CHAPTER 1 GENERAL INFORMATION

1-1 Provide tolerances for all Important to Safety (ITS) components on the licensing drawings so that the "as-built" package can be verified as being manufactured in accordance with the analyzed design.

All tolerances that support analyses for all ITS components in the application shall be placed on the licensing drawings so that the staff can assess whether the results of the analyses including structural, shielding, and thermal analyses are valid. Tolerances for non-ITS components shall also be included, if they have a potential to impact any ITS component performance.

This information is required to determine compliance with Title 10 of the *Code of Federal Regulations* (10 CFR) 71.33(a)(5), 71.71(c)(7), 71.73(c)(1), and 71.73(c)(3).

Holtec Response:

To ensure readability of the drawings and consolidate the required information, all dimensional limits have been collected in a separate "Dimensional Limits" report. This document collects all dimensions for safety related components contained within the referenced drawings, and the drawings have been revised to only contain nominal dimensions. The report defines the analysis limits for each dimension on the drawings, which discipline(s) the dimension is utilized by. In addition, the report states if a dimension is critical to the safety analysis and would be marked as "critical" on the fabrication drawings per Holtec's QA program.

Please note that certain dimensions do not have specific limits, as they are the result of assembly stackups, or are subject to changes based on flag notes, specific analysis, or other factors. Reference dimensions from the drawings have not been included in the list. The dimensional limits listed in the report only define the bounds for the safety analysis for that specific dimension, and have not been evaluated for fit up, fabrication, or tolerance stack-up.

CHAPTER 2 STRUCTURAL AND MATERIALS REVIEW:

2-1 Provide the information related to structural design and analysis of the Quiver damaged fuel container.

The Quiver damaged fuel container is added to Chapter 2, "STRUCTURAL EVALUATION" of the SAR, as SSC ITS. Section 2.1.2.2, "Acceptance Criteria," states that the inertial and structural design data on the Quiver were extracted from the reference, "*SKB Quiver – Data for external use", Report NRT 18-403, Latest Revision (Westinghouse Electric Sweden AB Proprietary)*," and were summarized in Table 2.2.11 of the SAR. However, Table 2.2.11 simply states the heights of free drop conditions required by 10 CFR 71.71(c)(7) and 71.73(c)(1).

Detailed information of the structural design and analysis is needed to ensure that the Quiver damaged fuel container will perform its intended functions under the normal conditions of transport (NCT) and hypothetical accident conditions (HAC).

This information is needed by the staff to determine compliance with 10 CFR 71.71 and 10 CFR 71.73.

Holtec Response:

The structural design and analysis of the Quiver damaged fuel container was performed by Westinghouse Electric, and their original work has been incorporated by reference in the HI-STAR 80 SAR. More detailed information on the Quiver design is provided in SAR reference [1.2.20] (“*SKB Quiver – Data for external use”, Report NRT 18-403, Latest Revision (Westinghouse Electric Sweden AB Proprietary”*), which is provided as a proprietary attachment to Holtec’s RAI response.

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2-2 Provide a technical discussion of how the Quiver damaged fuel container was modeled in the drop analysis when: (i) the Quiver and the fuel assembly have different external dimensions, and (ii) different material parameters (i.e., weight, loading-path, material properties, etc.).

Section 2.7.1, “9-meter Free Drop,” of the SAR stated that distinguishing the Quiver representation from the fuel assemblies in the model simulations is not warranted for the drop simulations because the Quiver and the fuel assembly have essentially identical external dimensions.

The staff is not clear whether the statement is valid when the Quiver and the fuel assembly have different external dimensions and material parameters.

This information is needed by the staff to determine compliance with 10 CFR 71.71 and 10 CFR 71.73.

Holtec Response:

For the 9-meter drop accident, the acceptance criteria for the Quivers are specified in terms of their maximum allowable impact decelerations (see response to RAI 2-1). Therefore, a key objective of the drop analysis is to predict the maximum rigid body deceleration of the cask contents, not to resolve the internal stresses or strains associated with the Quivers. [

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2-3 Provide correct and complete LS-DYNA modeling files for each case.

The modeling files provided consisted of the LS-DYNA input files (DYN) for the 4.2% side drop, 50% side drop, and 4.2% oblique drop (there were no LS-DYNA input files supplied for the 50% oblique drop), the LS-DYNA graphical output results files (D3PLOT), and LS-DYNA binary output results files (BINOUT).

The LS-DYNA graphical output results files (D3PLOT) for all four supplemental analyses showed corrupted analyses, partial analyses, or files incorrectly combined on the SharePoint site from multiple analyses. Three different LS-DYNA results files (BINOUT) were supplied for each supplemental analysis that are a different size, not in sequential order and have a different numbering convention between analyses. The correct and complete LS-DYNA modeling file sets for all the four supplemental cases should be supplied for review.

This information is needed by the staff to determine compliance with 10 CFR 71.71

and 71.73.

Holtec Response:

It seems that SharePoint can only list files in alphabetic order (A to Z or Z to A), so the LS-DYNA output files (i.e., d3plot files) generated in numeric order cannot be listed in correct numeric order. For example, output file d3plot10 would be followed by output file d3plot100, instead of d3plot11 when LS-DYNA d3plot output files are listed by names in A-to-Z order on SharePoint. This might be the reason that the uploaded d3plot files appear to be corrupted, incomplete, or incorrectly combined. If all those LS-DYNA output files on SharePoint are downloaded onto a local computer, they can be listed in numeric order and confirmed to be the complete set of analysis output files.

It should be pointed out that only the revised 4.2% (which should be 2.1%, representing the scenario where the cask is loaded with only one fuel assembly) side drop and oblique drop LS-DYNA analysis files are uploaded to SharePoint, since the two drop events represent the governing drop scenarios for the partially loaded package (i.e., the package is loaded with one light weight fuel assembly).

2-4 Justify and/or correct the method used to apply bolt preload and seal compression in the LS DYNA models.

From the LS-DYNA input files (DYNA), the bolt preload of 60 ksi and 20 ksi is applied to the inner closure lid bolts and outer closure lid bolts, respectively, during dynamic relaxation (DR) only, which indicates the preload was not sustained during the drop event. This is also the case for the elastomeric seals where the initial compression of 102.564 psi and 100 psi is applied to the inner seals and outer seals, respectively, during DR only. This is visually observed from the LS-DYNA graphical output results files (D3PLOT) at time equal zero.

The staff finds a statement in Section 4.3, “Preloading,” of Holtec Report No: 2167023, “Finite Element Analysis of HI-STAR 80 Transport Package for Postulated Drop and Puncture Accidents,” that the bolt preload of 60 ksi and 20 ksi is applied to the inner closure lid bolts and outer closure lid bolts, respectively, during the DR. However, the staff was not able to find any statement, which supports the application of the initial compression of 102.564 psi and 100 psi to the inner seals and outer seals, respectively, during the DR.

Describe how the initial compression of 102.564 psi and 100 psi was both calculated and applied in the current LS-DYNA models.

If an inconsistency with the methodology associated with the application of the initial compression is identified, update the SAR results as needed to demonstrate adequate safety margins and provide the corrected models.

This information is needed by the staff to determine compliance with 10 CFR 71.71 and 71.73.

Holtec Response:

Bolt preloads are applied during DR phase to establish the initial conditions for subsequent drop simulations. In other words, the state of stress in the bolts and the elastomeric seals at the conclusion of the DR is carried forward into the subsequent drop simulations. This can be confirmed by checking the stress in the bolts/seals at start of the drop simulations (time = 0 sec.).

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2-5 Justify and/or correct the method used to apply the initial condition of pressure in the LS- DYNA models.

The LS-DYNA models have pressure loads applied to only partial regions within the

internal cavity space of the cask and the cask inter-lid space.

A maximum normal operating pressure (MNOP) of 80 psi is applied in the LS-DYNA models as a uniform pressure on the inner closure lid plug and gamma shield cover plate (LS-DYNA Part IDs 8 and 81) instead of the entire internal cavity space.

A uniform pressure of 10 psi is applied to the outer closure lid (Part ID 11). The uniform pressure is not being applied to the entire cask inter-lid space and is not the maximum value of 20 psi shown in Table 2.1.1 of the HI-STAR 80 SAR.

Provide the necessary justifications for applying: (i) the MNOP of 80 psi only to the inner closure lid plug and gamma shield cover plate (LS-DYNA Part IDs 8 and 81) instead of the entire internal cavity space, (ii) a uniform pressure of 10 psi rather than the maximum value of 20 psi, and (iii) a uniform pressure only to the outer closure lid instead of the entire cask inter-lid space.

If an inconsistency with the methodology associated with the application of pressure is identified, update the SAR results as needed to demonstrate adequate safety margins and supply the corrected models.

This information is needed by the staff to determine compliance with 10 CFR 71.71 and 71.73.

Holtec Response:

The MNOP of 80 psi was applied only to the inner closure lid plug and the gamma shield cover plate for the following reasons: [

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2-6 Justify the use of element erosion in the LS-DYNA models.

The LS-DYNA input files (DYN) have enabled element erosion for all elastic-plastic material models using an effective plastic strain value as an indicator to erode elements. The effective plastic strain to failure value is different between parts and has not been documented anywhere in the HI-STAR 80 SAR or Enclosure 5.

Provide clarification on the plastic strain to failure values, discussion on where element erosion is occurring in the models, and justification that the use of element erosion is conservative.

This information is needed by the staff to determine compliance with 10 CFR 71.71 and 71.73.

Holtec Response:

Generally speaking, element erosion is needed if a negative volume is detected in any significantly deformed element of relatively weak impact limiter crush materials (e.g., polyurethane foam). Without element erosion the LS-DYNA simulation would slow significantly and eventually stop. Conversely, if only a very small number of crush material elements are eroded during the numerical simulation, the overall impact limiter performance would not be adversely affected.

For the aluminum honeycomb crush materials used in the HI-STAR 80 impact limiter design, there is no need to enable element erosion in the LS-DYNA drop analysis. Therefore, element erosion is disabled for the two revised 2.1% drop analyses presented in Appendix H of HI-2167023. In addition, results of the revised LS-DYNA analyses confirm that no element erosion occurs due to plastic strain levels exceeding the failure strain of the material.

2-7 Provide materials and structural design information for the quiver to support the

safety review of its mechanical performance and sealing capability.

Details of the materials and structural design of the important to safety (ITS) quivers are needed to verify the capability of the quiver to maintain the damaged fuel in the configuration relied on in the safety analysis.

Provide the Westinghouse SKB Quiver specification report (or portions thereof) or other design documentation that details:

- Structural materials of construction, including governing codes and standards
- If applicable, weld design, fabrication, and examination codes and standards
- Mechanical properties used in the structural analysis
- Results of the Westinghouse structural capacity evaluations in sufficient detail to allow verification of the safety analysis report (SAR) maximum acceleration limits
- Seal/gasket materials of construction in sufficient detail to support the SAR maximum temperature limits and the capability to maintain the quiver's leaktightness criteria per the operational requirements in SAR table 7.1.8

This information is needed to demonstrate compliance with 10 CFR 71.33, 71.43, 71.71 and 71.73.

Holtec Response:

A copy of the Westinghouse SKB Quiver specification (SAR Ref. [1.2.20]) is provided as a proprietary attachment to Holtec's RAI response.

2-8 Clarify the inner and outer lid bolt examination requirements.

The proposed amendment revised SAR Section 2.1.2.2, "Acceptance Criteria," to remove a requirement to perform volumetric examinations of the ferritic steel closure bolts, citing the absence of such a requirement in the ASME B&PV Code. As such, the SAR includes only a discussion of impact testing requirements for the bolts.

However, the staff notes that the ASME B&PV Code Paragraph NB-2581, "Required Examination," includes requirements to examine all bolting material (regardless of material type) to ensure it is free of defects. Those requirements vary based on the bolt size.

Revise the SAR to clarify if all lid bolts are to be examined in accordance with ASME B&PV Code Subsection NB or otherwise justify why such measures to ensure the

absence of defects are not required.

This information is needed to demonstrate compliance with 10 CFR 71.31(c), 71.43, 71.71 and 71.73.

Holtec Response:

SAR Section 2.1.2.2 has been revised to clarify that all inner and outer lid bolts are examined to meet or exceed the applicable requirements of ASME Code Subarticle NB-2580 and insure that they are free of defects.

2-9 Justify that the mechanical properties of the new allowable fuel cladding alloys are appropriately bounded by the existing structural analyses of the fuel rods.

The proposed amendment expanded the types of zirconium cladding alloys; however, the application did not provide a basis for the adequacy of the existing fuel rod structural analyses.

SAR Section 2.11, “Fuel Rods,” provides a reference for the cladding mechanical properties; however, it is unclear if the referenced 2004 study considered (or is otherwise bounds) the properties of the newer alloy types.

This information is needed to demonstrate compliance with 10 CFR 71.55, 71.71 and 71.73.

Holtec Response:

To address the RAI, we are providing a report with the RAI responses that compares cladding characteristics and performance. The report is also added to the reference list in the SAR as [1.0.14]. The report intends to show that the newly added fuel cladding types are just improved versions of the previously accepted cladding types, with essentially the same mechanical properties and performance as those. Note that the report only reproduces publicly available information and is therefore not proprietary.

The new reference is only added to the glossary of the SAR, as justification that the new cladding materials are covered by the term “zirconium-based fuel cladding” or “Zr” that is used in the safety analysis report, since cladding material names not used anywhere else throughout the SAR.

Below is a more detailed review of the various sections of the SAR that address cladding behavior and performance, and how it links with the information provided in the report.

With respect to Section 2.11, note that the safety basis for the cask is moderator exclusion, and therefore does not rely on the cladding to withstand damage during any hypothetical accident condition. The structural evaluation presented in that section is therefore provided and performed as a defense-in-depth solution, and characterized as such. Additionally, note that none of the other safety evaluations explicitly take credit

for the results in Section 2.11. Instead, they do evaluate the effect of potential fuel cladding under accident conditions as part of the defense-in-depth approach. For thermal evaluations, this is presented in Section 3.4.5, for shielding evaluations in Section 5.4.5, and for criticality evaluations in Section 6.3.5.

Under normal conditions, the fatigue performance of the cladding is evaluated in Section 2.6.5. [

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In summary, the new referenced report provides the justification that the newly added cladding types can be considered as zirconium-based cladding throughout the report.

Note that in a future license application we may resolve the issue of new cladding materials in a different way, namely by specifying numerical limits for the properties relevant for the performance of the fuel cladding under transport conditions. This would avoid using names, which are often just trade names selected by the fuel manufacturers for marketing purposes. However, we understand that this may need some additional considerations and discussions, so for this licensing application, we intend to stay with the trade names, based on the justification outlined above.

Except for adding the reference to the definition of zirconium-based cladding, no other changes are made to the SAR.

CHAPTER 4 CONTAINMENT REVIEW

4-1 Explain how the reference air leak rates reported in SAR Table 8.1.1 were obtained.

Provide details of the calculations used to obtain these values.

SAR Table 8.1.1 provides the allowable reference air leak rates used for all containment leakage tests for the HI-STAR 80. However, the calculation methods used to obtain the air leak rates were not provided. The staff needs this information to make sure the evaluations provided in SAR Section 4.6 and SAR Table 8.1.1 are consistent.

This information is needed to determine compliance with 10 CFR 71.35(a), 71.41(a), 71.43(f), and 71.51(a)(1)

Holtec Response:

The methodology for the calculations is described in Section 4.6, with further details documented in the corresponding report (Reference [4.6.3]). Principal results are shown in Table 4.6.17(a) and (b), as helium leakage rates. However, Table 8.1.1 shows the corresponding and equivalent leakage criteria for air, which have a different numerical value. These criteria are calculated directly from the helium values in Section 4.6 through division by a value of 1.85 as stated in Note 1 to the table, then slightly rounded down. To remove this inconsistency between Section 4.6 and Table 8.1.1, we have updated Table 8.1.1, replacing the values for air with those for helium from Section 4.6, again with some rounding, updated the units and sensitivities accordingly, and updated Note 1 and Note 3. These new values are also identical to those listed in the corresponding report (Reference [4.6.3]).

CHAPTER 5 SHIELDING REVIEW

5-1 Justify that the HI-STAR 80, when loaded with quivers that contain fuel debris, will meet regulatory dose rate limits when considering the reconfiguration of the source term.

The application does not contain an evaluation of the dose rate levels considering the presence of the quivers. Section 5.4.12 states that the magnitude of the source term from a quiver will be less than a design basis undamaged fuel assembly because there will be less fuel in a quiver than an assembly.

The HI-STAR 80 has decreased shielding between the top and bottom of the Holtite neutron shielding and lead gamma shielding and the lid. This is reflected in Tables 5.1.1 and 5.1.2 of the application showing that the limiting dose rate at the surface is at the upper forging and the lower forging for the F-32B and F-12P, respectively, despite spent fuel having the largest dose peak toward the axial center of the fuel. Although the overall magnitude of the source term would not increase when using a quiver, considering that the contents of the quiver is broken fuel rods and fuel debris,

the location of the source may be relocated toward one of these areas where shielding is decreased.

The staff needs this information to determine compliance with the requirements in 10 CFR 71.47 and 10 CFR 71.51(a)(2).

Holtec Response:

Quivers are bundles of a limited number of sealed steel tubes where each tube contains just a single rod (or the remnants thereof). See Figure 1.2.2 for a side view. Hence there is no large open volume at the bottom (or top) of the quiver where broken parts of individual rods could accumulate. Having each rod confined to a single tube also makes it difficult for any broken fuel parts to move up or down. Hence based on the limited number of rods compared to an intact assembly, and the limited ability of broken parts of the fuel rods to move up or down to accumulate, we believe it's reasonable and conservative to consider the Quiver to be bounded by an undamaged assembly.

Note that in that respect the quiver is different from the DFC (Damaged Fuel Container) that is often used for damaged fuel and fuel debris, with the DFC providing a more open volume inside that would be available for axial relocation.

No changes were made to the SAR in relation to this RAI and response.

5-2 Provide additional information justifying that the HI-STAR 80 meets regulatory dose rate limits with an increase in mass for the fuel hardware for fuel to be stored in the F-12P basket.

Based on the information from Tables 5.2.1, 5.3.2, and 5.3.5 of the application which includes the width, height and density of the regions of the PWR fuel assembly, the staff calculated the mass of the PWR assembly used in the dose rate calculations to be about 693 kg. The applicant proposed to increase the mass of the PWR assemblies in Table
7.D.1 of the application to 800 kg for all basket cell locations. Since the maximum fuel mass (i.e., uranium mass) in Table 7.D.1 of the application remains unchanged at 0.4976 MTU (consistent with the value used in the analysis from Table 5.2.1 of the application), the additional fuel mass up to 800 kg would mean that there is additional mass in the fuel hardware regions, or this is specifically meant to cover the non-fuel hardware.

The only non-fuel hardware allowed within the F-12P is CRAs, RCCAs, and CEAs which are only allowed in the four inner storage locations per Note 1 of Table 7.D.1.I.A.1 of the application. Since the 800 kg limit applies to all fuel assemblies, then the increase in mass is in the fuel hardware regions.

The fuel hardware regions can generate a Co-60 source due to the activation of Co-59

impurities within the stainless-steel regions in the upper and lower tie plates. Co-60 source terms are more significant for the cooling times allowed for the HI-STAR 80 contents (minimum cooling times from 12-24 months).

In addition, Table 5.1.2 of the application shows that the limiting dose rate at the surface is at the lower forging for the F-12P meaning that an increase in source term at the lower tie plate may impact the limiting dose rate for this basket.

The staff needs this information to determine compliance with the requirements in 10 CFR 71.47 and 10 CFR 71.51(a)(2).

Holtec Response:

We apologize for the confusion. The increased fuel weight was only intended to be used in the structural analyses, in preparation for heavier assemblies to be introduced in later Amendments, but where the details of such assemblies are currently not sufficiently well known to support updated dose evaluations. Hence for now, assemblies must still be consistent with the current shielding evaluations, i.e. the information in Tables 5.2.1, 5.3.2 and 5.3.5. Consequently, we are removing the change from the corresponding Section of Chapter 7 of the SAR. However, we propose to keep the structural qualification of those heavier assemblies in the Application, to simplify future Amendments.

No changes were made to Chapter 5 of the SAR in relation to this RAI and response.

5-3 Provide additional information justifying the proposed “condition set” related to the loading tables 7.D.4 of the application have appropriate cooling times to account for all allowed “number of cycles”

The amendment requests expansion of the burnup, enrichment, and cooling time tables. As part of this expansion, additional loadings specific to number of cycles burned, termed “condition sets,” has been added. For an assembly to achieve the same burnup but with a different number of cycles, it is exposed to a higher power. Assemblies burned at a higher power are associated with increased dose due to the additional activation products created. The applicant’s assumptions with respect to number of cycles burned are shown in Table 5.2.1 of the application.

As stated in Section 5.4.7.2 of the application, assemblies burned with a higher power (i.e., fewer cycles) for the same burnup will have a longer required cooling times. This section states that sensitivity studies were performed where the number of cycles was both increased and reduced by one to justify the cooling times for the fuel assemblies with different number of cycles than what was used to derive the design basis source terms. The results of these studies are presented in Table 5.4.38 for PWR fuel.

For PWR fuel, the previous CoC only authorized 2 condition sets for two different

"number of cycles burned." This corresponds to the "reference" and the "reduced number of cycles / Increased Power Density" from Table 5.4.38 of the application. As part of the current amendment request, Table 7.D.4 of the application has been expanded to include a third condition set.

However, Table 5.4.38 has not been expanded to justify the cooling times are appropriate for the third condition set. From Table G.1 in HI-2177694, "HI-STAR 80 SOURCE TERMS USING SCALE 6.2.1," March 31, 2021, the cycles burned for the burnup values achieved would result in specific powers that are outside of the range studied.

The staff needs this information to determine compliance with the requirements in 10 CFR 71.47 and 10 CFR 71.51(a)(2).

Holtec Response:

In response to this request, Table 5.4.38 has been updated to show cases with further reduced number of cycles and the increased cooling time where possible. In all cases, the resulting dose rates are similar to, or bounded by, those for the larger number of cycles.

Except for the added cases in Table 5.4.38, no other changes were made to Chapter 5 of the SAR in relation to this RAI and response.

5-4 Demonstrate that the MCNP calculations have properly converged.

The applicant provided multiple input files for the MCNP model for the HI-STAR 80. The input model indicates that the there was a set a cut-off computing time of 200 minutes. Provide additional information of how this cut-off time was determined and whether it can assure a proper convergence of the calculations.

One method of showing convergence is providing an "o" output file for the package that include the tally fluctuation charts. The only output files provided to the NRC are the "m" files for the mesh tally output.

Also, clarify whether the calculations were made on a multiprocessor computer cluster or single processor. For the CTME card, the MCNP 6.2 user's manual (LA-UR-17-29981, Los Alamos National Laboratory, 2017) explicitly points out that it is highly recommended that the NPS card (Section 3.3.7.1.1) should be used to limit the run time for multiprocessor cluster computers.

The staff needs this information to determine compliance with the requirements in 10 CFR 71.47 and 10 CFR 71.51(a)(2).

Holtec Response:

Holtec is using the statistical uncertainty of the results as the main and principal measure to judge the quality of the results of MCNP radiation transport calculations, with a criteria of no more than about 5% for the total dose rates, and no more than about 10% for the relevant components, e.g. neutrons, cobalt, fuel gammas, n-gammas. Additionally, results are viewed for consistency, namely consistency within the results for a specific calculated case, consistency between different cases for the same cask, and consistency with previous calculations, although no easy numerical criteria can be applied for this. Holtec considers these criteria to be sufficient for an appropriate quality of the results, and to demonstrate that there is reasonable assurance that the regulatory dose rate limits are met.

MCNP performs convergence checks, in addition to presenting uncertainties. However, each check only probes a small subset of the total result and is therefore not representative for that total result. Unfortunately, there is no single convergence measure in MCNP that would include the entire result for a dose location. That deficit was one of the motivations for Holtec to select the uncertainty of the results as the primary measure.

Holtec has performed an extensive study on this subject. The study shows that a rigorous consideration of even the results of the partial convergence checks is neither feasible nor necessary, and that the criteria based on uncertainty, as stated above, is sufficient. The remainder of this response presents the details and results of this study, followed by a discussion on CTME and NPS.

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5-5 Justify that the piece under the lower tie plate can be modeled as Zr rather than stainless steel.

The application was modified with the following statement: “The piece under lower tie plate could be Zr or stainless steel. In the analysis it is modeled as Zr, with its corresponding cobalt impurity. This is acceptable since the piece is relatively far from the active region where the neutron flux is relatively low, and thus the dose rate effect is insignificant.” This is Item #6 of the “HI-STAR 80 Modeling Deviations” in Section 5.3.1.1 of the application. The staff disagrees that because the piece is relatively far from the active region as a reason to determine that the dose rate effect is insignificant.

The fuel hardware regions can generate a Co-60 source due to the activation of Co-59 impurities within the stainless-steel regions below the lower tie plates. Co-60 source terms are more significant for the cooling times allowed for the HI-STAR 80 contents (minimum cooling times from 12-24 months).

In addition, Table 5.1.2 of the application shows that the limiting dose rate at the surface is at the lower forging for the F-12P meaning that an increase in source term at the lower tie plate may impact the limiting dose rate for this basket.

The staff needs this information to determine compliance with the requirements in 10 CFR 71.47 and 10 CFR 71.51(a)(2).

Holtec Response:

Since the material can be either Zr or Steel, the more conservative material is used for each of the separate aspects of the analysis as follows: The radiation transport analysis (MCNP) uses Zr, since that material is a weaker absorber of both neutron and gamma radiation, hence may result in higher dose rates. However, the source term analyses (SCALE) assume that the material is steel with its associated Co-59 impurity, which results in a higher gamma source term for this part then Zr, which again results in potentially higher dose rates.

The text in Section 5.3 of the SAR has been revised to clarify these conservative modeling details.

Miscellaneous editorial changes

The following editorial changes were made to Chapter 5 of the SAR. None of those affect any results or conclusions

- Some incorrect references to Table 5.4.37 and Table 5.4.38 were corrected in Section 5.4
- The units shown in Table 5.4.37 and 5.4.38 were corrected. They showed mrem/hr but

the values are in mSv/hr.

- The unit in one of the footnotes to Table 5.4.1 was corrected.

CHAPTER 6 CRITICALITY REVIEW

6.1 Clarify that the structural integrity of quivers containing fuel debris maintain their contents under hypothetical accident conditions (HAC).

In Section 6.3.4.4 the applicant states that preferential flooding of the basket is not possible due to the basket flow holes, and that these flow holes cannot be blocked by crud deposits, nor by fuel debris since the sealed quivers prevent fuel debris from blocking them. Provide addition discussion as to structural integrity of the quivers preventing fuel debris from escaping the quivers and blocking the flow holes during HAC. If structural integrity is not maintained, the applicant should perform calculations evaluating the reactivity effects of preferential flooding within the baskets.

This information is needed to determine compliance with 10 CFR Parts 71.55 and 71.73.

Holtec Response:

See responses to RAI 2-1 and RAI 2-2 for information on structural integrity of quivers under hypothetical accident conditions (HAC).

6.2 Demonstrate that the assumptions used in Section 6.3.5.1 of the SAR regarding using random locations for larger broken fuel rod segment configurations are bounding for all potential damaged fuel configurations.

The applicant evaluated the behavior of larger broken rod segments by moving them randomly in 10 different modeled configurations in each fuel basket (ref. Table 6.3.15). Staff noted that for the F-12P basket, all reactivities were below the reference case, however, for the F-32B basket, some calculations indicated an increase in reactivity.
Given that in the 10 randomized configurations there were some increases in reactivity, staff is unable to determine if the random set of calculations used in the applicant's analysis adequately captures all of the reactivity effects of these rod segments, and that they are adequately bounding for all potential fuel rod reconfigurations in both the F-12P and F-32B baskets.

This information is needed to determine compliance with 10 CFR Parts 71.55 and 71.73.

Holtec Response:

Note that no changes were made to this table and the underlying calculations in this LAR.

Nevertheless, to address the concern, we provide the following clarification:

The principal purpose of these evaluation is to show that the effect of potential fuel rod reconfiguration for HBF during accident conditions is not significant, so that any potential increase would be easily offset by other conservatisms in the analysis. The evaluations are therefore not performed to determine a bounding condition. And as pointed out in Section 6.3.5.1, the configuration condition is only applicable to HBF, i.e. fuel above 45 GWd/mtU, but calculations are conservatively performed for fresh unburned fuel, and this would be more than sufficient to offset small increases of the order observed:

> "Further it is important to recognize that the concerns about fuel damage are principally related to high burnup fuel (HBF), i.e. fuel with an assembly average burnup of about 45 GWd/mtU or more. However, fresh fuel was used in the analysis for both F-12P and F-32B baskets, which creates additional margin for the fuel of concern."

No changes were made to the SAR in relation to this RAI and response.

Additional Changes Not Described in RAIs

1.) [

PROPRIETARY INFORMATION WITHHELD PER 10CFR2.390

]

[

PROPRIETARY INFORMATION WITHHELD PER 10CFR2.390

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2.) Revise Table 7.1.4 to revise Notes 1 and 2 and remove and replace Note 3 with Note 4.

The change corrects/removes inaccurate statements in the HI-STAR 80 SAR Table 7.1.4 for casks loaded to heat loads higher than 43.5 kW.

When the initial helium backfill pressure limits are specified without requiring a direct helium temperature measurement, there is a high possibility of injecting less helium into the cask than the amount that is required to support the thermal analysis of the cask in vertical orientation. The thermal analysis for the HI-STAR 80 cask in the vertical orientation takes credit for convection of helium inside the cask for casks loaded to heat loads higher than 43.5 kW. The analysis uses 21.1 ^{o}C as a reference temperature and calculates the number of helium moles and cask pressures under operating conditions. Based on ideal gas law, to achieve the same initial helium pressure (P1) for a cask, the number of moles of Helium will be lower if the helium temperature is higher than the reference temperature used in the analysis. Indeed, the gas temperature inside the cask cavity will be higher after drying, but without measurement of the gas temperature, the amount of helium injected into the cask may be inaccurate. If the amount of helium is less than required, it may result in lower convection and therefore higher temperatures than computed in the safety analysis. The change has no impact on the computed temperatures and pressures presented in the SAR, but ensures that the casks as loaded are in accordance with the analysis.

3.) Bolt preloads are applied during they dynamic relaxation phase to establish the initial conditions for subsequent drop simulations. In other words, the state of stress in the bolts and the elastomeric seals at the conclusion of the dynamic relaxation is carried forward into the subsequent drop simulations. This can be confirmed by checking the stress in the bolts/seals at the start of the drop simulations (time = 0 sec.).

The applicant should correct the dynamic relaxation implementation or demonstrate that adequate safety margins for bolt stresses with the full preload value would be maintained during impact.

The response to RAI 2-5 addresses this concern.

4.) [

PROPRIETARY INFORMATION WITHHELD PER 10CFR2.390

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5.) The values given in Table 2.2.8 and 8.1.11 represent the nominal density and crush strength range for Type 2 crushable material. The values used as input to the LS-DYNA simulation models are not the nominal values, but the upper bound and lower bound values considering the manufacturing tolerance (+/- 10%). This ensures that the impact limiter performance is acceptable for the full range of possible manufactured properties.

There was no discussion of why different bounding values were selected for different orientations. That explanation should be included in or referenced to provide justification why the nominal/upper bound/lower bound crush properties were selected for each case.

This discussion has been added in SAR Section 2.7.1.2.

6.) The reduced density in the 2.1% side drop analysis is done deliberately to effectuate a package drop with a single loaded fuel assembly. This is necessary because the simulation model is half-symmetric, and all of the storage cells are offset from the symmetry plane (i.e., there are no half-symmetric fuel assemblies in the LS-DYNA model). Therefore, the model includes one complete fuel assembly adjacent to the symmetry plane, which is assigned a density equal to 50% of the fuel assembly weight. Due to symmetry considerations, the actual payload is then equal to the weight of one BWR fuel assembly.

There still seems to be an apparent discrepancy between the 2.1% oblique drop and 2.1% side drop analyses. Both are symmetric package models with a single complete fuel assembly represents 1 fuel assembly but the 2.1% oblique drop model represents 2 fuel assemblies). The objective stated for the enclosure analyses is only to demonstrate that the package integrity is not challenged by partial loading, so it is unclear how to confirm whether the different densities are intended or if this is an inconsistency.

This clarification has been addressed in responses RAI 2-3 and 2-5.