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Mr. John Goshen
c/o Document Control Desk
U. S. Nuclear Regulatory Commission
Washington, DC 20555-0001

June 4, 2010

Subject: Submittal of Responses to First Request for Additional Information for the Holtec International HI-STORM Flood/Wind Multipurpose Canister Storage System General License Application, USNRC Docket No. 72-1032 (TAC L24321)

References:

[1] Holtec Letter 5018004, dated September 18, 2009
[2] Holtec Letter 5018007, dated December 18, 2009
[3] NRC Letter (Goshen) to Holtec (Morin), dated December 1, 2009
[4] NRC Letter (Goshen) to Holtec (Morin), dated May 3, 2010
[5] NRC Letter (Goshen) to Holtec (Morin), dated January 21, 2010

Dear Mr. Goshen:

By letter dated September 18, 2009 [1], Holtec submitted a license application (LA) request for certification of the HI-STORM FW MPC Storage System Under 10CFR72, Subpart L. This LA submittal was supplemented on December 18, 2009 [2] as requested by the NRC on December 1, 2009 [3].

Staff requested additional information on the LA on May 3, 2010 [4]. The NRC letter requested a response from Holtec by June 4, 2010. Holtec International herein submits the response to the request for additional information (RAI).

Attachment 1 to this letter contains the individual responses to the RAI questions. To assist the Staff in their review of the responses, Attachments 2 and 3, respectively, contain the list of changes as a result of the RAI responses to the Safety Analysis Report (SAR) and proposed Certificate of Compliance (CoC) including Technical Specifications (TS). Attachment 4 contains the updated SAR; changes are marked with revision bars in the right hand margin. Attachment 5 contains the updated proposed CoC/TS; changes are marked with revision bars in the right hand margin. Holtec considers the SAR and CoC/TS to be proprietary information, therefore Attachment 6 to this letter is an affidavit prepared in accordance with 10 CFR 2.390 requesting that they be withheld from public disclosure. Non-proprietary (redacted) versions of these documents will be transmitted shortly under separate cover.

We appreciate the NRC's rigorous adherence to the technical review schedule published by the SFST in the LA acceptance letter [5] and for the thorough review as evidenced in the RAI. We have been equally diligent to ensure that the comprehensiveness of this response will obviate the need for another RAI and maintain the originally scheduled technical review completion date of August 15, 2010. With the issuance of the draft CoC/TS and Safety Evaluation Report in August 2010 and

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application of the Direct Final Rulemaking Process, the Final Rule Effective date is expected to be early in the first quarter of 2011. This will support industry needs as communicated to SFST in previous correspondence.

Please do not hesitate to contact me if you require any additional information or clarification at 1-856-797-0900 x687 or t.morin@holtec.com.

Sincerely,

Ms. Tammy S. Morin
Licensing Manager
Holtec Technical Services
Holtec International

cc (letter only):
Mr. Eric Benner, USNRC
Mr. Douglas Weaver, USNRC
Ms. Vonna Ordaz, USNRC
Holtec Group 1

List of Attachments:
Attachment 1: Responses to Request for Additional Information
Attachment 2: List of Changes to Proposed SAR
Attachment 3: List of Changes to Proposed CoC and Technical Specifications
Attachment 4: Proposed SAR, Holtec Report No. HI-2084239 Revision 1 (Proprietary)
Attachment 5: Updated Proposed CoC and Technical Specification (Proprietary)
Attachment 6: Affidavit Pursuant to 10CFR2.390 to Withhold Information from Public Disclosure

1.0 GENERAL DESCRIPTION

1-1 Provide the type of appropriate safety evaluations required to use a solid neutron shield material in the HI-TRAC VW. Page 1-43 of the Safety Analysis Report (SAR) states that in lieu of water, a solid neutron shield material such as Holtite-A or Holtite-B may be used at a host site after an appropriate safety evaluation. The thermal evaluation of the HI-TRAC VW should be based on all materials proposed for the design. For the same design heat load, a solid neutron shield material may result in higher cladding temperatures than predicted by using water liquid neutron shield. This information is needed to verify compliance with 10 CFR 72.11 and 72.236.

Holtec Response:

Because a complete safety evaluation to incorporate the option to use a solid neutron shield material in the HI-TRAC VW has not been performed at this time, this option is being removed from the SAR. Text changes are made to the Table of Contents and Glossary as well as Subsections 1.2.1.4.2, 5.1, and Section 8.8 to delete this option. Subsection 8.8.5 is deleted in its entirety along with References 8.8.2 through 8.8.4.

1-2 Provide the technical basis for the pitch arrangement of the casks reported in Table 1.4.1. In addition, page 1-66 states that the pitch values may be varied by the user's specific needs. Does this imply that the pitch values reported in the table are not minimum values? What prevents a user from building an array with significantly smaller pitch values?

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

Holtec Response:

Table 1.4.1 is updated to indicate the minimum allowed pitch (center-to-center distance) of the HI-STORM FW casks in the two orthogonal directions. Text in Section 1.4 has been updated to indicate that the pitch is "typical" rather than "nominal". The layout pitch arrangement can be varied by the user according to the needs of the host site as long as the minimum pitch arrangement in Table 1.4.1 is maintained. Please also see response to RAI 4-5 that utilizes the proposed minimum pitch in the safety analysis.

1-3 Provide a detailed list or table of Important-to-Safety (ITS) components which is subdivided in accordance with the three classification categories of NUREG/CR 6407, "Classification of Transportation Packaging and Dry Spent Fuel Storage System Components According to Importance to Safety." Storage canister components are presently classified as ITS/NITS per the licensing drawings. A detailed identification of each ITS component in accordance with the three category levels (A, B, and C) of NUREG/CR 6407 is needed to confirm the level of QA/QC documentation that is necessary for each ITS component.

This information is needed to verify compliance with 10 CFR 72.122(a).

Holtec Response:

The ITS/NITS categorization of the HI-STORM FW System components (and sub-components thereof) was shown on the parts list of the licensing drawings. Tables 2.0.1 through 2.0.8 are added to the SAR to include the ITS QA categorization (A, B, or C) of the ITS parts in accordance with NUREG/CR-6407. Text is updated in Section 2.0.2 to indicate that the ITS QA categories are in Tables 2.0.1 through 2.0.8.

2.0 PRINCIPAL DESIGN CRITERIA

2-1 Provide the operating restrictions to limit the maximum temperature excursion during short-term operations to 65°C (117°F) and the number of excursions to less than 10. Per page 2-2 of the SAR, provide the operating restrictions to limit the maximum temperature excursion during short-term operations to 65°C (117°F) and the number of excursions to less than 10. This should be included in the appropriate SAR sections.

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

Holtec Response:

There are no operational restrictions on the HI-STORM FW System to limit the maximum temperature excursion during short-term operations to 65°C and the number of excursions to less than 10. All thermal calculations for short-term operations show that the temperature of the cladding during vacuum drying with the specified maximum heat load for moderate and high burnup fuel remains below the allowed limits. This is consistent with the HI-STORM 100 System.

The provision from ISG-11 Rev. 3 for limiting the maximum temperature excursions of high burnup fuel to 65°C (117°F) and the number of excursions to less than 10 is adopted in Section 2.0.1 as a mandatory design criterion.

Tables 4.5.6 and 4.5.7 give the maximum cladding temperatures during vacuum drying of the MPC-37 and MPC-89, respectively. These results are for a steady state analysis, i.e. these are the maximum temperatures if vacuum drying is operated indefinitely. The temperatures given in the center column of the table are for MPCs loaded with design basis fuel. In both the MPC-37 and MPC-89 the fuel cladding temperatures are above the short-term temperature limit established in ISG-11 Rev. 3 for high burnup fuel but below the temperature limit established in ISG-11 Rev. 3 for moderate burnup fuel.

Therefore for moderate burnup fuel, vacuum drying can be used for MPCs containing full design basis heat load without the need for the thermal cycle limits. For high burnup fuel, a restriction on MPC heat load is established if the vacuum drying method is used so as to limit the peak cladding temperature to 400°C, thus obviating the need for a limit on the number of thermal cycles. This restriction has been proposed in the original submittal of the CoC Appendix A LCO 3.1.1 and Table 3-1.

For canisters dried using the FHD method the short term fuel cladding temperature limits for fuel at all burnup levels remains below 400°C. Therefore, no thermal cycling limit is required except for what was proposed in CoC Appendix A, LCO 3.1.1 and Table 3-1.

2-2 Clarify whether or not the non-fuel hardware specified in SAR section 2.1.8 contains any materials not previously reviewed and accepted for storage applications. Previously reviewed and accepted non-fuel hardware materials

include: boron carbide, borosilicate glass, silver-indium-cadmium alloy, and thorium oxide.

Should different materials from the above list be included in the non-fuel hardware listed in SAR section 2.1.8, provide an assessment of potential chemical/galvanic reactions, as per SAR section 8.12.

This information is required to verify compliance with 10 CFR 72.120(d).

Holtec Response:

The non-fuel hardware, including sources, specified in SAR Section 2.1.8 contains only materials previously reviewed and accepted for dry storage applications, specifically in the HI-STORM 100 System. With the exception of sources and instrument tube tie-rods (ITTRs), the non-fuel hardware currently proposed in the HI-STORM FW System was approved for storage in HI-STORM 100 CoC 1014 Amendment #1 for the MPC-24 and MPC-32 models; see NRC Safety Evaluation Report (ML022000249). The non-fuel hardware approved as part of that amendment can be found in the following DOE reports, specifically Volume 1, Section 2.8.

1. DOE/RW-0184, "Characteristics of Spent Fuel, High Level Waste, and Other Radioactive Waste Which May Require Long-Term Isolation," US Department of Energy, December 1987.
2. DOE/RW-0184-R1, "Characteristics Database System LWR Assemblies," US Department of Energy, July 1992

These non-fuel hardware do not produce any chemical or galvanic reactions in the MPC during wet loading conditions or dry storage conditions.

Primary and secondary sources were approved in the HI-STORM 100 CoC 1014 Amendment #3 (See NRC SER Proposed Change 6 – ML071500382). The materials used in these sources, antimony-beryllium, americium-beryllium, plutonium-beryllium, polonium-beryllium, and californium do not produce any chemical or galvanic reactions in the MPC during wet loading conditions or dry storage conditions.

The stainless steel ITTR was approved as non-fuel hardware in the HI-STORM 100 CoC 1014 in Amendment #6 (see NRC SER ML092300207). The stainless steel ITTR does not produce any chemical or galvanic reactions in the MPC during wet loading conditions or dry storage conditions. Please note the ITTR was inadvertently omitted from the original definition of non-fuel hardware in the SAR, however it was included in the proposed CoC. As part of this submittal, the ITTR has been added to the definition of non-fuel hardware in the SAR Glossary and discussion of the ITTR has also been added to Chapters 5 and 6 of the SAR.

2.-3 Provide material property data and discussion which supports the fuel basket normal condition design temperature of 400°C (SAR table 2.3.3).

The Metamic HT Sourcebook material property data is limited to a maximum temperature of 350° C. Design temperatures which exceed the highest available temperature data are not acceptable to the staff.

This information is required for compliance with 10 CFR 72.124(b).

Holtec Response:

To document a definitive safety evaluation to support a normal condition design temperature limit of 400 °C, additional thermal testing has been performed on Metamic-HT coupons for temperatures of 450°C and 500°C. The results of the testing are reported in the table in RAI response 4-1. This additional test data has also been incorporated into SAR Appendix 1.C and the Metamic-HT Sourcebook Chapter 9.

This testing also supports the two accident conditions which produce a peak temperature in the fuel basket above 350 °C but below 500 °C. Table 4.6.5 reports the temperatures during a HI-STORM FW blocked duct accident and Table 4.6.3 reports the temperatures under the scenario that all water in the HI-TRAC VW water jacket drains out. The maximum basket temperature under both of the above accident scenarios is below 500 °C.

The fuel basket, under these thermally limiting accident conditions, is always in the vertical orientation; therefore the only load is the self-weight of the fuel basket. The stress from self-weight, σ_b (compressive stress), is given by the product of material density, γ_b, and basket height, h_b:

$$\sigma_b = \gamma_b \times h_b = (0.098 \text{ lbf/in}^3)\ (199.5 \text{ in}) = 19.5 \text{ psi}$$

This stress is evidently too small to precipitate material failure and therefore the safety of the storage system under elevated temperature conditions is assured.

3.0 STRUCTURAL EVALUATION

3.1 Provide details of the fuel basket buckling analysis for design accident conditions.

SAR section 3.1.2.6 states that the Metamic HT fuel basket is not subject to buckling. However the SAR statements do not provide the mechanical properties of Metamic HT at 1000 degrees F (off-normal/design accident temperature) nor any buckling calculations. It is unclear, without supporting data or calculations, how the buckling performance statement is justified.

This information is required to verify compliance with 10 CFR 72.124(b).

Holtec Response:

The accident condition temperature limit for Metamic-HT in SAR Table 2.2.3 has been reduced to 500°C (932°F) to make it consistent with the measured physical property data in the Metamic-HT Sourcebook (see response to RAI 2-3). The maximum calculated Metamic-HT metal temperature is bounded by 500°C under all accident scenarios considered in the SAR (Chapter 12).

The assertion of the absence of buckling in the Metamic-HT fuel basket is based on the fact that there are no causative scenarios (normal or accident) that produce a significant in-plane compressive stress in the basket structure. As stated in the response to RAI 2-3, the maximum compressive stress, σ_b, in the fuel basket is merely 19.5 psi. The yield strength of the material at the bounding temperature of 500°C is 6,000 psi (see SAR Table 1.C.1). A lower bound Euler Buckling strength for the Metamic-HT fuel basket can be obtained by neglecting the strengthening effect of the honeycomb completely, assuming that the basket walls are fully continuous[1] over the entire height of the MPC fuel basket, and treating the Metamic-HT basket wall as an end-loaded plate 199.5" high by 8.94" wide by 0.59" thick (corresponding to the maximum height MPC-37 fuel basket). The top and bottom edges are assumed to be pinned and the lateral edges are assumed to be free to minimize the permissible buckling load (a particularly severe modeling artifice to minimize buckling strength). The Euler buckling load for this geometry is given by (see Timoshenko et al., "Theory of Elastic Stability", 2nd Edition):

$$P_{cr} = \frac{\pi^2 EI}{h^2} = 133 lbf$$

where E = Young's Modulus of Metamic-HT at 500°C = 3,500 ksi,
I = moment of inertia of 8.94" wide by 0.59" thick plate = 0.153 in^4,

[1] In reality, the basket walls are not fully continuous in the vertical direction since the fuel basket is assembled by vertically stacking narrow width Metamic-HT panels in a honeycomb pattern (see drawing 6506 in Chapter 1 of HI-STORM FW SAR). For the above buckling strength evaluation, the assumption that the basket walls are continuous over the full height of the fuel basket (without taking credit for the stiffening effect of the honeycomb) is extremely conservative since the critical buckling load is inversely proportional to the square of the height.

h = maximum height of fuel basket = 199.5"

The corresponding compressive axial stress is given by:

$$\sigma_{cr} = \frac{P_{cr}}{A} = \frac{133lbf}{(8.94in)(0.59in)} = 25.2psi$$

The factor of safety against buckling is given by:

$$SF = \frac{\sigma_{cr}}{\sigma_b} = \frac{25.2psi}{19.5psi} = 1.29$$

Thus, even with an exceedingly conservative model, the safety margin against buckling is more than 25%.

The substance of the above response is incorporated in Paragraph 3.1.2.6 of the SAR for archival reference.

3-2 SAR Section 12.2.1, page 12-11, Note 1: SA states:

"However, it is also a fact that at many sites a loaded HI-TRAC transfer cask is handled inside the Part 50 building, some of whom do not possess a single-failure-proof cask crane. At such plants, the licensee may use other means to mitigate a transfer cask drop event such as the use of an impact limiter."

There are no compensatory measures or guidelines provided in the proposed Technical Specifications (TS) or SAR. The staff finds this unacceptable. The TS will therefore require a single failure proof crane for this evolution.

This information is required to verify compliance with 10 CFR 72.236(l).

Holtec Response:

The language in SAR Section 12.2.1 cited in the question above is removed from the SAR along with Reference 12.2.2 because it is not within the scope of 10CFR72 and this SAR. Heavy load handling requirements inside the Part 50 structure are addressed in proposed CoC Condition #4. Handling requirements for the loaded transfer cask and overpack outside a Part 50 governed structure are proposed in CoC Appendix A, Section 5.2.

3-3 Evaluate the potential for crack propagation and growth for the MPC baskets under tipover conditions. Attachment D of the Metamic HT Sourcebook is based on results for conditions applicable only to the HI-STAR 180 and not the HI-STORM FW System.

This information is required to verify compliance with 10 CFR 72.236(l).

Holtec Response:

The table below provides a comparison of the parameters significant to crack propagation and crack growth for the Metamic-HT panels in the HI-STAR 180 F-37 fuel basket, qualified in Attachment D of the Metamic-HT Sourcebook, and the HI-STORM FW fuel baskets.

	HI-STAR 180 F-37 (Attachment D of Sourcebook)	**HI-STORM FW MPC-37**	**HI-STORM FW MPC-89**
Storage cell width, w (in)	8.11	8.94	6.01
Panel thickness, t (in)	0.59	0.59	0.40
Reference metal temperature (°C)	275	365	325
Design basis g-load under lateral loading event*, acc (g)	95	59.14	63.03
Fuel dead load per unit length, f (lbf/in)	8.04	9.79	4.25
Panel stress**, σ (ksi)	13.35	11.15	7.55

* For HI-STORM FW MPCs, the limiting lateral loading is from the non-mechanistic tip-over scenario.

** To facilitate comparison, panel stress is computed according to the following formula (parameters are defined in first column of table):

$$\sigma = \frac{3 \cdot acc \cdot f \cdot w}{4 \cdot t^2}$$

which assumes that the storage cell wall acts as a simply supported beam strip under a uniformly distributed load equal to the amplified fuel weight.

The above tabular comparison shows that the demand load (i.e., panel stress) on the HI-STAR 180 F-37 fuel basket due to the 9-meter drop accident bounds the demand load on the HI-STORM FW MPC-37 and MPC-89 fuel baskets due to the non-mechanistic tip over scenario. The reference metal temperature, however, is higher for the MPC-37 and MPC-89 fuel baskets. Thus, the crack propagation analysis in Attachment D (loc. cit.) does not uniformly bound the HI-STORM FW fuel baskets. Therefore, explicit calculations for the MPC-37 fuel basket, which is the more limiting of the FW basket designs, are carried out in the manner of the analysis in the Metamic-HT Sourcebook and included in Subsection 3.4.4.1.4 of the SAR to quantify the margins of safety under the non-mechanistic tip-over scenario.

3-4 Clarify the definitions of φ and Ψ in SAR section 3.2. It is not clear from the paragraph how the parameters are defined or applied.

This information is required to verify compliance with 10 CFR 72.230(a).

Holtec Response:

The dimensionless parameter ϕ is used in SAR Section 3.2 to provide the maximum radial offset of the center of gravity relative to the geometric centerline for various cask configurations. Similarly, the dimensionless parameter Ψ provides the maximum vertical offset of the center of gravity relative to the cask mid-height. Section 3.2 of the SAR has been revised to clarify the definitions of ϕ and Ψ and further explain how the parameters are applied.

3-5 Explicitly state whether the cask spacing will preclude impact between casks in the event of an earthquake, or whether the tipover is precluded by analysis. Otherwise, provide analyses that support that the casks are structurally adequate to withstand the impacts.

This information is required to comply with 72.236(l).

Holtec Response:

The acceptance criteria for freestanding deployment of the HI-STORM FW stated in Subsection 2.2.3 (item g) requires that under the host site's Design Basis Earthquake (DBE) (i) the casks must not undergo inter-body impacts and (ii) no cask overturns.

The above requirements must be met to enable a freestanding HI-STORM FW ISFSI to be installed and operated. The proposed verbiage in Section 3.4 of CoC Appendix B for HI-STORM FW mimics the verbiage in Appendix B of the HI-STORM 100 CoC, which requires a dynamic analysis to establish the system's kinematic stability on the storage pad if the (extremely conservative) static equilibrium-based inequality is not satisfied.

In summary, impacts between casks and cask tip over are precluded by the requirements in SAR Subsection 2.2.3 and the proposed Technical Specifications for the HI-STORM FW. Furthermore, the treatment of the consequence of the site's DBE for the HI-STORM FW ISFSI is identical to that for the HI-STORM 100 system in Docket No. 72-1014.

3-6 Explain how the ratio h/r governs the earthquake considerations versus the cylindrical cask used in NUREG/CR-6865 "Parametric Evaluation of Seismic Behavior of Freestanding Spent Fuel Dry Cask Storage Systems" without taking into account the total loaded weight into consideration.

This information is required to verify compliance with 72.236(l).

Holtec Response:

As can be seen from the derivation in SAR Subsection 2.2.3 (item g), r/h ratio (r is radius of the cask's footprint and h is the height of the C.G.) arises from the consideration of stability against tip over under the site's DBE wherein the

earthquake is represented by its ZPA (Zero Period Acceleration). The derivation does take into account the total loaded weight of the cask (W). However, since W appears on both sides of the moment equilibrium equation, it drops out of the final inequality that governs incipient tipping of the cylindrical cask. This static equilibrium-based criterion, also used in the HI-STORM 100 Technical Specification (see CoC No. 72-1014, Appendix B, Section 3.4) provides an extremely conservative criterion to establish safety against tip-over from seismic (inertial) loading. In the case of HI-STORM 100, the ratio r/h is 0.53, which incidentally is also the value of friction coefficient prescribed by the NRC, hence the value 0.53 in the Technical Specification inequality for seismic stability.

The static equilibrium based inequality is evidently very conservative, as amply demonstrated by the seismic stability analysis of the HI-STORM 100 system prepared by the Sandia National Laboratory (Reference 1) to support the NRC's position on the ASLB hearings on the seismic stability of HI-STORM 100 in the Private Fuel Storage (PFS), LLC docket (No. 72-22). NUREG/CR-6865, published subsequently, is a more generic treatment of a freestanding cask's stability with full consideration of soil-structure interaction and other parameters important to dynamic stability.

The HI-STORM FW CoC Appendix B, Section 3.4, which mimics the same section of the HI-STORM 100 CoC, requires a dynamic analysis to be utilized if the (extremely conservative) static equilibrium-based inequality cannot be satisfied.

In summary, the seismic qualification protocol for HI-STORM FW is identical to that of HI-STORM 100.

References:

1. V. Luk et. al., "Seismic Analysis Report on HI-STORM 100 Casks at Private Fuel Storage Facility", Revision 1, March 31, 2002.

4.0 THERMAL EVALUATION

4-1 Revise all material thermal properties to ensure the tabulated data provided in the SAR adequately covers the entire range of predicted temperatures.
Some of the thermal properties provided in the SAR do not seem to cover the expected range of operating temperatures. For example, SAR Table 1.B.2 indicates that the Metamic-HT thermal conductivity and specific heat properties are for temperature ranges between 200°C and 350°C. Temperatures of the MPC basket reach higher temperatures (see for example Table 4.6.5, page 4-63).

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

Holtec Response:

To comport with Staff's request, Metamic-HT coupons were tested at 450°C and 500°C using the same test procedures that were used to obtain the thermo-physical properties presented in the Metamic-HT Sourcebook. The 500°C test temperature comfortably bounds the maximum accident basket temperature (reached in the blocked inlet ducts accident). As the value of emissivity is already reported in the Sourcebook at 500°C, additional testing is not necessary. The additional tests therefore address the remaining thermal properties, namely conductivity and heat capacity. This additional test data is added to Chapter 1, Appendix 1.C of the HI-STORM FW SAR and the Metamic-HT Sourcebook is accordingly updated for archival reference.

The reference values of conductivity and specific heat obtained from the supplemental tests at 450 and 500 °C are as follows:

Property	Measured Data
Conductivity (W/m-°K) (Note 1)	193 @ 450°C 193 @ 500°C
Heat Capacity (J/kg-°C) (Note 2)	1129.2 @ 450°C 1098.2 @ 500°C

Notes:

1) In accordance with classification of conductivity as a Type 1 property in the Metamic-HT sourcebook the Minimum Measured Value (MMV) is tabulated herein and confirmed to comply with the 180 W/m-°K Minimum Guaranteed Value (MGV).
2) In accordance with classification of heat capacity as a Type 2 property in the Metamic-HT Sourcebook the mean measured values are tabulated herein. Data trending evaluation shows that heat capacity is a weak function of temperature. To bound the data a linear function is fitted and added to the SAR Chapter 1, Appendix 1.C.

4.2 Revise the effective thermal properties of the Pressurized Water Reactor (PWR) and Boiling Water Reactor (BWR) spent nuclear fuel.
Section 4.4 of the SAR includes effective thermal conductivity of both BWR and PWR design basis fuel for normal conditions of storage. Effective density and fuel

capacity for these conditions are not provided in the SAR. Also, effective thermal properties of the design basis fuel for short-term operation are missing the SAR. Please provide this information.

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

Holtec Response:

Effective density and heat capacity (specific heat) of PWR and BWR fuel is added to Section 4.4 of the SAR. These properties are used to analyze the helium filled normal storage condition in Section 4.4 and short term operations addressed in Section 4.5. Fuel properties under vacuum drying conditions are added to Section 4.5.

4.3 Provide a detailed description of the Metamic-HT thermal model.
Page 4-18 of the SAR states the Metamic-HT fuel basket is modeled in the same manner as the model described in the HI-STAR 180 FSAR. The HI-STORM FW SAR lacks the necessary details to make a determination of the adequacy of the model.

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

Holtec Response:

Detailed description of the HI-STORM FW thermal model is added to SAR Section 4.4.

4-4 Clarify if the flow resistance factors used in the porous media model described in Section 4.4.1.1 of the SAR are bounding for all MPC baskets and fuel assembly types. Section 4.4.1.1 of the SAR states that calculated flow resistance factors described in Holtec Report HI-2043285, Revision 5 are bounding for all proposed contents. Holtec may need to recalculate flow resistance factors because the basket storage cell may have a different (possibly larger) flow area.

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

Holtec Response:

The flow resistance factors used in the porous media model are bounding for all fuel types and MPC baskets. This was accomplished for the PWR fueled MPC-37 by placing the most resistive Westinghouse 17x17 fuel assembly in the smallest cell opening MPC-32 fuel basket and computing the flow resistance factors. In the case of BWR fueled MPC-89 the most resistive GE 10x10 fuel assembly is channeled and explicitly modeled in the MPC-89 fuel storage spaces as shown in SAR Figure 4.4.4. The channeled space occupied by the GE 10x10 fuel assembly is modeled as a porous region with effective flow resistance properties computed by deploying an independent 3D FLUENT model of the array of fuel rods and grid spacers.

In the case of PWR fuel resistance modeling physical reasoning suggests that the flow resistance of a fuel assembly placed in the larger MPC-37 storage cell will be less than that computed using the (smaller) counterpart cells cavities in the MPC-32. However to provide numerical substantiation FLUENT calculations are performed for a representative case of Westinghouse 17x17 fuel placed inside the baseline MPC-32

cell opening of 8.79" and the enlarged MPC-37 cell opening of 8.94". The FLUENT results for the cell pressure drops under the baseline (MPC-32) and enlarged cell opening (MPC-37) scenarios are shown plotted in Figure 4-4-1 below. The plot below shows that, as expected, the larger cell cross section case (MPC-37) yields a smaller pressure loss. Therefore, the MPC-37 flow resistance is bounded by the MPC-32 flow resistance used in the FLUENT simulations in the SAR. This evaluation is significant because the MPC-37 basket is determined in the SAR as the limiting MPC and therefore the licensing basis HI-STORM FW temperatures (by virtue of the use of higher-than-actual resistance) are overstated.

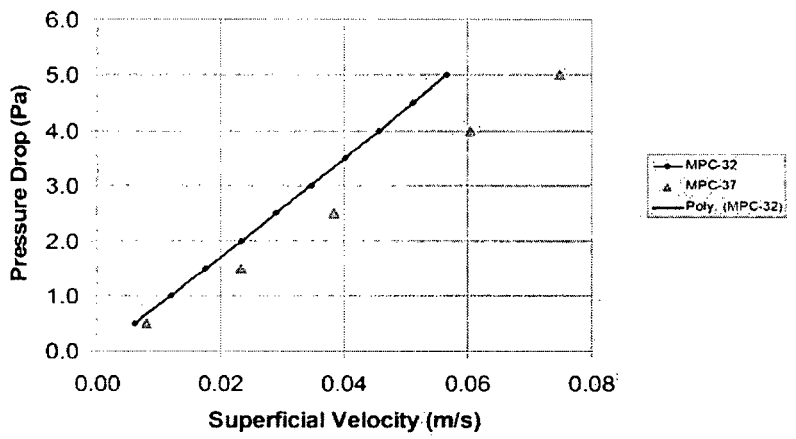


Figure 4-4-1: Storage Cell Pressure Drop as a Function of In-Cell Helium Velocity

The above figure provides an indirect measure of conservatism in the thermal analysis introduced by the use of HI-STORM 100 fuel basket cross section data in lieu of the HI-STORM FW MPC fuel basket data to represent axial flow resistances of the limiting MPC-37 in the fuel storage cavities. The discussion on flow resistance has been incorporated in the revised SAR in Section 4.4.

4-5 Perform a computational fluid dynamics (CFD) analysis on the heat transfer effects associated with the surrounding casks.

SAR page 1-66 states that the pitch dimension(s) of the cask array is a suggestion, not a minimum value. However, SAR page 4-23 calculates and compares the annular MPC area and lateral access area between casks and concludes that sufficient ventilation cooling is available. An analysis should be performed that conservatively takes into account the surrounding casks. This is especially true for a cask located in the center of the array as the overpack outer shell temperature would influence the heat transfer due to thermal radiation and convection heat transfer due to higher local ambient temperatures. A minimum array pitch must be specified to define the analysis of record.

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

Holtec Response:

The SAR has been revised to define the minimum pitch for the cask arrays (Please see response to RAI 1-2). To address this RAI, a conservative model to incorporate the presence of surrounding casks in the manner similar to that described in earlier versions of the HI-STORM 100 FSAR supporting CoC Rev. 0 and Amendment Nos. 1 through 4[2] is added to Subsection 4.4.2 of the HI-STORM FW SAR. The principal results are provided in the table below. The results show that the presence of casks has essentially no effect on the fuel cladding temperatures. These results are in keeping with the results reported for the effect of surrounding casks in HI-STORM 100 FSAR in Docket 72-1014.

Model	Peak Clad Temperature (°F)	Margin-to-Limit (°F)
Single Cask Model	707	45
Expanded Model (Effect of Surrounding Casks Included)	705[Note 1]	47
Note 1: The lower computed temperature is an artifact of the use of overstated inlet and outlet loss coefficients in the single cask model. The result supports the conclusion that surrounding casks have essentially no effect on the Peak Cladding Temperatures.		

The thermal analysis incorporating the effect of surrounding casks and PCT result showing compliance with the ISG-11 Rev 3 temperature limit have been incorporated in Section 4.4 of the SAR.

4-6 Identify the procedures for ensuring the correct number of Burnable Poison Rod Assemblies (BPRA) in each MPC. Per SAR pages 4-26 to 4-28, the MPC pressure analyses are based on a maximum allowable number of BPRA fuel assemblies and so means to ensure the correct loading should be included in the SAR.

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

Holtec Response:

The requirement in SAR Subsection 9.2.3 Item 1 has been enhanced to include a verification of the correct type, amount, and location of non-fuel hardware to be loaded into the MPC in addition to the required verification of the fuel assemblies to be loaded. The location and number restrictions for placement of non-fuel hardware is mandated in proposed CoC Appendix B, Table 2.1-1(I), and SAR Table 2.1.1. This approach is consistent with the CoC for HI-STORM 100 which deploys the Approved Contents table in CoC Appendix B (for MPC-32 and MPC24) to stipulate the quantity and location of non-fuel hardware in the MPCs.

[2] Because of the minor effect of surrounding casks this effect was neglected in HI-STORM 100 CoC Amendment No. 5.

4-7 Confirm the pressures listed in SAR Table 4.4.10 and Table 4.4.8.

The maximum pressure for MPC-37 is listed as 48 psig in Table 4.4.10 and Table 4.4.8 of the SAR. The maximum pressure for MPC-89 is listed as 50 psig in Table 4.4.10 and 47 psig in Table 4.4.8 of the SAR. Explain why is there the same MPC-37 pressure in Table 4.4.8 and Table 4.4.10 of the SAR but different MPC-89 pressures in Table 4.4.8 and Table 4.4.10 of the SAR?

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

Holtec Response:

We confirm that both Tables 4.4.8 and 4.4.10 are required to support the thermal design of the HI-STORM FW and that the pressures are correct. The pressure range in Table 4.4.8 is for casks being loaded close to the permitted maximum heat load (specifically, greater than equal to 80% of the Design Basis Heat load). Table 4.4.10 applies to canisters with heat load containing less than 80% of the design basis value in each storage location. The reason for the two tables is to provide operational flexibility to the extent possible and thus to minimize occupational dose as explained below.

The helium backfill pressures in Table 4.4.8 have a narrower band than Table 4.4.10 to support canisters loaded at or near design basis heat loads. These narrow pressure band helium backfill requirements are set to insure that the thermal analysis assumptions at the Design Basis heat load are satisfied by the pressure limits in the table. As narrow pressure band required by Table 4.4.8 can be challenging to the loading crew, it is limited to the scenario where the heat load is near the Design Basis heat load for the system.

The fill pressure band can be enlarged (increased tolerance in backfill pressure) because the thermal margin steadily increases with decreases in the system heat load. Therefore, it is not necessary to impose a narrow fill pressure range at low heat loads. Accordingly the band in Table 4.4.10 is enlarged for the scenarios where a canister is loaded to sub-design basis heat loads (values of sub-design heat loads are defined in SAR Subsection 4.4.5.1). As a great majority of canisters are expected to meet the sub-design heat load limit, Table 4.4.10 will apply affording an enhanced operational flexibility (ALARA) to the loading crew.

4-8 Discuss the "operationally reliable" ALARA methods that are mentioned on page 4-40 of the SAR.

The "operationally reliable" ALARA methods mentioned on SAR page 4-40 should be discussed or clarified in section 4.5 of the SAR.

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

Holtec Response:

The misplaced statement is deleted from the SAR. Considerations of ALARA and preservation of fuel integrity are contained in Section 4.0.

4-9 Clarify if CFD best practice guidelines (BPG) were applied to perform the thermal evaluation of HI-STORM FW storage system.

The thermal analysis methods described in Chapter 4 of the SAR do not include a discussion of the use of CFD BPG to perform the thermal evaluation of the HI-STORM FW spent fuel storage system. Per CFD BPG, the analyses results should include an estimate of the numerical uncertainty, grid convergence, and sensitivity of the performed CFD analyses. Holtec should provide an estimate of the numerical uncertainty and provide a response to the following questions:

a: Has a sensitivity analysis been performed concerning turbulence modeling, boundary conditions, grid independence and grid convergence?
b. Was grid convergence index (GCI) used to assess uncertainty of the predicted results? Holtec may consult to the following documents for further information on CFD BPG: (1) Best Practice Guidelines for the use of CFD in Nuclear Reactor Safety Applications, NEA/CSNI/R(2007)5, ADAMS accession number ML071581053. (2) Policy of Journal of Fluid Engineering of ASME about CFD analyses (http://journaltool.asme.org/Content/JFENumAccuracy.pdf).

This information is necessary to verify the requirements of 10 CFR 72.11 and 72.236.

Holtec Response:

We regret that the necessary sensitivity analysis was not performed in support of the original submittal. This deficiency has been remedied in this revised submittal.

In accordance with the above referenced ASME Journal procedure a grid sensitivity study is undertaken and the GCI index is computed. The sensitivity calculations address the principal mechanism of heat dissipation, namely annulus cooling of the MPC. As required by the ASME Journal procedure, grid refined thermal solutions are computed and results are post-processed to obtain the GCI and added to the SAR in Subsection 4.4.1.6. For this purpose the following discrete sensitivity analyses were performed using the peak cladding temperature as the telltale output to infer convergence:

a. The number of radial cells in HI-STORM FW annulus is increased until convergence is established.
b. The mesh density in the axial direction[3] is increased in steps to identify the converged configuration.

The grid sensitivity studies focus on the Peak Cladding Temperature (PCT) computed by the FLUENT model as the target output for checking convergence.

[3] Grid refinement in the lateral direction is judged to be not necessary because the flow inside the storage cells and downcomer area are laminar and therefore do not need a refined mesh to resolve near-wall effects.

The sensitivity studies, further discussed in the response to RAI 4-11, entailed thermal simulations for the following grid refinement level:

a. Radial cell sensitivity studies see table below:

Run No.	Number of Radial Cells in the Annulus	Average Grid Spacing "h"[Note 1]
1	6	9.5 mm
2	10	5.7 mm
3	11	5.18 mm
4	12	4.75 mm
5	17	3.35 mm
Note 1: Average grid spacing is defined as the HI-STORM annulus opening divided by number of radial cells.		

b. Axial cell sensitivity study.

Grid Refinement Case	Number of Axial Cells in the Fueled Region	Average Grid Spacing
Baseline	84	47.5 mm
Refined mesh	101	39.5 mm

The results from the study are post-processed in accordance with the guidance in the ASME Journal procedure cited by the staff in this RAI (specifically the Grid Convergence Index, GCI) and evaluated in the response to RAI 4-11 and are also summarized in the SAR.

In response to turbulence modeling in Item (a) of the RAI, the adequacy of the k-ω model was addressed in the licensing of the HI-STORM 100 System in CoC Amendment #5 in Docket No. 1014 and NRC acceptance obtained.

To address the question of boundary conditions in Item (a) of the RAI, the following study has been performed. The heat transfer coefficient from the HI-STORM FW external surfaces is reduced by 30% and the thermal solution obtained. The results archived in the calculation package show that the effect on the Peak Cladding Temperature is approximately 1°C.

4-10 Propose an adequate thermal acceptance test to validate the thermal analysis methods described in Chapter 4 of the SAR.

The proposed test should include experimental methods to measure the air flow through the annular gap between the MPC and the HI-STORM FW overpack. Also, due to the significant increase in the decay heat load of the system, as compared to previously approved storage systems of similar design, the proposed test should include experimental methods to perform some internal temperature measurements of the MPC. MPC Temperature measurements should include the location where the

peak cladding temperature has been predicted in Chapter 4 of the SAR in addition to some other measurements of the MPC basket.

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

Holtec Response:

To comport with Staff's request, two discrete thermal acceptance tests are proposed herein that will be carried out to confirm calculated safety margins in this SAR without the risk of increased occupational dose to site personnel or any adverse effect on the integrity of the storage system.

The first test is the air flow test on the loaded module that mimics the acceptance testing specified for the HI-STORM 100 system. The HI-STORM FW CoC Condition #8, "Special Requirements for the First System in Place", is accordingly updated in the proposed CoC. This thermal test is equivalent to the air flow test required on the HI-STORM 100 System in CoC 1014. SAR Subsection 10.1.7 is updated to include the test requirement and basic operational steps are added in SAR Operations Chapter 9, Subsection 9.2.6, Item 15.

In addition, a new MPC thermal test is proposed herein to be carried out upon completion of the manufacturing of the first MPC at the fabrication facility. The object of the test will be to determine the adequacy of the heat transmission capability of the Metamic-HT fuel basket under controlled thermal conditions on a test pad. The test will be carried out using a QA controlled test procedure that will have the following essential features:

1. The first manufactured MPC (MPC-37 or MPC-89) will be subjected to thermal testing.
2. The MPC will be arrayed in the vertical orientation on the test pad with interface insulation to minimize heat loss from the bottom.
3. Twelve storage cells (three in each quadrant) will be loaded with bayonet electric heaters. These will be calibrated to deliver one kilowatt heat uniformly over its length. The heaters will be situated co-axially within each storage cell. Thus the heat generation in the MPC shall be quadrant-symmetric.
4. The top of the MPC shall be enclosed by an insulated lid. Calibrated thermocouples will be fastened to selected cell walls in each quadrant in a symmetric manner.
5. The test will be run for a sufficiently long time such that steady state conditions are reached. The ambient temperature and the thermocouple readings will be taken as specified in the test procedure.
6. The test condition will be simulated on the design basis FLUENT model of the MPC described in Chapter 4 and the temperatures at all of the thermocouple locations predicted by FLUENT will be compared with the test data.
7. The amounts by which the FLUENT temperatures exceed the corresponding measured temperatures (positive margin) collectively define the margin of conservatism in the SAR analysis model. A negative margin will warrant NRC reporting and appropriate licensing action pursuant to Holtec's QA program.

The requirement for and short description of the new test outlined above is added to SAR Subsection 10.1.7.

4-11 Perform sensitivity calculations to determine the adequate use of the k-ω turbulence model with the transitional option enabled.

Page 4-19 of the SAR states that the air flow in the HI-STORM FW/MPC annulus is simulated by the k-o turbulence model with the transitional option enabled. The SAR does not specify if adequate guidelines were followed to use a mesh which will resolve the viscosity-affected region. A mesh which will resolve the viscosity-affected region will place the first near-wall node at $y^+ \sim 1$.

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

Holtec Response:

As discussed in the response to RAI 4-9, an adequate sensitivity analysis regrettably was not performed in the original safety analysis. To address this deficiency, a sensitivity analysis for both the HI-TRAC VW and the HI-STORM has been performed. Increasing the grid density in the HI-TRAC annulus showed that further grid refinement in the annulus was not necessary, i.e., the solution reported in the SAR was indeed converged. A similar investigation by increasing the grid density in the HI-STORM FW annulus and the axial grid in the fueled region yielded new information, as summarized below. The study addressed the effect of grid in the HI-STORM annulus and axial grid in the fueled region. All thermal analyses were carried out for the case of 47.05 kW design maximum heat load for the (limiting) MPC-37 canister.

The HI-STORM FW annulus grid sensitivity study showed that the results reported in the SAR were not fully converged. The results of this study are tabulated below and incorporated in Section 4.4 of the SAR.

Grid Refinement Run No	Number of Radial Cells	y+	PCT (°C)	Permissible Limit (°C)	Clad Temperature Margin (°C)
1	6	21	353	400	47
2	10	5	357	400	43
3	11	4	364	400	36
4	12	3	376	400	24
5	17	0.7	375	400	25
Note 1: The y^+ reported in the third column above is a measure of grid adequacy reported by the FLUENT code. Values of $y^+ \sim 1$ indicate an adequate level of mesh refinement is reached to resolve the viscosity affected region near the wall.					

Based on the above study the annulus grid refinement Run No 5 appears to be reasonably converged. To provide a definitive conclusion the sensitivity results are evaluated in accordance with the ASME Journal procedure cited in RAI 4-9 and the

Grid Convergence Index (GCI) which is a measure of the solution uncertainty is computed. The GCI for the finest grid (i.e. 17 radial cells) computes as $1.3 \times 10^{-5}\%$. The GCI result provides assurance of numerical convergence. Having obtained grid convergence in the annulus region, the Run No 5 grid is adopted for further grid sensitivity studies below.

The results of axial grid refinement in the fueled region are summarized below.

Grid Refinement	Number of Axial Cells	PCT (°C)	Permissible Limit (°C)	Clad Temperature Margin (°C)
Baseline run (Run No 5 adopted from above)	84	375	400	25
Refined Grid	101	376	400	24

The above shows that the baseline solution is essentially unchanged by axial grid refinement. Accordingly Run No. 5 grid is adopted in the HI-STORM FW SAR, all thermal cases rerun and results tables updated and affected CoC limits revised[4].

Results and conclusions

- The results of annulus grid refinement study above shows that the converged result produces an increase of approximately 22°C in the PCT which is not inconsiderable.
- The results of axial grid refinement study above shows that the axial grid is converged.
- The Run No 5 grid is adopted in the HI-STORM FW SAR and all thermal cases rerun. Cladding temperatures remain below the 400°C limit with significant margins. The SAR has been enhanced by a narrative on the sensitivity study reported herein and the applicable temperature tables have been amended accordingly. There is no change in the conclusions with respect to safety. (The failure to perform the necessary sensitivity analysis in the original submittal has been entered as a Quality Program Violation in Holtec's QA system for further action to insure that such oversight will not occur in the future).
- The non-mechanistic tip over analysis for the limiting cask configuration, HI-STORM FW carrying a loaded MPC-37, has been updated in Subsection 3.4.4.1.4 to reflect the higher Metamic-HT fuel basket temperatures (see SAR Figure 3.4.12A) that resulted from the sensitivity analysis.

[4] The CoC air temperature rise limits are aligned with the latest SAR results.

5.0 SHIELDING EVALUATION

5-1 Provide additional information about the design criteria for the HI-STORM FW such as ALARA and occupational exposure criteria. Also, Holtec needs to provide the criteria such as objectives dose rates and the basis for these criteria.

The staff does not find that Holtec has provided enough information to describe the design basis criteria for the HI-STORM FW in term of ALARA and/or occupational exposure.

This information is necessary to verify compliance with 10 CFR 72.236.

Holtec Response:

Due to the close similarity between the HI-STORM FW and the HI-STORM 100, the discussions on ALARA for the HI-STORM FW have been closely following those for the HI-STORM 100, except for the design objective dose rate targets, but those are now also added for the HI-STORM FW in Section 2.3.5.2 and referenced in Section 5.1.1. ALARA objectives and design features are discussed in detail in Chapter 11, Section 11.1 and 11.2 (HI-STORM 100 Chapter 10). Section 11.2 has been extended compared to the HI-STORM 100 to highlight the improvements that were made to the system to reduce dose. Among those are:

- Lighter fuel baskets that allow more external shielding
- Variable height and weight that allow site specific shielding optimization
- Optimized HI-STORM lid
- Regionalized loading that requires "colder" fuel on the cask periphery
- Larger capacity to increase self shielding of fuel and reduce number of casks

Note that the estimated occupational exposures presented in Section 11.3 have been based on the general cask loading experience over the years for the HI-STORM 100. In contrast, the information in Section 10.3 of the HI-STORM 100 was generated before such experience existed, and contained an excessive level of detail, as well as dose estimates that exceeded any later measured values.

5-2 Justify the use of Westinghouse (W) 17x17 and General Electric (GE) 10x10 as a design basis zircaloy clad fuel assemblies for the shielding analysis.

In Section 5-1 of the SAR, Holtec states that the design basis zircaloy clad fuel assemblies used for calculating the dose rates presented in the chapter are W 17x17 and the GE 10x10, for PWR and BWR fuel types, respectively. Provide this information and justify that it is applicable for all HI-STORM FW fuel contents.

This information is necessary to verify compliance with 10 CFR 72.236.

Holtec Response:

For the calculations in Chapter 5 the Westinghouse 17x17 and GE 10x10 assemblies were chosen as design basis assemblies since they are widely used throughout the

industry, as stated in Section 5.2.4. Text in Section 5.1 has been revised to clarify this. The purpose of chapter 5 is to present a general overview of the expected dose rates, next to the cask and at various distances, to aid the user in applying ALARA considerations and planning for the ISFSI. The site specific fuel characteristics, burnup, cooling time, and the site characteristics are factored into the site specific evaluations by the licensee when showing compliance with dose limits prescribed in the CoC and when showing compliance with 72.104.

5-3 Provide additional information about the assumptions related to photons with energies in the range of 0.45 to 3.0 MeV.

In Section 5-2 of the SAR, Holtec stated that the bases were the previous analyses performed for the HI-STORM 100 system. Due to the magnitude of the gamma source at lower energies, photons with energies as low as 0.45 MeV must be included in the shielding analysis, but photons with energies below 0.45 MeV are too weak to penetrate the HI-STORM FW overpack or HI-TRAC VW. The effect of gamma radiation with energies above 3.0 MeV, on the other hand, was found to be insignificant. This is due to the fact that the source of gamma radiation in this range is extremely low. Provide this information and justify that it is applicable for all HI-STORM FW system.

This information is necessary to verify compliance with CFR 72.236.

Holtec Response:

Standard Review Plan NUREG-1536 (Jan. 1997 and the new Revision 1A - draft) states that: "In general, only gammas with energies from approximately 0.8 to 2.5 MeV will contribute significantly to the dose rate through typical types of shielding". Based on this statement it was felt for the dose calculations for the HI-STORM 100 that using a range of 0.7 to 3.0 MeV would be sufficient.

However, upon investigation (Section 5.2.1 of HI-STORM 100), it was determined that the energy group from 0.45 to 0.7 MeV does noticeably contribute to the external dose rate. It was observed that approximately 50% of all gammas generated were in the 0.45 to 0.7 MeV energy group. Therefore, even though the energies are low, the gamma source is large enough to make a significant contribution to the dose rate. However, the next lower energy group from 0.3-0.45 MeV has only approximately 2% of all gammas generated. This combined with the lower energy indicates that the gammas with energies below 0.45 MeV do not make a significant contribution to the dose rate and can be ignored. This was confirmed by dose calculations for the HI-STORM 100 System. It can therefore be concluded that energies below 0.45 MeV can be ignored in the analysis.

On the other hand, gamma energies above 3 MeV were found to contribute only about 1% of the total dose rate, mainly due to the fact that the source strength is less than 1 % of the total gamma source.

These findings are documented in the corresponding proprietary calculation package of the HI-STORM 100 system, which can be provided upon request.

From a shielding perspective, both HI-STORM 100 and HI-STORM FW are of similar construction and utilize similar shielding materials. The same is also true for HI-TRAC VW which is similar to HI-TRAC. Based on that and the above it was concluded that the same gamma energy groups (0.45 to 3.0 MeV) relevant to HI-STORM 100 system will also be appropriate for the HI-STORM FW system.

5-4 Justify that the dose rates for both BPRAs and Thimble Plug Devices used from the HI-STORM 100 are applicable to HI-STORM FW.

In SAR Section 5.2.3.1, Holtec stated that the HI-STORM 100 presented dose rates for both BPRAs and TPDs. The results indicate that BPRAs are bounding, therefore all dose rates in the chapter will contain a BPRA in every PWR fuel location.

This information is necessary to verify compliance with CFR 72.236.

Holtec Response:

Please note that all dose rates presented in the HI-STORM FW SAR, including those for BPRAs, where specifically calculated for the HI-STORM FW system, and no dose rates from the HI-STORM 100 were used for the HI-STORM FW.

It is generally expected that qualitative conclusions on dose rates from the HI-STORM 100 are applicable to the HI-STORM FW, due to the similarity of the design and shielding materials. To verify this for the BPRA and TPD contribution, a comparison between the dose rates from BPRAs and TPDs in the HI-STORM FW is added to Section 5.4.4, including new results in Table 5.4.8. As expected, the results show that the dose rates from TPDs are in general bounded by those from BPRAs.

5-5 Provide additional information on alternate neutron shield materials for the HI-TRAC VW.

In SAR Section 5.3.2, Holtec states that the HI-TRAC VW transfer cask may be equipped with a water jacket to provide radial neutron shielding. Demineralized water (borated water) will be utilized in the water jacket. To ensure operability for low temperature conditions, ethylene glycol (25% in solution) may be added to reduce the freezing point for low temperature operations. Calculations were performed for the HI-STORM 100 system to determine the effect of the ethylene glycol on the shielding effectiveness of the radial neutron shield. Based on these calculations, it was concluded that the addition of ethylene glycol (25% in solution) does not reduce the shielding effectiveness of the radial neutron shield. The staff needs this information to determine if these calculations are applicable for this application

.

This information is necessary to verify compliance with CFR 72.236.

Holtec Response:

Ethylene glycol may be added to the radial neutron shield (water jacket) of the HI-TRAC VW to reduce the freezing point of water for low temperature operations. The effect of the ethylene glycol on the shielding effectiveness of the radial neutron shield has been specifically evaluated for the HI-STORM 100 system. Although ethylene

glycol has a greater density than the density of the water in the water jacket, the calculations conservatively assumed the same density (0.914 g/cc) for both ethylene glycol and water. The composition of the water jacket was assumed to be a uniform mixture of 75% water and 25% ethylene glycol. This is consistent with the NOTE box prior to Step 1.K in SAR subsection 9.2.4. The HI-STORM 100 System 100-ton HI-TRAC was analyzed with the water/ethylene glycol mixture in the water jacket. A comparison of the results for the outer edge of the water jacket at the axial mid-height yields the following.

Water Jacket Condition	Neutron Dose Rate [mrem/hr]	Gamma Dose Rate [mrem/hr]	Total Dose Rate [mrem/hr]
Ethylene Glycol and Water	47.69	838.26	885.95
Water only	45.46	829.92	875.38

This represents a difference of 1.2% which is within the statistical uncertainties of those calculations. Therefore, these results are statistically equivalent and it can be concluded that the addition of ethylene glycol to the water in the water jacket will not significantly impact the dose rate. Since the HI-TRAC VW and HI-TRAC 100 are of similar construction, the same conclusion can be applied to the HI-TRAC VW. Further details are documented in the corresponding proprietary calculation package of the HI-STORM 100 system which can be provided upon request.

6.0 Criticality Evaluation

6-1 For the HI-TRAC VW design, provide additional information demonstrating that flooding with unborated water cannot occur.

Since borated water is used for criticality control during loading and unloading operations, administrative controls and/or design features should be implemented to ensure that accidental flooding with unborated water cannot occur, or the criticality evaluation should consider accidental flooding with unborated water. The staff cannot locate any information about this consideration. Provide an analysis showing that the cask remain subcritical if there is accidental flooding with unborated water or state any administrative controls or design features that ensure that flooding with unborated water cannot occur.

This information is needed to verify compliance with 10 CFR 72.124(a).

Holtec Response:

Consistent with the HI-STORM 100 System, the principal protection against flooding with unborated water is the stringent administrative controls. The proposed CoC describes those controls in Appendix A, LCO 3.3.1.

The SAR Operations Chapter 9 specifically alerts the user in various locations to follow LCO 3.3.1 to ensure proper soluble boron content. Specifically for loading of the MPC, SAR Subsection 9.2.2 in steps 13 and 15 as well as the NOTE box in Subsection 9.2.3 refers the user to LCO 3.3.1. During decontamination of the HI-TRAC VW the user is also alerted to maintain the soluble boron concentration levels in Subsection 9.2.4, ALARA Note box. For unloading of the MPC, SAR Subsection 9.4.3 refers the user to LCO 3.3.1 in the NOTE box prior to Step 5.c. These steps/boxes have been expanded to include the frequency of testing and the requirement for two independent measurements, required by SR 3.3.1.1, to ensure compliance with 10 CFR 72.124(a). This is the approved method for monitoring soluble boron concentration in the HI-STORM 100 System, which uses higher levels of soluble boron than the HI-STORM FW to ensure criticality safety. See NRC Safety Evaluation Report for CoC 1014, Amendment 1, dated July 18, 2002 (ML022000249).

The TS Bases for LCO 3.3.1, provided in Appendix 13.A, has been expanded to include the frequency of testing and the requirement for two independent measurements, consistent with LCO 3.3.1, to ensure compliance with 10 CFR 72.124(a).

SAR Chapter 6 (Section 6.1) has been updated to address those controls as well.

6-2 Justify the fuel specification of the 9x9E and 9x9F fuel assemblies.

For the 9x9E and 9x9F Note 3 in Table 2.1.3 of the SAR says: For the SPC 9x9-5 fuel assembly, each fuel rod must meet either the 9x9E or the 9x9F set of limits or clad O.D., *clad I.D., and pellet diameter.* Provide additional information justifying that

the criticality analysis was performed considering the most conservative set of fuel specifications.

This information is needed to verify compliance with 10 CFR 72.236(a) and (c).

Holtec Response:

A schematic diagram has been added in Appendix 6.B, Section 6.B.4, that identifies the location of the different rod types in the assembly that is used in the analysis. Note that there are two known patterns of water rod locations for this assembly type. A new study in Section 6.2.1 verifies that the more conservative pattern is used in the design basis calculation. In this context, please also see the discussion in the response to RAI 6-13.

6-3 Provide the following additional information regarding the description of the 10x10G fuel assembly:

a. Table 2.1.3 of the SAR states that the 10x10G will have "96/84" for "No. of Fuel Rod Locations." Other fuel types with this type of description indicate in the notes that the "/" designator indicates number of full length rods (versus part-length rods). Table 2.1-3 of the Proposed TS state that the "No. of Fuel Rod Locations" for the 10x10G is "96." The staff is aware that this fuel type will have some partial length rods. In addition the staff is aware that the criticality analysis was performed with 96 full-length rods and that this was found to be conservative with respect to the inclusion of part-length rods. Although it would be acceptable by the staff to state in the TS that this fuel type will have 96 full-length rods, the staff believes that this does not adequately describe the assembly Holtec intends to represent by the 10x10G description. Therefore the staff will be changing the specification for "No. of Fuel Rod Locations" within the TS to state "96/84" and will additionally add a note similar to the other designs with part-length rods stating that this is to represent 96 total rods with 84 full length rods. Confirm that this change would adequately describe the fuel you wish to store under the 10x10G designation.

b. Table 6.1.2 of the SAR states that the "Maximum Allowable Planar-Average Enrichment" of the 10x10G is 4.6%. Table 2.1.3 of the SAR states that it is 4.8%. Clarify this value and correct the discrepancy.

This information is needed to verify compliance with 10 CFR 72.236(a).

Holtec Response:

(a) The 10x10G fuel is analyzed for 84 full length rods and 96 total rods, as shown in Table 2.1.3. It is therefore appropriate to also specify this assembly type in that way in the Proposed TS. The proposed TS has therefore been updated to be consistent with Table 2.1.3.

(b) Table 2.1.3 of the SAR has been corrected to reflect the maximum allowable planar-average initial enrichment of 4.6 wt % as in Table 6.1.2. The proposed TS has therefore been updated to be consistent with Table 2.1.3.

6-4 Justify the fuel specification of the 8x8B and 8x8D fuel assemblies.

a. In Table 2.1.3, the 8x8B and 8x8D are specified with two separate values for "No. of fuel rod locations." Justify that the most reactive value was used in the criticality analysis for these fuel types.

b. In Table 2.1.3, the 8x8B can have either 1 or 0 water rods. Justify that the most reactive value was used in the criticality analysis for this fuel type.

This information is needed to verify compliance with 10 CFR 72.236(a) and (c).

Holtec Response:
Studies have been added to Section 6.2.1 to demonstrate that versions of the 8x8B and 8x8D assembly with different number of fuel or water rod locations are bounded by the analyses that are currently presented for those assembly types.

6-5 Clarify the title of Table 6.2.2 in the SAR.

The title of Table 6.2.2 in the SAR is Reactivity Effect of Assembly Parameter Variations *for BWR Fuel in the MPC-68*. State if this is a typographical error, and if so, correct the error. If not, explain why these calculations were not performed in the geometry of the MPC-89.

10 CFR 72.11(a) requires that the information provided by Holtec be complete and accurate in all material respects.

Holtec Response:
This is a typographical error. These values reflect the geometry of the MPC-89. The title of SAR Table 6.2.2 is changed to say "MPC-89".

6-6 Correct the location of the acceptance testing for the neutron absorber material.

Section 6.1 (Page 6-3) and 6.3.2 (Page 6-19) of the SAR both state that the acceptance testing for the neutron absorber is located in Section 10.4.1 of the SAR. The staff did not find this information in Section 10.4.1 of the SAR. Correct this error.

10 CFR 71.11(a) requires that the information provided by Holtec be complete and accurate in all material respects.

Holtec Response:
Section 6.1 and 6.3.2 of the SAR are corrected to reflect Section 10.1.6 of the SAR as the subsection to find the acceptance testing of the neutron absorber.

6-7 Demonstrate that the fuel dimensional variations listed in Section 6.2.1 give the maximum reactivity for all fuel assembly types that are to be stored in the HI-STORM FW.

In Section 6.2.1 of the SAR you give the fuel dimensional variations that give the maximum reactivity for all fuel assembly types that are to be stored within the HI-

STORM FW. The staff does not find that the SAR provides enough information to show that these characteristics would be bounding for all PWR and BWR assemblies proposed for storage in the HI-STORM FW. As stated in this section of the SAR, these parameters are based on analyses performed for the HI-STORM 100. There are a few assemblies that are new to the HI-STORM FW that were not previously approved contents for the HI-STORM 100. This includes the PWR 15x15I, 17x17C, 17x17E and BWR 10x10G. In addition, some assemblies that were previously approved for storage in the HI-STORM 100 have increased enrichment limits for the HI-STORM FW. It also appears as though the calculations may be based on the MPC-24 and MPC-68 designs of the HI-STORM 100. Therefore, the referenced analyses performed for the HI-STORM 100 may not be applicable for the HI-STORM FW and its contents. Provide additional information demonstrating that the generic limiting fuel specifications are applicable to the all of the fuel types and enrichment limits within the MPC-37 and MPC-89 of the HI-STORM FW.

The staff needs this information to determine that k-eff has been calculated with the maximum reactivity and to ensure that Holtec has met the requirements in 10 CFR 72.124(a) and 72.236(c).

Holtec Response:

Section 6.2.1 has been expanded to discuss the applicability of those bounding fuel dimensions to all assembly classes. A new study is also presented in support of those discussions. Sections 6.3.1 and 6.4.2 have also been updated to refer to those discussions and studies in Section 6.2.1.

6-8 Justify the use of planar averaged enrichments rather than maximum or discrete radial enrichments.

a. Page 6-13 of the SAR states that *the results ... in Table 6.2.2 ... show that in all cases, the maximum keff calculated for the distributed enrichments is at or below that of the uniform enrichments*. However it appears as though in Table 6.2.2 of the SAR distributed enrichment case 2 gives higher reactivity than that of the reference case. Provide clarifying information on either the statement on Page 6-13 of the SAR or for the results reported in Table 6.2.2 of the SAR.
b. Appendix B of the HI-STORM 100 SAR states that the *calculations have been performed to confirm that the statement [the use of a uniform (planar-averaged) enrichment, as opposed to the distributed enrichments normally used in BWR fuel, produces conservative results] remains valid in the geometry of the MPC-68*. Provide information justifying that uniform (planar-averaged) enrichments produce conservative results within the geometry of the MPC-89.

This information is needed to verify compliance with 10 CFR 72.236(a) and (c).

Holtec Response:

a) The corresponding text (previously on Page 6-13) of the SAR has been revised to correctly present the results of the calculations for the distributed enrichments.
b) The calculations presented in Appendix 6.B of the HI-STORM 100 SAR have been re-performed in the MPC-89, and the those studies are now also discussed in Section 6.2.1

6-9 Justify that the use of full density fuel is more conservative than annular pellets.

On Page 6-42 of the SAR, Section 6.4.9 states that there were studies performed for the HI-STORM 100 that demonstrate that the use of full density fuel is more conservative than annular pellets. The staff reviewed the HI-STORM 100 SAR and did not find enough information to determine that these studies are applicable to the HI-STORM FW and its contents. Justify that the studies performed for the HI-STORM 100 are applicable to the HI-STORM FW. Specifically include information such as what fuel types were used in this study, fuel enrichment, boron concentration and the geometry (i.e. infinite lattice, specific MPC and basket geometry, etc.).

This information is needed verify compliance with 10 CFR 72.236(a) and (c).

Holtec Response:

Similar studies than those performed for the HI-STORM 100 have now also been performed for the HI-STORM FW and are documented in Section 6.2.1. They show, as for the HI-STORM 100, that the specified and analyzed annular pellets are acceptable. Since those are fuel-related parameter, the text from Section 6.4.9 has been relocated to Section 6.2.1, and Section 6.4.9 has been removed. Note that the studies were performed for several combinations of fuel type, annulus diameter, and conditions with and without damaged fuel, all for 5% enrichment. Note also that the annulus is always flooded with pure water.

6-10 Provide additional information about non-fuel hardware definitions.
Table 2.1.1 on Page 2-16 of the SAR states that CEAs will be included with the non-fuel hardware contents. Provide a definition of a CEA. It is not listed in the definition of non-fuel hardware definition on Page xvi of the SAR.

10 CFR 72.11(a) requires that the information provided by Holtec be complete and accurate in all material respects.

Holtec Response:

CEAs are Control Element Assemblies and this is added to the definition of Non-Fuel Hardware consistent with the definition proposed in CoC Appendix A. In addition the Instrument Tube Tie Rod (ITTR) is added to the definition of the Non-Fuel Hardware on page xvi of the SAR. This definition of Non-Fuel Hardware is now consistent with the latest amendment of the HI-STORM 100 System.

Section 6.4.7 has also been updated to include discussion of the instrument tube tie rod.

6-11 Provide additional information about the calculation used to support the conclusion that pure water in the guide tubes for the PWR assemblies is a bounding assumption for assemblies without soluble boron.

Section 6.4.7 of the SAR states that for pure water the presence of the non-fuel hardware decreases reactivity because it is replacing moderator. Page 6-41 of the SAR states that *this conclusion is supported by the calculation listed in Section 6.2, which shows a significant reduction in reactivity as a result of voided guide tubes,*

i.e., the removal of the water from the guide tubes. The staff did not find any discussion of this calculation mentioned in Section 6.2 of the SAR. Provide a more specific location of the referenced calculation and update the SAR providing a discussion and the results of this calculation.

10 CFR 72.11(a) requires that the information provided by Holtec be complete and accurate in all material respects.

Holtec Response:

The discussion on pure water and non-fuel hardware has been removed since all conditions in the MPC-37 utilize borated water. The condition of borated water and NFH is discussed appropriately in Section 6.4.7. See also response to RAI 6-12 below.

6-12 Demonstrate that the calculations performed to support the inclusion of non-fuel hardware are conservative.

Table 6.4.5 of the SAR shows the results of a study used to demonstrate that assuming that the guide tubes are flooded with borated water would bound any configuration when the guide tubes are filled with non-fuel hardware by demonstrating that the flooded guide tubes bound the condition where the guide tubes are voided. State the assembly type and enrichment for which this calculation was performed and demonstrate that it is applicable for all HI-STORM FW contents that are to be loaded in the presence of borated water. Include information about the soluble boron concentrations used and justify that it bounds all maximum possible soluble boron concentrations including that of damaged fuel evaluations.

The staff needs this information to determine that k-eff has been calculated with the maximum reactivity and to ensure that Holtec has met the requirements in 10 CFR 72.124(a) and 72.236(c).

Holtec Response:

Information has been added in Table 6.4.5 to clarify which assembly and enrichment is analyzed. Also, Table 6.4.5 has been expanded with results for the cases with damaged fuel that requires higher soluble boron levels. Additionally, a new Table 6.4.10 has been added to show the effect of the voided guide and instrument tube for all PWR assembly types.

6-13 Justify that the assumed location of guide tubes and water rods is conservative. The location of guide tubes and water rods is not specified in Tables 2.1.2 and 2.1.3 of the SAR. Provide additional information demonstrating that the locations of guide tubes and water rods assumed in the criticality models are conservative as compared to the actual lattice geometry.

The staff needs this information to determine that k-eff has been calculated with the maximum reactivity and to ensure that Holtec has met the requirements in 10 CFR 72.124(a) and 72.236(a) and (c).

Holtec Response:

The analyses use the usual guide tube and water rod locations for the respective fuel assemblies. No attempt has been made to determine bounding guide tube and water rod locations. Therefore, to ensure that the loaded content is consistent with the analyses, schematics of the guide/instrument tube and water rod locations are added in Appendix 6.B, Section 6.B.4. Note that several variations of known configurations have been analyzed, as discussed in Section 6.2.1, to show they are addressed in the evaluation.

6-14 Provide additional information about the modeling of assemblies with a "water cross" design.

For fuel assemblies that employ a "water cross" design, the water cross geometry is not specified in Table 2.1.3 of the SAR. Provide additional information about the geometry used for the water cross in the criticality calculations. Justify that it gives conservative results compared to the actual lattice geometry. This applies to assemblies 8x8F, 9x9G, 10x10C and 10x10G.

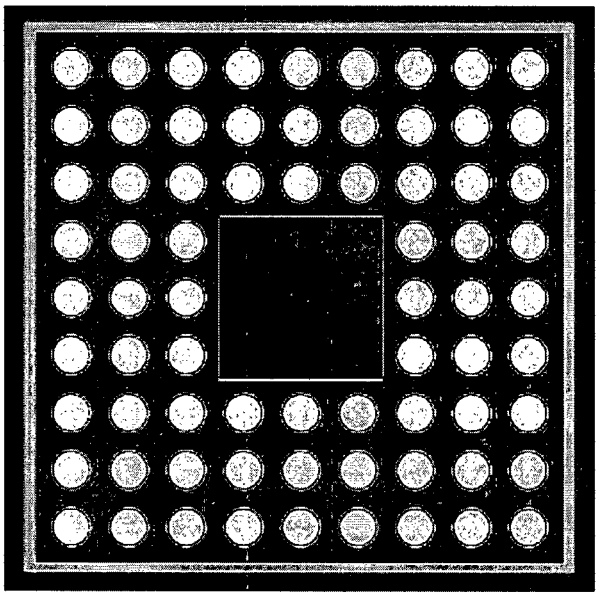
The staff needs this information to determine that k-eff has been calculated with the maximum reactivity and to ensure that Holtec has met the requirements in 10 CFR 72.124(a) and 72.236(a) and (c).

Holtec Response:

Note that all analyses for those assemblies are performed with the actual geometries as they are known. Models were directly taken from the corresponding calculations in the HI-STORM 100, with dimensional adjustments for the new assembly class 10x10G.

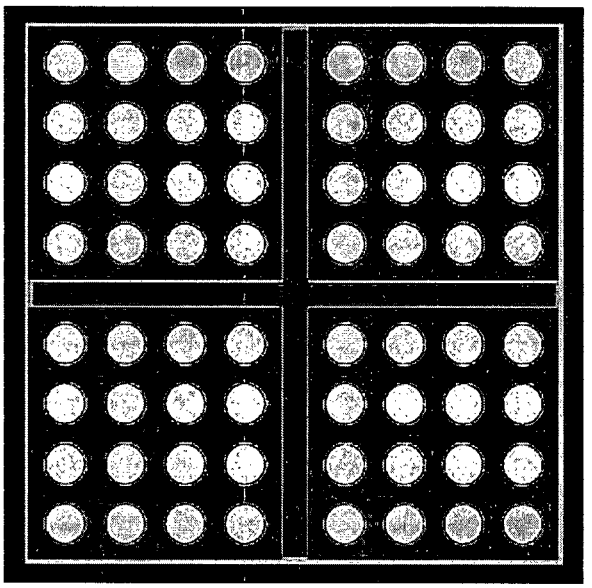
The 9x9G assembly does not have a water cross. However, instead of the typical round water rod it has a square water rod, replacing the center 9 fuel rods. The corresponding MCNP model is shown below. The water rod thickness specified in Section 2.1 refers to the thickness of the material for this square rod.

MCNP model for 9x9G assembly:

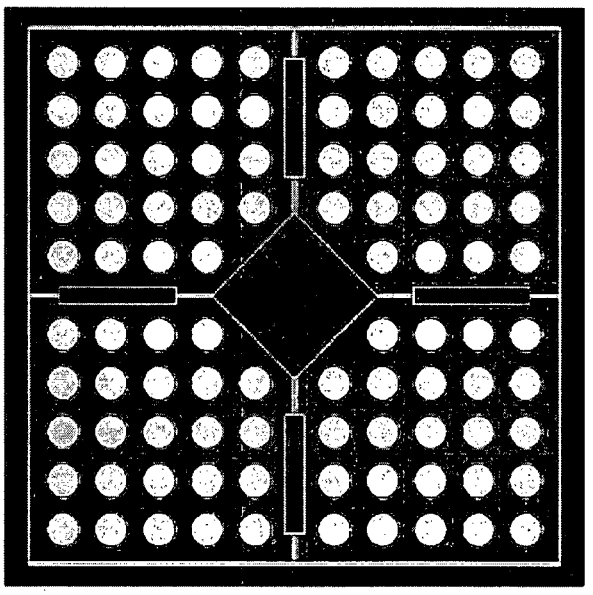


The 8x8F, 10x10C and 10x10G do contain water crosses. For these assemblies, the water rod thickness specified in Section 2.1 refers to the thickness of the material that forms those crosses. The corresponding MCNP models are shown below, first for the 8x8F, followed by the 10x10C. The model for the 10x10G is essentially identical for that for the 10x10C, just with slightly different dimensions.

MCNP model for 8x8F assembly:



Principal MCNP model for 10x10C and 10x10G assembly:



6-15 Provide additional information on the modeling of damaged fuel for the 17X17D and 17x17E.

Page 6-39 of the SAR states that for the damaged fuel evaluations an active fuel length of 150 inches is used. Explain how this is bounding for the 17x17D and 17x17E assemblies which have an active fuel length of ≤170 inches.

The staff needs this information to determine that k-eff has been calculated with the maximum reactivity and to ensure that Holtec has met the requirements in 10 CFR 72.124(a) and 72.236(c).

Holtec Response:

The analyses were based on the assumption that the effect of the increased active length would be more than offset by the reduced reactivity of those fuel types compared to those presenting the bounding cases, based on a comparison of reactivity differences already determined. A discussion has been added in Section 6.4.4.1 to discuss this.

6-16 Justify that the bare fuel array analysis for damaged and moderately damaged fuel is conservative.

Section 6.4.4.1 (Page 6-40) of the SAR states that: For the HI-STORM 100, additional evaluations for damaged fuel assemblies were performed to further show that the above *approach using arrays of bare fuel rods are bounding. The evaluations considered conditions including*

- Fuel assemblies that are undamaged except for various numbers of missing rods
- Variations in the diameter of the bare fuel rods in the arrays
- Consolidated fuel assemblies with cladded rods
- Enrichment variations in BWR assemblies

The staff was unable to locate the stated evaluations in the HI-STORM 100 SAR. Provide this information. Justify that it is applicable for all of the HI-STORM FW fuel contents, moderately damaged fuel, MPC-89 and 37 basket geometry, design and applicable soluble boron requirements.

The staff needs this information to determine that k-eff has been calculated with the maximum reactivity and to ensure that Holtec has met the requirements in 10 CFR 72.124(a) and 72.236(c).

Holtec Response:

Note that the analyses using bare fuel rod arrays, which had been developed as a conservative approach for damaged fuel in the HI-STORM 100 System and HI-STAR transport package (Docket 71-9261, HI-STAR SAR HI-951251, latest revision), were re-performed in the HI-STORM FW System to determine the maximum k_{eff} in the presence of damaged fuel in this basket. This was necessary, since the number and location of the DFCs in the MPC-37 and MPC-89 are different from those in the MPC-32, MPC-24 and MPC-68 in the HI-STORM 100. The discussion quoted above refers to additional evaluations that were performed in the HI-STORM 100, but not in the HI-STORM FW, since they were shown to be bounded by the bare fuel rod analyses in the analyses performed for the HI-STORM 100. References to the appropriate tables, figures and sections in the HI-STORM 100 FSAR have been added to Section 6.4.4.1.

6-17 Demonstrate that the 9x9E fuel is bounding for 10x10G damaged fuel evaluations.

When performing damaged fuel evaluations, Section 6.4.4.1 of the SAR (page 6-38) states that the 9x9E undamaged fuel was used to fill the cells that did not include Damaged Fuel Canisters and that this bounds the 10x10G fuel. Provide additional information demonstrating that this is conservative. Table 6.1.2 of the SAR shows that the 10x10G has higher reactivity than the 9x9E.

The staff needs this information to determine that k-eff has been calculated with the maximum reactivity and to ensure that Holtec has met the requirements in 10 CFR 72.124(a) and 72.236(c).

Holtec Response:

Discussions are added (Section 6.4.4.1) which point out that in the presence of damaged fuel, as modeled, the 9x9E assembly class actually bounds the 10x10G assembly class.

6-18 State the cross section set used to perform the criticality analysis and benchmark calculations.

Section 6.5 of the SAR states The benchmark calculations were performed with the same computer codes and cross-section data, described in Section 6.4, that were used *to calculate the keff values for the cask.* Section 6.4 of the SAR does not

specify the cross sections used in the analysis. State that the cross section set used in the analysis and in the benchmark calculations.

10 CFR 72.11(a) requires that the information provided by Holtec be complete and accurate in all material respects.

Holtec Response:

Cross section information has been added to Section 6.3.2 and 6.A.1

6-19 State the soluble boron concentrations assumed in the damaged fuel evaluations and justify that they are conservative.

The staff needs this information to determine that k-eff has been calculated with the maximum reactivity and to ensure that Holtec has met the requirements in 10 CFR 72.124(a) and 72.236(c).

Holtec Response:

Table 6.1.4 contains the soluble boron requirements for loading fuel that is classified as damaged or fuel debris. These are the values used in the analysis. This information is also listed in the Proposed CoC Appendix A, LCO 3.3.1, as well as in Table 2.1.6 in Chapter 2. Table 6.1.4 also shows the results of the bounding calculations for those conditions. Those show a considerable margin to the regulatory limit, hence, the soluble boron concentrations are conservative.

6-20 State the fuel enrichment assumed for the intact fuel in the damaged fuel evaluations for the BWR fuel and justify that it is conservative.

Table 2.1.3 of the SAR states there are reduced enrichment limits for some damaged fuel assemblies. Table 6.1.5 of the SAR reflects these lower enrichment limits. However it is not clear to the staff what enrichment was used when modeling the intact fuel for these evaluations. Provide this information.

The staff needs this information to determine that k-eff has been calculated with the maximum reactivity and to ensure that Holtec has met the requirements in 10 CFR 72.124(a) and 72.236(c).

Holtec Response:

The text in Section 6.4.4.1 has been revised to clarify the enrichment used in the BWR analyses.

Additionally, CoC Appendix B, Table 2.1-1(I) is updated to reflect the maximum initial enrichment for PWR fuel assemblies to be loaded into the MPC-37. In the previously proposed CoC Appendix B there was a reference to Table 2.1-2 which did not include the proper information.

6-21 Justify the UO_2 fuel density used in the criticality calculation is realistic or conservative for all fuel types.

The staff needs this information to determine that k-eff has been calculated with the maximum reactivity and to ensure that Holtec has met the requirements in 10 CFR 72.124(a) and 72.236(c).

Holtec Response:

The discussion on fuel density in Section 6.1 has been updated to highlight the conservative nature of the fuel density value used in the analyses

6-22 Provide additional information on how the structural material for the fuel assemblies was modeled.

The staff was unable to locate any information describing how the structural material was modeled in the criticality analysis. Justify that the modeling assumptions are conservative.

The staff needs this information to determine that k-eff has been calculated with the maximum reactivity and to ensure that Holtec has met the requirements in 10 CFR 72.124(a) and 72.236(c).

Holtec Response:

All minor structural material (such as grid straps) is replaced by borated or unborated water, as applicable, as stated in Section 6.1. The discussion in this section has been updated to further justify those modeling assumptions.

6-23 Demonstrate that the results of the partial flooding calculations are representative of all fuel types and fuel conditions that would be loaded in the HI-STORM FW.

Table 6.4.2 of the SAR gives the results for the partial cask flooding evaluations. The results are presented for the 17x17B for the MPC-37 and the 10x10A for the MPC-89. It is not clear to the staff that the results of these two configurations would represent the behavior of all fuel types and fuel conditions (damaged and undamaged). In addition, per Tables 6.1.1 and 6.1.2 of the SAR, these fuel types are not the most reactive fuel types for the HI-STORM FW. Provide additional information demonstrating that these calculations are representative of all possible loadings in the HI-STORM FW.

The staff needs this information to determine that k-eff has been calculated with the maximum reactivity and to ensure that Holtec has met the requirements in 10 CFR 72.124(a) and 72.236(c).

Holtec Response:

Sections 6.3.1 and 6.4.2 have been expanded to discuss that it is sufficient to use a single PWR and BWR assembly in a number of studies and that this is representative for all fuel types qualified, rather than performing those calculations for all fuel types. This addresses the studies performed for partial flooding (RAI 6-23), Pellet-to-clad-gap flooding (RAI 6-24), Preferential Flooding (RAI 6-25), External Moderation (RAI 6-26), Eccentric Positioning (RAI 6-27), Basket Manufacturing Tolerances (RAI 6-28), and Panel Gaps (RAI 6-30).

6-24 Demonstrate that the results of the pellet-to-clad gap flooding calculations are representative of all fuel types and fuel conditions that would be loaded in the HI-STORM FW.

Table 6.4.3 of the SAR gives the results of the evaluations performed to determine the most reactive flooding conditions of the pellet-to-clad gap. The results are presented for the 17x17B for the MPC-37 and the 10x10A for the MPC-89. It is not clear to the staff that the results of these two configurations would represent the behavior of all fuel types. In addition, per Tables 6.1.1 and 6.1.2 of the SAR, these fuel types are not the most reactive fuel types for the HI-STORM FW. Provide additional information demonstrating that these calculations are representative of all possible loadings in the HI-STORM FW.

The staff needs this information to determine that k-eff has been calculated with the maximum reactivity and to ensure that Holtec has met the requirements in 10 CFR 72.124(a) and 72.236(c).

Holtec Response:
See response to RAI 6-23.

6-25 Justify the results of the preferential flooding calculations are applicable for all fuel loadings with DFCs.

The results of the preferential flooding calculations in Table 6.4.4 of the SAR do not state what fuel types were used in these calculations. Given the values of k-eff the staff can infer that these are for the 17x17B for the MPC-37 and the 10x10A for the MPC-89. Confirm if this is true. Justify that the results of these calculations would be applicable for all fuel loadings with DFCs and all boron concentrations.

The staff needs this information to determine that k-eff has been calculated with the maximum reactivity and to ensure that Holtec has met the requirements in 10 CFR 72.124(a) and 72.236(c).

Holtec Response:
See response to RAI 6-23.

6-26 Justify that calculations used to determine the most reactive external moderator conditions are applicable for all fuel types and boron concentrations.

Table 6.4.1 of the SAR gives the results of the evaluations performed to determine the most reactive external moderator conditions. The results are presented for the 17x17B for the MPC-37 and the 10x10A for the MPC-89. It is not clear to the staff that the results of these two configurations would represent the behavior of all fuel types and boron concentrations. In addition, per Tables 6.1.1 and 6.1.2 of the SAR, these fuel types are not the most reactive fuel types for the HI-STORM FW. Provide additional information demonstrating that these calculations are representative of all possible fuel loadings and boron concentrations in the HI-STORM FW.

The staff needs this information to determine that k-eff has been calculated with the maximum reactivity and to ensure that Holtec has met the requirements in 10 CFR 72.124(a) and 72.236(c).

Holtec Response:
See response to RAI 6-23.

6-27 Justify that the calculations used to determine the most reactive assembly positioning are applicable for all fuel types and boron concentrations.

Table 6.3.5 of the SAR gives the results of the evaluations performed to determine the most reactive assembly positioning within the basket. The results are presented for the 17x17B for the MPC-37 and the 10x10A for the MPC-89 and corresponding DFC evaluations. It is not clear to the staff that the results of these configurations would represent the behavior of all fuel types and boron concentrations. In addition, per Tables 6.1.1 and 6.1.2 of the SAR, these fuel types are not the most reactive fuel types for the HI-STORM FW. Provide additional information demonstrating that these calculations are representative of all possible fuel loadings and boron concentrations in the HI-STORM FW.

The staff needs this information to determine that k-eff has been calculated with the maximum reactivity and to ensure that Holtec has met the requirements in 10 CFR 72.124(a) and 72.236(c).

Holtec Response:
See response to RAI 6-23.

6-28 Justify that the manufacturing tolerances for the basket assumed in the criticality analysis are conservative with respect to reactivity for all assemblies that are to be stored in the HI-STORM FW.
Section 6.3.1 (Page 6-18) of the SAR states: the conservative dimensional assumptions listed in Table 6.3.3 were determined for the basket designs. Because the reactivity *effect (positive or negative) of the manufacturing tolerances is not assembly dependent, these dimensional assumptions were employed for all criticality analyses.* The results of the analysis used to determine these tolerances are based on the 10x10A fuel for the MPC-89 and 17x17B fuel for the MPC-37. Per Tables 6.1.1 and 6.1.2 of the SAR, these fuel types are not the most reactive fuel types for the HI-STORM FW. The staff requires additional information justifying that the tolerances used are not assembly dependent.

The staff needs this information to determine that k-eff has been calculated with the maximum reactivity and to ensure that Holtec has met the requirements in 10 CFR 72.124(a) and 72.236(c).

Holtec Response:
See response to RAI 6-23.

6-29 Provide the assemblies and conditions (boron concentration, etc.) used and justify that it is bounding for determining the bounding temperature effects using CASMO-4.

The results of the calculations used to determine the bounding temperature effects are presented in Table 6.3.1 of the SAR. This table does not state what assemblies were used to perform these calculations. Provide this information and justify that it is applicable for all HI-STORM FW fuel contents and conditions including all applicable boron concentration.

The staff needs this information to determine that k-eff has been calculated with the maximum reactivity and to ensure that Holtec has met the requirements in 10 CFR 72.124(a) and 72.236(c).

Holtec Response:

The conditions used in those analyses have been clarified in the SAR. Note that the purpose of those calculations is NOT to determine a bounding temperature effect. The purpose is merely to confirm that, as expected, the reactivity decreases when the temperature increases. This is expected since the dominating consequence in terms of parameters important to the reactivity is the reduction in water density when then temperature goes up. The reduction in water density has been shown in Table 6.4.5 to result in a reduction in reactivity. The discussion in Section 6.3.1 has been updated to discuss this.

6-30 Justify the separation in METAMIC in the basket panels used. Section 6.3.1 of the SAR (Page 6-18) states that a 0.06" gap was assumed in the panels every 10". Justify these values. The analysis results in Table 6.3.6 of the SAR are for the 10x10A fuel for the MPC-89 and 17x17B fuel for the MPC-37. Per Tables 6.1.1 and 6.1.2 of the SAR, these fuel types are not the most reactive fuel types for the HI-STORM FW. Justify the use of these assemblies in this calculation.

The staff needs this information to determine that k-eff has been calculated with the maximum reactivity and to ensure that Holtec has met the requirements in 10 CFR 72.124(a) and 72.236(c).

Holtec Response:

See response to RAI 6-23. Note that the gap and gap distance are conservatively assumed. The drawing requires that the panels are placed in direct contact (see Drawing 6506, Note 13).

6-31 Justify the use of the assemblies used to calculate the "representative" value of the overpack.

Holtec calculated "representative values" of k-eff for the storage cask (overpack) calculations and presented the results in Table 6.1.3 of the SAR. The staff notes that these may not be for the fuel that gives the maximum k-eff based on the results presented in Tables 6.1.1 and 6.1.2 of the SAR. Justify the use of these assemblies in this calculation.

The staff needs this information to determine that k-eff has been calculated with the maximum reactivity and to ensure that Holtec has met the requirements in 10 CFR 72.124(a) and 72.236(c).

Holtec Response:

The condition in the HI-STORM FW overpack under dry conditions is bounded by a large margin by the calculation for the flooded conditions in the HI-TRAC VW. Therefore, and consistent with the approach in the HI-STORM 100, not all assembly classes are evaluated in the HI-STORM. This is considered sufficient, since the purpose is to give reasonable assurance that the maximum k_{eff} is very low. However, the assembly class that results in the highest maximum k_{eff} under flooded conditions may not be the one that results in the highest maximum k_{eff} under dry conditions. The calculation under dry condition is therefore considered representative. To determine a bounding k_{eff} under dry conditions would require a re-analysis of all classes, an effort that does not appear warranted given the large margin.

6-32 Justify the exclusion of the footnote information from the table describing the BWR contents in the proposed Technical Specifications.

Some of the information used to describe the fuel contents for the HI-STORM FW in the footnotes in Table 2.1.3 of the SAR are not listed in the proposed TS (Table 2.1-2). The staff intends to copy Table 2.1.3 in its entirety to be used for the Technical Specifications. Otherwise provide additional information justifying the exclusion of this information.

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

Holtec Response:

Table 2.1-3 "BWR Fuel Assembly Characteristics" of proposed CoC Appendix B is updated to include the complete list of footnotes from SAR Table 2.1.3. The notes have been renumbered so that both tables are identical.

6-33 Justify the statement that inclusion of neutron sources will not increase reactivity.

Start-up neutron source assemblies are stated as allowed contents in the HI-STORM FW. Section 6.4.8 of the SAR states that "a neutron source of any strength will not increase reactivity, but only the neutron flux in a system, and no additional criticality analyses are required." Section 5.2.6 of the SAR gives the following examples of neutron sources: californium, americium-beryllium, plutonium-beryllium, poloniumberyllium, and antimony-beryllium. State the plutonium isotopes allowed and justify that they will not increase the reactivity by adding fissile material. Beryllium can also act as a moderator, justify that the inclusion of Beryllium will not increase reactivity.

The staff needs this information to determine that k-eff has been calculated with the maximum reactivity and to ensure that Holtec has met the requirements in 10 CFR 72.124(a) and 72.236(c).

Holtec Response:

The plutonium isotope used in primary sources is Pu-238 (see Discussion in HI-STORM 100 FSAR, Section 5.2.7.1), which is non-fissile, and therefore will not affect the reactivity of the system. Regarding Beryllium, it is recognized that this is a neutron moderator that could potentially affect the k_{eff} if it would be present in large quantities. However, it would only be present in a single assembly in the MPC, and then typically only in a limited number of guide tubes. The effect of any beryllium is therefore considered negligible.

6-34 Provide additional information on alternate neutron shield materials for the HI-TRAC VW and their potential impact on the criticality analyses.

Section 1.2.1.4.2 of the SAR states that Holtite may be used in lieu of the water jacket for neutron shielding for the HI-TRAC VW transfer cask and that the water jacket may be fortified with ethylene glycol. Provide additional information discussing these other materials and what, if any, impact they will have on the criticality analyses.

The staff needs this information to determine that k-eff has been calculated with the maximum reactivity and to ensure that Holtec has met the requirements in 10 CFR 72.124(a) and 72.236(c).

Holtec Response:

See Response to 1-1. Solid neutron absorber (e.g., Holtite) will not be used in the HI-TRAC VW.

With regards to the ethylene glycol, this material is too far away from the fuel, and separated by absorbing and reflecting material (steel) to have a noticeable effect on the reactivity of the system. This is supported by numerous studies for similar baskets in storage and transportation casks (HI-STAR 100 SAR) that consistently show that the presence or absence of materials outside of the MPC shell or containment boundary shell has a negligible effect on reactivity.

7.0 CONFINEMENT EVALUATION

7-1 Clarify Note 1 on Table 3-1 in the TS (Appendix A) so that MPC pressure acceptance criteria is met *while the MPC is isolated from the vacuum pump.*

This clarification is included in Table 9.1.1 of the SAR but should be included in the TS.

This information is needed to verify compliance with 10 CFR 72.120(d) and 10 CFR 72.122(h).

Holtec Response:

This clarification has been added to Table 3-1 of the proposed TS (Appendix A) so the MPC pressure acceptance criterion is met while the MPC is isolated from the vacuum pump.

7-2 Specify in the Technical Specifications that the leak rate through the Multi-Purpose Canister shop welds (shell seams and shell-to-base plate shop welds) shall be helium leak tested and found "leak-tight" in accordance with the requirements of ANSI N14.5 as part of the initial acceptance criteria.

This requirement is specified in Section 8.14.1 of the SAR but should be included in the TS.

This information is needed to verify compliance with 10 CFR 72.120(d).

Holtec Response:

This language is proposed as CoC Condition #2, "Acceptance Tests and Maintenance Program", similar to Condition #3 in the HI-STORM 100 CoC 1014, Amendment #7. Holtec proposes that the two documents be consistent in this manner.

7-3 Clarify that the helium leak testing of the vent and drain cover shall be leak tight in accordance ANSI N14.5 in Table 3-1 of the TS (Appendix A).

The specific requirements of ANSI N14.5 are described in Section 7.1.1 of the application, but should be also included in the TS.

This information is needed to verify compliance with 10 CFR 72.120(d) and 10 CFR 72.122(h).

Holtec Response:

The helium leak testing requirements are not in Table 3-1, however the surveillance request (SR) for LCO 3.1.1 (SR 3.1.1.3), already in the proposed CoC Appendix A, specifies that the helium leak test requirements on the vent port confinement weld and the drain port confinement weld. They must each be helium leak tested and meet the leaktight criteria of ANSI N14.5. It is important to note that Section 7.1 of the ANSI standard indicates "Component leakage tests of the containment boundary of packages with a leaktight criterion need only be shown individually to be leaktight.

The summation of individual component leakage rates of the containment boundary of a package with a leaktight criterion is not required."

In addition, please note SR 3.1.1.3 was modified slightly from the original proposed CoC Appendix A to remove any ambiguity on the testing acceptance criteria. Chapters 7, 9, and 10 were also clarified to be consistent with SR 3.1.1.3 and ANSI N14.5.

Not related to this RAI but included for completeness, the reference to Action C.2.2 in SR 3.1.1.2 was corrected to read Action B.2.2.

7-4 Clarify or remove Note 25 on Sheet 3 of licensing drawing 6512. Note 25 on Sheet 3 of licensing drawing 6512 would appear to permit the MPC lid to be fabricated out of dissimilar materials, austenitic stainless steel, and ferritic carbon steel.

The latter of which is not included in the "Alloy X" grouping of stainless steels and was not included in the engineering design.

This information is needed to verify compliance with 10 CFR 72.120(A).

Holtec Response:

The top portion of the MPC lid, which is made of Alloy X, is only credited in the confinement analysis. The lid of the MPC is made significantly thicker than that required to meet the structural requirements (viz., MPC handling and internal pressure). Approximately 50% of the total thickness of the lid is adequate to meet the structural requirements (please see Section 3.4 of the SAR). The remaining metal mass is provided as shielding to minimize occupational dose to the loading crew.

In the original HI-STORM 100 MPC designs the two lids were subsumed into one thick lid to minimize shop machining and welding work. However, the ability to make these large forgings has become scarce and even temporarily unavailable in the U.S. at times; therefore the dual-lid option was invoked and implemented in the HI-STORM 100 system.

The lid structure is a dual-lid configuration wherein the top portion of the lid, made of Alloy X and qualified to Section III Class 1 (NB) requirements, forms the confinement (and pressure retention) boundary. The bottom portion of the lid, on the other hand, serves only the shielding function, and as such is non-Code (but important-to-safety category B).

In the dual-lid configuration, the bottom portion of the lid used for shielding only is made of carbon steel with a prophylactic layer of stainless steel (overlayed or lined) to eliminate any wetting of carbon steel during short-term operations.

9.0 ACCEPTANCE TESTS AND MAINTENANCE PROGRAM

9-1 Explain the reason for not referring to the SAR section 4.5.5 unloading thermal analysis results in section 9 and section 12 of the SAR.

Per NUREG-1536, the thermal analysis associated with unloading operations should be referenced in section 9 and section 12 of the SAR. Explain the reason for not referring to the section 4.5.5 unloading thermal analysis results in section 9 and section 12 of the SAR.

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

Holtec Response:

The unloading operation was explicitly treated as an event without the potential to challenge the integrity of the storage system and the health and safety of the public in the HI-STORM 100 docket. The same heuristic reasoning was used to omit the safety analysis of MPC re-flooding as a potentially consequential event. In light of this RAI, the following additional material has been added to the SAR:

1. A stress analysis to evaluate the effect of quenching of the fuel cladding during the re-flood operation has been performed using a simplifying set of assumptions that lead to a conservative estimate of the cladding strain from the thermal transient. The analysis and results are summarized in Chapter 3, Subsection 3.4.4. A large margin of safety with respect to the cladding failure strain has been determined to exist, validating the assumption in the HI-STORM 100 docket.

2. The safety analysis of the MPC re-flooding event, which is categorized as "other events", has been performed in Subsections 3.4.4 to evaluate the structural integrity of the fuel cladding based on the scenario discussed in Subsection 4.5.5. The consequences of this event have been reported in Section 12.3.

3. The "Caution" Box in Subsection 9.4.3 is updated to include a reference to SAR Subsection 4.5.5 in addition to the reference to the CoC Appendix A LCO 3.1.3 which was already present.

10. RADIATION PROTECTION

10-1 Revise various incorrect SAR and TS references to the Metamic HT acceptance criteria of SAR section 10.1.6.3.

SAR sections 6.1 and 6.3.2 refer to these acceptance criteria being in SAR section 10.4 (which is leakage testing). The TS refer to these acceptance criteria being in SAR section 10.1.7.3 instead of 10.1.6.3.

Holtec Response:

The Metamic-HT acceptance criteria are in 10.1.6.3 and all references have been changed to indicate this. This includes SAR Sections 6.1, 6.3.2, and proposed CoC Appendix B Subsection 3.2.3.

12.0 TECHNICAL SPECIFICATIONS AND OPERATING CONTROLS AND LIMITS EVALUATION

12-1 Include a discussion of the off-normal malfunction of Forced Helium Dehydration (FHD) system event in SAR subsection 2.2.2.

SAR Page 12-1 states that the off-normal malfunction of FHD system event is discussed in FSAR subsection 2.2.2. However, this event is not listed in this subsection. For completeness and consistency of the information provided in the application, a discussion of this event should be included in SAR Section 2.2.2.

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

Holtec Response:

SAR Subsections 2.2.2, 4.6.1, and 12.1.5 are updated to discuss the off-normal malfunction of the FHD, consistent with HI-STORM 100 System.

12-2 Provide proposed TS wording describing the requirements and acceptance criteria for the confinement (canister) shell helium leakage test described in SAR section 10.1.4 and SAR table 10.1.1.

Since the helium leakage test is the approved method used to demonstrate compliance with 10 CFR 72.104 and 72.106, its inclusion in the TS is necessary since it is a license condition.

This information is necessary to verify compliance with 10 CFR 72.104, 72.106, and 72.126.

Holtec Response:

See response to 7-2.

13.0 MATERIALS EVALUATION

13-1 Clarify the coating qualification program used to qualify "equivalent" coatings (to be used on the HI-TRAC) which are not specifically recommended for immersion service by the coating manufacturer.

SAR section 8.7 and the SAR Chapter 8 appendices (Carboline data sheets) describe some coatings for use on the HI-TRAC that is not recommended for immersion service by Carboline but have been demonstrated as acceptable for use. SAR section 8.7 mentions several standard American Society of Testing Materials coating tests but does not specifically relate those tests to a qualification program for qualifying an equivalent coating from another manufacturer. Consequently, the substitution of "equivalent" coatings is not adequately supported for cases where the equivalent coating is not specified by the manufacturer for immersion service.

The staff understands that coatings are not classified as important to safety. However, historical experience with some unqualified coatings resulted in unanalyzed safety conditions when coating failure impeded loading operations.

This question does not concern the zinc-rich primers specified for use elsewhere.

This information is required to verify compliance with 10 CFR 72.120(d).

Holtec Response:

The text in the SAR does not purport to permit use of a coating in immersion service that is not endorsed for such purpose by its manufacturer. To avoid ambiguity, Section 8.7 of the SAR has been clarified to prohibit the use of coatings to protect components (such as the HI-TRAC cask) in underwater service that are not determined to be suitable for immersion (contact with pool water) applications. Specific coating types that have a proven track record of service for protecting dry storage components in Holtec's fleet, listed in the SAR Section 8.7.2 and Appendix 8.A, have been revisited to insure that an inappropriate coating has not been prescribed.

The recommended exterior coating for HI-TRAC VW (e.g., Carboguard 890 of Carboline) is suitable for immersion service. The recommended interior coating (e.g., Thermaline 450) has been satisfactorily used for years. It has excellent barrier protection and resistance to wet/dry cycling at elevated temperatures. The HI-TRAC interior surfaces are exposed during loading operation to only demineralized water.

The technical considerations and acceptance criteria for selecting coatings are also provided to serve as the guidance in the event that the coatings presently in use in Holtec's dry storage components become unavailable, or need to be replaced for an (at present) unforeseen reason. A coating that meets the acceptance criteria set down in Section 8.7 is termed an "equivalent coating".

Attachment 2 to 5014009 - Summary of Changes to the HI-STORM FW MPC Storage System Safety Analysis Report

The following are a list of changes made to the HI-STORM FW MPC Storage System Safety Analysis Report (SAR) to aid in the Staff's review. Some of the changes are a result of the response to the request for additional information (RAI) and some are minor changes, either typographical errors or clarifications, changed during this revision. They are described accordingly below.

Chapter 1

The following changes are made to Chapter 1 of the HI-STORM FW MPC Storage System SAR.

1) Removed Holtite from Subsection 1.2.1.4.2 as a result of response to RAI 1-1.
2) Changed "nominal" to "typical" in first paragraph of Section 1.4 as a result of response to RAI #1-2
3) Added minimum pitch of 15 feet for intercask spacing to Table 1.4.1 as a result of response to RAI #1-2
4) Added "minimum" to title of Table 1.4.1 as a result of response to RAI #1-2
5) Updated the issue date of Reference 1.B.1 to be consistent with latest Metamic-HT Sourcebook revision as a result of RAI #2-3.
6) Added Appendix 1.C for the high temperature properties of Metamic-HT to address RAI #2-3.

Chapter 2

The following changes are made to Chapter 2 of the HI-STORM FW MPC Storage System SAR.

1) Added text to Section 2.0.2 (page 2-6) to indicate that the ITS QA categorization is in Tables 2.0.1 through 2.0.8 as a result of RAI 1-3.
2) Section 2.0 - Added Tables 2.0.1 through 2.0.8 as a result of RAI 1-3.
3) Editorial clarifications are made in Table 2.1.1.
4) Corrected the value for maximum planar average initial enrichment for fuel assembly array class 10x10G in Table 2.1.3. Correct value of 4.6% is consistent with Table 6.1.2 of the SAR and 2.1-3 of the TS Appendix B. (RAI 6-3b)
5) Added a discussion on the malfunction of FHD (off-normal condition) per RAI 12-1 in Section 2.2.2 Item f.
6) The off-normal and accident condition temperature limits for the MPC basket and basket shims in Table 2.2.3 is changed from 1000 °F to 932 °F to reflect the Metamic-HT test data. (RAI 3-1)
7) Design objective dose rates are added to Subsection 2.3.5.2 in response to RAI 5-1.

Chapter 3

The following changes are made to Chapter 3 of the HI-STORM FW MPC Storage System SAR. As a result of the initial acceptance review, Chapter 3 was supplemented on December 18, 2009 via Holtec letter 5018007. These changes, in addition to the

changes due to this response, are marked with a revision bar. Appendices 3.A, 3.B, and 3.C were submitted with the Supplement but are not marked with revision bars. The changes made as a result of this RAI response are as follows.

1) Subsection 3.1.2.6 of the SAR was updated to address buckling in response to RAI 3-1.
2) Subsection 3.4.4.1.4 of the SAR to quantify the margins of safety under the non-mechanistic tip-over scenario in response to RAI 3-3.
3) Section 3.2 of the SAR has been revised to clarify the definitions of ϕ and Ψ and further explain how the parameters are applied in response to RAI 3-4.
4) Subsection 3.4.4.1.11 is added to evaluate the effect of MPC reflood on fuel cladding as a result of RAI 9-1.

Chapter 4
The following changes are made to Chapter 4 of the HI-STORM FW MPC Storage System SAR.

1) Changed "MPCS" to "MPCs" on page 4-4.
2) Clarification in Table 4.2.1 that Appendix 1.D is from HI-STORM 100 FSAR
3) Modified Section 4.4.1.1 and 4.5.2.1 to discuss the detailed description of the thermal model per RAI 4-3.
4) Added Section 4.4.2.1 for evaluation of surrounding casks per RAI 4-5.
5) Modified Subsection 4.4.1.3 discussion of bounding flow resistance per RAI 4-4.
6) Added Section 4.4.1.4 and Figures 4.4.5 though 4.4.7 as a result for evaluation of enlarged cell opening per RAI 4-4.
7) Added Section 4.4.1.5 and modified Table 4.4.2 for screening calculations to determine the limiting storage scenario per RAI 4-11.
8) Added Section 4.4.1.6 for grid sensitivity per RAI 4-9.
9) Table 4.4.1 is updated to provide effective fuel properties of the fuel.
10) Section 4.4.2 - changed 192 inch pitch to 180 inches (15 ft) per RAI 1-2 and 4-5.
11) Modified Subsection 4.4.5.2. to discuss the removal of the conservatism in the MPC pressure calculations.
12) Tables in 4.4, 4.5, and 4.6 are updated to reflect updated thermal analysis results.
13) Table 4.5.8 updated for effective conductivity of fuel assemblies per RAI 4-2.
14) Removal of ALARA statement in Section 4.5 per RAI 4-8.
15) Added Section 4.6.1.4 to discuss FHD malfunction per RAI 12-1.

Chapter 5
The following changes are made to Chapter 5 of the HI-STORM FW MPC Storage System SAR.

1) Editorial; Corrected a page numbering problem between Tables 5.2.14 and 5.2.15.
2) Section 5.1 - Removed mention of Holtite as a result of response to RAI 1-1.
3) Discussion of ITTRs are added to Section 5.0 and Subsection 5.4.4 as a result of RAI 2-2.
4) Design basis dose rate objectives are included in Section 5.1 as a result of response to RAI 5-1.
5) A sentence is added to support the use of design basis fuel in 5.1as a result of RAI 5-2.
6) Section 5.4.4, including new results in Table 5.4.8 are added as a result of RAI 5-4.
7) TPD masses and curies were added to support the response to RAI 5-4.

Chapter 6

The following changes are made to Chapter 6 of the HI-STORM FW MPC Storage System SAR.

1) Table 6.1.1: values for 15x15I were updated for more flexible guide rod locations (see RAI 6-13).
2) Table 6.2.2 changed title MPC-68 to MPC-89 per RAI 6-5.
3) Table 6.2.2 corrected (swapped) active length/ water rods.
4) Changed 10.1.4 on page 6-2, 6-3, and 6-19 to 10.1.6.3.
5) Section 6.4.1, fixed typo "foe" -> "for".
6) RAI 6-1, Section 6.1, added brief discussion on admin control of soluble boron.
7) RAI 6-2 and 6-13, Section 6.2.1, added discussion that locations are now specified in Appendix 6.B, Section 6.B.4; added discussions/study on 9x9E/F water rod location; added discussion/study on 15x15I guide rod number/location.
8) RAI 6-4, Section 6.2.1, added discussion and results Table 6.2.5 for 8x8B and 8x8D assemblies.
9) RAI 6-7, Section 6.2.1, added discussion on applicability of bounding dimensions to all classes, added Table 6.2.3.
10) RAI 6-8, Section 6.2.1, added distributed enrichment cases from HI-STORM 100, Appendix B, re-analyzed in FW in Table 6.2.4, and expanded/corrected discussion.
11) RAI 6-9, Section 6.2.1, moved discussion on annular pellets from 6.4.9, and presented results in new Table 6.2.6.
12) RAI 6-10, addition of ITTR, Section 6.4.7 is updated. Note that voiding the instrument tubes was already included in the models, so the original text in 6.4.7 was not correct.
13) RAI 6-11, Section 6.4.7, removed discussion on pure water and NFH.
14) RAI 6-12, Table 6.4.5, added 2300 ppm (undamaged and damaged); added Table 6.4.10 for all PWR classes with voided guide tubes.
15) RAI 6-14, Water Cross details added to Appendix 6.B.
16) RAI 6-15, Section 6.4.4.1, added discussion on different active length.

17) RAI 6-16, Updates in Section 6.4.4.1 to reference the HI-STORM 100 tables and figures.
18) RAI 6-17, Section 6.4.4.1, added discussion on 9x9E vs. 10x10G as undamaged assembly with damaged fuel.
19) RAI 6-18, Section 6.3.2, discussed cross section set and showed them in new Table 6.3.8.
20) RAI 6-18, Section 6.A.1, discussed cross sections used and added Table 6.A.4 with cross section IDs.
21) RAI 6-19, -20, Section 6.4.4.1, provided enrichment and soluble boron limits for damaged fuel.
22) RAI 6-21, Section 6.1, revised discussion on fuel density assumption.
23) RAI 6-22, Section 6.1, assumption on structural materials has been updated.
24) RAIs 6-23, -24, -25, -26, Section 6.4.2, Discussion added to show that studies with a single assembly type are sufficient.
25) RAIs 6-27, -28, -30, Section 6.3.1, Discussion added to show that studies with a single assembly type are sufficient.
26) RAI 6-29, The discussion in Section 6.3.1 has been updated to discuss that a reduction in water density results in a reduction of reactivity.

Chapter 7
The following changes are made to Chapter 7 of the HI-STORM FW MPC Storage System SAR.

1) Added clarification on the two piece lid in response to RAI 7-4.
2) Clarified leak testing of the vent and drain port cover plate welds in 7.1.1 and 7.1.4 to be consistent with SR 3.1.1.3 per RAI 7-3.

Chapter 8
The following changes are made to Chapter 8 of the HI-STORM FW MPC Storage System SAR.

1) Various changes to 8.7 "Coatings" per RAI 13-1
2) Removed Holtite from two places in 8.8, Section 8.8.5 in its entirety, and references 8.8.2 through 8.8.4 as a result of the response to RAI 1-1.
3) Removed datasheet for Carboguard 890N from Appendix 8.A as a result of the response to 13-1

Chapter 9
The following changes are made to Chapter 9 of the HI-STORM FW MPC Storage System SAR.

1) Added the word "gauges" to Table 9.1.1 in the row discussing damage to vacuum drying system vacuum gauges.
2) Editorial; Changed "is" to "are" on page 9-8.
3) Editorial; Changed "supplied" to "approved" and removed the following sentence.

4) Updated boron controls during loading (Subsection 9.2.2 step 15 and ALARA Note in 9.2.4) and unloading (Subsection 9.4.3 step 5 Note box) to ensure consistency with LCO 3.3.1 per RAI 6-1.
5) Updated 9.2.3 to include a verification of the non-fuel hardware before MPC loading as a result of RAI 4-6.
6) Changed the required helium backfill pressure in the Caution box after 9.2.4 Step 8 to be consistent with FHD malfunction discussion in 12.1.5.
7) Added clarification in 9.2.4 Step 10 on helium leak testing of the vent and drain port cover plate welds to ensure consistency with LCO 3.1.1.
8) Editorial; Changed "and" to "any" on page 9-17.
9) Updated Section 9.2.6 Item 15 for the annular air mass flow test as a result of RAI 4-10.
10) Updated text and Caution Boxes in 9.4.3 to include reference to SAR Subsection 4.5.5 (reflood analysis) and specific directions resulting from RAI 9-1.

Chapter 10
The following changes are made to Chapter 10 of the HI-STORM FW MPC Storage System SAR.

1) Editorial correction; Changed "criteria" to "criterion" on page 10-10.
2) Add description of the test proposed for first manufactured MPC per RAI 4-10 to 10.1.7.
3) In 10.1.7 modified type of thermal test to be done on first loaded system per RAI 4-10.
4) Change in Table 10.1.1 row labeled "Leak Tests", column labeled "Maintenance and Operations" since the leak testing requirements are listed in the Technical Specification rather than in the Bases.
5) Editorial correction; Removed "$" from Table 10.1.2
6) Made some clarifications to Metamic-HT nomenclature in Table 10.1.6 to be consistent with actual testing. This change is not of a result of any RAI.
7) Added Reference 10.1.9 to Section 10. 4 to support the proposed MPC testing per RAI 4-10.

Chapter 11
No changes are made to Chapter 11 of the HI-STORM FW MPC Storage System SAR.

Chapter 12
The following changes are made to Chapter 12 of the HI-STORM FW MPC Storage System SAR.

1) Modifications made to Section 12.1.5 as a result of RAI 12-1.
2) Modifications to 12.2.1 as a result of RAI 3-2.
3) Removal of Reference 12.2.2 as a result of RAI 3-2.
4) Addition of Section 12.3 as a result of RAI 9-1. Reference Section 12.3 now becomes 12.4.

Chapter 13
The following changes are made to Chapter 13 of the HI-STORM FW MPC Storage System SAR.

1) Added text to the Bases for LCO 3.3.1 in Appendix 13.A as a result of RAI 6-1.

Chapter 14
No changes are made to Chapter 14 of the HI-STORM FW MPC Storage System SAR.

Attachment 3 to 5018009 - Summary of Changes to the Proposed HI-STORM FW MPC Storage System Certificate of Compliance and Technical Specification

The following are a list of changes made to the proposed HI-STORM FW MPC Storage System Certificate of Compliance (CoC) and Technical Specifications (TS) to aid in the Staff's review. Some are a result of the response to the request for additional information (RAI) and some are minor changes, either typographical errors or clarifications, changed during this revision. They are described accordingly below.

The following changes are made to the CoC for HI-STORM FW MPC Storage System.

1.) Added the requirement for helium leak testing of the MPC shell and shell to base plate welds prior to use to Condition 2 in response to RAI 7-2
2.) Added Condition 8 to include an air flow test for first system in place consistent with HI-STORM 100 in response to RAI 4-10.

Appendix A
The following changes are made to the TS, Appendix A "TECHNICAL SPECIFICATIONS FOR THE HI-STORM FW MPC STORAGE SYSTEM".

1.) Added text to Note 1 on Table 3-1 (per RAI 7-1)
2.) Changed "C.2.2" to "B.2.2" in SR 3.1.1.2 to reflect the correct reference. Please note this was an error that was identified by Holtec during the RAI process and not requested by a particular RAI question.
3.) Modified language in SR 3.1.1.3 to make it clear that each confinement weld (vent port and drain port) shall be tested and meet the "leaktight" criteria of ANSI N14.5-1997. See RAI 7-3.
4.) Changed the temperatures in SR 3.1.2 as a result of response to RAI 4-9 and 4-11.
5.) Changed MPC Helium backfill limits in Table 3-2 to reflect updated thermal analysis and added Note 2.
6.) Section 5.2, paragraph a. - added "MPC" to the statement to be consistent with CoC Condition #4.

Appendix B
The following changes are made to the TS, Appendix B "APPROVED CONTENTS AND DESIGN FEATURES FOR THE HI-STORM FW MPC STORAGE SYSTEM".

1.) The requirement for initial enrichment in Table 2.1-1 page 1 of 4 (MPC-37) was changed to read that Maximum Initial Enrichment specified as 5.0%. Please note this was an error that was identified by Holtec during the RAI process and not requested by a particular RAI question.
2.) In Table 2.1-3 the maximum average planar enrichment for fuel array class 10x10G was changed to 4.6% to be consistent with Table 6.1.2 and 2.1.3 of the SAR (Per RAI 6-3.b). For this same array class the number of fuel rods was changed to reflect 96 total rods with 84 partial length rods (per RAI 6-3.a).
3.) The notes and the numbering of the notes in TS Table 2.1-3 were made consistent with SAR Table 2.1.3 per RAI 6-32.
4.) Section 3.2.3 was corrected to reference the neutron absorber testing in 10.1.6.3 instead of 10.1.7.3 per RAI 10-1.

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Document ID 5018009
Non-Proprietary Attachment 6

AFFIDAVIT PURSUANT TO 10 CFR 2.390

I, Tammy S. Morin, being duly sworn, depose and state as follows:

(1) I have reviewed the information described in paragraph (2) which is sought to be withheld, and am authorized to apply for its withholding.

(2) The information sought to be withheld is provided in Attachments 4 and 5 to Holtec letter Document ID 5018009, which contain Holtec Proprietary information.

(3) In making this application for withholding of proprietary information of which it is the owner, Holtec International relies upon the exemption from disclosure set forth in the Freedom of Information Act ("FOIA"), 5 USC Sec. 552(b)(4) and the Trade Secrets Act, 18 USC Sec. 1905, and NRC regulations 10CFR Part 9.17(a)(4), 2.390(a)(4), and 2.390(b)(1) for "trade secrets and commercial or financial information obtained from a person and privileged or confidential" (Exemption 4). The material for which exemption from disclosure is here sought is all "confidential commercial information", and some portions also qualify under the narrower definition of "trade secret", within the meanings assigned to those terms for purposes of FOIA Exemption 4 in, respectively, Critical Mass Energy Project v. Nuclear Regulatory Commission, 975F2d871 (DC Cir. 1992), and Public Citizen Health Research Group v. FDA, 704F2d1280 (DC Cir. 1983).

AFFIDAVIT PURSUANT TO 10 CFR 2.390

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(4) Some examples of categories of information which fit into the definition of proprietary information are:

a. Information that discloses a process, method, or apparatus, including supporting data and analyses, where prevention of its use by Holtec's competitors without license from Holtec International constitutes a competitive economic advantage over other companies;

b. Information which, if used by a competitor, would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality, or licensing of a similar product.

c. Information which reveals cost or price information, production, capacities, budget levels, or commercial strategies of Holtec International, its customers, or its suppliers;

d. Information which reveals aspects of past, present, or future Holtec International customer-funded development plans and programs of potential commercial value to Holtec International;

e. Information which discloses patentable subject matter for which it may be desirable to obtain patent protection.

The information sought to be withheld is considered to be proprietary for the reasons set forth in paragraphs 4.a, 4.b, and 4.e above.

(5) The information sought to be withheld is being submitted to the NRC in confidence. The information (including that compiled from many sources) is of a sort customarily held in confidence by Holtec International, and is in fact so held. The information sought to be withheld has, to the best of my knowledge and belief, consistently been held in confidence by Holtec International. No public disclosure has been made, and it is not available in public sources. All

disclosures to third parties, including any required transmittals to the NRC, have been made, or must be made, pursuant to regulatory provisions or proprietary agreements which provide for maintenance of the information in confidence. Its initial designation as proprietary information, and the subsequent steps taken to prevent its unauthorized disclosure, are as set forth in paragraphs (6) and (7) following.

(6) Initial approval of proprietary treatment of a document is made by the manager of the originating component, the person most likely to be acquainted with the value and sensitivity of the information in relation to industry knowledge. Access to such documents within Holtec International is limited on a "need to know" basis.

(7) The procedure for approval of external release of such a document typically requires review by the staff manager, project manager, principal scientist or other equivalent authority, by the manager of the cognizant marketing function (or his designee), and by the Legal Operation, for technical content, competitive effect, and determination of the accuracy of the proprietary designation. Disclosures outside Holtec International are limited to regulatory bodies, customers, and potential customers, and their agents, suppliers, and licensees, and others with a legitimate need for the information, and then only in accordance with appropriate regulatory provisions or proprietary agreements.

(8) The information classified as proprietary was developed and compiled by Holtec International at a significant cost to Holtec International. This information is classified as proprietary because it contains detailed descriptions of analytical approaches and methodologies not available elsewhere. This information would provide other parties, including competitors, with information from Holtec International's technical database and the results of evaluations performed by Holtec International. A substantial effort has been expended by Holtec International to develop this information. Release of this information would improve a competitor's position because it would enable Holtec's competitor to copy our technology and offer it for sale in competition with our company, causing us financial injury.

AFFIDAVIT PURSUANT TO 10 CFR 2.390

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(9) Public disclosure of the information sought to be withheld is likely to cause substantial harm to Holtec International's competitive position and foreclose or reduce the availability of profit-making opportunities. The information is part of Holtec International's comprehensive spent fuel storage technology base, and its commercial value extends beyond the original development cost. The value of the technology base goes beyond the extensive physical database and analytical methodology, and includes development of the expertise to determine and apply the appropriate evaluation process.

The research, development, engineering, and analytical costs comprise a substantial investment of time and money by Holtec International.

The precise value of the expertise to devise an evaluation process and apply the correct analytical methodology is difficult to quantify, but it clearly is substantial.

Holtec International's competitive advantage will be lost if its competitors are able to use the results of the Holtec International experience to normalize or verify their own process or if they are able to claim an equivalent understanding by demonstrating that they can arrive at the same or similar conclusions.

The value of this information to Holtec International would be lost if the information were disclosed to the public. Making such information available to competitors without their having been required to undertake a similar expenditure of resources would unfairly provide competitors with a windfall, and deprive Holtec International of the opportunity to exercise its competitive advantage to seek an adequate return on its large investment in developing these very valuable analytical tools.

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Document ID 5018009
Non-Proprietary Attachment 6

AFFIDAVIT PURSUANT TO 10 CFR 2.390

STATE OF NEW JERSEY)
) ss:
COUNTY OF BURLINGTON)

Ms. Tammy S. Morin, being duly sworn, deposes and says:

That she has read the foregoing affidavit and the matters stated therein are true and correct to the best of her knowledge, information, and belief.

Executed at Marlton, New Jersey, this 4th day of June, 2010.

Tammy S. Morin
Holtec International

Subscribed and sworn before me this 4th day of June, 2010.

Maria C. Masci

MARIA C. MASCI
NOTARY PUBLIC OF NEW JERSEY
My Commission Expires April 28, 2013