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Structural RAIs

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Presentation to NRC
June 18, 2009

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RAI 2-1

RAI: Justify the absence of the Classical Dynamics evaluation

Response: Classical Dynamics evaluation will be performed and added to the SAR. Peak G loads predicted by LS-DYNA are expected to bound the Classical Dynamics results based on past experience (i.e., HI-STAR 60). Since the amplification factor used in the Classical Dynamics approach to determine the IL dynamic crush strength was originally determined based on the HI-STAR 100 ¼-scale test program, the amplification factor may need to be adjusted for the HI-STAR 180 package.

RAI 2-2

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RAI: Revise the puncture evaluation to remove non-physical deformation and unrealistic material failure

Response: Side puncture model has been revised to utilize “automatic_eroding_single_surface” contact option, which has eliminated the non-physical deformations. The new results will be incorporated in the SAR.

RAI 2-3

HOLTEC INTERNATIONAL

RAI: Clarify the value assumed for the dimension of the interstitial space between the single fuel pin model and contact boundary

Response: The gap dimension used in the single fuel pin model is consistent with simulation approach used in joint paper by PNNL and the USNRC [1], and it is calculated as:

$$gap = (W_{compartment} - n_{pin} \cdot D_{pin}) / 2$$

RAI 2-4

HOLTEC INTERNATIONAL

RAI: Explain the discrepancy between the peak G load when extracted from the monolithic shield cylinder versus the containment shell

Response: The difference in peak G loads is due to high frequency vibration modes (above 200 Hz) in the containment shell. The peak G loads converge as the cut-off frequency used for filtering is reduced from 450 Hz to 200 Hz.

RAI 2-4 (cont.)

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Response (cont.):

HI-STAR 180 Overpack Rigid Body Peak Deceleration (g's) – Bottom End Drop			
Cutoff Frequency	Containment Shell	Monolithic Shield Cylinder	Difference
450	104.3	85.029	22.66%
400	96.125	82.558	16.45%
350	88.155	79.42	11.0%
300	80.851	75.706	6.80%
250	74.48	71.861	3.64%
200	69.758	70.799	-1.47%

RAI 2-4 (cont.)

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Response (cont.): The minimum calculated safety factor using ANSYS for 90 G bottom down end drop is 1.59 based on ASME Subsection NB stress intensity limits (see SAR Table 2.7.6). Therefore, even at 104 G the minimum safety factor will remain above 1.0 [90/104 x 1.59 = 1.38].

RAI 2-5

HOLTEC INTERNATIONAL

RAI: Clarify the design criteria value of 0.5 mm for total allowable global average basket panel deformation

Response: The allowable panel deformation is dictated by the criticality analysis, which assumes that all basket panels experience a deformation of 0.5 mm (across its entire width) as a result of the 9-meter side drop. With respect to the criticality analysis, the 0.5 mm deformation is in addition to material and manufacturing tolerances. The design basis criticality analysis assumes that ALL cells and flux traps are at their most conservative dimension.

RAI 2-6

HOLTEC INTERNATIONAL

RAI: Provide a comparison of the 0.5 mm global average basket panel deformation criterion as it relates to ASME Subsection NG

Response:

- SAR will be revised to express the basket panel deformation criterion in dimensionless form as:

$$\theta = \frac{\delta}{W} \leq 0.005$$

where δ equals the maximum total deflection (elastic + plastic) of the basket panel and W equals the nominal width of the storage cell panel.

RAI 2-6 (cont.)

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Response (cont.):

- For a typical stainless steel basket (e.g., MPC-32), the NG allowable stress intensity limit for Level D conditions is equivalent to a maximum panel deflection of 0.582” (θ = 0.582” / 8.937” = 0.065)
- Per ASME Section III, Appendix F (F-1341.2), if plastic analysis is used the maximum primary stress intensity at any location shall not exceed $0.90S_u$
- When evaluated on a plastic basis, the maximum primary stress intensity predicted by ANSYS in a Metamic-HT basket panel at a maximum deflection of 1 mm (θ = 0.005) is only 76% of the true ultimate strength
- See Holtec Position Paper DS-331 for further details

RAI 2-7

RAI: Justify the use of ANSYS when determining the average global panel deformation for the side drop while using LS-DYNA for the end drop

Response: The most severe loading for the fuel basket panels is the 9-meter side drop, which produces a lateral pressure on the basket panels due to the amplified weight of the fuel. The lateral pressure exerted on the fuel basket panels during an end drop is relatively small, and therefore the panel deformations are bounded by the results for the side drop as determined by ANSYS.

RAI 2-8

RAI: Provide a sensitivity study showing that thick shell elements perform similarly to solid elements when predicting the structural performance of Metamic-HT

Response: A sensitivity analysis has been performed using ANSYS to investigate the performance of solid shell elements (SOLSH190) versus solid elements (SOLID185). Based on the results, solid shell elements (which are used in the application) are computationally more efficient and yield higher stresses and peak displacements.

RAI 2-9

HOLTEC INTERNATIONAL

RAI: Provide comparison tables in the application showing the relative component stresses, strains, etc. from the ANSYS and LS-DYNA simulations

Response: A comparison table will be added to the HI-STAR 180 SAR. The following table shows the maximum stress intensity results for the HI-STAR 180 containment boundary components, as predicted by ANSYS and LS-DYNA. In general, there is excellent agreement between the two sets of results.

RAI 2-10

HOLTEC INTERNATIONAL

RAI: Clarify whether design internal pressure was included in the pressure values calculated for the 9 meter drops

Response: Per SAR Table 2.1.1, the maximum normal operating pressure (MNOP) for the HI-STAR cavity is 0 psig. Since the normal operating pressure is sub-atmospheric, it does not contribute to the tensile stress in the closure lid bolts.

RAI 2-10 (cont.)

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Response (cont.): The design internal pressure of 80 psig bounds the cavity pressure during drying operations using the FHD system, and therefore it is not applicable to the 9-meter drops.

RAI 2-11

HOLTEC INTERNATIONAL

RAI: Provide a rationale which illustrates why the 9 meter side drop deceleration time history is not influenced by FSL failure

Response: The 9 meter side drop deceleration time history is not influenced by the FSL failure in the same manner as the HI-STAR 60 because the FSL failure does not occur for the HI-STAR 180 until the primary impact is almost over.

RAI 2-11 (cont.)

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Response (cont.): The difference in the FSL behavior between the two packages is the result of the following impact limiter design differences: (1) the HI-STAR 180 impact limiter skirt is much longer than that of HI-STAR 60 impact limiter; a longer skirt significantly reduces the relative rotation between the impact limiter and the cask body and hence the loading in the impact limiter attachment bolt; (2) each HI-STAR 180 impact limiter is attached to the cask by 16 bolts, two times that of the HI-STAR 60 package, which result in a more evenly distributed load among impact limiter attachment bolts.

RAI 2-12

HOLTEC INTERNATIONAL

RAI: Justify the use of a limiting G load of 60 Gs when evaluating fuel performance during 9 meter bottom down fuel drop

Response: For the fuel rod integrity analysis, the impact limiter crush force is set based on the initial impact between the HI-STAR 180 package and the ground (i.e., before the gap between the fuel assemblies and Fuel Impact Attenuators (FIA) closes) as determined by LS-DYNA.

RAI 2-12 (cont.)

HOLTEC INTERNATIONAL

Response (cont.): The peak cask deceleration of 85 G predicted by LS-DYNA occurs after the fuel assemblies have impacted the FIA assemblies and have started to rebound. By that time, the most severe loading on the fuel pins has already occurred. Since the single fuel pin model explicitly includes the FIA spring and the 20 mm maximum clearance gap between the fuel assembly and the FIA, it is appropriate to set the impact limiter crush force based on the initial impact with the ground.

RAI 2-12 (cont.)

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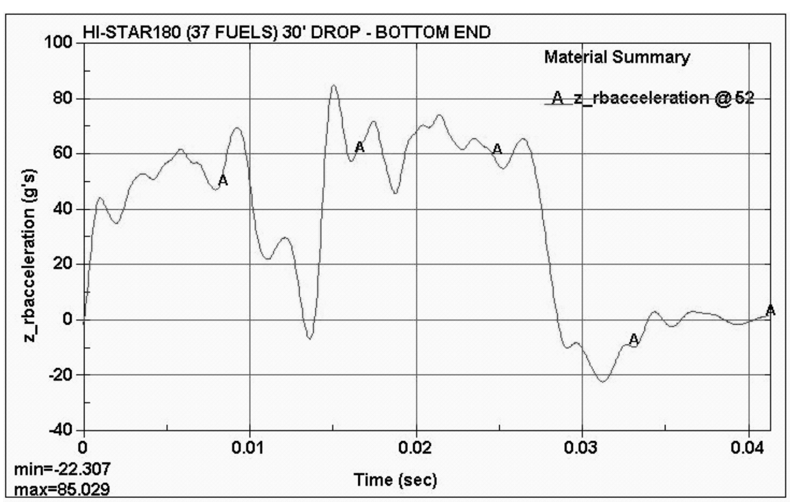
Response (cont.):



RAI 2-13

HOLTEC INTERNATIONAL

RAI: Revise Section 2.3.2, “Examinations,” to be consistent with the format and content in the HI-STAR 60 application

Response: The format and content of SAR Section 2.3.2 will be revised to make it similar to the HI-STAR 60 application.

RAI 2-14

HOLTEC INTERNATIONAL

RAI: Clarify whether or not the fuel basket design employs a strain control approach as opposed to the ASME Subsection NG stress limit approach

Response: The fuel basket design employs a strain control approach as permitted by NUREG-1536 [2]. See response to RAI 2-6.

RAI 2-15

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RAI: Provide an analysis for the vent and drain port cover bolts to confirm that the seals do not unload

Response: An analysis of the vent and drain port cover bolts under a maximum impact load of 90 G will be included in the SAR.

References

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[1] Adkins, H.E., B.J. Koeppel, and D.T. Tang, "Spent Nuclear Fuel Structural Response When Subject to an End Drop Impact Accident," Proceedings ASME/JSME Pressure Vessels and Piping Conference, PVP-Vol. 483, American Society of Mechanical Engineers, New York, New York, 2004.

[2] NUREG-1536, "Standard Review Plan for Spent Fuel Dry Storage Systems at a General License Facility," USNRC, Draft Revision 1A