PROPOSED

SAFETY EVALUATION REPORT

DOCKET NO. 72-1014

HOLTEC INTERNATIONAL

HI-STORM 100 CASK SYSTEM

CERTIFICATE OF COMPLIANCE NO. 1014

AMENDMENT NO. 3

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SUMMARY

By letter dated November 7, 2005, Holtec International (Holtec) submitted an application to the United States Nuclear Regulatory Commission (NRC) to amend Certificate of Compliance (CoC) No. 1014 for the HI-STORM 100 Cask System (License Amendment Request 1014-4, Revision 0), in accordance with U.S. Code of Federal Regulations, “Licensing Requirements for the Independent Storage of Spent Nuclear Fuel and High-Level Radioactive Waste and Reactor-Related Greater than Class C Waste,” Title 10, Part 72 (10 CFR Part 72). By letter dated November 23, 2005, the NRC staff, hereafter referred to as the staff, informed Holtec that the LAR 1014-4 application contained sufficient information for the staff to begin a technical review.

The application, as supplemented April 30, 2006, (LAR 1014-4, Revision 1) in response to the staff Request for Additional Information (RAI) dated March 23, 2006, requested changes to the CoC, Technical Specifications (TS), and Final Safety Analysis Report (FSAR) to modify the HI-STORM 100 Cask System. The amendment proposed to:

1. Modify the CoC to incorporate minor editorial changes.
2. Modify the TS to eliminate the requirement to perform helium leak rate testing on vent and drain port cover plates if the associated welds are performed with at least a two weld passes and with liquid penetrant examinations of the root and final weld passes.
3. Modify the TS to eliminate cooling of the Multi-Purpose Canister (MPC) cavity prior to reflood with water (as part of cask unloading operations). The existing helium exit temperature requirement is to be replaced by a requirement on the MPC cavity pressure.
4. Modify the TS to allow linear interpolation between minimum soluble born concentrations of 4.1 wt% and 5.0 wt% fuel enrichment in the MPC-32/32F.
5. Modify the definition of fuel debris to permit containers or structures that provide support to loose fuel assembly parts and non-fuel hardware to be stored as fuel debris in damaged fuel containers (DFC’s).
6. Modify the definition of non-fuel hardware to include primary and secondary neutron sources (neutron source assemblies). Modify Tables 2.1-1 and 2.1-8 in Appendix B of the CoC to permit storage of neutron source assemblies in the MPC-24, MPC-24E/EF and MPC-32/32F.
7. Modify the TS to permit storage of Pressurized Water Reactor (PWR) fuel assemblies with annular fuel pellets in the top and bottom 12 inches of the active fuel length.

This Safety Evaluation Report (SER) documents the review and evaluation of the amended FSAR, supplemental materials, and proposed CoC changes. The FSAR follows the format similar to that of the U.S. Nuclear Regulatory Commission, "Standard Review Plan for Dry Cask Storage Systems," NUREG-1536, January 1997 (NUREG-1536) with differences implemented for clarity and consistency.

I. REVIEW CRITERIA

The staff's evaluation of each of the seven proposed changes is based on whether the applicant meets the applicable requirements of 10 CFR Part 72 for independent storage of spent fuel and of 10 CFR Part 20 for radiation protection. The staff's evaluation focused only on modifications requested in the LAR 1014-4 and did not reassess previously approved portions of the CoC, TS, and the FSAR or those areas of the FSAR modified by Holtec as allowed by 10 CFR 72.48. The technical objectives for the following review disciplines are as described below for each of the proposed changes.

The objectives of the structural review is to assess the safety analysis of the structural design features, the structural design criteria, and the structural analysis methodology used to evaluate the expected structural performance capabilities under normal operations, off-normal operations, accident conditions and natural phenomena events for those structures, systems and components important to safety included in this amendment.

The review was conducted against the appropriate regulations as described in 10 CFR 72.236 that identify the specific requirements for spent fuel storage cask approval and fabrication. The unique characteristics of the spent fuel to be stored are identified as required by 10 CFR 72.236(a) so that the design basis and the design criteria that must be provided for the structures, system and components important to safety can be assessed under the requirements of 10 CFR 72.236(b). LAR 1014-4 was also reviewed to determine whether the modifications to the HI-STORM 100 Cask System fulfills the acceptance criteria listed in Section 3 of NUREG-1536.

None of the seven proposed changes were found to have an impact on the structural criteria or the structural design of the HI STORM 100 cask system. A review of Attachments 2 and 3 of the amendment application dated November 7, 2005, containing the proposed changes to the CoC, FSAR Chapters 1, 2, 3, 8 and 11 and the TS of Chapter 12, verified that no changes have be proposed in these sections of the submittal that impact the structural aspects of the HI-STORM 100 Cask System.

The objectives of the thermal review is to ensure that the cask component and fuel material temperatures of the HI-STORM Cask System and HI-TRAC Spent Fuel Transfer System will remain within the allowable values or criteria for normal, off-normal, and accident conditions. These objectives include confirmation that the fuel cladding temperature will be maintained below specified limits throughout the storage period to protect the cladding against degradation that could lead to gross ruptures. This portion of the review also confirms that the cask thermal design has been evaluated using acceptable analytical techniques and/or testing methods.

The review was conducted against the appropriate regulations as described in 10 CFR 72.236 that identify the specific requirements for spent fuel storage cask approval and fabrication. The unique characteristics of the spent fuel to be stored are identified as required by 10 CFR 72.236(a) so that the design basis and the design criteria that must be provided for the structures, system and components important to safety can be assessed under the requirements of 10 CFR 72.236(b). This amendment was also reviewed to determine whether the modifications to the HI-STORM 100 Cask System fulfills the acceptance criteria listed in Section 4 and 11 of NUREG-1536 as well as associated Interim Staff Guidance (ISG) documents. Proposed change 3 that affect the thermal performance of the HI-STORM 100 Cask System was reviewed to the above criteria.

The objective of the shielding review is to verify that there is adequate protection to the public and workers against direct radiation from the cask contents. The review verifies that both changes to the shielding features and contents provide adequate protection against direct radiation to the operating staff and members of the public and that direct radiation exposures can satisfy regulatory requirements during normal operating, off-normal, and design-basis accident conditions. The objective includes review of changes to the shielding design description, radiation source definition, shielding model specification and shielding analyses for the HI-STORM 100 Cask System proposed by LAR 1014-4.

The regulatory requirements for providing adequate radiation protection to licensee personnel and members of the public include 10 CFR Part 20, 10 CFR 72.104, 10 CFR 72.106(b), 10 CFR 72.212, and 10 CFR 72.236(d). Because 10 CFR Part 72 dose requirements for members of the public include direct radiation, effluent releases, and radiation from other uranium fuel-cycle operations, an overall assessment of compliance with these regulatory limits was evaluated. Proposed changes 1, 5, and 7 that affect the shielding performance of the HI-STORM 100 Cask System were reviewed to the above criteria.

The objective of the criticality review is to ensure that the spent fuel will remain subcritical under all credible normal, off-normal, and accident conditions encountered during handling, packaging, transfer, and storage. The objective includes a review of the changes to the criticality design criteria, features and fuel specifications, a verification and review of the configuration and material properties for the HI-STORM 100 Cask System, and a review of the criticality analyses that might include computer programs, benchmark comparisons, and multiplication factors proposed in LAR 1014-4.

The applicant proposed several modifications to the HI-STORM 100 Cask System design and CoC. Only those changes that may affect the criticality safety of the system are discussed in this SER. The staff reviewed the proposed changes to the HI-STORM 100 Cask System criticality safety analysis to ensure that all credible normal, off-normal, and accident conditions have been identified and their potential consequences on criticality considered such that the HI-STORM 100 Cask System, as revised, meets the following regulatory requirements: 10 CFR 72.124(a), 72.124(b), 72.236(c), and 72.236(g). The staff's review also involved a determination on whether the cask system satisfies the acceptance criteria listed in Section 6 of NUREG. Proposed changes 4 and 7 that affect the criticality performance of the HI-STORM 100 Cask System were reviewed to the above criteria.

The objective of the confinement review is to ensure that radiological releases to the environment will be within the limits established by the regulations and that the spent fuel cladding and fuel assemblies will be sufficiently protected during storage against degradation that otherwise might lead to gross ruptures. The objective includes review of changes to the confinement design characteristics and confinement analyses for the HI-STORM 100U Cask System, proposed by this amendment request. None of the seven proposed changes were found to have a direct impact on the confinement design of the HI STORM 100 cask system.

The objective of review of the operating procedures is to ensure that the applicant's FSAR presents acceptable operating sequences, guidance, and generic procedures for key operations. The staff reviewed the proposed changes to ensure the changes in the operating procedures meet the following regulatory requirements: 10 CFR 72.104(b), 72.122(l), 72.212 (b)(9), 72.234(f), and 72.236(h) and (l). LAR 1014-4 was also reviewed to determine whether the cask system fulfills the acceptance criteria listed in Section 8 of NUREG-1536. Proposed changes 1, 4, and 7 that affect the operating procedures for the HI-STORM 100 Cask System were reviewed to the above criteria.

The objective of review of the radiation protection program is to ensure that the capability of the current and revised radiation protection design features, design criteria, and the operating procedures, as appropriate, of the HI-STORM 100 Cask System, can meet regulatory dose requirements for the proposed changes. The regulatory requirements for providing adequate radiation protection to site licensee personnel and members of the public include 10 CFR Part 20, 10 CFR 72.104(a), 72.106(b), 72.212(b), and 72.236(d).

Calculated occupational exposures from the HI-STORM 100 system are based on the direct radiation dose rates calculated in Chapter 5 of the FSAR and the operating procedures discussed in Chapter 8 of the FSAR. Calculated doses to individuals beyond the controlled area boundary (members of the public) are determined from the direct radiation (including skyshine) dose rates calculated in Chapter 5 of the FSAR. Proposed changes 5 and 6 were reviewed to the above criteria.

The objective of the accident analysis review is to evaluate the applicant's identification and analysis of hazards, as well as the summary analysis of system responses to both off-normal and accident or design-basis events. This ensures that the applicant has conducted thorough accident analyses, as reflected by the following factors:

1) Identified all credible accidents
2) Provided complete information in the FSAR
3) Analyzed the safety performance of the cask system in each review area
4) Fulfilled all applicable regulatory requirements

The proposed modifications to the applicant's description and conclusions regarding the cause of an event, detection of an event, summary of event consequences and regulatory compliance, and corrective course(s) of action were reviewed. The regulatory requirements applicable to accident analysis changes proposed by this amendment include 10 CFR 72.104(a), 10 CFR

72.106(b), 10 CFR 72.122(b)(2), (3), (d), (g), (h)(4), (I), and (I), 10 CFR 72.124(a), 10 CFR 72.236(c), (d), and (I), and 10 CFR 72.212(b). LAR 1014-4 was also reviewed to determine whether the modifications to the HI-STORM 100 Cask System fulfills the acceptance criteria listed in Section 11 of NUREG. Proposed changes 3, 5 , and 6 were reviewed to the above criteria.

The objective of the review of the TS is to assess the proposed modifications to CoC 1014 “Conditions” and Appendix A to the CoC (Technical Specifications) and determine if the changes are appropriate to accommodate the design modifications requested by the amendment. This review focused on evaluating whether the Conditions and TS had been revised to ensure that all safety limits and regulations were met. The proposed changes to the CoC and TS for the HI-STORM 100 Cask System were reviewed to the above criteria.

II. GENERAL DESCRIPTION OF THE CASK DESIGN

The HI-STORM 100 Cask System is a dry cask storage system for spent light water reactor fuel. The system comprises three discrete components: the multi-purpose canister (MPC), the HI-TRAC transfer cask, and the HI-STORM 100 storage overpack.

The MPC is the confinement system for the stored fuel. It is a welded, cylindrical canister with a honeycombed fuel basket, a baseplate, a lid, a closure ring, and the canister shell. It is made entirely of stainless steel. All MPC components that may come into contact with spent fuel pool water or the ambient environment, with the exception of neutron absorber, aluminum seals on vent and drain port caps, and optional aluminum heat conduction elements, are constructed of stainless steel. The canister shell, baseplate, lid, vent and drain port cover plates, and closure ring are the main confinement boundary components. The honeycombed basket, which is equipped with neutron absorbers, provides criticality control. There are eight approved MPC designs; MPC-24, MPC-24E, and MPC-24EF which can contain a maximum of 24 pressurized water reactor (PWR) fuel assemblies; the MPC-32 and MPC-32F which can contain a maximum of 32 PWR fuel assemblies; and the MPC-68, MPC-68F, and MPC-68FF which can contain a maximum of 68 boiling water reactor (BWR) fuel assemblies. Vibration suppressors are considered integral non-fuel hardware consisting of zircaloy or stainless steel tubes.

The HI-TRAC transfer cask (TC) provides shielding and structural protection of the MPC during loading, unloading, and movement of the MPC from the spent fuel pool to the storage overpack. The HI-TRAC was previously reviewed and approved by the staff for the original application. No significant design changes were made to the HI-TRAC as such the staff only reviewed the HI-TRAC with respect to whether it was affected by the proposed changes.

The HI-STORM 100 overpack provides shielding and structural protection of the MPC during storage. The overpack is a heavy-walled, steel and concrete, cylindrical vessel. In addition to the HI-STORM 100 overpack, there are three additional approved variations including the HI-STORM 100S, HI-STORM 100A, and the HI-STORM 100SA, and one proposed variation, the HI-STORM 100U currently under review by the staff (LAR 1014-3). The HI-STORM 100S is a shorter version of the HI-STORM 100. To accommodate the height change, the location of the air ducts and MPC pedestal height was modified. The HI-STORM 100A and 100SA are similar

to the HI-STORM 100 and 100S overpacks except that they have a baseplate that is anchored to the concrete pad at the independent spent fuel storage installation (ISFSI). The HI-STORM 100A and 100SA overpacks may be used to store fuel in high seismic areas. The HI-STORM 100S, 100A, and 100SA overpacks were approved under Amendment 1 to CoC 1014.

The basic sequence of operations for the HI-STORM 100 Cask System is as follows: (1) the transfer cask, with the MPC inside, is lowered into the spent fuel pool and the MPC is loaded with spent nuclear fuel; (2) the transfer cask and loaded MPC are removed from the spent fuel pool and the MPC is drained, dried, welded closed, inspected, and backfilled with an inert gas; (3) the transfer cask is placed on top of the overpack and the MPC is lowered into the overpack; and (4) if necessary the overpack, with the MPC inside, is moved to the storage pad. A loaded HI-TRAC transfer cask can be handled vertically or horizontally. A loaded HI-STORM 100, 100S, 100A, and 100SA, overpack can only be moved vertically. The proposed HI-STORM 100U design can only be loaded in situ. MPC transfer between the transfer cask and overpack can be performed inside or outside a 10 CFR Part 50 controlled structure (e.g., a reactor building).

III. FINDINGS

Each of the seven proposed changes were reviewed to the criteria and regulations described in section II. of this SER and a discussion of the staff review and findings are described for each below.

Proposed Change No. 1

The applicant proposed to modify the HI-STORM 100 Cask System CoC to incorporate minor changes to wording as follows:

- Item 1) Section 1.b, Paragraph 2, Sentence 2 – replace “carbon steel/lead/carbon steel” with “carbon steel and/or lead” and replace “water jacket” with “neutron shield jacket.”
- Item 2) Section 1.b, Paragraph 2, Last sentence – Delete “lead and water.”
- Item 3) Section 1.b, paragraph 3, Sentence 6 – Replace “channels” with “support” and delete “flexible.”
- Item 4) Section 10.k – Delete “cooling fuel assemblies.”

The applicant indicated that the proposed modifications to the CoC are to eliminate potential conflicts and ensure “verbatim compliance” with applicable requirements. The staff, in a RAI No. P1-1 questioned the clarity of the proposed language regarding Item 1 inasmuch that the proposed language could be interpreted to mean that a transfer cask could be made entirely of lead. The applicant revised the proposed modified CoC language to read “a multi-walled (carbon/steel/lead/carbon steel) cylindrical vessel with “a carbon steel or carbon steel and lead cylindrical vessel.”

The staff has determined the inner shell of the overpack for the HI-STORM 100 continues to have supports attached to it that provide a medium to absorb impact loads from the MPC and the revised terminology generalizes the previous terminology, i.e., “support “ in lieu of “channel”

and the deletion of “flexible.”. The staff considers the revised terminology acceptable and reflects a design function of these supports.

Based on the NRC staff's review of information provided in the HI-STORM 100 Cask System LAR 1014-4, as supplemented the staff finds that the LAR 1014-4 sufficiently describes modifications to the HI-STORM 100 Cask System CoC that incorporates minor wording changes as listed above and that the minor wording changes to the HI-STORM 100 Cask System CoC, as listed above, are in compliance with 10 CFR Part 72 and applicable design and acceptance criteria have been satisfied. The evaluation of the minor editorial changes provides reasonable assurance that the HI-STORM 100 Cask System will provide safe storage of spent fuel. These findings are based on a review that considered the regulation itself, the appropriate regulatory guides, the applicant’s analyses, and the staff’s review.

Proposed Change No. 2.

In the November 23, 2005, NRC letter to Holtec, the staff stated that LAR 1014-4 Proposed Change No. 2, “elimination of the helium leak test requirement for the vent and drain port cover plates,” would not constitute an acceptable approach for ensuring the integrity of a storage cask confinement boundary. The NRC recognized that the language of ISG -18, “The Design/Qualification of Final Closure Welds on Austinetic Stainless Steel Canisters as Confinement Boundary for Spent Fuel Storage and Containment Boundary for Spent Fuel transportation,” as written, was unclear and may therefore result in misinterpretation and misapplication. The intent of ISG-18 was to provide relief from the helium leak test requirement for the structural lid to shell weld only. No other welds were intended to be subject to this relief.

As a result of this clarification Holtec informed the NRC at a public meeting on December 15, 2005, that it was the intent of Holtec, as part of the LAR 1014-3 to the HI-STORM 100 Cask System CoC, to continue to implement leakage testing of the vent and drain port cover plates and revise the FSAR to be consistent with the criteria in the TS. Commensurate with these changes Holtec provided revised FSAR pages for LAR 1014-4, consistent with changes made to LAR 1014-3, to reflect the continued implementation of helium leak test requirements for the vent and drain port cover plates.

Proposed Change No. 3

The applicant proposed to eliminate cooling of the MPC cavity prior to reflood with water, as part of cask unloading operations, in the CoC (Appendix A, LCO 3.1.3). The existing helium exit temperature requirement is replaced by a requirement on the MPC cavity pressure.

The applicant stated that verification that the MPC cavity pressure is within allowable limits can be achieved either via analysis or direct measurement. It appears to the staff that direct pressure measurement would constitute the preferred method of verifying cavity pressure because of associated uncertainties related to the analysis method. In a response to an Request for Additional Information (RAI) (Response to RAI on License Amendment Request #4 to HI-STORM 100 CoC, Document ID: 5014595, April 30, 2006) the applicant agrees with the staff that direct measurement is the preferred method. However, the applicant stated that

eliminating the need to monitor a pressure gauge installed near the MPC may reduce personnel doses in accordance with ALARA principles.

The FSAR states that the industry standard practice has historically been to directly reflood the cask with water and that this practice is known not to induce fuel cladding failure. The staff asked the applicant, in RAI P3-3, to provide specific cases where cool-down by directly reflooding the cask with water had occurred and to provide some studies and/or experiments that concluded direct cool-down by water did not result in fuel cladding failure (especially for high burnup fuel). The applicant cited a specific case where direct water reflooding had been used successfully for transportation casks being used to ship fuel assemblies from the Brunswick Steam Electric Plant to the Shearon Harris Nuclear Power Plant. The applicant's statement that "many dry storage casks use a direct reflood of water" was intended to mean that other casks had been licensed by the NRC for such operations. The applicant also provided examples of casks that were licensed by NRC which included cool-down by direct water quenching and pressure monitoring.

Direct MPC cooldown is performed by introducing water through the lid drain line. Steam produced during the quenching process is vented from the MPC cavity though the lid vent port. In order to avoid MPC over pressurization, it is necessary to limit the rate of water addition. The applicant performed steam flow calculations using bounding assumptions (100% steam production and MPC at design pressure). Based on this calculation, the applicant showed that the MPC is adequately protected up to a reflood rate of 3715 lb/hr.

Based on the NRC staff's review of information provided in the HI-STORM 100 Cask System LAR 1014-4, the staff finds that direct MPC cooldown is acceptable provided MPC over pressurization beyond the normal condition design pressure is avoided. By preforming a bounding calculation, the applicant has shown that the MPC is adequately protected up to a reflood rate of 3715 lb/hr. Therefore the staff finds that the thermal design of the HI-STORM 100 Storage System is in compliance with 10 CFR Part 72, and that the applicable design and acceptance criteria have been satisfied. This finding is based on a review that considered the regulation itself, appropriate regulatory guides, applicable codes and standards, and accepted engineering practices.

Proposed Change No. 4

The applicant proposed a modification to LCO 3.3.1 in Appendix A to the CoC to allow linear interpolation between minimum soluble boron concentrations when loading fuel enriched to 4.1 wt.% and 5.0 wt.% in the MPC-32/32F. The current CoC requires that any fuel over 4.1 wt.% enrichment be loaded under the requirements for 5.0 wt.% enriched fuel, which is very conservative and requires large swings in the soluble boron concentration of the fuel pool (e.g., up to an additional 800 ppm ^{10}B concentration).

The licensee proposes that linear interpolation be permitted since the maximum multiplication factor is a near linear function of both enrichment and soluble boron concentration. In fact, the licensee states that this function demonstrates a saturation effect in which the reduction in reactivity for the same increase in the soluble boron concentration is reduced for higher soluble

boron concentrations and that a linear interpolation would result in a slight overestimation of the minimum soluble boron concentration for the analyzed enrichments and is conservative.

Staff reviewed the proposed justification provided by the licensee and agrees with the logic of using linear interpolation to determine the soluble boron concentration required for loading fuel enriched to greater than 4.1 wt.% ^{235}U. The applicant provided sufficient analyses that demonstrate that this approach results in the maximum k_{eff} values for the proposed enrichments that are lower than those that had been previously calculated in Tables 6.1.5, 6.1.6, and 6.1.12.

Based on the NRC staff's review of information provided in the HI-STORM 100 Cask System LAR 1014-4, as supplemented, the staff finds that linear interpolation of the soluble boron concentrations when loading fuel enriched to 4.1 wt.% and 5.0 wt.% in the MPC-32/32F continues to provide reasonable assurance of maintaining subcriticality under 10 CFR Part 72. This finding is based on a review that considered the regulation itself, appropriate regulatory guides, applicable codes and standards, and accepted engineering practices.

Proposed Change No. 5

The applicant proposed to modify the definition of fuel debris in Section 1.0 in Appendix B to the CoC to permit containers or structures that provide support to loose fuel assembly parts (i.e., loose rods, guide tubes, end fittings, fuel pellets, etc.) and non-fuel hardware to be stored as fuel debris in damaged fuel containers (DFC's).

The applicant believes that the current definition of fuel debris is too narrow to permit storage of loose fuel assembly parts (i.e., loose rods, guide tubes, end fittings, fuel pellets, etc.) and non-fuel hardware that are stored in baskets while in the spent fuel pool. Currently these types of debris are required to be transferred from the basket and stored in damaged fuel containers (DFCs) prior to loading into the cask and feel that the extra handling required increases the potential for further damage to these items or even dispersal of these items into the spent fuel pool or cask. Also, the current definition does not allow storage of non-fuel hardware that is not part of a fuel assembly and since the form of these items may not be self-supporting when placed in a cask, the licensee would like to place them into DFCs as well.

Staff reviewed the justification provided by the licensee that would allow these changes and agrees with their conclusion that allowing the baskets or other supporting structures that fuel debris is stored in while in the spent fuel pool does not impact the amount of fissionable or active material that would be allowed in any single fuel storage location. DFCs are weight limited, and any fissile material that could be potentially stored in these locations would be reduced by the weight of the supporting structures and would be bounded by the current analysis. In addition, by allowing non-fuel hardware to be stored in DFCs the licensee is reducing the number of stored fuel assemblies that may be stored in each cask since only a single item may be placed in each DFC, and as such is bounded by the current criticality analysis. NRC staff concludes that this proposed change is acceptable.

The applicant revised the definition of fuel debris to permit the inclusion of containers or structures that provide support to loose fuel parts. The staff finds that the allowance of these

support structures does not alter the amount of fissionable or activated material that can be stored in the cask system, therefore the shielding analysis is not affected by this change and the shielding analysis remains bounding. This finding is based on a review that considered the regulation itself, appropriate regulatory guides, applicable codes and standards, and accepted engineering practices.

Proposed Change No. 6

The applicant proposed to modify the definition of fuel debris in Section 1.0 in Appendix B to the CoC to include primary and secondary neutron sources (neutron source assemblies). Tables 2.1-1 and 2.1-8 in Appendix B of the CoC will be modified to permit storage of neutron source assemblies in the MPC-24, MPC-24E/EF and MPC-32.32F.

The addition of certain non-fuel hardware (neutron source assemblies) to the approved list of items to be stored could introduce a new material type to the cask environment. As a result the staff performed an assessment of potential chemical or galvanic reactions to determine compliance with 10 CFR 72.120(d). The neutron sources being added to the approved contents are similar in design to BPRAs with the poison material replaced by source material. The source material is typically clad in stainless steel and contained within stainless steel rods. The following source materials have been used: antimony-beryllium, americium-beryllium, plutonium-beryllium, polonium-beryllium, and californium. These materials do not pose a significant threat of galvanic or chemical reaction through interaction with the MPC cavity materials or environment during wet loading operations or long-term dry storage operation, as described below.

If damaged neutron source assemblies were to expose the poison material inside to the MPC internal environment, no chemical interaction would be expected unless internal temperatures were high enough to result in the melting of the material. All of these materials are designed for service in fuel assemblies during reactor operations, where temperatures are in the same range as those experienced by the hardware in storage. Therefore, no melting of the material and no adverse chemical reactions is expected. Galvanic corrosion requires the presence of a electrically conductive medium between the dissimilar elements that would not exist during storage in the MPC (helium filled). Any possible galvanic interaction could only occur during the short time period when the cask is flooded during loading operations (up to approximately 4 days). This time frame is sufficiently short to render any reaction as insignificant. Thereafter, the system is dry and filled with an inert gas (helium) and galvanic interaction cannot occur.

The applicant provided additional justification concerning the suitability of these components for storage within the HI-STORM 100 Cask System. The staff determined that the storage of these components is justified because the shielding source term of these components are bounded by previously approved non-fuel hardware. This is based on the restriction to one such component per MPC, and that this component be placed in the inner region as specified Section 2.1.9.

The staff reviewed the design criteria and finds it acceptable based on the requirements of 10 CFR Part 20 and 10 CFR Part 72. The shielding and source term design criteria defined in the FSAR provides reasonable assurance that the HI-STORM 100 Cask System can meet the radiological requirements of 10 CFR Part 20 and 10 CFR Part 72. Each user will be required to

protect personnel from the increased dose rates in accordance with ALARA principles and the regulations of 10 CFR Part 20. Additionally, the staff finds that addition of neutron source assemblies in the allowable contents does not add any material that would create a concern from a chemical or galvanic reaction perspective and that the requirement of 10 CFR 72.120(d) is met.

Based on the NRC staff's review of information provided in the HI-STORM 100 Cask System amendment request, the staff finds that the FSAR amendment sufficiently describes shielding design features and design criteria for the structures, systems, and components important to safety and that the radiation shielding features of the HI-STORM 100 Cask System are sufficient to meet the radiation protection requirements of 10 CFR Part 20, 10 CFR 72.104, and 10 CFR 72.106. Additionally, the staff concludes that the design of the HI-STORM 100 Cask System can be operated in compliance with 10 CFR Part 72 and the applicable design and acceptance criteria have been satisfied. The evaluation provides reasonable assurance that the HI-STORM 100 Cask System will provide safe storage of spent fuel. These findings are based on a review that considered the regulation itself, the appropriate regulatory guides, applicable codes and standards, the applicant's analyses, the staff's confirmatory analyses, and acceptable engineering practices.

Proposed Change No. 7

The applicant proposed to modify table 2.1-2 in Appendix B to the CoC to permit the storage of PWR fuel assemblies with annular fuel pellets in the top and bottom 12 inches of active fuel length. Current users of the HI-STORM 100 cask utilize these types of assemblies and are not able to load them under the current CoC.

The staff reviewed the proposed justification provided in FSAR Section 6.4.12, as supplemented, and found that the addition of annular fuel pellets in the top and bottom 12 inches of active fuel length has such a minor effect on reactivity that their addition does not affect the ability of the HI-STORM 100 Cask System to maintain the fuel in a sub-critical configuration.

Based on the NRC staff's review of information provided in the HI-STORM 100 Cask System LAR 1014-4, as supplemented the staff finds that the change to the CoC to permit the storage of PWR fuel assemblies with annular fuel pellets in the top and bottom 12 inches of active fuel length meets the requirements of 10 CFR Part 72. This finding is based on a review that considered the regulation itself, appropriate regulatory guides, applicable codes and standards, and accepted engineering practices.

Proposed Change: Definition of Damaged Fuel

The applicant proposed to modify the definition of damaged fuel. Specifically, the proposed definition is:

> Damaged fuel assemblies are fuel assemblies with known or suspected cladding defects, as determined by a review of records, greater than pinhole leaks or hairline cracks, empty fuel rod locations that are not filled with dummy rods, assemblies whose structural integrity has been impaired such that geometric rearrangements of fuel or gross failure of

the cladding is expected, or those that cannot be handled by normal means. Fuel assemblies that cannot be handled by normal means due to fuel cladding damage are considered fuel debris.

The current accepted definition of damaged fuel is based primarily upon a listing of fixed characteristics (e.g. flaw types) that, if present, would cause a fuel assembly to be characterized as "damaged." This approach has some shortcomings. The staff is proposing to resolve the problems inherent with this traditional, characteristic based, definition of damaged fuel by adopting a performance based definition. A performance based definition depends upon the design characteristics of the spent fuel storage cask and/or transportation systems and the regulatory requirements for fuel performance which are unique to the separate storage and transportation regimes. With this approach, the designer identifies the requirements that the fuel must meet, both from the 10 CFR Part 72 regulations, and by the unique design characteristics of the specific storage or transport cask.

Considering the above, the staff finds that the proposed definition of damaged fuel is adequate and satisfies the requirements of 10 CFR Part 72.124(a) and ensures that the requirements of 72.122(h)(1) and 72.122(h)(5) can be satisfied by a general licensee. This finding is based on a review that considered the regulation itself, appropriate regulatory guides, applicable codes and standards, and accepted engineering practices.

Proposed Change: Control of Water Level During Cask Loading/Unloading Operations

The applicant was asked to verify that, during loading operations, when the water level in the loaded cask is lowered in preparation for lid welding, that either of these conditions occur; 1) the water level reduction is restricted so as to avoid uncovering any portion of the fuel cladding, or, 2) an inert gas is used to displace the water. Also the applicant was asked to verify that similar controls exist during cask unloading.

The intent is to ensure that no fuel is in contact with air when it is at an elevated temperature (above the boiling point of water). This ensures that no deleterious oxidation of the fuel pellets can occur. Note that the fuel cladding need not be classified as damaged for this situation to occur. The definition of undamaged fuel still permits pinhole leaks and hairline cracks, which may allow oxidation of the fuel pellets and consequent splitting of the cladding.

The applicant confirmed that procedural and mechanical barriers have been in place during loading and unloading of Holtec MPCs from the very beginning of their dry storage program to prevent exposure of fuel to air. The water lowering process during loading is currently controlled by using a fixed length dip tube to draw water from the MPC and limit the minimum water level that can be achieved (which has proved to be a reliable barrier against inadvertent lowering of water level below the top of the fuel). Final water removal is accomplished by blowing down the water in a welded canister using inert gas. During unloading, the MPC is initially filled with helium which is then replaced by water.

The applicant proposed to add the following text to Section 3.4 of Appendix B to the Certificate of Compliance:

"10. Users shall establish procedural and/or mechanical barriers to ensure that during LOADING OPERATIONS and UNLOADING OPERATIONS, either the fuel cladding is covered by water, or the MPC is filled with an inert gas."

The staff finds that the existing and proposed controls to avoid the introduction of air to the spent fuel canister interior are acceptable and provides reasonable assurance that oxidation of fuel pellets is prevented. This finding is based on a review that considered the regulation itself, appropriate regulatory guides, applicable codes and standards, and accepted engineering practices.

IV. CONCLUSIONS

The staff has reviewed the proposed changes to the Final Safety Analysis Report (FSAR) for the HI-STORM 100 Cask System. Based on the statements and representations contained in the FSAR as amended, and the conditions given in the CoC as amended, the staff concludes that the HI-STORM 100 Cask System meets the requirements of 10 CFR Part 72.

The staff determined that, unless otherwise noted in this SER, all analytical methods used by the applicant, that provide the basis for design modifications and the addition to the list of approved cask contents for the HI-STORM 100 Cask System proposed in LAR 1014-4, are acceptable. However, for the purposes of the LAR 1014-4 review, the staff did not revisit any previously approved methodologies used in the original HI-STORM 100 Cask System application or those reviewed for LAR 1014-1 or LAR 1014-2 and did not make any new determination on the adequacy of those methodologies, unless the methodology was used as the basis for a proposed LAR 1014-4 change.

Issued with Certificate of Compliance No. 1014,
on _________________