Holtec International Response to NRC RAIs on HI-STAR 100

Chapter 3 – Structural Evaluation

3-1 Provide an evaluation that demonstrates that storage of the HI-STAR 100 overpack in a horizontal orientation meets structural performance requirements under normal, off-normal, and credible accident conditions.

The staff has determined that the application does not contain sufficient information to demonstrate that storage of a loaded HI-STAR 100 overpack in a horizontal orientation meets the structural performance requirements in 1 O CFR Part 72 under normal, off-normal, and accident conditions. The applicant should provide the evaluations to demonstrate that a loaded HI-STAR 100 overpack in the horizontal orientation properly considers normal, off-normal, and accident conditions, including natural phenomena and man-made events.

This information is necessary to meet the regulatory requirements of 10 CFR 72.236(1).

Holtec Response:

The structural loads and load combinations for the HI-STAR 100 overpack under normal, off-normal, and accident conditions are summarized in Subparagraph 3.1.2.1.2, as well as Table 3.1.1 and Tables 3.1.3 through 3.1.5, of the HI-STAR 100 FSAR. As discussed below, the storage of a loaded HI-STAR 100 overpack in a horizontal orientation has no impact on the existing structural evaluations for the normal and off-normal loads, but it does affect the structural evaluations for the accident conditions.

Under normal and off-normal conditions, the structural evaluations that were originally performed for the vertically oriented HI-STAR 100 overpack (prior to LAR 1008-3) are also bounding for the HI-STAR 100 overpack when stored horizontally. This is because of the following considerations.

i) The normal design pressures and temperatures listed in Tables 2.2.1 and 2.2.3 of the HI-STAR 100 FSAR, which are used as input to the structural evaluations, are bounding for both storage orientations (horizontal and vertical) as confirmed by the thermal evaluations in Chapter 4.

ii) As stated in Subparagraph 3.1.2.1.2, normal handling encompasses both vertical and horizontal orientations (regardless of the final storage configuration). Accordingly, the MPC fuel basket and enclosure shell are analyzed separately in Subparagraph 3.4.4.3.1 under axial and lateral loads due to normal handling. The evaluations for the HI-STAR lifting trunnion, pocket trunnions, and the various lid lifting points are not affected by the final storage configuration.

iii) As explained in Section 11.1 of the HI-STAR 100 FSAR, the maximum component temperatures due to off-normal environmental conditions, when the HI-STAR 100 overpack is stored horizontally, are bounded by the results presented in Chapter 3 of the HI-STAR 100 SAR for normal conditions of transport. Moreover, the bounding component temperatures reported in Tables 3.4.10, 3.4.17, and 3.4.18 of the HI-STAR 100 SAR are less than the design temperatures listed in Table 2.2.3 of the HI-STAR 100 FSAR for normal conditions of storage, which are used as input for the structural evaluations. Finally, the off-normal design pressures are the same as the normal design pressures, as shown in Table 2.2.1 and further discussed in Paragraph 11.1.1.3, so that the load combinations for normal and off-normal conditions are subsumed into a bounding set of load combinations.

In summary, the structural evaluations for the normal and off-normal load combinations presented in Chapter 3 of the HI-STAR 100 FSAR are bounding for a loaded HI-STAR 100 overpack stored in the vertical or horizontal orientation. The same, however, is not true for the accident load combinations, where the final orientation of the storage cask has some effect on the structural evaluations.

The accident events that are evaluated in Chapter 3 of the HI-STAR 100 FSAR are (as reported in Subparagraph 3.1.2.1.1):

a) Tip-over
b) Handling accident
c) Flood
d) Explosion
e) Tornado
f) Earthquake
g) Lightning

Each of these accident events is discussed below in the context of the structural performance of a loaded HI-STAR 100 overpack stored horizontally.

a) Tip-over

A tip-over analysis of a loaded HI-STAR 100 overpack stored on an ISFSI pad in the horizontal orientation is not required because:

i) the HI-STAR 100 is analyzed in Appendix 3.A for a 72” horizontal side drop (where 72” is the clear distance from the ISFSI pad surface to the nearest point on the cask);

ii) the proposed CoC has been updated to include a requirement that if the HI-STAR 100 overpack is stored horizontally the center of gravity height of the overpack above the ISFSI pad must not exceed 72 inches.

This approach is consistent with the guidance in 3.5.1.4(i)(3)(a) of NUREG-1536 (Rev. 1), which states:

> "The NRC has also accepted analysis of cask drops with the longitudinal axis horizontal which, together with analysis of a vertical drop, could bound a non-mechanistic tipover case."

b) Handling accident

As mentioned above, normal handling encompasses both vertical and horizontal orientations. Therefore, the HI-STAR 100 overpack is analyzed in Appendix 3.A for a vertical end drop from a height of 21" and a horizontal side drop from a height of 72". These drop analyses establish the carry height limits for an ISFSI owner assuming that the cask is handled using non-single failure proof lifting devices and the ISFSI pad complies with design parameters in Table 2.2.9. Furthermore, these two drop analyses apply regardless of whether the cask is stored in the horizontal or vertical orientation.

c) Flood

As discussed in sub-subparagraph 3.1.2.1.1.3, the flood event has two effects on the structural performance of the HI-STAR 100 overpack, which are:

i) the moving floodwater acts to destabilize the cask, and;
ii) the submergence under water causes an external pressure load on the cask.

The design basis accident external pressure (300 psi) specified in Table 2.2.1 bounds the effect of deep submergence under water, and it is independent of the cask orientation on the ISFSI pad.

The destabilizing effects of the moving floodwater are analyzed explicitly for a vertically oriented cask in Subsection 3.4.6 of the HI-STAR 100 FSAR, which concludes that the cask will not slide or overturn as a result of the design basis flood water velocity (13 ft/sec) specified in Table 2.2.8. The sliding and overturning evaluations for the vertically oriented cask are also bounding for a loaded HI-STAR overpack stored on an ISFSI pad in the horizontal orientation for the following reasons.

The sliding evaluation depends on the mass and the projected (or impingement) area of the cask. These two quantities are quite similar whether the cask is stored horizontally or vertically. In the horizontal orientation, the cask does rest on a low profile support structure, which adds slightly to the total mass and the impingement area, but these increases are offsetting with respect to the net sliding force. Therefore, the sliding evaluation presented in Subsection 3.4.6 is also bounding for the horizontal orientation.

With regard to the overturning evaluation, the cask is inherently more stable when it is stored horizontally because of its lower overall height above the ISFSI pad[1] and the added mass of the low profile support structure, both of which reduce the net overturning moment on the cask due the moving floodwater.

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[1] CoC requires that the center of gravity height (i.e., centerline) of the cask not be higher than 72" above the ISFSI pad surface.

d) Explosion

Sub-subparagraph 3.1.2.1.1.4 of the HI-STAR 100 FSAR states the following:

> "Explosive materials are not permitted within the protective boundary of an ISFSI where a loaded HI-STAR 100 System is maintained in normal storage. The accident condition overpack external pressure specified in Table 2.2.1 is also set as the overall external pressure that bounds all credible external explosion events. There are no credible internal explosion events."

The above statements hold true regardless of whether a loaded overpack is stored horizontally or vertically. In addition, since the accident condition external pressure is analyzed as an all-around pressure acting on all external surfaces of the HI-STAR 100 overpack, the analysis results in Table 3.4.10 (Accident External Pressure - Load Case 02) are valid for both storage orientations.

e) Tornado

The structural performance of the HI-STAR 100 System under the effects of tornado wind and tornado-borne missile impacts is evaluated in Subsection 3.4.8. As discussed above in relation to the flood event, the HI-STAR 100 overpack is inherently more stable when it is stored horizontally on an ISFSI pad. Therefore, the stability evaluation performed in Subsection 3.4.8 for a freestanding HI-STAR 100 overpack in the vertical orientation, under the combined effects of tornado wind and a large missile impact, is also bounding for a HI-STAR 100 overpack stored horizontally.

With regard to the small and intermediate missiles, the calculated indentation and penetration results in Subsection 3.4.8 are valid for both storage orientations. When the HI-STAR 100 overpack is stored horizontally, it is also vulnerable to a missile impact strike on the overpack bottom plate. However, the bottom plate is the same thickness, and is made from the same material, as the overpack closure plate, so the results for the closure plate can be extended to the bottom plate.

f) Earthquake

The stability of the HI-STAR 100 overpack under earthquake loading is evaluated in subparagraph 3.4.7.1 for both storage orientations. For storage in the horizontal orientation, the following inequality should be satisfied to insure stability (i.e., no lift-off) (see paragraph 3.4.7.1 for definition of variables):

$$\frac{H_{CGH}}{B} \leq \frac{(1 - \varepsilon G)}{2G}$$

As an example, for H_{CGH} = 72" and B = 96", the following results are obtained for different values of ε.

Acceptable Horizontal g-Level in Each of Two Orthogonal Directions	Vertical Acceleration Multiplier (ε)	Vectorial Sum of Acceptable Horizontal Accelerations (g)
0.40	1.0	0.566
0.44	0.75	0.622
0.46	0.667	0.651
0.50	0.50	0.707

If the above inequality cannot be satisfied for a particular site, then a 3-D time history analysis may be performed to demonstrate the stability of the HI-STAR 100 overpack in its horizontal storage configuration.

Lastly, it is noted that the low profile support structure that is used for horizontal storage of a loaded HI-STAR overpack is an ancillary device, which is classified as not important to safety (NITS). The justification for its NITS designation is because the HI-STAR 100 overpack has been designed and qualified to withstand a horizontal drop from a height of 72” above the ISFSI pad surface. Therefore, since the HI-STAR 100 CoC requires that the center of gravity height of the HI-STAR 100 overpack above the ISFSI pad must not exceed 72” when stored horizontally, a gross failure of the low profile support structure does not pose any safety risk to the HI-STAR 100 System.

g) Lightning

The ability of the HI-STAR 100 overpack to withstand a lightning strike is independent of its physical orientation (horizontal or vertical) on the ISFSI pad. Thus, the structural evaluation provided in Subparagraph 3.1.2.1.1 applies to both orientations.

Based on the above, storage of the HI-STAR 100 overpack in a horizontal orientation meets structural performance requirements under normal, off-normal, and credible accident conditions. Finally, Chapters 2 and 3 of the HI-STAR 100 FSAR have been updated, as appropriate, to incorporate the additional justifications provided above. Specifically, changes have been made to Subsections 2.2.3, 3.1.2, 3.4.6, 3.4.7, and 3.4.8.

Chapter 4 – Thermal Evaluation

4-1 Provide clarification regarding the fuel transfer conditions temperature limit for moderate burnup fuel (MBF. In addition, provide clarification regarding the repeated thermal cycling fuel applicability and operating restrictions.

Section 4.0, #2 of the application states, "For fuel transfer conditions the fuel cladding temperature should be maintained below 570°C (1058°F) for MBF." In contrast, ISG 11 Rev. 3 states, "For all fuel burnups (low and high), the maximum calculated fuel cladding temperature should not exceed 400°C (752°F) for normal conditions of storage and short-term loading operations (e.g ., drying, backfilling with inert gas, and transfer of the cask to the storage pad). However, for low burnup fuel , a higher short-term temperature limit may be used, if the applicant can show by calculation that the best estimate cladding hoop stress is equal to or less than 90 MPa (13,053 psi) for the temperature

limit proposed." Therefore it is not clear to the staff how the fuel transfer conditions for MBF should be maintained below 570°C (1058°F) for MBF, but rather should be maintained below 400°C (752°F) to assure integrity of the cladding material.

The top of page 2.0-3 of the application states, "iv. For HBF (High Burn-up Fuel), operating restrictions are imposed to limit the maximum temperature excursion during short-term operations to 65°C (117°F) and the number of excursions to less than 10." In contrast, ISG 11 Rev. 3 states, "During loading operations, repeated thermal cycling (repeated heatup/cooldown cycles) may occur but should be limited to less than 10 cycles, with cladding temperature variations that are less than 65°C (117°F) each." Therefore it is not clear to staff how this only applies to high burn-up fuel, but should apply to all fuel to assure integrity of the cladding material. It is also not clear what specific operating restrictions in the technical specifications are being referred to and how the operating restrictions ensure the cladding temperature variations are less than 65°C (117°F) each and limited to less than 10 cycles.

This information is necessary to meet the regulatory requirements of 10 CFR 72.122(h)(1), 72.122(1) , 72.236(m).

Holtec Response:

As has already been approved in the HI-STORM 100 (Docket 72-1014), a PNNL study[2] has evaluated a number of bounding fuel rods for reorientation under hydride precipitation temperatures for MBF. The study concludes that hydride reorientation is not credible during short-term operations involving low to moderate burnup fuel (up to 45 GWD/MTU) for temperatures up to 570°C. Accordingly, this higher ISG-11 temperature limit of 570°C was justified for moderate burnup fuel and was adopted in the HI-STORM FSAR for short-term operations for MBF fueled MPCs. The text of HI-STAR 100 FSAR Section 4.3 is modified to include the previously NRC-reviewed (in Subsection 4.3.1 of the HI-STORM 100 FSAR) description of the acceptability of the MBF cladding temperature limit. The lower 400°C limit is applied for HBF cladding for all long-term normal conditions and for short-term operations.

4-2 Demonstrate that Metamic material properties are thermally bounded by Boral® material properties.

Section 4.2 of the application states, 'The neutron absorber materials Boral® and Metamic are both made of aluminum powder and boron carbide powder. Although their manufacturing processes differ, from a thermal standpoint, their ability to conduct heat is virtually identical. Therefore the values of conductivity of the original neutron absorber (Boral®) continue to be used in the thermal calculations." Table 4.2.1 of the application states that the thermal conductivity, density, and heat capacity of Boral® and Metamic are from test data, but it is not clear from this table how the values of Boral® are bounding. Also, a reference was given for the Metamic Sourcebook (Reference 4.2.11 of the application), but no year was provided for this reference, therefore it is not clear what

[2] Lanning and Beyer, "Estimated Maximum Cladding Stresses for Bounding PWR Fuel Rods During Short Term Operations for Dry Cask Storage," PNNL White Paper, (January 2004).

specific values are being referenced, how the properties are thermally bounded by Boral®, or if those specific values have already been approved by NRC staff.

This information is necessary to meet the regulatory requirements of 10CFR 72.236(b) and (f).

Holtec Response:

It is noted that the thermal equivalence between Boral and Metamic has previously been approved by the NRC for Holtec's HI-STORM 100 System (Docket 72-1014). The wording added to Section 4.2 of the HI-STAR 100 FSAR is the same as that already existing in the HI-STORM 100 FSAR. However, even though this change to the HI-STAR 100 FSAR only adds information that has already been accepted, a technical discussion on the stated equivalence is provided next.

[PROPRIETARY INFORMATION WITHHELD IN ACCORDANCE WITH 10CFR2.390]

4-3 Provide discussion and results of the thermal analysis for the HI-STAR 100 for the MPC-32 during normal, off-normal, and accident storage conditions which address the peak cladding temperature and SSCs maximum temperatures, maximum pressure, and maximum thermal stresses. The associated thermal analysis input and output files should also be provided. This analysis should consider all fuel and cladding types, boundary conditions, and the thermal interaction among casks in an array.

It is not clear from the discussion provided in Chapter 4 of the application how the thermal analysis for the vertically oriented HI-STAR 100 MPC-68 during storage is bounding for the vertically oriented HI-STAR 100 MPC-32 during storage. The similarities and differences between the 1) HI-TRAC transfer cask with the HI-STORM 100 from Rev. 2 of the FSAR and the 2) HI-STAR 100 from this application, as well as the similarities and differences for the MPC-32 and MPC-68 within 1) and 2) and between 1) and 2) were not described in the application.

The complexity of these systems does not lend themselves to this type of comparison and a thermal analysis for the vertically oriented MPC-32 in the HI-STAR 100 needs to be provided. In addition, contents with stainless steel cladding are part of CoC No. 1008 Appendix B, Amendment 3. Ensure it is clearly described in Chapter 4 of the application that the thermal analysis specifically addresses each cladding type, or how the thermal analysis is bounding for all fuel and cladding types described in CoC No. 1008 Appendix B, Amendment 3. Also, the thermal analysis should consider all boundary conditions and the thermal interaction among casks in an array. Therefore, the staff cannot make a safety determination based on the limited information provided and the lack of thermal analysis.

This information is necessary to meet the regulatory requirements of 10 CFR 72.236(f).

Holtec Response:

The HI-STAR 100 overpack and the 125-ton HI-TRAC transfer cask described in the referenced HI-STORM 100 FSAR have nearly identical cavity dimensions and overall dimensions. They also both have multi-layered construction, both include a radial neutron shield layer, have very similar overall dimensions, both credit the same heat transfer mechanisms, and neither is ventilated. Considering the extent of the similarity between the 125-ton HI-TRAC and the HI-STAR 100, it is reasonable to conclude that the canister design which is thermally-limiting in a 125-ton HI-TRAC (the MPC-68) will also be thermally-limiting in a HI-STAR 100. The text of HI-STAR 100 FSAR Paragraph 4.4.2.1 is modified to provide much more detail on the similarities between the two overpacks and their credited heat transfer mechanisms to demonstrate the equivalence in their thermal performance trends.

With respect to stainless-steel clad fuel in the HI-STAR 100 storage system, this has been removed from the approved contents section of the proposed technical specifications. Some discussions of stainless-steel clad fuel are left in Chapter 4, however, but for information only.

With respect to the thermal interactions among casks in an array of horizontal casks, as described in Section 1.4 and Paragraph 3.4.1.1.7 a site-specific analysis is required for every array of horizontal casks. This requirement was imposed because horizontal casks occupy more area than vertically-oriented ones, so there would likely be more geometric constraints to the design of an array of horizontal systems necessitating site-specific qualifications. The same thermal evaluation method described, and the same acceptance criteria imposed, in the HI-STAR 100 FSAR would be applied to all such site-specific evaluations.

4-4 Describe in Section 4.2 of the application how the heat conduction elements in the MPC-32 impact the heat transfer.

*In Section 4.2 of the application the footnote * states, "In MPC-32, aluminum heat conduction inserts are optional equipment available by user request." Also, Section 4.4.1.1.10 of the application states, "Due to the high thermal conductivity of aluminum alloy 1100 (about 15 times that of Alloy X) , a significant rate of heat transfer is possible along thin flexible plates." It is not clear how the lack of heat conduction elements in the MPC-32 canister impacts the heat transfer and as a consequence the peak cladding temperature and SSC maximum temperatures.*

This information is needed to meet the regulatory requirements of 10 CFR 72.236(f).

Holtec Response:

The HI-STAR 100 transportation SAR, being incorporated by reference for the storage of horizontally-oriented systems with MPC-32, permits (but does not require) aluminum heat conduction inserts in the basket-to-shell peripheral spaces. The aluminum heat conduction inserts provide a high-conductivity heat transfer path from the outer surfaces of the fuel basket to the inner surface of the enclosure vessel shell. Their presence would improve heat transfer from the fuel basket to the enclosure vessel shell. This discussion will be added to the footnote in Section 4.2.

4-5 Clarify the discrepancy between the decay heat values referenced in Section 4.4.2.1 of the application and Table 1.2.2 of the application.

Section 4.4.2.1 of the application states, The MPC-68 bounds the MPC-32, both of which have nearly identical decay heat loads (21.4 kW for the MPC-68 and 21 .25 for the MPC-32, a difference of only 0.7%)." The decay heat provided in Table 1.2.2 of the application is 18.5 kW for the MPC-32 and MPC-68 in vertical orientation.

This information is needed to meet the regulatory requirements of 10CFR 72.236(f).

Holtec Response:

The incorrect decay heat loads for these two canisters were inadvertently quoted in the text. The heat loads for these two canisters in the HI-TRAC should have been taken from the HI-STORM 100 FSAR, and are 28.19 kW for the MPC-68 and 28.74 kW for the MPC-32 for a difference of less than 2%. The text in Paragraph 4.4.2.1 will be corrected.

As stated in Paragraph 4.5.2.1 of the applicable HI-STORM 100 FSAR [4.4.10], "A bounding steady-state analysis of the HI-TRAC transfer cask has been performed using the hottest MPC, the highest design-basis decay heat load … and design-basis insolation levels." The MPC-68 bounds the MPC-32, both of which have nearly identical decay heat loads (28.19 kW for the MPC-68 and 28.74 for the MPC-32, a difference of less than 2%). These results from an analysis of a similar style cask using the same thermal analysis methods leads to the conclusion that the thermal performance of a vertically-oriented HI-STAR 100 System containing an MPC-32 basket will be bounded by the thermal performance of a vertically-oriented HI-STAR 100 System containing an MPC-68. Having said that, the licensing-basis decay heat load for these two canisters in the HI-STAR 100 system have an 18.5 kW heat load (see HI-STAR 100 FSAR Table 1.2.2).

4-6 Address the following regarding the forced helium dehydration system:

a. Section 4.4.2 of the application refers to the design criteria in the HI-STORM 100 technical specifications, yet this application is for the HI-STAR 100.

b. Section 4.4.3 (iii.) of the application refers to subsections 4.4.1.1.1 through 4.4.1.1.4, confirm if those sections are accurate and if those sections are for this application.

It is not clear if the technical specifications and subsections referenced are accurate for the HI-STAR 100 application.

This information is needed to meet the regulatory requirements of 10 CFR 72.236(f).

Holtec Response:

The FHD is discussed in Paragraphs 4.4.1.1.12 and 4.4.2.2 of the HI-STAR 100 FSAR. No reference to the HI-STORM 100 technical specifications exists in these paragraphs. There is reference to Appendix 4.A, and the reference to the HI-STORM technical specifications in 4.A.2

is a typographical error. It should have referred to the HI-STAR 100 technical specifications, and is corrected.

4-7 Provide justification for the accident design pressure limit of 200 psig in the application.

The design pressure limit was 125 psig and has been revised to 200 psig.

This information is needed to meet the regulatory requirements of 10 CFR 72.236(b).

Holtec Response:

The structural evaluation to demonstrate that the accident internal pressure results in acceptable MPC enclosure vessel stresses is presented in Chapter 3 of the FSAR, specifically in Subparagraph 3.4.4.3.1.2. As stated therein, “a safety factor greater than 1.0 exists for the case of normal and accident pressures,” for the accident design pressure limit of 200 psig.

4-8 Provide discussion and results of the thermal analysis that includes the maximum temperatures, pressures, stresses, associated limits, time-to-boil, etc. for the HI-TRAC transfer cask and of the MPCs and contents while in the HI-TRAC transfer cask. The associated thermal analysis input and output files should also be provided.

Section 1.2.1.4 of the application states, "MPC handling operations are performed using a HI-TRAC transfer cask of the HI-STORM 100 System (Docket No. 72-1014). The HI-TRAC transfer cask allows the sealed MPC loaded with spent fuel to be transferred from the HI-STORM Overpack (storage-only) to the HI-STAR Overpack, or vice versa.," therefore the discussion and the results of the thermal analysis that includes the maximum temperatures, pressures, stresses, associated limits, time-to-boil, etc. for the HI-TRAC transfer cask and of the MPCs and contents while in the HI-TRAC transfer cask should be addressed in the application for normal, off-normal, and accident conditions.

This information is needed to meet the regulatory requirements of 10 CFR 72.236(f).

Holtec Response:

Operations involved with loading an MPC in a HI-STAR 100 directly from the spent fuel pool are described and evaluated throughout the HI-STAR 100 FSAR. The statements in Paragraph 1.2.1.4 are meant only to explain that a HI-TRAC transfer cask can be used to move a previously-loaded MPC between a HI-STORM 100 storage system and a dual-purpose HI-STAR 100 system. Not explicitly stated (but implied by reference to Docket No. 72-1014) is the fact that the entire time that such an MPC is being handled in a HI-TRAC it would have to meet the requirements of the HI-STORM 100 license, technical specifications and FSAR. The statements in Paragraph 1.2.1.4 do not imply that the HI-TRAC is part of the HI-STAR 100 system, so it is not necessary to provide information on HI-TRAC in the HI-STAR 100 FSAR.

4-9 Address the following regarding the HI-STAR 100 in horizontal orientation:

a. Provide design drawings, description, etc. for the structure that will maintain the HI-STAR 100 location and horizontal orientation during storage.

b. Provide discussion and results of the thermal analysis for the HI-STAR 100 in horizontal orientation during normal, off-normal, and accident storage conditions which addresses the peak cladding temperature and SSCs maximum temperatures, maximum pressure, and maximum thermal stresses. The associated thermal analysis input and output files should also be provided. This analysis should consider the structure to maintain the location and horizontal orientation, all fuel and cladding types, as well as the thermal interaction among casks in an array. The boundary conditions should be completely described and be valid for the structure used to maintain the HI-ST AR 100 location and horizontal orientation during storage.

The design details for the structure to maintain location and horizontal orientation of the cask have not been provided in the application. It is not clear from the discussion provided in Chapter 4 of the application how the thermal analysis for the HI -ST AR 100 for transportation is bounding. In addition, contents with stainless steel cladding are part of CoC No. 1008 Appendix B, Amendment 3. Ensure it is clearly described in Chapter 4 of the application that the thermal analysis specifically addresses each cladding type, or how the thermal analysis is bounding for all fuel and cladding types described in CoC No. 1008 Appendix B, Amendment 3. The thermal analysis should consider any structure used to maintain the location and horizontal orientation of the HI-STAR 100, as well as the thermal interaction among casks in an array. It is not clear from the application if horizontal and vertically oriented casks will be mixed. Therefore, the staff cannot make a safety determination based on the limited information provided and the lack of thermal analysis.

This information is necessary to meet the regulatory requirements of 10 CFR 72.236.

Holtec Response:

As discussed in the response to structural RAI 3-1 above, the structure designed to support the HI-STAR 100 in a horizontal orientation is classified as not important to safety (NITS), and therefore, no design of such is included in the HI-STAR 100 FSAR. The thermal qualification of the horizontally-oriented HI-STAR 100 is through reference to the NRC-approved transportation license (Docket No. 71-9261), which also supports the cask in a horizontal orientation. With respect to thermal performance qualifications, it is conservative to neglect the presence of the horizontal support structure just like the transport frame used under 71-9261 is neglected. Both of these structures can conservatively be neglected because they are steel structures in intimate contact with the outside surface of the horizontal HI-STAR 100, and provide a large surface that will conduct heat from the cask and passively convect and radiate it to the environment. Neglecting an additional heat transfer pathway is conservative, so the support structure has been conservatively excluded from the thermal qualification evaluations.

With respect to stainless-steel clad fuel and the thermal interaction between casks in an array, please see the response to RAI 4-3.

Chapter 5 – Confinement Evaluation

5-1 Clarify the certification level of the personnel developing/approving the helium leakage rate testing procedures considering that industry standards indicate that this should be performed by qualified personnel.

The applicant described the leakage tests in FSAR Sections 8.1 .6 without identifying the certification level of the personnel developing/approving the helium leakage rate testing procedures. For example, ANSI/ASNT CP-189-2006, "Standard for Qualification and Certification of Nondestructive Testing Personnel", states that a nondestructive testing personnel Level Ill examiner has the qualifications to develop and approve written instructions for conducting the leak testing.

This information is needed to meet the regulatory requirements of 10 CFR 72.236(e).

Holtec Response:

In the HI-STAR 100 Storage FSAR HI-2012610 Proposed Rev. 4A, Section 8.1.36 a note has been added stating “NDE personnel shall be qualified per the requirements of Section V of the ASME Code [8.1.3] or site specific program.” This note is consistent with the notes related to personnel qualification in both the HI-STORM100 FSAR (Chapter 8) and the HI-STORM FW FSAR (Chapter 9).

The following reference will be added: [8.1.3] American Society of Mechanical Engineers "Boiler and Pressure Vessel Code".

5-2 Identify the helium leak rate testing acceptance criteria for the MPC vent and drain port cover plates in the Technical Specifications.

FSAR Section 8.1.6 and Table 9.1.1 both reference that helium leak rate testing shall be performed on the vent and drain port cover plate to MPC lid field welds and the cover plate base metals and that the MPC helium leakage rate test acceptance criteria are defined in the Technical Specifications. The Technical Specifications only identify limits for the overpack helium leak rate and do not identify the MPC helium leak rate test acceptance criteria.

This information is needed to meet the regulatory requirements of 10 CFR 72.236(e).

Holtec Response:

To ensure that the acceptance criteria for the MPC helium leak rate test is clear,the HI-STAR 100 Part 72 CoC App A Amendment 3, Technical Specification LCO 2.1.1, Surveillance Requirement 2.1.1.3 has been revised to the following, “Verify that the helium leak rate through the MPC vent and drain port cover plates (confinement welds and base metal) meets the leaktight criteria of ANSI N14.5-1997.” This Surveillance Requirement has a frequency of “Once, prior to TRANSPORT OPERATIONS.”

Chapter 6 – Shielding Evaluation

6-1 *Provide shielding analyses that demonstrate that the 32/24 scaling of MPC-24 cask external dose rates for the MPC-32 is conservative for PWR fuel storage in the HI-STAR 100 System.*

In Section 5.3.3 of the UFSAR, the applicant states that a simple 32/24 scaling of external dose rates for the MPC-24 in the HI-STAR 100 cask system is adequate to determine conservative external dose rates for the MPC-32 in the HI-STAR 100. The applicant should provide a shielding analysis demonstrating that this approach is conservative. Additionally, the applicant should provide a side-to-side comparison of loading criteria for the MPC-24 and MPC-32. This comparison should demonstrate that assuming each fuel assembly in the MPC-32 has the same source term as each fuel assembly in the MPC-24 is appropriate for determining a bounding external dose rate of the MPC-32 in the HI-STAR 100 system.

This information is necessary to meet the regulatory requirements of 10 CFR 72.104, 72.106, and 72.236(d).

Holtec Response:

Realizing the inherent limitations of using a scaling factor, all dose rate calculations for the MPC-32 basket were re-performed by correctly modeling the MPC-32 basket in the MCNP models. This provides consistency with the results obtained for the other baskets. The updated approach and results are provided in the revised HI-STAR 100 FSAR Chapter 5. With this approach, separate burnup-cooling time combinations are now used for the MPC-32, conservatively bounding the allowable burnup-cooling time combinations specified in Chapter 2 of the HI-STAR 100 FSAR.

6-2 *Provide the minimum distance required for various configurations of the most bounding MPC that results in a dose rate below 25 mrem per year.*

Provide the calculations necessary to show the annual dose to an individual from a single cask and various arrays of casks does not exceed 25 mrem per year. The applicant only demonstrated this requirement for the MPC-24. Since the MPC-32 will have the bounding external dose rate, per Section 5.3.3, the applicant should revise the site boundary dose rate calculations to consider the MPC-32, or otherwise demonstrate that the current calculation is conservative.

This information is necessary to meet the regulatory requirements of 10 CFR 72.104, 72.106, and 72.236(d).

Holtec Response:

Annual dose rates from a single cask and array of casks for MPC-32 are now provided in revised Section 5.4.3 using evaluations discussed in response to RAI 6-1.

6-3 Provide and justify the acceptable fuel characteristics of stainless steel clad fuel for storage in the MPC-32.

Table 1.2.1 for the SAR states the MPC-32 can have up to 32 intact zircaloy or stainless steel clad PWR fuel assemblies. Tables 2.1.11 and 5.2.18 of the SAR only list the design characteristics of the stainless steel clad fuel assemblies for the MPC-24 and MPC-68. Furthermore, Table 5.4.14 of the SAR only lists the dose rates of the overpack for the design basis stainless steel clad fuel for the MPC-24 and MPC-68 canisters.

This information is necessary to meet the regulatory requirements of 10 CFR 72.104, 72.106, and 72.236(d).

Holtec Response:

We apologize for the confusion. The MPC-32 was not intended to be qualified for fuel assembly with stainless steel clad. The option has been removed from the revised Chapter 2, and Appendix B of the CoC updated accordingly. Hence no further changes to Chapter 5 are required.

Chapter 11 – Accident Analyses Evaluation

11-1 Provide additional explanation regarding why the partial blockage of the MPC basket flow holes is not credible for each basket type (e.g. MPC-24, MPC-68, and MPC-32).

In Section 11.2.4 of Rev. 3 of the HI -STAR 100 application, the partial blockage of the MPC basket flow holes was a credible accident for the MPC-24 and MPC-68 baskets. In Section 11.2.4 of Rev. 4 of the HI-STAR 100 application, the inclusion of the MPC-32 basket was also requested. But it is not clear how this type of accident was determined to be not credible for each basket type.

This information is necessary to meet the regulatory requirements of 10 CFR 72.236(f).

Holtec Response:

Since the HI-STAR 100 System takes no credit for any motion of the backfill gas through the fuel baskets, the elongated semi-circular holes at the top and bottom of the fuel baskets are not relied upon for the performance of the system and so, technically speaking, are not vent holes. If blockage of these holes were to occur it would have no impact on the thermal performance of the system. Additionally, it is noted that the text in Subsection 11.2.4 already been approved by the NRC in the HI-STORM 100 System (Docket No. 72-1014), which has the same MPCs and can hold the same fuel assemblies.

11-2 Revise the vertically-oriented and horizontally-oriented thermal analysis in Section 11.2.13.2 of the application to address the environmental temperature of 125°F.

The vertically-oriented analysis in Section 11.2.13.2 of the application summarizes that adding 45°F to temperature of analysis performed at 80°F is also equivalent to performing an analysis at 125°F ambient. In addition, the horizontally-oriented analysis in Section 11.2.13.2 of the application summarizes that adding 25°F to temperatures of an analysis performed at 100°F ambient is equivalent to performing an analysis at 125°F ambient. This methodology does not necessarily result in accurate or bounding temperature results and is not an appropriate methodology for analyzing the off-normal ambient temperature of 125°F. For example, Section 4.8.4 of NUREG-2174, "Impact of Variation in Environmental Conditions on the Thermal Performance of Dry Storage Casks, Draft Report for Comment," shows an analysis where a 10°F increase in ambient temperature results in a 14.4°F increase in peak cladding temperature.

This information is necessary to satisfy the regulatory requirements of 10 CFR 72.236(f).

Holtec Response:

Adding 45°F to the temperature results of analysis performed at 80°F ambient to determine equivalent temperatures at 125°F ambient is the current NRC-approved method used in the HI-STAR 100 FSAR. Use of this method is not a change to the HI-STAR 100 FSAR. Also, while Table 4-19 of NUREG-2174 does show that a 10°F increase in ambient temperature results in a larger than 10°F increase in peak cladding temperature, this is observed for a ventilated system. In a ventilated system the increase in air temperature directly affects the density of air in the ventilation passages, thereby changing the ventilation air flow rate. This effect causes the impact of the ambient temperature change to be greater than it would be for a non-ventilated system like the HI-STAR 100.

Additionally, it is noted that large margins to the accident temperature limit (approximately 320F) exists for this extreme hot ambient condition. Any potential small differences in the temperatures due to the method of evaluation that would exist under this condition are much smaller than the available temperature margin.

11-3 Provide additional details in Section 11 .2.3.2 of the application based on the structure used to orient the cask horizontally to confirm that the fuel puddle for a horizontal cask is larger than the fuel puddle for a vertical cask.

Because details of the structure for horizontal orientation were not provided, it is not clear that the fuel puddle for a horizontally oriented cask will be larger than the fuel puddle for a vertically oriented cask. Therefore it is not clear if the fuel depth for a vertically oriented cask will be larger than that for a horizontally oriented cask, or if the fire duration will be larger for a vertically oriented cask.

This information is necessary to meet the regulatory requirements of 10 CFR 72.236(b) and (f).

Holtec Response:

The HI-STAR 100 System design-basis fire is defined using the guidance of 10CFR71.73, which is endorsed by NUREG-1536. As described therein, the fuel puddle must extend horizontally at least 1 m (40 in) beyond any external surface of the cask. For a vertical HI-STAR 100 the external surface of the cask is defined by a 93 3/4” circle. For a horizontal HI-STAR 100 the external surface of the cask is defined by a 93 3/4” x 191 1/8” rectangle. The fuel puddle formed around the much larger rectangular area will also be much larger, and therefore shallower, than that formed around the vertical cask. As a shallower puddle results in a shorter fire, it is apparent that the vertical cask fire duration will be bounding. A discussion of this is added to the text of Paragraph 11.2.3.2.