of this, the seismic analysis of these fuel racks is typically performed using nonlinear dynamic time history analysis methods. NUREG/CR-5912 provides further guidance on the design and analysis of free-standing racks."

Since the Holtec computer code DYNARACK is fully capable of simulating the combination of motions and the various impact scenarios described above, and it employs the time history analysis method together with nonlinear spring elements, the seismic analyses of the AP1000 new and spent fuel racks are in compliance with Appendix D of SRP 3.8.4 Rev. 2.

Table 2-3 is revised and can be seen in the TR Revision section below.

Reference:
1. APP-GW-GLR-026, Revision 0, "New Fuel Storage Rack Structural/Seismic Analysis,"

Design Control Document (DCD) Revision:
Table 9.1-1 as shown above has been revised in DCD Revision 16.

PRA Revision:
None

Technical Report (TR) Revision:
Table 2-3 as shown above will revised in Technical Report Number 44.

Revisions to DCD, PRA, and TR following May 21 and 22, 2008 Technical Review:

Design Control Document (DCD) Revision:
Table 9.1-1 has been revised as follows:

Table 9.1-1

LOADS AND LOAD COMBINATIONS FOR FUEL RACKS

Load Combination	Service Level
D + L $D + L + T_o$	Level A
$D + L + T_a$ $D + L + T_o + P_f$	Level B
$D + L + T_a + E'$	Level D
$D + L + F_d$	The functional capability of the fuel racks should be demonstrated.

Notes:

1. There is no operating basis earthquake (OBE) for the AP1000 plant.
2. The fuel racks are freestanding; thus, there is minimal or no restraint against free thermal expansion at the base of the rack. As a result, thermal loads applied to the rack (T_o and T_a) produce only local (secondary) stresses.

Abbreviations are those used in NUREG-0800, Section 3.8.4 (including Appendix D) of the Standard Review Plan (SRP):

D = Dead weight induced loads (including fuel assembly weight)

L = Live load (not applicable to fuel racks since there are no moving objects in the rack load path)

F_d = Force caused by the accidental drop of the heaviest load from the maximum possible height

P_f = Upward force on the racks caused by postulated stuck fuel assembly

E' = Safe Shutdown Earthquake (SSE)

T_o = Differential temperature induced loads based on the most critical transient or steady state condition under normal operation or shutdown conditions

T_a = Differential temperature induced loads based on the postulated abnormal design conditions

PRA Revision:
None

Technical Report (TR) Revision:
Table 2-3 was revised as follows:

Table 2-3 Loading Combinations for AP1000 New Fuel Storage Rack

Loading Combination	Service Level
D + L D + L + T_o	Level A
D + L + T_a D + L + T_o + P_f	Level B
D + L + T_a + E'	Level D
D + L + F_d	The functional capability of the fuel rack should be demonstrated.

Notes:

1. There is no operating basis earthquake (OBE) for the AP1000 plant.
2. The fuel rack is freestanding; thus, there is minimal or no restraint against free thermal expansion at the base of the rack. As a result, thermal loads applied to the rack (T_o and T_a) produce only local (secondary) stresses.

Abbreviations are those used in Reference 6:

D = Dead weight induced loads (including fuel assembly weight)

L = Live load (not applicable to fuel rack since there are no moving objects in the rack load path)

F_d = Force caused by the accidental drop of the heaviest load from the maximum possible height

P_f = Upward force on the rack caused by postulated stuck fuel assembly

E' = Safe Shutdown Earthquake (SSE)

T_o = Differential temperature induced loads based on the most critical transient or steady state condition under normal operation or shutdown conditions

T_a = Differential temperature induced loads based on the postulated abnormal design conditions

Section 2.0, "Technical Background", was revised as follows:
This report considers the structural adequacy of the proposed AP1000 New Fuel Storage Rack under postulated loading conditions. Analyses and evaluations follow the ~~U.S. Office of Technology Position Paper (Reference 5) and the~~ NRC Standard Review Plan, Revision 1 (Reference 6). Although the licensing basis for the AP1000 design invokes NRC SRP 3.8.4, Revision 1, an evaluation has been performed to confirm that the stress analysis of the new fuel rack also satisfies the applicable provisions of NRC SRP 3.8.4, Revision 2 (Reference 24).The dynamic analyses use a time-history simulation code used in numerous previous licensing efforts in the United States and abroad. This report provides a discussion of the method of analyses, modeling assumptions, key evaluations, and results obtained to establish the margins of safety. The objective of this report is to develop the loads on the AP1000 New Fuel Storage Rack and confirm that the loads do not pose a threat to the stored fuel assemblies.

Section 2.3.1, "Introduction", was revised as follows:
The AP1000 New Fuel Storage Rack is designed as seismic Category I. ~~The U.S. Office of Technology Position Paper (Reference 5) and~~ The NRC Standard Review Plan 3.8.4 (Reference 6) states that the ASME Code Section III, subsection NF (Reference 11), as applicable for Class 3 Components, is an appropriate vehicle for design. In the following sections, the ASME limits are set down first, followed by any modifications by project specification, where applicable.

Revised Reference 5 in Section 4.0 as follows:
5. Deleted

Revised Reference 6 in Section 4.0 as follows:
6. U.S. NRC Standard Review Plan, NUREG-0800 (SRP 3.8.4, Rev. 1)

Revised Section 4.0 to include the following reference:
24. U.S. NRC Standard Review Plan, NUREG-0800 (SRP 3.8.4, Rev. 2)

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-TR44-020
Revision: 1

Question:

When utilizing ASME Code, Section III, Subsection NF, are all of the applicable provisions in NRC Regulatory Guide, 1.124, Revision 1 also satisfied? This should be clearly stated in the report and the DCD.

Staff Assessment: Response similar to response for spent fuel racks. See RAI-TR54-030.

Westinghouse Response:

The following statement "The stress analysis of the new fuel rack satisfies all of the applicable provisions in NRC Regulatory Guide 1.124, Revision 1 for component supports designed by the linear elastic analysis method" will be added to Technical Report APP-GW-GLR-026 and the DCD.

Westinghouse Supplemental Response following May 21 and 22, 2008 Technical Review:

Based on the resolution to RAI-TR54-30, the following statements were added to Section 2.3.1 of TR44:

"In addition, the stress analysis of the new fuel rack satisfies all of the applicable provisions in NRC Regulatory Guide 1.124 (Reference 25) for component supports designed by the linear elastic analysis method. Although the licensing basis for the AP1000 design invokes Reg. Guide 1.124 Revision 1, an evaluation has been performed to confirm that the stress analysis of the spent fuel racks also satisfies the applicable provisions of Reg. Guide 1.124, Revision 2 (Reference 26)."

Also, Section 4.0 was revised to include the following references:

25. U.S. NRC, Regulatory Guide 1.124, Rev. 1, "Service Limits and Loading Combinations for Class 1 Linear-Type Component Supports," January 1978.

26. U.S. NRC, Regulatory Guide 1.124, Rev. 2, "Service Limits and Loading Combinations for Class 1 Linear-Type Component Supports," February 2007.

References:

1. APP-GW-GLR-026, Revision 0, "New Fuel Storage Rack Structural/Seismic Analysis," (Technical Report Number 44)

2. US NRC Regulatory Guide 1.124, Revision 1, "Service Limits and Loading Combinations for Class 1 Linear-Type Component Supports," January 1978.

Design Control Document (DCD) Revision:
A statement will be added to DCD Subsection 9.1.1.1 stating that the stress analysis of the new fuel rack satisfies all of the applicable provisions in NRC Regulatory Guide 1.124, Revision 1.

Table 1.9-1 (Sheet 10 of 15) "Regulatory Guide/DCD Section Cross-References" will be revised for Regulatory Guide 1.124 to include DCD Subsection 9.1.1.1.

PRA Revision:
None

Technical Report (TR) Revision:
A statement will be added to Technical Report Number 44 stating that the stress analysis of the new fuel rack satisfies all of the applicable provisions in NRC Regulatory Guide 1.124, Revision 1.

Revisions to DCD, PRA, and TR following May 21 and 22, 2008 Technical Review:

Design Control Document (DCD) Revision:
None

PRA Revision:
None

Technical Report (TR) Revision:
Section 2.3.1 was revised to include the following statements:
The stress analysis of the new fuel rack also satisfies all of the applicable provisions in NRC Regulatory Guide 1.124, Revision 1 (Reference 25) for components designed by the linear elastic analysis method. In addition, an evaluation has been performed to confirm that the stress analysis of the new fuel rack also satisfies the applicable provisions of Reg. Guide 1.124, Revision 2.

Section 4.0 was revised to include the following references:

25. U.S. NRC, Regulatory Guide 1.124, Rev. 1, "Service Limits and Loading Combinations for Class 1 Linear-Type Component Supports," January 1978.

26. U.S. NRC, Regulatory Guide 1.124, Rev. 2, "Service Limits and Loading Combinations for Class 1 Linear-Type Component Supports," February 2007.

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-TR44-021
Revision: 1

Question:

Section 2.3.4.3, first paragraph, refers to 304L stainless steel material and uses 70 ksi for ultimate and 25 ksi for yield. Explain why these values are lower than the ultimate and yield strengths given in Table 2-5 for type 304 stainless steel.

Staff Assessment: Acceptable, pending staff review of the formally submitted Technical Report revision. **Therefore, this RAI is confirmatory.**

Westinghouse Response:

There was a mistake made in the first paragraph of Section 2.3.4.3. Table 2-5 is correct in its reference to Type 304 stainless steel. The revised first paragraph of Section 2.3.4.3 is as follows: Section F-1334 (ASME Section III, Appendix F [Reference 14]), states that limits for the Level D condition are the smaller of 2 or 1.167 S_u/S_y times the corresponding limits for the Level A condition if $S_u > 1.2\ S_y$ or 1.4 if $S_u < 1.2\ S_y$ except for requirements specifically listed below. S_u and S_y are the properties for 304 stainless steel demonstrate that 1.2 times the yield strength is less than the ultimate strength. Since 1.167* (75,000/30,000) = 2.92, the multiplier of 2.0 controls.

Westinghouse Supplemental Response following May 21 and 22, 2008 Technical Review:

This response has already been assessed by the NRC staff and determined to be acceptable. However, a sentence was inadvertently omitted in the markup. The first paragraph of Section 2.3.4.3 of TR44, Revision 1, is changed as follows:

Section F-1334 (ASME Section III, Appendix F [Reference 14]), states that limits for the Level D condition are the smaller of 2 or 1.167 S_u/S_y times the corresponding limits for the Level A condition if $S_u > 1.2\ S_y$ or 1.4 if $S_u < 1.2\ S_y$ except for requirements specifically listed below. S_u and S_y are the properties for 304 stainless steel at the specified rack design temperature. Examination of material properties of 304 stainless steel demonstrates that 1.2 times the yield strength is less than the ultimate strength. Since 1.167* (75,000/30,000) = 2.92, the multiplier of 2.0 controls.

Reference:

1. APP-GW-GLR-026, Revision 0, “New Fuel Storage Rack Structural/Seismic Analysis,” (Technical Report Number 44)

Design Control Document (DCD) Revision:
None

PRA Revision:
None

Technical Report (TR) Revision:
The first paragraph of Section 2.3.4.3 is revised as follows:

Section F-1334 (ASME Section III, Appendix F [Reference 14]), states that limits for the Level D condition are the smaller of 2 or 1.167 S_u/S_y times the corresponding limits for the Level A condition if $S_u > 1.2\ S_y$ or 1.4 if $S_u < 1.2\ S_y$ except for requirements specifically listed below. S_u and S_y are the properties for 304 stainless steel at the specified rack design temperature. Examination of material properties of 304 stainless steel demonstrates that 1.2 times the yield strength is less than the ultimate strength. Since 1.167* (75,000/30,000) = 2.92, the multiplier of 2.0 controls.

RAI Response Number: RAI-TR44-024
Revision: 1

Question:

Some of the information provided in Section 2.8.2 (Rack Structural Evaluation) and Tables 2-6 through 2-14 (stress results) is not clear. Therefore, describe/explain the following:

(a) Section 2.8.2.1, 2nd paragraph, indicates that the tables also report the stress factors for the AP1000 New Fuel Storage Rack cellular cross section just above and below the baseplate. This implies that the fuel cells continue below the baseplate. Please explain.

(b) The same paragraph refers to "pedestal five in the first sheet of the summary tables for each simulation (that is, 9.M.0 where M stands for run number)." Please explain what this means since the tables do not reflect this terminology.

(c) The same paragraph refers to "ensures that the overall structural criteria set forth in subsection 2.2.3 are met." Structural criteria are not presented in subsection 2.2.3.

(d) Section 2.8.2.2 a., refers to a stress factor of 2.1516 which it states is given in the tables. However, no such stress factor is given, please explain. Also, are all cells welded to the baseplate on all four sides?

(e)Section 2.8.2.2 b., indicates that a separate finite element model is used to check the baseplate to pedestal welds. Provide a short description of the model, computer code, loading, and location of the maximum tabulated stress in the weld referred to in Table 2-12.

(f) Section 2.8.2.2 c., indicates that for calculation of cell welds, the fuel assemblies in adjacent cells are conservatively calculated by assuming that the fuel assemblies in adjacent cells are moving out of phase with one another. It then states that cell to cell weld calculations are based on the maximum stress factor from all runs. However, elsewhere in the report, it was stated that all of the fuel assemblies in the simulation are assumed to vibrate in phase. Provide more information to explain this.

(g) Section 2.8.2.3 refers to Tables 2-6 through 2-13 for limiting thread stresses under faulted conditions for every pedestal. These tables do not seem to apply to pedestal thread shear stress. Therefore, clarify or correct this information.

(h) For Table 2-6, Results Summary, please identify what rack component/element applies to each of the column headings (i.e., Max Stress Factor, Max. Shear Load, Max Fuel to Cell Wall Impact). Similarly, for Tables 2-11, 2-13, and 2-14, identify what rack component/element the table applies to.

(i) Why is Table 2-14 labeled, "Allowable Shear Stress for Level D"? This is inconsistent with other tables. Please explain.

Staff Assessment: RAI and Westinghouse response are similar to RAI-TR54-036 and Westinghouse's response for spent fuel racks.

Westinghouse Response:

(a) The fuel cells do not continue below the baseplate. Stress factors are computed just above the baseplate, where the fuel cells are welded to the baseplate, and just below the baseplate where the support pedestals are welded. Section 2.8.2.1 (2nd paragraph, 2nd sentence) will be revised as follows:

> "The tables also report the stress factors for the AP1000 New Fuel Storage Rack cellular cross section just above the baseplate."

(b) The computer code DYNAPOST, which is listed in Table 2-15, computes the stress factors for the four support pedestals and for the cellular structure just above the baseplate based on the time history analysis results. For convenience, these five locations are identified as pedestal numbers 1 through 5 in the DYNAPOST output tables, which are not included in Technical Report APP-GW-GLR-026. Therefore, the sentence, "The locations above the base plate ... are referred to as pedestal five in the first sheet of the summary tables for each simulation (that is, 9.M.0 where M stands for run number).", is not relevant to the report and will be deleted.

(c) The reference to subsection 2.2.3 is a typo. The correct reference is subsection 2.3.3.

(d) The factor of 2.1516 is not provided in the tables as stated in text. Section 2.8.2.2 a. (2nd paragraph) will be revised as follows:

> "Weld stresses are determined through the use of a simple conversion (ratio) factor (based on area ratios) applied to the corresponding stress factor in the adjacent rack material. This conversion factor is developed from the differences in base material thickness and length versus weld throat dimension and length:"

All fuel cells are welded to the baseplate on all four sides.

(e) The finite element code ANSYS is used to resolve the tension and compression stresses in the pedestal weld due to the combined effects of a vertical compressive load in the pedestal and a bending moment caused by pedestal friction. The compression interface between the baseplate and the pedestal is modeled using contact elements. The perimeter nodes on the pedestal are connected to the baseplate by spring elements in order to simulate tension in the weld. The maximum instantaneous friction force on a single pedestal from the rack seismic analysis is conservatively applied to the finite element model in the horizontal x- and y-directions simultaneously, along with the concurrent vertical load, at the appropriate offset location. The perimeter nodes on the pedestal are restrained to move only in the vertical direction so that the spring elements only resist bending. The limiting ANSYS results are combined with the maximum horizontal shear loads to obtain the maximum weld stress. The maximum weld stress reported in Table 2-12 occurs at the corner of the pedestal where the tensile stress in the weld due to bending is maximum.

(f) All stored fuel assemblies within a rack are assumed to rattle in phase for the seismic analysis of the new fuel rack using the Holtec proprietary computer code MR216 (a.k.a. DYNARACK). This analysis yields the maximum impact force between a single fuel assembly and the surrounding cell walls. When evaluating the weld connection between adjacent storage cells, the maximum fuel-to-cell impact force from the dynamic analysis is conservatively multiplied by a factor of 2 to consider out-of-phase fuel rattling.

(g) The reference to "Tables 2-6 through 2-13" in Section 2.8.2.3 is incorrect. The first sentence in Section 2.8.2.3 should be revised as follows: "Table 2-14 provides the limiting thread stress under faulted conditions."

(h) In Table 2-6, the "Max. Stress Factor" column applies to the rack cell structure. The "Max. Vertical Load" and "Max. Shear Load" columns apply to a single rack pedestal. The "Max. Fuel-to-Cell Wall Impact" column provides the maximum impact force between a single fuel assembly and the surrounding cell wall at any of the five rattling fuel mass elevations (refer to Figure 2-5 of the report).

Table 2-11 applies to the base metal adjacent to the baseplate to cell welds. Table 2-13 provides the shear stress in the cell to cell welds as well as the adjacent base metal. Table 2-14 applies to the pedestal internal threads.

(i) Table 2-14 should be labeled "Pedestal Thread Shear Stress" instead of "Allowable Shear Stress for Level D". The allowable stresses reported in Tables 2-10 through 2-14 are Level D stress limits since the design basis earthquake is a faulted condition (Level D).

Westinghouse Supplemental Response following May 21 and 22, 2008 Technical Review:

Following the May 21 and 22, 2008 technical review, all of the items of the similar spent fuel racks RAI-TR54-036 were considered technically acceptable or confirmatory pending the incorporation of the described changes into TR54. Since the same approach was applied to the new fuel rack, Westinghouse considers the Rev. 0 responses of this RAI shown above to be technically acceptable for the new fuel rack as well.

References:

1. APP-GW-GLR-026, Revision 0, "New Fuel Storage Rack Structural/Seismic Analysis," (Technical Report Number 44)
2. APP-GW-GLR-033, Revision 2, "Spent Fuel Storage Rack Structural/Seismic Analysis," (Technical Report Number 54)

Design Control Document (DCD) Revision:
None

PRA Revision:
None

Technical Report (TR) Revision:
Revisions will be made to Technical Report Number 44 as shown below:

(a) Section 2.8.2.1 (2nd paragraph, 2nd sentence) will be revised as follows:

> "The tables also report the stress factors for the AP1000 New Fuel Storage Rack cellular cross section just above the baseplate."

(b) Section 2.8.2.1, 2nd paragraph, the entire sentence, "The locations above the base plate … are referred to as pedestal five in the first sheet of the summary tables for each simulation (that is, 9.M.0 where M stands for run number)." is not relevant to the report. This sentence will be deleted.

(c) Section 2.8.2.1, 2nd paragraph will be revised to reference subsection 2.3.3.

(d) Section 2.8.2.2 a. (2nd paragraph) will be revised as follows:

> "Weld stresses are determined through the use of a simple conversion (ratio) factor (based on area ratios) applied to the corresponding stress factor in the adjacent rack material. This conversion factor is developed from the differences in base material thickness and length versus weld throat dimension and length:"

(g) The first sentence in Section 2.8.2.3 will be revised as follows:

> "Table 2-14 provides the limiting thread stress under faulted conditions."

(i) Table 2-14 will be revised to "Pedestal Thread Shear Stress"

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-TR44-025
Revision: 1

Question:

In the markup of the DCD, provided in Section 5 of the topical report, Figure 9.1-1, New Fuel Storage Rack, is identified for deletion. Please explain why you are deleting this figure. This figure should be retained in the DCD.

Westinghouse Response:

We are in agreement. Revision 16 of the DCD will have a revised Figure 9.1-1 New Fuel Rack Layout. This figure will show the new fuel rack configuration in plan and elevation views identifying significant features and dimensions.

Westinghouse supplemental response from NRC Technical Meetings May 21 & 22, 2008

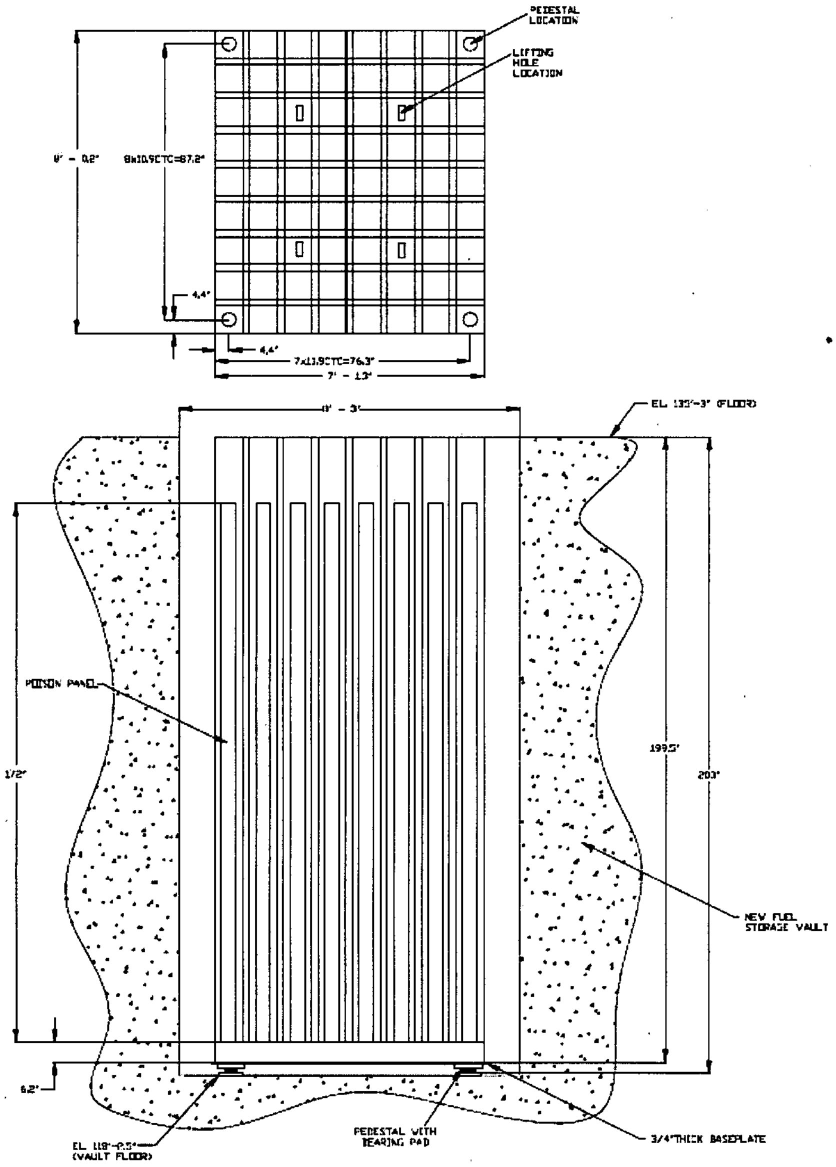
The new fuel rack has been changed to have additional storage cell height to protect control elements that are stored in the new fuel assemblies. Also the rack is not wedged in place in the North –South directions and is free to move within the new fuel storage vault. Revision 17 of the DCD and TR-44 revision 1 will have figures showing significant features and dimensions of the new fuel rack. The format for the new fuel rack significant features and dimensions is the same format reviewed and accepted by the NRC for the spent fuel racks. See changes in DCD revision and TR revision.

References:

1. APP-GW-GLR-026, Revision 0, "New Fuel Storage Rack Structural/Seismic Analysis," (Technical Report Number 44)
2. APP-GW-GLR-026, Revision 1, "New Fuel Storage Rack Structural/Seismic Analysis," (Technical Report Number 44)

Design Control Document (DCD) Revision:
Yes- Figure 9.1-1 New Fuel Rack Layout will be revised in DCD Revision 16 to show the new fuel rack configuration in plan and elevation views identifying significant features and dimensions.
Westinghouse supplemental response from NRC Technical Meetings May 21 & 22, 2008

Figures 9.1-1 (Sheet 1 of 2) and Figures 9.1-1 (Sheet 2 of 2) are changed as shown below.



NOTE
CTC=CENTER TO CENTER SPACING

Figure 9.1-1 (Sheet 1 of 2)

New Fuel Storage Rack Layout (72 Storage Locations)

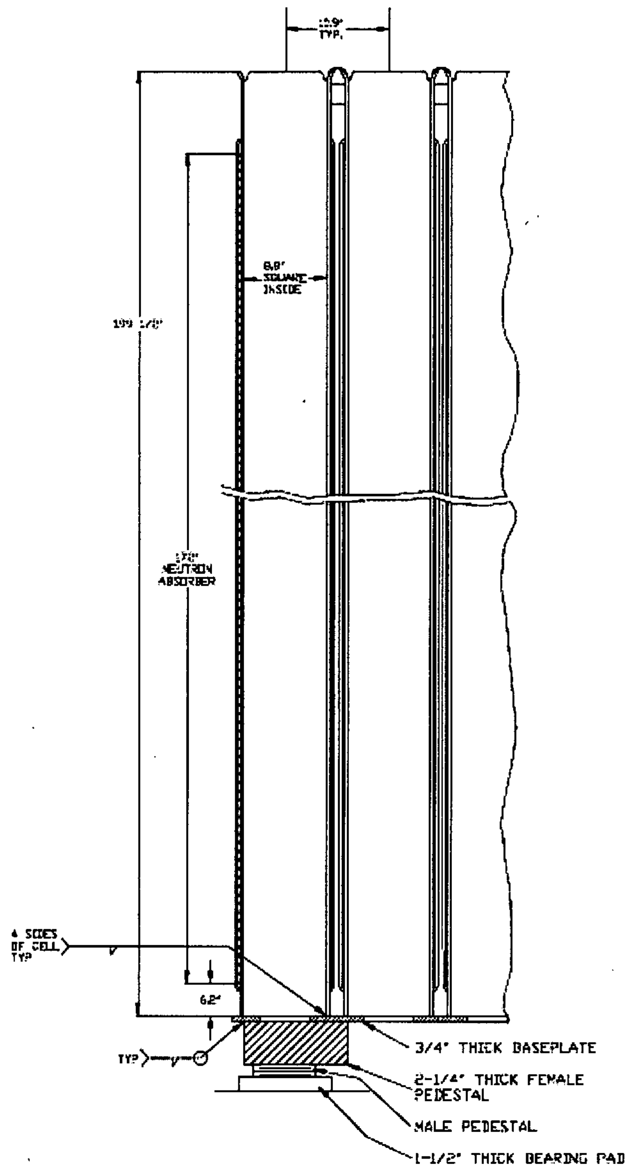


Figure 9.1-1 (Sheet 2 of 2)
New Fuel Storage Rack Cross Section

PRA Revision:
None

Technical Report (TR) Revision:
Yes- Figure 9.1-1 New Fuel Rack Layout will be will be added to the revision of APP-GW-GLR-026, Revision 0, "New Fuel Storage Rack Structural/Seismic Analysis," (Technical Report Number 44).

<u>Westinghouse supplemental response from NRC Technical Meetings May 21 & 22, 2008</u>

<u>Figures 9.1-1 (Sheet 1 of 2) and 9.1-1 (Sheet 2 of 2) shown in DCD revision are also placed in TR 44 Revision 1 subsection 2.1.1.</u>

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-TR44-026
Revision: 1

Question:
The computer code MR216 (a.k.a. DYNARACK) as well as the other computer analysis codes should have complete validation documentation and should be made available for review of selected package(s) during the audit. If any of the computer codes have been previously reviewed and approved by the staff on other licensing applications, for the same version of the code, these should be identified.

Westinghouse Response:
Computer analysis codes used to perform the seismic analysis of the spent fuel racks have been validated in accordance with Holtec's 10CFR50 Appendix B quality assurance program. The validation documentation will be available for review during the audit. The validation documentation for the computer code MR216 has been previously submitted by Holtec International to the NRC staff for review and approval several times. Most recently it was reviewed by the NRC in 1998 in Docket 50-382 for the Waterford 3 Steam Electric Station.

Westinghouse supplemental response from NRC Technical Meetings May 21 & 22, 2008

The validation package for DYNARACK was reviewed at the NRC Technical Meetings for review of TR-54 RAIs and documentation on May 21 & 22, 2008. It was found acceptable by the NRC Reviewer and RAI-TR54-039 was closed as resolved. This review of the DYNARACK validation package is directly applicable to RAI-TR44-026 and Westinghouse considers this RAI closed based on the successful review of RAI-TR54-039.

References:

1. APP-GW-GLR-026, Revision 0, "New Fuel Storage Rack Structural/Seismic Analysis," (Technical Report Number 44)
2. APP-FS02-Z0C-001, Revision 0, "Analysis of AP1000 Fuel Storage Racks Subjected to Fuel Drop Accidents"
3. US NRC, "Amendment No. 144 to Facility Operating License No. NPF-38 for the Waterford Steam Electric Station, Unit 3," July 10, 1998.

Design Control Document (DCD) Revision:
None

PRA Revision:
None

Technical Report (TR) Revision:
None