May 10, 2001

Mr. Brian Gutherman
Licensing Manager
Holtec International
555 Lincoln Drive West
Marlton, NJ 08053

SUBJECT: REQUEST FOR ADDITIONAL INFORMATION - HOLTEC HI-STORM 100 CASK SYSTEM AMENDMENT 1

Dear Mr. Gutherman:

On August 31, 2000, Holtec International (Holtec) submitted a revised application in accordance with 10 CFR Part 72 for an amendment to Certificate of Compliance No. 72-1014 for the HI-STORM 100 Cask System to permit design changes and allow the use of a 32 assembly fuel basket. Enclosed is the staff's request for additional information (RAI) for the continued review of the amendment request.

Your full and complete response to the enclosed RAI is necessary for the staff to complete its review. Upon receipt of your RAI responses, we will perform an acceptance review to determine if sufficient information has been provided to allow completion of the review and inform you if the information provided is not complete.

If you have any comments or questions concerning this request, you may contact me at (301) 415-2947. Please refer to Docket No. 72-1014 and TAC No. L23082 in future correspondence related to this request.

Sincerely,

/RA/

Christopher P. Jackson, Project Manager
Licensing Section
Spent Fuel Project Office
Office of Nuclear Material Safety
and Safeguards

Docket No. 72-1014
TAC No. L23082

Enclosure: RAI on HI-STORM 100 Cask Storage System

May 10, 2001

Mr. Brian Gutherman
Licensing Manager
Holtec International
555 Lincoln Drive West
Marlton, NJ 08053

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(Original Signed by:)

Christopher P. Jackson, Project Manager
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Docket No. 72-1014
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Enclosure: RAI on HI-STORM 100 Cask Storage System

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NAME	CJackson		EZiegler		SWhaley		CBajwa		CRegan	
DATE	5/8/2001		5/9/01		5/9/01		5/9/01		5/9/01	

OFC	SFPO		SFPO	E	SFPO	E	SFPO	E	SFPO	E
NAME	JMyers		RShewmaker		CBrown		JGuttmann		NOsgood	
DATE	5/9/2001		5/9/01		5/9/01		5/10/01		5/10/01	

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ENCLOSURE

HI-STORM 100 CASK STORAGE SYSTEM
DOCKET NO. 72-1014
TAC NO. L23082

REQUEST FOR ADDITIONAL INFORMATION

This document, titled Request for Additional Information (RAI), contains a compilation of additional information requirements identified to-date by the U.S. Nuclear Regulatory Commission (NRC) staff, during its review of Holtec International's revised application for approval of an amendment to the proposed Certificate of Compliance (CoC) for the HI-STORM 100 Cask under 10 CFR Part 72. This RAI follows the same format as Holtec's Safety Analysis Report (SAR).

Each individual RAI describes information needed by the staff for it to complete its review of the application and the SAR and to determine whether Holtec International has demonstrated compliance with the regulatory requirements.

1.0 General Description

1.1 Provide detailed procedures of how a loaded HI-STORM 100S is moved into and out of the Part 50 facility with neither the temporary lid nor permanent lid installed as described on page 1.2-8 of the Safety Analysis Report (SAR). "Users who require specific configuration may move the loaded HI-STORM 100S overpack into or out of the Part 50 facility with neither the temporary nor the permanent lid installed. Before moving the overpack to the ISFSI, the permanent lid should be installed as soon as practicable after the loaded overpack leaves the Part 50 facility."

These evolutions are not described in SAR Chapter 8, "Operating Procedures." This information is not provided and is needed to assure compliance with 10 CFR 72.11.

1.2 Revise description of multi-purpose canister (MPC)-68F on page 1.2-25 to be consistent with CoC Appendix B and Table 1.2.1. The correct number of allowed damaged fuel canisters (DFCs) containing debris is 4.

This information is needed to assure compliance with 10 CFR 72.11.

1.3 Explain and resolve the discrepancy between description of MPC-68FF on page 1.2-26 and the description in table 1.2.1. According to table 1.2.1, the MPC-68FF can only store up to 4 DFCs with Dresden Unit 1 or Humboldt fuel debris, but the description implies that any number of DFCs with this debris can be stored.

This information is needed to assure compliance with 10 CFR 72.11.

1.4 Table 1.2.6 on page 1.2-33 does not identify the need for special bolt down procedures for the HI-STORM 100A/100SA when the units are placed in storage at the ISFSI pad. Include this step to the HI-STORM 100 Operations Sequence.

This information is not included and is needed to assure compliance with 10 CFR 72.11.

1.5 Address the apparent conflict between the general verbal description of the basket assembly and the configuration for the MPC-24 series as shown on the drawings with regard to the welding of the baskets. Also revise the title of Figure 3.1.1 to "MPC-68 Fuel Basket Geometry." On page 1.2-3, in the third paragraph, last sentence, it is stated that, "All MPC baskets are formed from an array of plates welded to each other, ..." On page 3.1-3, second paragraph, the last two sentences, it is stated that, "Welding of the basket plates along their edges essentially renders the fuel basket into a multiflange beam. Figure 3.1.1 provides an isometric illustration of a fuel basket for the MPC-68 design." It is noted that the title of Figure 3.1.1 is, "MPC Fuel Basket Geometry."

The MPC-24 series as shown in Drawing Number 1395, Sheets 1 and 2, the proposed MPC-24E/24EF cross-section shown in Figure 1.2.4A and Drawings 2889 and 2890 each show a corner detail that indicates all basket cells in this series have at least one corner that is not constructed by welding intersecting plates, but is instead a formed or bent corner configuration. In some cases there are only two of the four corners that are fabricated by welding with the other two being formed or bent. In these cases there is at least one corner of the cell that is unsupported by intersecting plates.

This information is needed to assure compliance with 10 CFR 72.11 and 72.236.

2.0 Principal Design Criteria

2.1 SAR Table 2.0.5, included in the section of the principal design criteria, addresses the interface between the cask and the pad for the anchored version of the Hi-Storm 100A.

A. Clarify if the embedment for the connection of an anchor stud to the concrete pad is cast-in-place exclusively or post-installed.

B. Provide sample design parameters for an acceptable embedment to which the anchor studs will be connected for staff audit.

C. ACI 349-85, Appendix B, has been shown to be non-conservative in some applications through testing and there are changes that are ready for implementation by the building and construction industry. Justify the continued use of ACI 349-85, Appendix B, as a reference for anchorage to concrete. Explain what design provisions need to be mandated for the designer of the cask concrete pad and the anchorage embedment that would become part of the certificate of compliance under the site-specific parameters and analyses.

This information is required to assure compliance with 10 CFR 72.236.

2.2 In proposed Appendix 2.A, on pages 2A-1 and 2A-2, the requirements of ACI-349 are noted as Reference 2.02 for the design and construction of the ISFSI pad. Reference 2.02 is ACI-349-85, a document that has been revised, issued, and become effective twice (1990 and 1997) since the 1985 document became effective. As discussed in the previous RAI, ACI-348-85 has been revised (ACI 349-01) and became effective on February 1, 2001.

Provide your justification for prescribing the use of an outdated version of the ACI 349 Code, especially in view of the significant changes that have been made in such subject areas as in Chapter 12, Development and Splices of Reinforcement. In providing this justification, indicate how any changes made in the current ACI 349-01 since the 1985 version will have no significant impact on the design of an ISFSI pad.

This information is required to assure compliance with 10 CFR 72.236.

2.3 On page 2A-1, Section 2.A.2, Item 4, it is stated that, “The American Concrete Institute guidelines on reinforced concrete design of ground level slabs to minimize thermal and shrinkage induced cracking shall be followed.” This statement identifies an important aspect of the design, construction, and subsequent performance of the important to safety ISFSI pad that is to be provided by the anchored cask user. The statement however, lacks sufficient specificity for the cask user to design, construct, and monitor the ISFSI pad. Based on the Holtec statement it would appear that ACI 360R-92, “Design of Slabs on Grade,” ACI 302.1R, “Guide for Concrete Floor and Slab

Construction," and ACI 224R-90, "Control of Cracking in Concrete Structures," represent the major documents that should be identified. Provide additional specificity regarding the performance characteristics that are needed for the concrete ISFSI pad such as limits on concrete shrinkage and/or minimum steel areas beyond any that are identified in the ACI 349 code requirements for the 100S.

This information is required to assure compliance with 10 CFR 72.236.

2.4 Clarify the apparently conflicting requirements for the steel embedments. On page 2A-2 it is stated that, "The steel embedment, including the anchorage bolts, are required to follow the provisions stipulated in ACI 349 [2.02], Appendix B "Steel Embedment" and the associated Commentary on Appendix B." On page 1.2-8 in discussing the anchor studs it is stated that, "during the seismic event the maximum bolt axial stress remains below the limit prescribed for bolts in the ASME Code, Section III, Subsection NF (for Level D conditions)." It appears that these two different code references will not provide consistent requirements. In one case the allowable stress for the embedment steel in tension would be the yield strength or 0.7 times the ultimate strength, whichever is smaller whereas the other would be 0.9 times the yield strength or 0.8 times the ultimate strength, whichever is smaller.

This information is required to assure compliance with 10 CFR 72.236.

3.0 Structural Review

3.1 A number of editorial issues were identified. Review the issues and make changes as necessary. The SAR should be internally consistent.

A. Page 2 of 71 of Attachment 1, "Summary of Proposed Changes," to the Holtec letter, dated October 6, 2000, appears to have some erroneous text. The 3rd line of the 2nd paragraph under the "Reason for Proposed Changes" for Change No. 2A contains the following words: "...where the heat removal system may not be able to cannot be restored within Completion Times."

B**.** The proposed page 3.6-10 for Revision 1 that continues the List of Appendices Included in Chapter 3 that begins on page 3.6-9 has not been updated to be consistent with the addition of Appendices AO, AP, AQ, AR, and AS identified in the List of Effective Pages for Proposed FSAR Revision 1. The Table of Contents has also not been updated.

C. Pages v and vi of the Table of Contents, Revision 1A, indicates that Appendices 3.P, 3.Q, and 3.V have been deleted. On page 3.6-9, Revision 1, under "Appendices Included in Chapter 3," it is indicated that Appendices 3.P, 3.Q and 3.V are included and address the MPC-32, and on pages 10, 11 and 16, Revision 1 of the "List of Effective Pages for Proposed FSAR Revision 1," it is indicated these Appendices are included as Revision 1.

D. Page 3.6-9, Revision 1, lists Appendix 3.U as, "HI-STORM 100 Component Thermal Expansions-MPC-24 and 24E." Page vi, Revision 1A, of the Table of Contents lists

Appendix 3.U as, “HI-STORM 100 Component Thermal Expansions-MPC-24" and Appendix 3.AQ as “HI-STORM 100 Component Thermal Expansions; MPC-24.”

E. On page 2A-1 under Section 2.A.2, Item 3, the document “ACI 3449" is identified instead of ACI 349.

3.2 For the new lid concept of the 100S on page 3.AO-4 it is noted that welds on the shear bar of the 100S include a groove weld and a fillet weld. On page 3.AO-2 the weld size is noted to be 0.43125". The welds call out and sizing were not located on Drawings 3068 or 3074 or in the Notes on Drawing 3073 where it would be expected. Indicate where these welds are specified on the drawings, or revise the drawings as necessary.

This information is required to assure compliance with 10 CFR 72.236.

3.3 On Drawing 3073 for the new lid concept of the 100S there is a call out for Item 52, Shear Bar, “See Note 2 and Detail B on Drawing 3074.” Drawing 3074 appears to have only a Note 1. Clarify this reference.

This information is required to assure compliance with 10 CFR 72.236.

3.4 Clarify the design changes and drawing 3074 associated with the 100S lid. Drawing 3074 is indicated to be Revision 0, however it appears that there have been changes made in the design concept during the design process since the remnants of a previous concept to transfer the lid load to the cask body under accident conditions in the area of the lid stud as opposed to the periphery of the lid. A call out for Item 52, the shear bar, is shown pointing to no part within the dotted circle defining Detail C and there is a vertical dimension of 2.25 +/- 1/16 shown in the same highlighted area that apparently does not dimension a current part.

This information is required to assure compliance with 10 CFR 72.236.

3.5 Clarify and make any necessary revisions associated with the inconsistencies with the lid studs for the 100S. On pages 3.AO-3 and 3.AO-4 the calculations show that the four 3-1/4" diameter lid studs in transferring the lateral load from the tipover accident condition will impose such a large bearing stress on the edge of the 0.5" thick lid shield ring that the load cannot be sustained since the bearing stresses will exceed 190,000 psi. The statement is then made that, “This demonstrates that the bolts cannot support the shear load.” The design calculation (see Drawing 3074) then proposed to utilize the addition of the approximate quadrants of circumferential shear bars (Item 52) that will be welded to the cask top plate (Item 9). The shear bar is then to resist the total lateral lid load by the edge bearing of the lid shield ring (Item 27) on the shear bar (Item 52). The permitted radial gap between the lid shield ring (Item 27) and the shear bar (Item 52) can be as much as 0.25" as shown on Drawing 3074, Detail Item 52. The hole in the lid shield ring (Item 27) is detailed on Drawing 3074 to be 3-3/4" +/- 1/16" in diameter. With the -1/16" diameter tolerance the hole could have a radius of 1.84375". The stud that passes through this hole is 3-1/4" diameter (radius=1.625") leaving a radial gap between the stud and the edge of the hole in the lid shield ring (Item 27) of 0.21875". This radial gap is less than the 0.25" gap allowed between the lid shield ring and the shear lug. This appears to mean that the stud will still be loaded before the lid shield ring comes into bearing contact against the shear bar. This condition would negate the design assumptions used in the design calculation in Appendix 3.AO.

This information is required to assure compliance with 10 CFR 72.236.

3.6 Describe how the load of the 100S lid is to be transferred to the cask body when uniform edge contact without deformation has been assumed between the lid shield ring (Item 27) and the shear bar (Item 52) over one of the four circumferential sector sections of the shear bar. On page 3.AO-4 the calculations for the safety factors for steel bearing stresses and for weld shear stresses are provided to demonstrate the integrity of the lid to cask body connection under the tip over accident condition. It appears that uniform edge contact without deformation has been assumed between the lid shield ring (Item 27) and the shear bar (Item 52) over one of the four circumferential sector sections of the shear bar. Because the edge radius of the shear beam and the lid shield ring can be up to 0.25" in difference, there will not be uniform contact. For radial movement of one with respect to the other, the contact between them will not be described as a surface with an area equal to the thickness of Item 27 times the arc length of Item 52. The contact without deformations will be a line across the thickness of Item 27 because of the different radii. It appears that the assumption needs to be reassessed.

This information is required to assure compliance with 10 CFR 72.236.

3.7 Describe the load transfer mechanism of the new 100S lid under the cask tip over accident condition when the tip over rotational axis coincides with the centerline axis of a pair of opposite exhaust vents, making the direction of the gravity loading coincident with the other pair of exhaust vents. The calculation on page 3.AO-4 apparently does not consider this orientation. Provide an expansion of Appendix 3.AO to address this.

This information is required to assure compliance with 10 CFR 72.236.

3.8 Explain and justify the assumed behavior considering the rigidity of the volume of the material in the space around the lid bolt holes and clarify the proposed appendix for the 100S. Appendices 3.AO and 3.AP contain conflicting information in the form of statements regarding the shear capability of the four lid studs. At the top of page 3.AO-4 the following statement is made. “This demonstrates that the bolts cannot support the shear load.” Apparently as a result of fact, the four peripheral shear bars were introduced into the design. On page 3.AP-1, Section 3.AP.1, Introduction, the following statement is made. “This appendix provides a calculation which shows that the 4 studs holding the lid to the overpack top plate have sufficient capacity to resist any shear load that may be imposed by the lid during the non-mechanistic tipover of the cask.” In Section 3.AP.2 Methodology, it is stated that, “The load is shown to be larger than the load causing enlargement of the clearance hole in the lid so the actual bolt load is reduced.” In discussing the transfer of any shear load in the studs from the lid to the top of the cask on page 3.AP-2, in the last paragraph, the following statement is made, “Since we have line contact, there will be an immediate local yielding and hole enlargement. Conformance of the bolt and the hole cannot occur prior to the shear bars becoming effective. (text omitted) The bolt hole will begin to substantially open up at the ‘flow stress’ that is assumed to be the average of yield and ultimate stress.”

The assumption that there will be deformation (ovalling) of the hole in the lid shield ring as the radius of the stud and the radius of the hole edge change contact from a line load to some edge area of loading apparently does not consider the fact that for such behavior the contact line on the edge of the hole must move into the edge of the hole. However, in the actual configuration it is not just an edge of 0.5" thickness of steel that is the contact line, but the plate is topped with a steel pipe sleeve as an axial liner in the hole with the entire sealed volume in the annular space being filled with concrete. With this degree of rigidity, the contact line probably extends further axially into the hole than just the thickness of the lid shield ring. The statement made in the middle of page 3.AP-3 that, "It is clear that the bolts cannot resist the entire load because the bolt holes will simply open due to the high stress in the lid material," would appear to only be true if the concrete behind the steel above the inside face of the shield ring were to deform.

This information is required to assure compliance with 10 CFR 72.236.

3.9 On page 3.1-6 in the section addressing accident conditions, only the free-standing HI-STORM 100 is mentioned regarding demonstration that no tip over of a fully loaded HI-STORM 100 overpack is possible under seismic conditions. The HI-STORM 100A is not addressed. Address the HI-STORM 100A in this section.

This information is required to assure compliance with 10 CFR 72.236.

3.10 The proposed Revision 1 for Figures 3.1.2 and 3.1.3 adds the configuration of the side drop orientations of the fuel baskets for the MPC-32 configuration to those side drop orientations for the MPC-24 and MPC-68. The proposed revision does not describe any re-analysis for the MPC-24, yet the orientation with respect to the direction of gravity for MPC-24 from Revision 0 to proposed Revision 1 was changed. Explain the change in the orientation of the baskets for the MPC-24 and why there was no change in the computed stresses reported in Appendix T, for example, in the case of the 45-degree basket orientation with a side drop.

This information is required to assure compliance with 10 CFR 72.236.

3.11 Proposed Table 3.4.1 is titled, "Finite Elements in Representative MPC Structural Models," and provides the data on the models for the MPC-24 and MPC-68 units with no information on the MPC-32 model regarding the element types used in the three listed model types. Provide the same information for the MPC-32 and leave the title of the table as it currently is, "Finite Elements in MPC Structural Models."

This information is not provided and is needed to assure compliance with 10 CFR 72.236.

4.0 Thermal Evaluation

4.1 Describe the effect of the presence of the heat conduction elements on restricting helium movement in the down-comer region when evaluating the thermo-siphon effect.

The presence of the heat conduction elements in the canister design has been neglected in the thermo-siphon enabled models (i.e., the heat transfer contribution has been eliminated), however, in reality they still remain within the cask. This information is not provided and is needed to assure compliance with 10 CFR 72.236.

4.2 Describe the effect of the damaged fuel canisters on inhibiting the movement of helium when calculating the heat transfer capabilities from the thermo-siphon effect. Additionally, provide calculations or suitable references, to support the conclusions reached in Section 4.4.1.1.4 with regard to decreased basket conductivities and effects on the overall basket heat dissipation rate (page 4.11).

This information is not provided and is needed to assure compliance with 10 CFR 72.236.

4.3 Provide clarification regarding the temperature range where the postulated conductivity, as noted in SAR Section 4.2 for Holtite is valid. Additionally, verify that the lower bound is appropriate for the temperature range that this material is exposed to during normal and off-normal accident conditions.

Holtite is a composite material consisting of epoxy poly and as delineated elsewhere, B_4C and Aluminum trihydrate. Thermal conductivity values for polymeric components are provided in the range of 0.05 to 0.2 Bu/ft-hour-°F. The addition of Alumina fillers increases conductivity by up to a factor of 10. Holtec thus considers a postulated lower bound conductivity value of 0.3 Btu/ft-hour-°F in their thermal models for the neutron shield region.

This information is not provided and is needed to assure compliance with 10 CFR 72.11 and 72.236.

4.4 Provide the conductivity values for temperatures outside the 200°F to 700°F range.

In table 4.2.2 thermal conductivity values are provided for 200°F, 450°F, and 700°F with intermediate values linearly interpolated. Values for ambient conditions for temperatures are below 200°F, notably air temperatures, are not provided.

This information is needed to assure compliance with 10 CFR 72.11 and 72.236.

4.5 As an editorial note, Section 4.3.1.2 page 4.3.6 lists internal rod gas pressure as P_i and Section 4.3.1.2 page 4.3.7 lists rod internal pressure as P_o. Clarify this inconsistency.

4.6 Correct the inconsistent statements with regard to crediting the conduction through the aluminum heat conduction elements in the thermal analyses.

Section 4.4.1 "thermal model" states that conduction through the aluminum heat conduction elements is neglected in the thermal modeling analyses. Use of this assumption is not consistent throughout the thermal section. For example Section 4.4.1.1.9 Fluent Model for Hi-STORM, Pg 4.4-18 states, "To this 'helium conductance-radiation' based peripheral gap conductivity, the effective conductivity of the aluminum heat conduction elements added to obtain a combined peripheral gap conductivity." This is not consistent with the methodology defined elsewhere in the application.

This information is needed to assure compliance with 10 CFR 72.11 and 72.236.

4.7 Justify that the conclusions regarding fuel cladding temperatures for a MPC placed in the HI-STORM 100S overpack are bounded the HI-STORM 100 overpack fuel cladding temperatures and provide references to the specific calculations that support this assertion. Include a discussion of those pertinent elements of the model that change with regard to convective heat transfer.

This information is not provided and is needed to assure compliance with 10 CFR 72.11 and 72.236(f).

4.8 For regionalized fuel loading where the inner region heat load limit will govern peak cladding temperature limits for the hot fuel, provide justification and pertinent calculations, or suitable references, in support of the justification as to why the cladding temperature limits for the longer cooled fuel in the periphery region at the interface are not exceeded for all loading combinations and for each basket design.

It was not clear in the discussion provided on page 4.4-30 which loading configuration and temperature limits govern. This information is not provided and is needed to assure compliance with 10 CFR 72.11 and 72.236(f).

4.9 With temperatures in excess of 700 ^{o}F noted for long term normal storage, clarify if the pressurized water reactor (PWR) and boiling water reactor (BWR) fuel assembly effective thermal conductivity values delineated in tables 4.4.1 through 4.4.3, and 4.4.5 and 4.4.6 are adequate considering that these tables only denote values up to a maximum temperature of 700 ^{o}F.

This information is not provided and is needed to assure compliance with 10 CFR 72.11 and 72.236.

4.10 Provide an explanation why use of an averaged temperature through the section (footnote to table 4.4.36) is adequate to bound surface temperatures. Justify this method for maintaining adequate thermal margin for the cask materials when considering that surface temperatures may exceed the averaged value. For example, the lid bottom plate and radial shield temperatures are within 3% and 14% respectively of their long term temperature limit using averaged values.

This information is needed to assure compliance with 10 CFR 72.236.

4.11 Provide additional discussion and sensitivity analyses to demonstrate that analysis in the vertical orientation is bounding for cask transport with the HI-TRAC transfer cask. Specifically, will the loss of convective heat transfer be greater than the addition of heat transfer due to more metal to metal surface contact area or will the increased heat transfer due to convective means govern the amount of heat transfer lost due to larger gap resistance?

Section 4.5.2.1 asserts that analysis in the vertical orientation is bounding for cask transport with the HI-TRAC transfer cask. This is in part due to less metal to metal contact between the physically distinct entities and thus gap resistance will be higher than in a horizontally oriented HI-TRAC.

This information is not provided and is needed to assure compliance with 10 CFR 72.236.

4.12 Provide a technical rationale for why it is acceptable to allow temperature limits for non-fuel clad materials to be exceeded. For users with site-specific design basis which includes an event that results in blockage of air inlets or outlets for an extended period of time, the proposed TS (Appendix B, 3.4.9) only requires verification the fuel clad temperature limits are not exceeded.

This information is not provided and is needed to assure compliance with 10 CFR 72.236.

4.13 Provide the specific changes in annulus geometry and dimensions due to thermal expansion and the effect on the thermo-syphon determinations and subsequent conclusions regarding maximum calculated temperatures.

Explain how tolerances inherent in the fabrication process are addressed regarding the relative contribution to heat transfer effectiveness from the thermo-syphon effect.

Provide a sensitivity analysis, or suitable references, that show fabrication tolerances and changes in annulus dimensions from thermal expansion do not significantly effect the thermo-syphon calculations and results.

This information is not provided and is needed to assure compliance with 10 CFR 72.236.

4.14 Provide a justification and bases, or suitable references, for the minimum helium mass required to induce and sustain natural circulation for the MPC designs described in this amendment. Include in your justification a sensitivity study for the helium loading values. Additionally, provide an evaluation, or suitable references, of the long term effects of reduced helium inventory given a minimal helium leakage rate over the licensed period.

This information is not provided and is needed to assure compliance with 10 CFR 72.236.

4.15 Evaluate quantitatively the conservatisms in the thermal model by comparing the results for the limiting case with the results of a best-estimate calculation for same limiting case.

This information is needed to assure compliance with 10 CFR 72.236.

4.16 For the finite element analysis (FEA) models submitted in the thermal section (Chapter 4) of the SAR and as described in Holtec Report No. HI-992252, and Report No. HI-981892 provide the following:

a) List of the elements, key point options, and real constants used in the FEA models. Provide justifications for the elements, key point options, and real constants used.

b) An explanation and justification if error functions were disabled for steady state analyses and where those error warnings occurred.

c) A listing of materials and corresponding material numbers used in the FEA models.

This information is not provided and is needed to assure compliance with 10 CFR 72.236.

4.17 For all transient thermal analyses described in the SAR provide the following:

a) A list of all load steps and load step options.

b) A list of all time/time step options.

c) A sensitivity analysis which demonstrates that models are not mesh dependent

For transient analysis in ANSYS, refining mesh sizes may effect the accuracy of the solution. Solutions for transient FEA models should not be mesh dependent. This means that the refining of the element mesh should not affect the solution for transient analysis of a given FEA model.

This information is not provided and is needed to assure compliance with 10 CFR 72.11 and 72.236.

Appendix 4.A Clad Temperature Limits For High-Burnup Fuel

10 CFR 72.122(h)(1) requires that spent fuel cladding must be protected from degradation that leads to gross ruptures, or the fuel must otherwise be confined so that degradation of the cladding will not impose operational safety problems. Further, 10 CFR 72.122(l) requires that the storage system must be designed to allow ready retrieval of the spent fuel from the storage system for further processing or disposal. The following questions request information associated with the fuel clad temperature that is not provided in the applications and is needed to assure compliance with the regulations.

4A.1 Explain why none of the BWR temperatures in Table 4.A.2, Rev. 1A, match those in Appendix F (pages F-4 to F-25) for spent fuel having burnups greater than 45 GWd/MTU (hereafter referred to as high burnup fuel).

4A.2 Demonstrate the acceptability of the rod hoop stress equation as stated in Appendix F of the calculation package, HI-2002407 for determining creep stain in storage. This equation does not appear to account for the stress in the fuel rods at ambient temperature. Additionally, the equation appears to be in error because the hoop stress appears to approach zero for long times.

4A.3 Provide examples of temperature and stress values versus time in dry storage used to determine the temperature limits in Table 4.A.2, Rev. 1A, for PWR and BWR fuel at 60

GWd/MTU with 6 and 10 year cooling before dry storage. The example calculations are necessary to understand the application of these equations for temperature and stress.

4A.4 Provide an explicit calculation of the integrated primary strains (0 to 10,000 hours) using the Holtec creep equation from Appendix G for one cooling time, e.g., 6 years. Attempts to duplicate the calculated primary strains (identified as "creep strain after 10,000 hours" in Appendix F) presented in Appendix G was not possible.

4A.5 Justify that the data used to derive critical strain energy density (CSED) approach is bounding for fuel greater than 63.5 GWd/MTU. Rashids paper (page 6) indicates that test were conducted between burnup levels between 25 - 63.5 GWd/MTU. Additionally, Rashids paper (page 11) states that test were conducted on samples that contained incipient hydrides. Hydrides have been postulated by some researchers to be the limiting condition for cladding integrity.

4.A.6 Justify why the high density hydride rim and blister (due to spallation) is not considered in the metal loss for creep to failure.

4A.7 Justify that the information used in the Holtec Report HI-20022407 calculation package pertaining to fuel heat decay attenuation for short cooled fuel between 50-60 GWd/MTU is bounding for all fuel greater than 60 GWd/MTU that will be stored in the cask.

Page G-3, states that these calculations employ certain information pertaining to fuel heat attenuation for short cooled fuel between 50-60 GWd/MTU.

4A.8 Demonstrate that the available corrosion reserve and reduced oxide thickness, and hydrides due to oxidation do not compromise the material properties and structural integrity of the cladding to withstand the expected loads encountered during storage under normal, off-normal, and accident conditions.

4A.9 Demonstrate that the two sets of data from the FRG-2 reactor and compared to the Holtec creep model in Figures 4.A.2 and 4.A.3 are independent and from two different creep tests. This is because both data sets show nearly identical creep strain, have the same temperature and stress levels, and the specimens came from the same reactor. Therefore, it appears that they are the same data just presented in two different references (see below).

Two sets of data from the FRG-2 reactor in Germany, from H Spilker et al. ("Spent LWR Fuel Dry Storage in Large Transport and Storage Casks After Extended Burnup," Journal of Nuclear Materials 250,1997, 63-74) and G Kasper et al. ("Spalproductfreisetzung und Post-Pile-Kreichverhalten trohen gelagerter, abgebrannter Brennstabe," BMFT-KWA 2100BO, 1985) have been referenced and used to verify the Holtec creep model in Section 4.A, Revision 1A. However, examination of these two references (similar authors with their arrangement different) and the data, it appears that they are the same creep tests with only differences in the number of data points and total time to which the data is presented, i.e., 6,000 hours and 8,000 hours.

4A.10 Compare the Holtec creep model predictions to the creep strain data that are more applicable to the temperature and stress for dry storage. Suggested creep data that are more applicable are from R. E. Einziger and R. Kohli, "Low-Temperature Rupture Behavior of Zircaloy-Clad Pressurized Water Reactor Spent Fuel Rods under Dry Storage Conditions," Nuclear Technology, 67:107, 1984 with data at 323 °C and 150 MPa from cladding irradiated in the Turkey Point reactor; and from G Kaspar et al., Spalproductfreisetzung und Post-Pile-Kreichverhalten trohen gelagerter, abgebrannter Brennstabe, BMFT-KWA 2100BO, 1985, Erlangen, Germany with data at 350 °C and 50 MPa from cladding irradiated in the KWO reactor in Germany.

The Holtec post-irradiation creep equation may underestimate strains at low temperature and stresses below 200 MPa because the activation energy for creep of 250 kJ/mole is high, particularly for the creep mechanisms active in the temperature and stress range for dry storage. The Holtec creep equation is normalized to post-irradiation creep data in the range of 380 to 420°C and very high stress data at 300°C which may be the reason why the activation energy is too high.

4A.11 Provide the experimental evidence (creep data) that demonstrates that Zircaloy cladding creep remains in the primary creep stage, i.e., decreasing creep rate with time, for up to 1% creep strain or 10,000 hours, as applied in the Holtec creep model.

Most of the creep data in the temperature and stress range relevant to dry storage conditions indicate that primary creep saturates at less than 0.5% strain and much less than 10,000 hours. The assumption that the secondary creep rate (i.e., steady-state creep rate with time), is equal to the primary creep rate at 10,000 hours or 1% creep strain (whichever is achieved first) will most likely cause an under prediction of the secondary creep strain rate. As defined in this application for dry cask storage conditions, the 10,000 hour limit will always determine the secondary creep rate. Therefore, it is difficult to conclude that the creep approach, as submitted, will be conservative for dry cask storage applications.

4A.12 Clarify whether the secondary creep rate calculated at 10,000 hours is assumed to remain constant for all dry storage time periods beyond this point for determining total accumulated strain even though temperature and stress are decreasing beyond this point.

Page 4.A.11 and Equation (16) appear to imply that the secondary creep rate is assumed to be constant after it is calculated at the 10,000 hours time in dry storage and does not take into account the decrease in temperature and stress beyond the 10,000 hours time; however, the text is not entirely clear on this point.

4A.13 Provide an estimate of the non-conservative error that is introduced in Equation 14 in Appendix 4A, Rev. 1, by the assumption that there is a linear relationship between fuel temperatures versus the decrease decay heat with time. Further, confirm that the $T(\tau)$ and T_0 terms in Equation 14 are relative delta temperatures above ambient temperature.

The above assumption of linearity between decay heat and temperature introduces a non-conservative estimate of fuel temperatures with decreasing decay heat because part of the heat transfer process is non-linear with decreasing temperature, (e.g., heat transfer due thermal radiation decreases with temperature to the fourth power).

4A.14 Justify that the allowable temperatures given in Table 4.5.9, “Peak Cladding Temperature in Vacuum,” will not result in major annealing of the cladding.

4A.15 Describe the quantitative effects nitrogen will have on highly spalled zircaloy fuel cladding during the moisture removal process. In the discussion, consideration should be given to (1) the reaction rate of nitrogen with the cladding, and (2) formation of nitric acid. Additionally, revise Chapter 8 of the SAR to specify the purity of the nitrogen gas used for moisture removal.

Page 8.1-19 of the SAR discusses how the MPC employs forced helium or nitrogen recirculateion to remove residual moisture from the MPC fuel cavity. If nitrogen is used the possibility of creating nitric acid due to the radiolytic decomposition of water needs to be evaluated along with the impact of nitrogen reaction with the Zircaloy components in the fuel assemblies.

4.A.16 Demonstrate that the moisture removal process ensures that the maximum quantity of oxidizing gases is limited to 1 gram-mole per cask. This 1-gram-mole limit reduces the amount of oxidants below levels where any cladding degradation can occur.

4A.17 Justify why strain hardening applies in the Holtec creep equation at temperatures and stresses where coble creep may be the controlling creep mechanism for irradiated cladding.

Coble creep may be the active creep mechanism in irradiated cladding at stresses below 200 MPa and temperatures below 400°C. Further, coble creep does not appear to have a mechanism that would allow for strain hardening because coble creep does not require dislocation motion.

5.0 Shielding Evaluation

5.1 Revise the SAR (Chapters 5 and 8) to show the gamma cross shield plates as mandatory auxiliary equipment.

The dose rates for dose point locations 1 and 3, in Tables 5.1.1 through 5.1-6, assume the gamma cross shield plates are installed.

This information is not provided and is needed to assure compliance with 10 CFR 72.236.

5.2 Justify the acceptability of fuel with burnups greater than 45 GWd/MTU for PWR, and 34 GWd/MTU for BWR spent fuel, considering the uncertainties with source term determinations associated with high burnup fuel.

The application does not provide benchmark data for SAS2H to provide adequate validation of the isotopic depletion calculations for burnups above 45 GWd/MTU for PWR, and 34 GWd/MTU for BWR spent fuel. This information is needed to assure compliance with 10 CFR 72.236.

6.0 Criticality Evaluation

6.1 Provide a detailed description of the calculational model used for the MPC-32 PWR basket in Section 6.3.1 of the SAR. Justify any differences in calculational techniques used for each of the MPC basket designs.

The description in the SAR is not detailed enough to complete the review. Specifically, the discussion in Section 6.3.1 of the SAR concerning the use of CASMO-3 to determine reactivity effects due to manufacturing tolerances appears to apply to all of the different basket configurations, but CASMO-3 results are not given for the MPC-32.

This information is required for the staff to assess compliance with the nuclear criticality safety requirements specified in 10 CFR 72.124 and 72.236.

6.2 Provide a detailed description of the calculational models used for the MPC-24E and MPC-24EF PWR baskets in Section 6.3.1 of the SAR.

The description in the SAR is not detailed enough to complete the review. Specifically, Section 6.3.1 of the SAR discusses the modeling assumptions used for the reduced width of the periphery Boral panels for the MPC-24 basket, but it is not clear that the same modeling assumptions apply to the MPC-24E and -EF baskets.

This information is required for the staff to assess compliance with the nuclear criticality safety requirements specified in 10 CFR 72.124 and 72.236.

6.3 Provide SCALE inputs for the following cases:
a) the most limiting normal and accident cases for the MPC-24E/ MPC-24EF, and
b) the most limiting normal and accident cases for the MPC-32.

The inputs used in the SCALE calculational models are not provided. This information is required for the staff to assess compliance with 10 CFR 72.124 and 72.236.

6.4 Provide a justification that uneven draining is not credible with the mesh size used in the damaged/failed fuel cans. Alternatively, a criticality analysis considering uneven flooding for the MPC-24E and -24EF should be provided.

Statements in the SAR Section 6.4.2.2 regarding the credibility of uneven flooding are not justified. Uneven draining may be possible for screens with a mesh size of 350 or less because the water surface tension may be capable of supporting water and uneven draining in the canister may be more reactive than a fully flooded cask. In previous reviews the staff safety evaluation report noted that the assumptions regarding uneven flooding being not credible were not justified.

This is required for the staff to assess compliance with 10 CFR 72.124 and 72.236.

6.5 Explain in further detail, and justify, the analysis performed in Section 6.4.4.2.2 to determine the optimum moderation and maximum reactivity for damaged fuel and fuel debris. The description does not state if the analysis was performed on a cask basis or if some other configuration was used.

This information is not provided and is required for the staff to assess compliance with 10 CFR 72.124 and 72.236.

7.0 Confinement Evaluation

7.1 Revise the exposure-to-dose conversion factors (DCFs) in the spreadsheet in Appendix 7.A of the application to use the most limiting value for each radionuclide and each organ. Alternatively, justification should be provided if the most limiting value is not used. For example, the DCF for a less restrictive lung-clearance class is used (SR-90, RU-106, Y-90, CD-113M, SN-119M, SB-125, TE-125M, CE-144, PR-144, PM-147, PU-238, PU-239, PU-240, PU-241 and PU-242).

This information is not provided and is needed to assure compliance with 10 CFR 72.104 and 72.236.

7.2 Revise the confinement analysis to include the DCF values for Rh 106m, or justify the omission of Rh-106m and the use of the zero DCF values for Rh 106.

The spreadsheet in Appendix 7.A lists the DCF for the radionuclide Rh 106 as zero. It is not clear that Rh 106 is the appropriate radionuclide to be considered, since Rh-106m would be more likely to occur due to the decay of Ru-106.

This information is needed to assure compliance with 10 CFR 72.11.

7.3 Provide the imbedded formulas that are used to calculate the results presented in the spreadsheet in Appendix 7.A. Also provide the assumptions used for the constants used in the spreadsheet that are not listed in Appendix 7.A, such as cask diameter and cask length, fuel rod and assembly specifications, etc., used for the analysis.

This information is not provided and is needed to assure compliance with 10 CFR 72.11.

8.0 Operating Procedures

8.1 Clearly state which steps and sequences in Chapter 8 are optional. Additionally, all statements implying that 10 CFR 72.48 evaluations are not necessary and should be removed.

These statements are too open-ended and can not be evaluated by the staff. The information is needed to assure compliance with 10 CFR 72.11. The following are examples of statements that should be removed.

Page 8.0-1, “Users may add, modify the sequence of, perform in parallel, or delete steps as necessary provided that the intent of this guidance is met, and the requirements of the CoC are met. Such changes are within the scope of this chapter and do not require a 72.48 evaluation.”

Page 8.0-2, “Users may select alternate configurations, equipment, and methodology to accommodate their specific needs provided that the intent of this guidance is met and the requirements of the CoC are met. Such changes are within the scope of this chapter and do not require a 72.48 evaluation.”

8.2 Clearly specify which “other configurations” of the HI-TRAC cask may be used for fuel transfer. The following statement is not specific enough to perform an evaluate.

Page 8.1-1, “Users may opt to use other configurations (e.g., a single lid) as long as there is sufficient crane capacity, available room to perform the operating and that appropriate measurers are available to prevent contamination of the MPC external shell. Any alternate configuration must be evaluated by the certificate holder on a site-specific basis to ensure that the design margins for criticality, shielding, structural, and thermal remain adequate and that all appropriate operation and safety features are maintained.”

The information is needed to assure compliance with 10 CFR 72.11.

8.3 Clearly state in the applicable SAR sections, that installation of the vent screens is mandatory.

There are places in the SAR that imply that the screen vents are optional. The following is an example on page 8.1-28, “If necessary, install the HI-STORM exit vent gamma cross plates, thermocouples and vent screens.”

This information is needed to assure compliance with 10 CFR 72.236.

9.0 Acceptance Tests and Maintenance Program

9.1 Revise SAR Section 9.1.5.3 to include the areal density numerical value for boron and that a visual examination for defects for the Boral plates will be performed. Alternatively, a justification can be provided that an examination is not needed.

This information is not provided and is needed to assure compliance with 10 CFR 72.236.

9.2 Revise SAR Section 9.1.6 to include thermal acceptance testing and criteria for the Boral absorber plates. To assure performance of the plates thermal safety function as described in SAR section 4.3.2, the thermal conductivity should be verified through ASTM E1225, ASTM E1461, or by an equivalent method. Alternatively, a justification should be provided to demonstrate that thermal acceptance testing is not required.

This information is not provided and is needed to assure compliance with 10 CFR 72.236.

12.0 Technical Specifications

12.1 Revise definition of non-fuel hardware in CoC Appendix B to delete "other similarly designed devices with different names,” or provide information in the SAR on these items.

This information is not provided and is needed to show compliance with 10 CFR 72.236.

12.2 Revise Section II. B of Table 2.1-1, CoC Appendix B, to state that fuel debris is not authorized in the MPC-68 to be consistent with the other MPC formats. Revise Section VI. A.1 of Table 2.1-1, CoC Appendix B, to renumber lettering.

This information in the submittal appears to be erroneous and should be corrected.

12.3 Explain the discrepancy between Section VI. B. of Table 2.1-1, CoC Appendix B, and Table 1.2.1 of the SAR. Table 1.2.1 allows the storage of up to 68 damaged Dresden Unit 1 or Humboldt fuel assemblies whereas the CoC does not.

This information is needed to show compliance with 10 CFR 72.11.

12.4 Revise note 6 of Table 2.1-2 CoC Appendix B to include the two rod pitches.

This information is not provided and is needed to show compliance with 10 CFR 72.236.