AP1000DCDFileNPEm Resource

From: Altmayer, Scott A [altmaysa@westinghouse.com]
Sent: Monday, June 14, 2010 11:07 PM
To: Buckberg, Perry
Cc: Joe Braverman (braverman@bnl.gov); Richard J Morante (morante@bnl.gov); Morrow, Robert J.; Stipanovich, Steven M; Loza, Paul G.
Subject: Fuel Rack RAI Drafts (per audit discussions) - audit actions 8 and 16
Attachments: Copy of RAI-TR54-01 R1B-NRC DRAFT.doc; Copy of RAI-TR44-08 R2A NRC DRAFT.doc

Perry,

Here are two more draft RAIs for your review (designated as next rev alpha) for audit action items as follows:
audit item 8, RAI-TR54-01 Rev1B
audit item 16; RAI-TR44-08 Rev2A

The RAI for audit item 7 is being sent tomorrow.

I am making these available to Joe/Rich since they may be in PA this week on Ch. 3.7 audit.
As time allows, Rob M./Steve S./I can be available to talk about feedback directly with them.
Thank you.

--SCOTT ALTMAYER--
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Hearing Identifier: AP1000_DCD_Review
Email Number: 419

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AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-TR54-1
Revision: 1BB

Question: (Revision 0)

Section 2.8.5 indicates that all 3 drop scenarios are from 36 in. above the top of the AP1000 Spent Fuel Storage Rack. Describe the fuel handling operation that leads to this drop height.

Additional Question: (Revision 1)

New Question (Revision 1B)

During the June 2010 fuel rack technical audit, the NRC The NRC has questioned how this limitation (that the fuel handling process precludes a fuel assembly from being dropped from a height in excess of 36" above the top of the Spent Fuel Storage Racks) is established in the DCD.

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Westinghouse Response: (Revision 0)

The fuel handling operations for the Section 2.8.5 scenarios are the normal fuel handling operations such as that performed during refueling outages, i.e., core fuel offloaded and reloaded from/to the Reactor Building via the fuel transfer system into and out of the spent fuel pool storage racks. There are also instances where fuel inspection and/or fuel repair will occur which require the fuel to be removed from the spent fuel storage racks and moved to the designated fuel inspection or fuel repair workstation. Also, these fuel handling operations include the transfer of fuel from the rack cells and into the cask area during dry cask storage operations.

The current AP1000 Fuel Transfer System in the Spent Fuel Building which lift and lower the fuel during normal fuel handling operations are the Fuel Handling Machine (FHM) and the Spent Fuel Handling Tool (SFHT). The FHM is a fixed- mast manipulator-type bridge crane similar in design to numerous existing Westinghouse operating plants Reactor Building manipulator crane bridges. The SFHT is a long handled tool which latches onto the fuel assembly top nozzle via a manually actuated gripper. Lifting of the SFHT and attached fuel assembly is performed using an auxiliary hoist on the FHM Bridge. The design of the SFHT is very similar in design to the fuel handling tool currently in use at numerous existing Westinghouse operating plants Spent Fuel Buildings.

The current designs of the AP1000 spent fuel pool, spent fuel storage racks, FHM, and SFHT limit the height that the fuel assembly can be lifted above the spent fuel racks to 9 inches maximum. This height is limited by the water coverage above the fuel assembly and is limited by the physical design of the FHM and SPHT via mechanical stops and/or tool length.

The maximum fuel drop height will be approximately 9 inches, which is bounded by the Section 2.8.5 scenarios of 36 inches.

Response: (Revision 1)

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The current FHM design utilizes a gantry style, non-single failure proof hoist with the Spent Fuel Handling tool to move spent fuel in the Spent Fuel Pool.

To ensure that proper water shielding is maintained above irradiated fuel assemblies in the spent fuel pool, ITAAC 2.1.1.5 requires that the design of the fuel handling machines which handle fuel assemblies in the spent fuel pool be such that a fuel assembly bottom nozzle is restricted from being raised to within 24'- ft, 6" of the operating deck floor.

The operating deck floor is at Elevation 135'-3". Considering that Tthe floor of the spent fuel pool is at elevation 92'-8.5", and the top of the Spent Fuel Storage Racks is 204.5" (17'-0.5") 204.5" above the floor of the spent fuel pool (or Elevation 109'-9" = 92'-8.5" + 17'-0.5"), Therefore, tthe top of the Spent Fuel Storage Racks is is 25'- ft, 6" (=135'-3" – 109'-9") below the floor of the operating deck. .

Therefore, meeting ITAAC 2.1.1.5 (bottom of assembly nozzle at 24'-6" below the operating floor) ensures that a fuel assembly can only be dropped from a maximum distance of one foot 12 inches(25'-6" – 24'-6") above the top of the Spent Fuel Storage Racks. This e maximum 12 inch " (=1 foot) drop height is governed by that could result from this this ITAAC requirement, and iis well below the 36 inch " drop height evaluated in the drop scenarios considered for the AP1000 Spent Fuel Storage Racks in Reference 1.

Reference:

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

Design Control Document (DCD) Revision:

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None

PRA Revision:

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None

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

Technical Report (TR) Revision:
None

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AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-TR44-008
Revision: 2A

Question: (Revision 0)

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 (Revision1): 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.

New Question: (Revision 2A)

During the June 2010 fuel rack technical audit, the NRC asked for clarification why the proposed DCD change in RAI Revision 1 was never implemented. The proposed DCD change stated:

"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 <u>a 4000</u> pound load."

Westinghouse Response: (Revision 0)

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: (Revision 1)

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

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

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

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

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.)

Response (Revision 2A)

The New Fuel Handling Crane (referenced as new DCD 9.1.4.2.4 Item Q by earlier RAI submittals) has been removed by design changes. The functions required are now attributed to the Fuel Handling Machine (FHM). This is described in DCD Section 9.1.4.2.4 Item B that states the Fuel Handling Machine performs fuel handling operations in the new and spent fuel handling areas. The FHM is equipped with two 2-ton hoists, one of which is single failure proof. The single failure proof hoist is used to move new fuel only..

References:

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

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