NON-PROPRIETARY INFORMATION

Response to Request for Additional Information
Holtec International
Docket No. 71-9325
HI-STAR 180D Transportation Package

Licensing Drawings

1-1 Revise Licensing Drawing 8545, Rev. 3, sheet 2 to include the following:

a. Specifically reference Appendix 8.A, rather than Chapter 8 in general, in notes 38 and 39. The seal descriptions including dimensions and specific material combinations unique to each manufacturer are located in Appendix 8.A and should be specifically referred to in the licensing drawings.

b. Table 2.2.12 of the application includes critical characteristics of the seals; it should therefore be referenced in notes 38 and 39.

This information is needed by the staff to determine compliance with 10 CFR 71.33(a)(4), 71.51(a)(1) and (2).

Holtec Response to RAI 1-1:

Notes 38 and 39 of proposed licensing drawing 8545 have been revised to include specific reference to Appendix 8.A. Note 39 has not been revised to include reference to Table 2.2.12 since reference to the pertinent critical characteristics in Table 2.2.12 are already made in the introductory paragraph in Appendix 8.A specifically for springback and seating load. Note 38 has not been revised to include reference to Table 2.2.12 since Table 2.2.12 does not specify seal dimensions.

Chapter 2 – Structural Evaluation

2-1 Explain why the LS-DYNA calculated stress intensities for the primary lid bolts are markedly lower than those calculated by ANSYS, as listed in Table 2.7.6 of the application.

The finite element analyses for the Model No. HI-STAR 180D package are included in the Holtec Report No: HI-2125251. The Average Service Stress of 87.4 ksi and Maximum Service Stress at Extreme Fiber of 121 ksi, in Table 8.2 of the application, are about 83% and 90% of the respective values of 105.5 ksi and 135 ksi in Table 2.7.6 of the application. The differences appear to be larger than those which would have been commonly reported for the type of bolt stress analysis on which the calculation robustness is relied for demonstrating bolt joint leakage tightness for the package moderator exclusion consideration.

This information is needed by the staff to determine compliance with 10 CFR 71.31(a)(2).

Holtec Response to RAI 2-1:

The following Table compares the bolt stresses obtained from the LS-DYNA and the ANSYS analyses.

Stress	LS-DYNA	ANSYS
Average Service Stress, ksi	87.4	105.5
Maximum Service Stress, ksi	121	135.0

The large difference in the results is noted for the following reasons:

1. The instantaneous peak deceleration (119.6 g's) under a top end drop accident observed from the LS-DYNA analysis occurs when the fuel assemblies bounce back and lose contact with the inner lid; the sudden reduction in the total mass participating in the crushing process of the impact limiter leads to the instantaneous peak deceleration shown in Figure 8.1.1 of Holtec Report HI-2125251 (also shown in Figure 2-1.1 below). [

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] The safety factors reported in the SAR are based on the ANSYS solution.

2. In addition, as noted in the SAR (page 2.7-8), the ANSYS evaluation also includes the maximum normal operating internal pressure on the containment boundary (viz. the shell, the top flange, the inner closure lid and the baseplate). **[Withheld in Accordance with 10 CFR 2.390]**

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2-2 Revise, as appropriate, the last paragraph of page 2.0-1 of the application, "the analysis methods, models, and acceptance criteria utilized in the safety evaluation documented in this chapter mirror those used in the SAR for HI-STAR 180 certified in Docket No.71-9325," by also submitting a summary matrix tabulating key deviations between the two applications.

Given that potential enhancements could have been introduced in evaluating the structural performance of the HI-STAR 180D design, compared to the HI-STAR 180, a tabulated "consistency matrix" is needed to clarify the use of the word "mirror" in context.

This information is needed by the staff to determine compliance with 10 CFR 71.31(a)(2).

Holtec Response to RAI 2-2:

Response to 2-2: Section 2.0 of the SAR has been expanded with additional justifications and a comparison table of major design features.

2-3 Clarify the statement of page 2.1-2 of the application,"...The inter-lid gap between the closure lids is sufficiently small...such that both lids can act in tandem in the event of a hypothetical drop accident. This feature limits the maximum deflection in the inner lid and keeps check on the demand on the inner lid bolting...," by identifying the reference analysis submitted, or to be submitted, to demonstrate the implementation of the structural interaction modeling for the as-stated closure lids' behavior.

There is a lack of clarity in the application for using analytical modeling to quantify the effectiveness of the structural interaction between the inner and outer lids to limit the maximum lid deflection during the hypothetical drop accident. Reference to the analysis and corresponding summary results should appropriately be presented in the application.

This information is needed by the staff to determine compliance with 10 CFR 71.31(a)(2).

Holtec Response to RAI 2-3:

The potential interaction between the two lids is considered by defining a surface to surface contact between the two lids in both the LS-DYNA model and the ANSYS model developed for the drop accident analysis. The SAR statement on page 2.1-2 as referred to in the RAI has been revised by clarifying that all analyses implement the structural interaction modeling of this design feature.

Section 2.7 of the HI-STAR 180D SAR has been revised to demonstrate that the structural interaction between the lids is captured by the analytical model during the drop accident. [

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2-4 Revise Table 2.1-3 "Stress Limits for Lid Closure Bolts (Elastic Analysis per NB-3230)" to also list the ASME Code, Section III, Subsection NB, Appendix F, Section F-1335, provisions for the closure lid bolts to meet the tensile, shear, and combined tensile and shear stress allowables. This is consistent with the Section 2.1.2.2 (1)(e) commitment of the application for meeting the stress intensity limits for the containment closure lids.

The present stress categories and Level D stress allowables are incomplete and the "Maximum Service Stress" and corresponding stress allowable are not presented to fully meet the ASME Code provisions for the closure lid bolts. If code alternatives are introduced for demonstrating bolt structural performance, appropriate justifications and compensatory measures should also be noted in the subject and other applicable tables, including Table 8.1.8, "ASME Code Requirements and Alternatives for the HI-STAR 180D Package," of the application.

This information is needed by the staff to determine compliance with 10 CFR 71.31(a)(2) and 71.31(c).

Holtec Response to RAI 2-4:

Since the closure lid bolts are significantly preloaded [**Withheld in Accordance with 10 CFR 2.390**] the closure lid bolt joints effectively act as friction type joints since they can prevent both the inner lid and outer lid [**Withheld in Accordance with 10 CFR 2.390**] from slipping under a deceleration well above maximum value obtained in the 9-meter drop event [**Withheld in Accordance with 10 CFR 2.390**], as demonstrated in the following calculations per the slip resistance equation in ASME Code, Section III, Division 1, Subsection NF, NF-3324.6(a)(4) for friction type bolt joints:

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Since a bolt in a friction type joint is not subjected to shear per NF-3324.6(a)(3)(b), there is no need in SAR Table 2.1-3 to also include the shear and combined tensile and shear stress allowables for the closure lid bolts.

A note has been added to SAR Table 2.1-3 for clarification.

2-5 Add the top-down cask free drop accident analysis results to Table 2.11-4, "Key Dynamic Results for 9 Meter End Drop of HI-STAR 180D Transportation Package," in page 2.11-7 of the application.

As indicated in Table 2.7.3 and Figure 8.1.1 of the Holtec Report No. HI-2125251, a peak axial acceleration of 119.6 g is reported for the fuel rod response under the free drop accident.

This information is needed by the staff to determine compliance with 10 CFR 71.31(a)(2) and 71.31(c).

Holtec Response to RAI 2-5:

The fuel integrity analysis is performed for the governing scenario that results in the maximum cask deceleration before the fuel assemblies rebound and lose contact with the cask. The peak cask deceleration (119.6 g's) reported in Table 2.7.3 of the HI-STAR 180D SAR and shown in Figure 8.1.1 of Holtec Report No. HI-2125251 for the top-end down drop case occurs after fuel assemblies rebound and lose contact with the cask (inner closure lid). [

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In conclusion, the bottom-end down vertical drop accident is the bounding case for the fuel integrity evaluation and the top-end down vertical drop solution does not need to be considered. A note has been added to SAR Table 2.7.3 for clarification.

Chapter 3 – Thermal Evaluation

3-1 Clarify how a quarter-symmetric three-dimensional thermal model of the Model No. HI-STAR180D package would capture the heat transfer characteristics in the horizontal configuration.

Page 3.3-3 of the application states the fuel basket is modeled as a quarter-symmetric array of fuel storage cells. A quarter-symmetric model may not capture the heat transfer characteristics of the external surfaces for which boundary conditions are not symmetric (e.g., presence of the personnel barrier, uneven solar heat, etc.)

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

Holtec Response to RAI 3-1:

The reviewer is correct in identifying that the three-dimensional CFD model, except for personnel barrier scenario, is quarter-symmetric. A quarter-symmetric thermal model of the HI-STAR 180 package conservatively captures all the heat transfer characteristics in the horizontal configuration due to multiple reasons summarized below:

1. The natural convection inside the cask is neglected – only conduction and radiation heat transfer is credited, and is therefore quarter symmetric.

2. Air flow motion around the cask is not modeled explicitly. The heat transfer from the package exterior surfaces is dissipated to the environment by thermal radiation and external natural convection heat transfer. The heat transfer outside the cask is modeled using the correlations provided in Section 3.3 of the SAR.

3. The fuel, basket and the containment shell are conservatively modeled in concentric alignment though the cask is in horizontal orientation and therefore quarter symmetric. This ensures that the gap between the cask contents (fuel, basket & basket shims) and the containment shell is uniform. This is conservative since no direct contact between cask contents and the cask reduces heat transfer from the cask contents and cask.

4. The decay heat load patterns provided in Tables 7.D.2 and 7.D.3 are quarter-symmetric.

5. The reviewer is correct that solar insolation on bottom half of the cask is less than the remaining part of the cask. However, solar insolation is conservatively applied uniformly on ALL the package exterior surfaces.

However, when the Package is equipped with a personnel barrier (see Paragraph 3.3.1.3), the thermal model is half-symmetric since the direction of gravity has an impact on the gas convection. The air flow around the cask and gas motion inside the cask is modeled explicitly.

For all the above reasons, the CFD models that do not explicitly include gas motion can be modeled as quarter-symmetric.

Based on discussions with NRC staff on February 19, 2014, a mesh sensitivity study is performed for the half-symmetric thermal models of HI-STAR 180D Package equipped with a personnel barrier. This study is performed in accordance with the guidelines provided in ASME V&V 20-2009. Table 3.3.12 in Section 3.3 of the SAR gives a summary of the three different grids evaluated along with the PCT results. The grid refinement factor for these three meshes meets the ASME V&V recommended criteria of 1.3. The grid convergence index (GCI) is estimated to be 0.365% with a calculated apparent order of approximately 2. The results also demonstrate that the solutions from these different grids are well within the asymptotic range of convergence. SAR Paragraph 3.3.1.3 is revised to include the grid sensitivity study for HI-STAR 180D half symmetric thermal models with a personnel barrier. The calculations are documented in Appendix C of Holtec Report HI-2125241, Revision 3.

3-2 Demonstrate by analysis that the F-37 bounding configuration results in the highest cladding temperature during short-term and accident condition, as compared to the F-32 basket.

Holtec Report HI-2125241 states that the liming scenario (F-37 basket) bounds the HI-STAR180D temperatures for normal, short-term, and accident conditions. Since the thermal inertia is lower for the F-32 basket, temperatures may increase to higher values during short-term operations and accident conditions for this basket.

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

Holtec Response to RAI 3-2:

The reviewer is correct in identifying that the thermal inertia of the cask with F-32 basket is lower than the cask with F-37 basket. However, an explicit thermal analysis of the accident conditions for F-32 basket is not required due to the following reasons:

1. The thermal inertia of the cask with F-32 basket is approximately only 1.1% lower than the limiting scenario i.e. F-37 basket (See Table 7.10 of Holtec Report HI-2125241, revision 2). Such an extremely small difference in the thermal inertia does not have a material effect on the temperature field during short-term and accident conditions.

2. The maximum permissible heat load in F-32 basket, 33.08 kW (Table 7.D.1 of the SAR), is significantly lower than that companion F-37 basket which allows a heat load of 36.4 kW (Table 7.D.1 of the SAR). Therefore, the temperatures in F-37 basket are expected to increase higher values than F-32 basket during short-term and accident conditions.

3. Fuel and containment seal temperatures have significant margins (more than 140 deg. C) to temperature limits during fire accident. Therefore, additional analysis is not merited.

Therefore, for all the above reasons, a thermal analysis of the cask with F-32 basket under accident conditions is not required and will have no material impact on the thermal safety conclusions made in the SAR.

However, an explicit transient thermal analysis of cyclic vacuum drying of an F-32 basket is performed with design maximum heat load. The methodology is exactly the same as that adopted for F-37 basket documented in Section 3.3.4.1 of the SAR. The results of the transient analysis are presented in Table 3.3.10 of the SAR. Figure 3.3.7 is also added to the SAR to show variation of PCT during heatup and cooldown cycles.

3-3 Demonstrate that the peak cladding temperature results from the different grids are in the asymptotic range for the simulation series.

Holtec Report HI-2125241 states that the peak cladding temperature results from the grid sensitivity study are in the asymptotic range but a demonstration is not provided. A calculation that demonstrates this can be performed using the methods described in ASME V&V 20-2009.

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

Holtec Response to RAI 3-3:

We regret the statement on asymptotic behavior in Section 3.3 of the SAR and Holtec report HI-2125241 Revision 2. This statement is removed from updated revision of both documents. An explicit evaluation to study the asymptotic behavior of the solution from the meshes is now performed and documented in Holtec Report HI-2125241 Revision 3. Per ASME V&V, a three grid solution is adequate if the predicted PCT on three grids are in the asymptotic region for the simulation series. However, since the results indicate that the meshes are not in an asymptotic region, a fourth mesh is generated. Based on the guidance provided in ASME V&V, a four grid solution which results in a constant apparent order of the method for the simulation series and close to the theoretical order (equal to 2), gives a reasonable assurance of mesh convergence.

Table 3.3.5 of the SAR is updated to include four different meshes - Mesh 0 to Mesh 3, which satisfy the ASME recommended grid refinement criteria of 1.3. The PCT result from these meshes is also presented in Table 3.3.5 of the SAR. The grid convergence index and demonstration of asymptotic behavior is revised in Holtec report HI-2125241. Mesh 1 continues to be the licensing basis mesh. Therefore, all other calculations documented in the SAR remain unaffected.

Chapter 4 – Containment Evaluation

4-1 Remove all language from the application stating or indicating that each of the seals in the American Seal & Engineering “Seal option 1” seals and the Technetics “Seal option 2” can be changed without NRC approval.

The staff identified several areas throughout the application that make reference to the ability of a user to make changes to seal options 1 and 2 without NRC approval (e.g., in Appendix 8.A and in Section 2.6.1.3.4 of the application). The seal / groove design is an important to safety component. Therefore, the staff expects to review a unique design for each of the seals in the American Seal & Engineering “Seal option 1” and the Technetics “Seal option 2” based on the design drawings for the associated seal part/drawing number. The application, licensing drawings, and any information incorporated by reference in the licensing drawings should be written as such to reflect this requirement and any language implying that the seal designs can be changed without NRC review and approval should be removed from the application.

This information is needed by the staff to determine compliance with 10 CFR 71.33, 71.51(a)(1) and (2).

Holtec Response to RAI 4-1:

Appendix 8.A and Chapter 2, Subparagraph 2.6.1.3.4, have been updated to remove statements that allow the user to employ a seal design that has not been reviewed and approved by the NRC through the licensing process

4-2 Provide minimum and maximum dimensional values, or dimensions with tolerances for the following parameters in Appendix 8.A (this would also necessitate the removal of the word "Nominal" for each parameter):

a. Nominal Inner Seal Groove OD "Dg"
b. Nominal Inner Seal Seal OD "Ds"
c. Nominal Outer Seal Groove ID "Dg"
d. Nominal Outer Seal Seal ID "Ds"
e. Nominal Groove Width "W"
f. Nominal Seal Groove OD "Dg"
g. Nominal Seal OD "Ds"

The information in Appendix 8.A, "Confinement boundary seal data," should provide the location of the containment boundary components through the use of dimensions with tolerances. This information is necessary to ensure sufficient clearance between the seal and the cavity to prevent the seal from binding and not deforming properly in the cavity.

This information is needed by the staff to determine compliance with 10 CFR 71.33, 71.51(a)(1) and (2).

Holtec Response to RAI 4-2:

The information on seal and groove dimensions and associated tolerances has been revised in Appendix 8.A of the SAR to accord with the seal suppliers' recommendations for the limiting dimensions for the seal and groove. Sheets 11 and 12 to proposed licensing DWG 8545 have been revised accordingly.

4-3 Provide minimum and maximum values, or values with tolerances, for the nominal seal seating load in Appendix 8.A. This would also necessitate the removal of the word "Nominal" from the nominal seal seating load.

The American Seal & Engineering "Seal option 1" seal design drawings stated that the seating load was 850 lbs/in +/- 10% or 3200 lbs/in +/- 10%, depending on the seal. The Technetics "Seal option 2" seal design drawings stated that the seating load was ~942 lbs/in circumference or ~2284 lbs/in circumference, depending on the seal. The tolerance should be included for this value, or a minimum and maximum value should be given.

This information is needed by the staff to determine compliance with 10 CFR 71.33, 71.51(a)(1) and (2).

Holtec Response to RAI 4-3:

Appendix 8.A of the SAR has been updated to include the tolerance on the seating load for all proposed seals. The tolerance is aligned with the seal suppliers' recommendations.

4-4 Revise Appendix 8.A of the application to ensure clarity that the seal manufacturer, seal part / drawing number, seal core, jacket, and lining materials, as well as specific material combinations of those materials, surface finish range, and minimum and maximum seal and groove dimensions (or dimensions with tolerances) are seal parameters that are subject to NRC approval.

Appendix 8.A of the application states that the seal cross section diameter, groove depth, seating load, and spring-back are the only critical seal parameters and that all other seal properties are representative and may vary with seal manufacturer recommendations. Each seal manufacturer proposed specific seal designs to meet the reliability, sealing requirements, and life and recovery of the HI-STAR 180 seals. In Appendix 8.A of the application, the seal manufacturer was described as "Representative," and the seal part / drawing numbers were not provided. Specific seal materials and combinations of seal materials ensure there will be no chemical, galvanic, or other reactions. In addition, the surface finish can impact the performance of the seal. These parameters, as well as the seal and groove dimensions (see RAI 4.2), are all part of the seal / groove design which is an important to safety component not subject to change without NRC approval. The application should be revised to ensure that these parameters will not be changed by a future user without NRC approval.

This information is needed by the staff to determine compliance with 10 CFR 71.33, 71.43(d), 71.51(a)(1) and (2).

Holtec Response to RAI 4-4:

Appendix 8.A of the SAR has been revised to add the information requested in this RAI. The specification of the acceptable seals now includes "component materials", the range of acceptable surface finishes, geometric data, tolerances and supplier's model number Critical characteristics that cannot be changed without prior NRC approval have been identified in the tables.

4-5 Revise Appendix 8.A of the application, and/or the sealing proposals, to ensure clarity between the seal and groove dimensions provided in Appendix 8.A and the dimensions provided in the American Seal & Engineering Seal option 1 and the Technetics seal option 2 sealing proposals.

The staff noted specific discrepancies in Tables 8.A-1 and 8.A-2 of the application for the "Inner Seal Groove OD," "Inner Seal, Seal OD," "Outer Seal Groove ID," and "Outer

Seal, Seal ID." Address these discrepancies and provide an updated version of Appendix 8.A, and/or of the sealing proposals. Any analysis dependent on these dimensions should be modified, if necessary.

This information is needed by the staff to determine compliance with 10 CFR 71.33, 71.51(a)(1) and (2).

Holtec Response to RAI 4-5:

Appendix 8.A of the SAR has been revised to reflect the dimensional information contained in the latest seal proposals from American Seal & Engineering and Technetics.

4-6 Revise Table 2.2.12 of the application, Appendix 8.A, and/or the sealing proposals, to ensure clarity between the minimum seal seating load in Table 2.2.12 and the seal seating load values provided in Appendix 8.A and the sealing proposals.

It appears the minimum seal seating load value in Table 2.2.12 is less than the values in Appendix 8.A. Referring to the same minimum and maximum values for both seal options in Table 2.2.12 is inconsistent with the information provided in Appendix 8.A and the sealing proposals, where each seal manufacturer provided a unique seal seating load. Address in Table 2.2.12 if the minimum seal seating load value and maximum seal seating load value are each specific to the Technetics "Seal Option 2" and the American Seal & Engineering "Seal option 1" designs respectively. Any analysis dependent on these values should be modified, if necessary.

This information is needed by the staff to determine compliance with 10 CFR 71.33, 71.51(a)(1) and (2).

Holtec Response to RAI 4-6:

Table 2.2.12 of the SAR has been revised to reflect the seal seating loads of the seals proposed for use in the HI-STAR 180D and described in Appendix 8.A, Tables 8.A-1 through 8.A-3.

4-7 Describe how the information below has been verified for each of the seals in the Technetics “Seal option 2.”

The “Notes” section of the Technetics “Seal option 2” states that for each seal:

1. Customer to verify that the bolting and hardware can generate the required seating load without warping or distorting.
2. Customer to verify material compatibility.
3. Customer to test and verify that seal meets all performance and safety requirements.

The application does not explain how these notes in the Technetics "Seal option 2" have been verified by the customer in order for the NRC to consider approval of the seal design.

Warping or distorting of the bolting hardware could impact containment capability during normal or accident conditions. Material compatibility is necessary to ensure there are no significant chemical, galvanic, or other reactions among the packaging components, or between the packaging components and the packaging contents. The staff acknowledges that the seals are leakage rate tested to the leaktight criterion in accordance with ANSI N14.5, as described in Chapters 7 and 8 of the application. If there are any additional tests that are being performed to verify that the seals meet all performance and safety requirements, those tests should be described.

This information is needed by the staff to determine compliance with 10 CFR 71.43(d), 71.51(a)(1) and (2).

Holtec Response to RAI 4-7:

We hereby confirm that satisfying the three requirements stated in Technetic's literature cited above is intrinsic to all seal selections made in Holtec's cask designs. In particular, for the HI-STAR 180D joints:

1. The specified bolt preloading stress meets the ASME NB Level A stress limit and is significantly smaller than the yield strength of the bolt material. Therefore, the bolted joint can generate the required seating load without warping or distorting due to excessive bolt preloading. Moreover, bolt preloading is a controlled operation, which is required to strictly follow the relevant operation procedure to ensure that the requirements contained in the "Notes" are satisfied.

2. All cask sealing surfaces have been specified to be made of stainless steel. The seals specified in Appendix 8.A of the SAR have been qualified for compatibility of the environment attendant to their use in HI-STAR 180D. This statement also applies to the aluminum jacketed seals manufactured by Technetics which have been used for multiple years in storage casks subject to continuous leakage monitoring in Europe. The operating experience for these casks has demonstrated there is no evidence of corrosive attack that can degrade seal performance.

3. Every cask is tested with the seals to ensure that the seals meet the criteria defined in chapter 8 of the SAR. There are no additional tests required to confirm the performance capability of the seals and the sealing configuration.

4-8 Address the following relative to springback in association with the seal design and the ability of the closure lid seals to remain leaktight under all hypothetical accident events.

   a. Define the springback to maintain leaktight closure lid seals in the SAR.

b. Provide justification for the minimum numerical value of 0.01339 inches and maximum numerical value of 0.03 inches for springback provided in Table 2.2.12 of the application. Address in Table 2.2.12 of the application if one value or the other is specific to the American Seal & Engineering "Seal option 1" design or the Technetics "Seal option 2" rather than minimum and maximum values being appropriate for both seal options.

c. Provide clear and complete documentation in Section 2.7 of the application to show that, based on the structural analysis, the closure lid seals for the American Seal & Engineering "Seal option 1" and the Technetics "Seal option 2" will remain leaktight under all hypothetical accident events based on the springback, as well as the associated margin for these analyses.

d. Explain how the closure lid seals in the American Seal & Engineering "Seal option 1" and Technetics "Seal option 2" have been designed to provide the minimum springback required in Table 2.2.12 of the application and how this can be concluded from the design drawings provided.

Springback has not been defined in the application, although it is a required characteristic in Table 2.2.12 of the application. Springback could refer to "Useful" or "Total" springback. Section 2.7 of the application does not tie the numerical values for springback to the analysis results for each of the hypothetical accident events. Nor does it show the margin associated with each of these analysis. The design drawings provided for the Technetics "Seal option 2" closure lid seals do not tie the springback to the design of the Technetics "Seal option 2" closure lid seals. It is not clear if the design drawings provided for the American Seal & Engineering "Seal option 1" tie the springback to 0.03 inches and how that value and how the minimum value provided in Table 2.2.12 of the application meets that value.

This information is needed by the staff to determine compliance with 10 CFR 71.51(a)(2).

Holtec Response to RAI 4-8:

We agree that a clear distinction between the terms "total spring-back" and "useful spring-back" is necessary to avoid incorrect interpretation of the results. For this purpose, Figure 4-8.1 below illustrates the loading/unloading/re-loading curve for a typical O-ring gasket. The terms noted in the figure's legend are used in the explanation below to facilitate presentation.

a) The term "useful" springback is defined as the amount that the seal can unload without the leakage rate exceeding the required value. In Figure 4-8.1 below, the "useful" springback is the distance between points F and C', denoted by the letter e in the figure. In the prior submission, the term "Total Springback Available" was used which represents the amount that the seal diameter recovers when completely unloaded, i.e., the total springback. In the figure below, the "Total Springback Available" is the distance between point F and the end point (i.e., zero load point) of the unloading curve, D. This distance is denoted by the letter r in the figure.

b) The following features of the seal's loading unloading curve are germane to understanding the performance of the bolted joints in HI-STAR 180D:

(i) At initial compression, upon reaching point A (lineal pressure Y0), the gasket can seal the joint to the required leakage rate level. However, additional compression is necessary to insure protection against unacceptable leakage.

(ii) The point B in the figure represents the optimum compression of the seal to insure maximum joint sealworthiness. The depth of the groove in which the gasket sits is accordingly desired to be smaller than the gasket diameter by the amount denoted by letter g. As explained in the Holtec Position Paper DS-337 (submitted as Enclosure 7 to Holtec letter 2178008-NRC), in the controlled compression joint utilized in HI-STAR 180D, any bolt load in excess of compressing the gasket by distance denoted by letter g is taken up by the "land". This compression force serves as the initial buffer (reserve) that protects the seal from decompression under loads trying to pry the joint apart.

(iii) The gasket follows the unloading/reloading curve in Figure 4-8.1 if it were to decompress and re-compress after initial seating. The gasket responds as an elastic element (no hysteresis) during the unloading/reloading cycle.

(iv) As the gasket is made to relax during unloading, its lineal pressure, Y, drops. The pressure corresponding to point C is the minimum required pressure to meet the minimum specified leak rate.

(v) If the gasket were to continue to unload, then the lineal pressure will fall below the threshold pressure Y1, and the leak rate may begin to exceed the specified minimum. Nevertheless, the gasket will continue to load/unload along the "elastic" curve under all subsequent cycles.

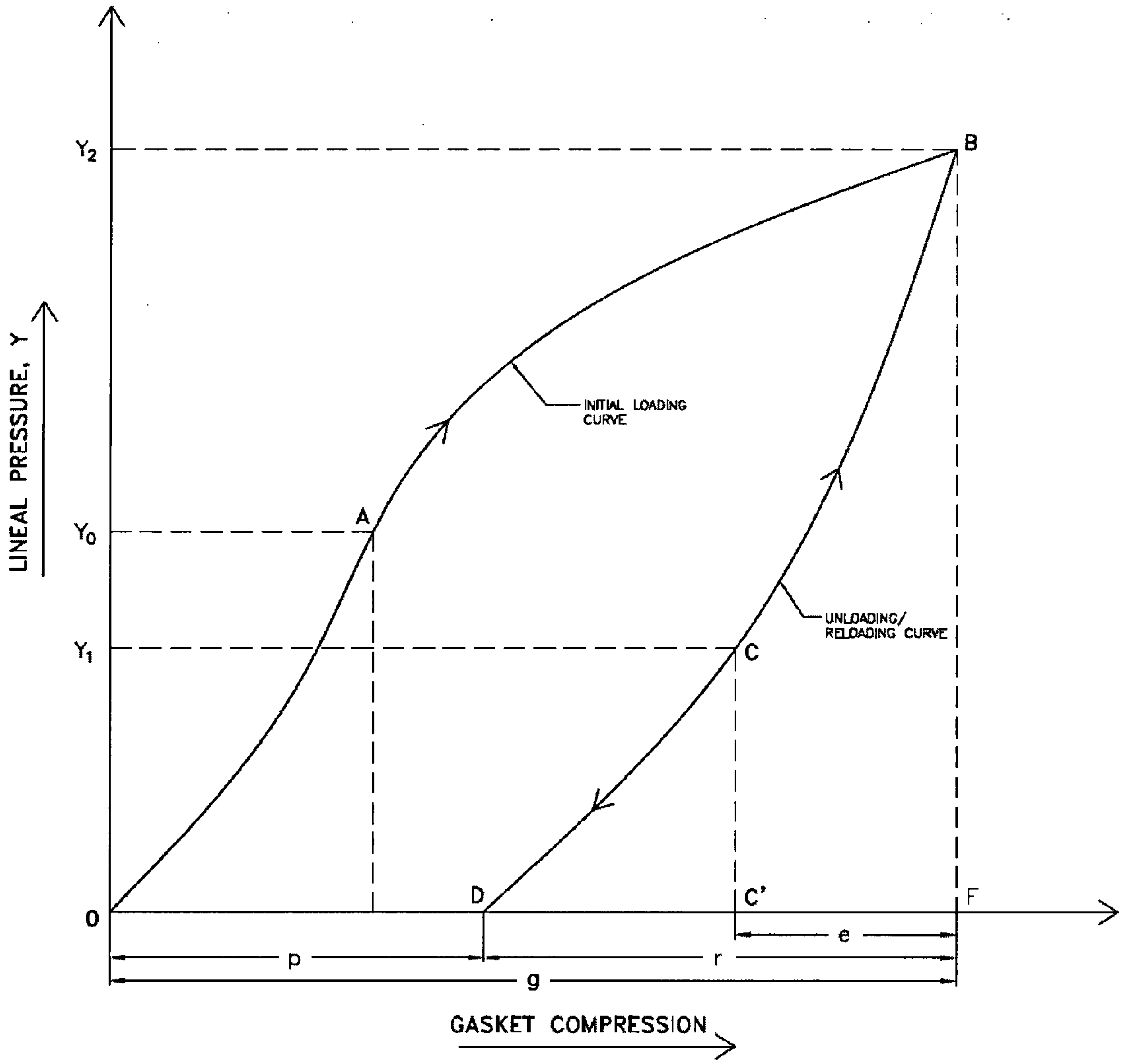
(vi) In order to maintain joint seal, it is necessary that the compression of the seal lie between points F and C'; i.e., in the useful springback range.

(vii) The total recovery, denoted by letter r, is substantially greater than the useful (elastic) springback recovery, denoted by letter e.

The structural analyses reported in SAR sections 2.6 and 2.7 conclude that the seal will remains fully seated (at point B in Figure 4-8.1) after all of the analyzed Level A and Level D accidents. In other words, the seal springback at the end of the analyzed accident is *zero*. As an example, Figure 4-8.2 below shows the relative gap between the top flange and inner lid under the 30' end drop case, which is measured at the inner edge of the inner seal groove. While the gap opens up momentarily during the course of the drop, the springback of the seal after the accident is zero. Seal testing has demonstrated that the seal returns to the leak-tight condition after opening and returning to fully seated. A value of 0.01" was selected as the limit for minimum useful springback to provide additional margin against leakage of the seal. SAR sections 2.6 and 2.7 have been revised to provide the necessary clarification.

c) SAR Section 2.7 and Appendix 1.B have been revised to demonstrate that both seal options will remain leaktight under all hypothetical accident events. The revised SAR also makes it clear that the final seal springback should be checked against the 0.01" useful springback required for the system. Since the final seal springback is zero, the bolt joint has a significant safety margin against leaking (recall that the joint will remain leak-tight even if a springback equal to "e" had occurred). As a quantitative measure, the m value discussed in Subparagraph 2.6.1.3.4 of the SAR is an excellent indicator of the safety margin in the seal design. Subparagraph 2.6.1.3.4 has also been updated to introduce "useful springback" along with other changes necessary to support changes to Table 2.2.12.

d) The only reliable way for establishing the "useful" springback for a seal design is through product testing. Seal suppliers supply the values for "useful" springback based on testing of the seals. The "useful" springback for the American Seal and Engineering and Technetics Seals have been provided based on manufacturer's testing.



SYMBOL	DESCRIPTION
g	OPTIMAL GASKET COMPRESSION
e	USEFUL ELASTIC SPRING-BACK
p	PERMANENT GASKET DIAMETER CHANGE
r	TOTAL SPRING-BACK
Y_2	OPTIMAL LINEAL LOADING
Y_0	MINIMUM LINEAL LOADING TO PRODUCE A SEAL
Y_1	MINIMUM LINEAL LOADING ON DECOMPRESSION TO MAINTAIN A SEAL

Figure 4-8.1: Loading-Unloading Characteristics of O-Ring Seals

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Chapter 5 – Shielding Evaluation

5-1 Provide the "cut-off" payload limit from "exclusive use" to "non-exclusive use" of the package and clarify what other contents could be transported by the package.

Section 1.1 of the application states that the package, when not loaded with design basis radioactive material contents, may be shipped in a non-exclusive use conveyance, provided the threshold limits of 10 CFR 71.47 are not exceeded. The applicant needs to provide cut-off payload limits from exclusive use to non-exclusive use of the package, and specify the other contents, if different from the burnup and cooling time combinations specified in Appendix 7.D of the application. The applicant needs also to provide complete definitions for all intended contents and their corresponding safety analyses.

This information is needed by the staff to determine compliance with 10 CFR 71.47 and 71.51

Holtec Response to RAI 5-1:

Holtec Response: The option to allow a "non-exclusive use" of the package has been removed from the SAR for any shipment of spent nuclear fuel and the SAR has been revised to clearly require "exclusive use" shipment for any shipment of spent nuclear fuel. The initial HI-STAR 180 license (CoC Revision 0) only approves spent nuclear fuel as contents and this license amendment request (LAR 9325-1) does not request the approval of package contents other than spent nuclear fuel; therefore, there are no "other" radioactive waste contents to define. Moreover by removing the "nonexclusive use" option for shipments containing spent nuclear fuel, there is no longer a need to define a "cut-off" payload limit and the specification of package contents corresponding to a "cut-off" payload limit. Lastly, for clarification, the SAR will not disallow the "nonexclusive use" shipment of an empty package that was previously used.

5-2 Justify why the best estimate is considered to be conservative and bounding without accounting for the effects of major uncertainties. Clarify the minimum and maximum enrichments for fuel loading, noting that the minimum enrichment and maximum burnup should be used for the bounding condition.

Section 5.2.1 of the application states that: "The dose rates listed in this subsection are based on a number of conservative assumptions. However, they *do not explicitly account for any uncertainties* except for the inherent uncertainties of the Monte Carlo calculations." The application also states that a 4.55% enrichment, slightly higher than the maximum initial fuel enrichments of 4.25% and 4.5 %, is used in the MCNP model. Section 5.4 states that: "For each pattern, a reference loading is specified in Appendix 7.D, where the maximum burnup, minimum cooling time, and minimum initial enrichment (for UO2 assemblies) is specified for each region of the basket". Appendix 7D shows the 4.25% and 4.5 % enrichments for loading the package.

Section 5.4.6 states that "a combination of 45 GWd/MTHM burnup, 4.5 wt% initial enrichment and 2.5 years cooling is assumed for all fuel in the MCNP model" and used for the evaluation of the best estimate. Although Tables 5.4.9 through 5.4.12 include the MCNP, depletion input, and code uncertainties, no uncertainty due to tolerance in model geometry is considered in the best estimate evaluation.

This information is needed by the staff to determine compliance with 10 CFR 71.47 and 71.51

Holtec Response to RAI 5-2:

Holtec Response: The cited statement in SAR Subsection 5.2.1 is about the design basis approach, not the best estimate approach. The major uncertainties are added to the best estimate approach. It is concluded that the best estimate (including uncertainties) dose rates are bounded by design basis dose rates. Please see SAR Subsection 5.4.6, and SAR Tables 5.4.9 through 5.4.12.

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Regarding "not considering any tolerance in the model geometry," the minimum density is used for several materials. [
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SAR Table 5.C.1 shows samples of how loading patterns are selected. **[Withheld in Accordance with 10 CFR 2.390]** As can be seen, the burnup is increased and the cooling time is decreased for source term calculations. In summary, the minimum enrichment, the maximum burnup and the minimum cooling time are used for the bounding condition.

4.25 and 4.5 % are the initial minimum enrichments. **[Withheld in Accordance with 10 CFR 2.390]** For clarification, bullet 11 under "HI-STAR Modeling Simplifications" (in SAR Paragraph 5.3.1.1) has been revised.

5-3 Clarify the different enrichments used to develop the source term.

Section 5.2.2 of the application states that "three UO_2 fuel enrichments (see Table 5.2.1) were used to develop the source terms." Table 5.2.1 shows only two enrichments, i.e., 4.25% and 4.5 %. Specify the third enrichment value.

This information is needed by the staff to determine compliance with 10 CFR 71.47 and 71.51.

Holtec Response to RAI 5-3:

Holtec Response: We regret the editorial error and we confirm that two enrichments are used to develop the source terms. SAR Subsection 5.2.2 has been revised to replace "three UO2 fuel enrichments" with "two UO2 fuel enrichments".

Chapter 6 – Criticality Evaluation

6-1 Revise the application to ensure that the criticality analysis models a reduced areal density of ^{10}B in the Metamic-HT neutron absorber plates.

NUREG-1617, *Standard Review Plan for Transportation Packages for Spent Nuclear Fuel*, recommends that no more than 75% of the specified minimum neutron poison concentration of the packaging generally be considered in the criticality evaluation. Some neutron absorber materials have been qualified for up to 90% credit, provided there is acceptance testing which can adequately verify the presence and uniformity of the neutron absorbing nuclide. The criticality analysis does not state that a reduced areal density, either at 75% or 90% with acceptable tests, is considered for the Metamic-HT neutron absorber plates.

This information is needed by the staff to determine compliance with 10 CFR 71.55 and 71.59.

Holtec Response to RAI 6-1:

The minimum B4C loading for the Metamic-HT neutron absorber plates is listed in Table 8.1.3 of SAR, and shown that the B4C content by weight shall be ≥ 10 wt. %. For all criticality calculations, the composition of Metamic-HT was calculated based the B4C content of 9%, therefore only up to 90% credit was considered for Metamic-HT. In addition, various tests performed on Metamic-HT were presented in Sections 1.2.1.6.1 and 8.1.5.4 of SAR, which showed that the quantity and homogeneity of dispersion of B4C were confirmed by neutron attenuation testing and wet chemistry testing. Therefore up to 90% credit of B4C considered for Metamic-HT is appropriate to be used. However, the following sentence has been added to SAR Section 6.1.2 for clarification: "The criticality analyses assume up to 90% of the manufacturer's minimum Boron-10 content for the neutron absorber, with acceptance criteria as specified in Subsection 8.1".

6-2 Revise the isotopic depletion benchmarking analysis in Section 6.B of the application to ensure that measured concentrations for nuclides that vary with the decay time are adjusted according to analytical decay equations, to account for differences between the time of measurement and a reference time corresponding to the application.

Appendix A of Interim Staff Guidance 8, Revision 3, *Burnup Credit in the Criticality Safety Analyses of PWR Spent Fuel in Transportation and Storage Casks*, Section 5, states that decay time correction is an important factor when using the direct difference method. NUREG/CR-7108, *An Approach for Validating Actinide and Fission Product Burnup Credit Criticality Safety Analyses — Isotopic Composition Predictions*, recommends that a review of the measurement data and reported decay times be performed to identify nuclides that require decay-time corrections, because fuel sample nuclide concentrations for criticality calculations must correspond to the fuel cooling time considered in the safety analysis models.

This information is needed by the staff to determine compliance with 10 CFR 71.55 and 71.59.

Holtec Response to RAI 6-2:

In the current isotopic depletion benchmarking analysis, only 9 major actinides (Uranium isotopes U-234, U-235, U-236, U-238 and plutonium isotopes Pu-238 through Pu-242) as well as Am-241 were credited in the criticality analyses of HI-STAR 180D. **[Withheld in Accordance with 10 CFR 2.390]** Additional work is then necessary to revise of the isotopic depletion benchmarking analysis.

Among the 10 isotopes used in the analysis, Pu-241 and Am-241 are the only two isotopes that have a cooling time impact because Am-241 is predominantly generated by the decay of Pu-241 after fuel discharge, therefore one more set of calculation for the depletion benchmark are run, **[Withheld in Accordance with 10 CFR 2.390]**, which is consistent with the methodology presented in NUREG/CR-7108.

All results of the calculations, i.e. the reactivity for each sample with the calculated and the measured isotopic composition and the reactivity difference, are listed in Table 1 below. The resulting bias and bias uncertainty values are also shown at the end of Table 1. **[Withheld in**

Accordance with 10 CFR 2.390] Table 2 shows the combined bias and bias uncertainty **[Withheld in Accordance with 10 CFR 2.390]** used in the design basis calculations.

Changes have been made correspondingly in SAR Section 6.B.3.1.3, Table 6.B.4, Table 6.B.6, and Figures 6.B.1 through 6.B.4 to revise the isotopic depletion benchmarking analysis. However, since the combined bias and bias uncertainty value currently used are still bounding, all the other results and conclusions in the SAR remain appropriate and no change is necessary.

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6-3 Revise the isotopic depletion benchmarking analysis in Section 6.B of the application to clarify the generation of surrogate data for the direct difference benchmarking method.

Section 6.B.3 of the application states that "in some experiments the measured data for some isotopes is not available, therefore, surrogate values are generated and used." This section does not provide any details on how the surrogate data values are generated. NUREG/CR-7108 states that surrogate data can be generated based on measurement results from other samples for which nuclide measurements are available. Calculated nuclide concentrations adjusted for the mean measured-to-calculated concentration ratio obtained from other similar samples can be used as surrogate data for nuclides without measurements. This NUREG/CR also provides an example of how to generate a surrogate data value.

This information is needed by the staff to determine compliance with 10 CFR 71.55 and 71.59.

Holtec Response to RAI 6-3:

Surrogate values of measurement results in the isotopic depletion benchmark analysis were generated strictly based on the methodology presented in ISG-8 Rev.3 and NUREG/CR-7108, i.e. the surrogate data value was determined by multiplying the calculated nuclide concentration by the mean value of the measured-to-calculated concentration ratio values obtained from samples with measured data. No additional calculation is needed. Editorial changes have been made in SAR Paragraph 6.B.3.1.3 to provide the information of surrogated values.

Chapter 7 – Operating Procedures

7.1 Provide justification for the comment in Table 7.1.1 of the application relative to the containment boundary outer closure lid access port plug, "Alternate torque may be permitted with Holtec approval."

A minimum torque should be provided for an important to safety containment boundary closure device to maintain a leaktight closure.

This information is needed by the staff to determine compliance with 10 CFR 71.43(c), 71.51(a)(1) and (2).

Holtec Response to RAI 7-1:

SAR Table 7.1.1 has been revised to provide a minimum torque value for the outer closure lid access port plug.