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WASHINGTON, D.C. 20555-0001

Final Safety Evaluation Report

Docket No. 72-1008
Holtec International
HI-STAR 100 Cask System
Certificate of Compliance No. 1008
Amendment No. 3

SUMMARY

By letter dated September 25, 2015 (Agencywide Document Access and Management System [ADAMS] Accession No. ML15280A178), as supplemented by letters dated January 15, and April 29, 2016, December 15, 2017, July 2, 2018 and February 6, 2019 (ADAMS Accession Nos. ML16041A041, ML16133A518, ML17360A162, ML18183A447, and ML19037A152, respectively), Holtec International (Holtec) submitted an amendment request to the U.S. Nuclear Regulatory Commission (NRC) for the HI-STAR 100 Certificate of Compliance (CoC) No. 1008. The proposed changes include the following:

1. Inclusion of multipurpose canister (MPC)-32 for storage of pressurized-water reactor (PWR) spent fuel in the Holtec International Storage, Transport and Repository (HI-STAR) 100 storage system.
2. Inclusion of the Metamic neutron absorber for MPC-32, MPC-24 and MPC-68.
3. Revise the confinement boundary criterion to be leaktight in accordance with Interim Staff Guidance (ISG) -18, Revision 1, “The Design and Testing of Lid Welds on Austenitic Stainless Steel Canisters as the Confinement Boundary for Spent Fuel Storage” (ADAMS Accession No. ML081220694).
4. Credit the soluble boron in criticality analyses for both the MPC-32 and MPC-24.
5. Designate the pocket trunnions as optional in the HI-STAR 100 design.
6. Incorporate standard system features and ancillaries such as the forced helium dehydration (FHD).
7. Allow for horizontal storage of the casks.
8. Update the permissible fuel cladding temperature limits under normal, accident, and short term operating conditions to be consistent with ISG-11, Revision 3, “Cladding Considerations for the Transportation and Storage of Spent Fuel” (ADAMS Accession No. ML033230244).”
9. Designate the cask transporter as single-failure-proof.
10. Include a summary of the quality assurance program from the HI-STORM UMAX SAR (Docket No. 72-1040) as it is applied to safety significant activities for the HI-STAR 100.
11. Provide updated drawings.
12. Revise the MPC design pressure for accident condition to be 200 psig.

Based on the changes listed above, and other proposed changes, Holtec requested the following changes to the technical specifications (TS), Appendix A:

1. Revise the TABLE OF CONTENTS page to reflect the addition of Section 2.3, "SFSC Criticality Control," deletion of Sections 3.1, "Training Program," 3.2, "Pre-Operational Testing and Training Exercise," and 3.3, "Special Requirements For First Systems In Place," and the changes to the page numbers.
2. Change the following definitions:
   a. Revise definition for DAMAGED FUEL ASSEMBLY under TS 1.1 from "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, missing fuel rods that are not replaced with dummy fuel rods, or those that cannot be handled by normal means. Fuel assemblies which cannot be handled by normal means due to fuel cladding damage are considered FUEL DEBRIS" to read "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 fuel rods, missing structural components such as grid spacers, whose structural integrity has been impaired such that geometric rearrangement of fuel or gross failure of the cladding is expected based on engineering evaluations, or that cannot be handled by normal means. Fuel assemblies which cannot be handled by normal means due to fuel cladding damage are considered FUEL DEBRIS."
   b. Revise definition for DAMAGED FUEL CONTAINER (DFC) under TS 1.1 from "DFCs are specially designed enclosures for DAMAGED FUEL ASSEMBLIES or FUEL DEBRIS which permit gaseous and liquid media to escape while minimizing dispersal of gross particulates. The DFCs authorized for use in the HI-STAR 100 design are shown in Figures 2.1.1 and 2.1.2 of the Final Safety Analysis Report (SAR) for the HI-STAR 100 Cask System," to "DFCs are specially designed enclosures for DAMAGED FUEL ASSEMBLIES or FUEL DEBRIS which permit gaseous and liquid media to escape while minimizing dispersal of gross particulates."
   c. Add a new definition "ZR" under TS 1.1 as "ZR means any zirconium-based fuel cladding or fuel channel material authorized for use in a commercial nuclear power plant reactor."
3. Make the following changes to TS 2.1.1 for incorporation of FHD, as discussed in Change Nos. 3 and 6, above:
   a. Revise CONDITION A of limiting condition for operation (LCO) 2.1.1 from "MPC cavity vacuum drying pressure limit not met" to "MPC cavity vacuum drying pressure or demoisturizer exit gas temperature limit not met."
   b. Revise TS surveillance requirement (SR) 2.1.1.1 from "Verify MPC cavity vacuum drying pressure is within the limit specified in Table 2-1 for the applicable MPC model" to "Verify MPC cavity has been dried in accordance with the applicable limits in Table 2-1 for the applicable MPC model."
   c. Revise TS SR 2.1.1.3 from "Verify that the total helium leak rate through the MPC lid confinement weld and the drain and vent port confinement welds is within the limit specified in Table 2-1 for the applicable MPC model" to "Verify that the helium leak rate through the MPC vent and drain port cover plates (confinement welds and the base metal) meets the leaktight criteria of [American National Standards Institute] ANSI N14.5-1997." The corresponding FREQUENCY was revised from "During LOADING OPERATIONS" to "Once, prior to TRANSPORT OPERATIONS."

4. Under Table 2-1, “MPC Model-Dependent Limits,” make the following changes for incorporation of FHD and horizontal storage orientation, as discussed in Change Nos. 6 and 7, above:
   a. Revise item 1.a. for MPC Model MPC-24 from “MPC Cavity Vacuum Drying Pressure” to “MPC Cavity Vacuum Drying Pressure OR FHD gas temperature,” and add the LIMITS value for FHD gas temperature as ≤ 21 °F [fahrenheit] for ≥30 min.[minutes].
   b. Revise item 1.c., “MPC Helium Backfill Pressure[1],” LIMITS from “≤22.2 psig [pounds per square inch gauge]” to “≤ 22.2 psig (Vertically-Oriented System) and 40.8 psig +/-2 psi [pounds per square inch] (Horizontally-Oriented System).”
   c. Delete item 1.e. (MPC Helium Leak Rate for MPC-24).
   d. Revise item 2.a. for MPC Model MPC-68 from “MPC Cavity Vacuum Drying Pressure” to “MPC Cavity Vacuum Drying Pressure OR FHD gas temperature,” and add the LIMITS value for FHD gas temperature as ≤ 21 °F for ≥30 min.
   e. Revise item 2.c, “MPC Helium Backfill Pressure[1],” LIMITS from “≤28.5 psig” to “≤28.5 psig (Vertically-Oriented System) and 40.8 psig +/-2 psi (Horizontally-Oriented System).”
   f. Delete item 2.e. (MPC Helium Leak Rate for MPC-68).
   g. Revise item 3.a. for MPC Model MPC-68F from “MPC Cavity Vacuum Drying Pressure” to “MPC Cavity Vacuum Drying Pressure OR FHD gas temperature,” and the LIMITS value for FHD gas temperature was added as ≤21 °F for ≥30 min.
   h. Revise item 3.c, “MPC Helium Backfill Pressure[1],” LIMITS from “≤28.5 psig” to “≤28.5 psig (Vertically-Oriented System) and 40.8 psig +/-2 psi (Horizontally-Oriented System).”
   i. Delete item 3.e. (MPC Helium Leak Rate for MPC-68F).
   j. Add item 4., for MPC Model MPC-32.
   k. Revise Footnote 1 from “Helium used for backfill of MPC shall have a purity of ≥99.995%” to “Helium used for backfill of MPC shall have a purity of ≥99.995%. The backfill pressure for horizontally-oriented systems is a reference pressure at a reference temperature of 70 °F, and the backfill procedure shall compensate for actual conditions.”
5. Incorporate change 9 above, by revising TS LCO 2.1.3 b from “The OVERPACK is lifted with lifting devices designed in accordance with ANSI N14.6 and having redundant drop prevention design features.” to “The OVERPACK is lifted with lifting devices designed to be single failure proof in accordance with NUREG-0612, “Control of Heavy Loads at Nuclear Power Plants: Resolution of Generic Technical Activity A-36” and having redundant drop prevention design features.”
6. Make the following changes to TS 2.1.4:
   a. Revise TS 2.1.4 title from “Fuel Cool-Down” to “MPC Cavity Reflooding.”
   b. Revise TS LCO 2.1.4 from “The MPC exit gas temperature shall be ≤200 °F” to “The MPC cavity pressure <100 psig.”
   c. Revise APPLICABILITY of TS LCO 2.1.4 from “UNLOADING OPERATIONS prior to flooding” to “UNLOADING OPERATIONS prior to and during re-flooding.”
   d. Revise NOTE under ACTIONS of TS LCO 2.1.4 from “Separate Condition entry is allowed for each SFSC” to “Separate Condition entry is allowed for each MPC.”
   e. Revise CONDITION A of TS LCO 2.1.4 from “MPC exit temperature not within limit” to “MPC cavity pressure not within limit.”
   f. Revise REQUIRED ACTION A.1 of TS LCO 2.1.4 from “Establish MPC helium gas exit temperature within limit” to “Stop re-flooding operations until MPC Cavity pressure is within limit.”

g. Revise COMPLETION TIME for A.1 of TS LCO 2.1.4 from “Prior to initiating MPC re-flooding operations” to “Immediately.”
h. Revise REQUIRED ACTION A.2 of TS LCO 2.1.4 from “Ensure adequate heat transfer from MPC to the environment” to “Ensure MPC vent port is not closed or blocked.”
i. Revise COMPLETION TIME for A.2 of TS LCO 2.1.4 from “24 hours” to “Immediately.”
j. Revise TS SR 2.1.4.1 SURVEILLANCE from “Verify MPC helium gas exit temperature within limit” to “Ensure via analysis or direct measurement that MPC cavity pressure is within limit.”
k. Revise TS SR 2.1.4.1 FREQUENCY from “Prior to initiation of MPC re-flooding operations” to “Prior to initiation of MPC re-flooding operations. AND Once every 1 hour thereafter when using direct measurement.”

7. Make the following changes to TS 2.2.1:
   a. Revise SURVEILLANCE of TS SR 2.2.1.1 from “Verify average surface dose rates of OVERPACK containing fuel assemblies are within limits. OVERPACK dose rates shall be measured at locations shown in Figure 2.2.1-1” to “Verify average surface dose rates of OVERPACK containing fuel assemblies are within limits. OVERPACK dose rates shall be measured at the top and sides of the overpack. A minimum of 12 dose rate measurements shall be taken on the side of the overpack in three sets of four measurements. One measurement set shall be taken approximately at the cask mid-height plane, 90 degrees apart around the circumference of the cask. The second and third measurements shall be taken approximately 60 inches above and below the mid-height plane, respectively, also 90 degrees apart around the circumference of the cask. A minimum of four measurements shall be taken on the top of the overpack. Measurements shall be taken on a 32 inch diameter circle between the center and edge of the lid, 90 degrees apart.”
   b. Revise the first NOTE of TS SR 2.2.1.1 from “SR 2.2.1.1 shall be performed after the MPC has been vacuum dried” to “SR 2.2.1.1 shall be performed after the MPC has been dried.”
   c. Delete Figure 2.2.1-1, “OVERPACK Surface Rate Measurement Locations” and provide description of the location for the dose rate measurements in SR 2.2.1.1.
8. Incorporate change 4, above by adding TS 2.3, “SFSC CRITICALITY CONTROL,” addressing the boron concentration limits.
9. Delete TS 3.1, TS 3.2, and TS 3.3. Technical Specifications 3.2 and 3.3 were moved to the certificate of compliance.

The Holtec staff requested the following changes to Appendix B of CoC No. 1008, “Approved Contents and Design Features for the HI-STAR 100 Cask System:”

1. Delete the duplicative definitions and add a reference to Appendix A for definitions in Section 1.0.
2. Delete TS 1.1.2, “Preferential Fuel Loading,” and incorporate preferential loading condition for Thoria rod canisters in Table 1.1-1.
3. Delete a sentence in TS 1.2, “Functional and Operating Limits Violations,” associated with the reporting requirements contained in Title 10 of the *Code of Federal Regulations* (10 CFR) Part 72, Section 72.75.
4. Add a reference to Section II of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel (B&PV) Code in Section 1.3.2.
5. Incorporate horizontal storage in change 7 above, by adding inequality equation as item 4, and renumber the rest of the items in Table 1-4.

6. Incorporate METAMIC neutron absorber in change 2 above by adding the METAMIC minimum ^{10}B loading in the Boral neutron absorbers in Subsection 1.5.1.1 for MPC-24, and in Subsection 1.5.1.2 for MPC-68.
7. Incorporate changes 1 and 2 for MPC-32 and METAMIC neutron absorber, above, by adding new Subsection 1.5.1.3 for MPC-32 providing information for minimum fuel cell pitch and minimum ^{10}B loading in the Boral and Metamic neutron absorbers.
8. Make the following changes to Table 1.1-1
    a. Revise Table 1.1-1, "Fuel Assembly Limits," item II. A. 1. d. i. to include fuel assembly array/class 6x6B and 7x7A decay heat for Zr clad for MPC Model MPC-68 allowable contents.
    b. Revise Table 1.1-1, item II. A. 1. e. i. to include fuel assembly array/class 6x6B and 7x7A post-irradiation cooling time and an average burnup per assembly for Zr clad for MPC Model MPC-68 allowable contents.
    c. Revise Table 1.1-1, item II.B from "Quantity per MPC: Up to one (1) Dresden Unit 1 Thoria Rod Canister plus any combination of DAMAGED FUEL ASSEMBLIES in DAMAGED FUEL CONTAINERS and INTACT FUEL ASSEMBLIES, up to a total of 68" to "Quantity per MPC: Up to one (1) Dresden Unit 1 Thoria Rod Canister loaded toward the basket periphery (i.e., away from the hot central core of the fuel basket) plus any combination of DAMAGED FUEL ASSEMBLIES in DFCs and INTACT FUEL ASSEMBLIES, up to a total of 68".
    d. Revise Table 1.1-1, item II. A. 2. to include fuel assembly array/class 6x6B for [Boiling Water Reactor] BWR DAMAGED FUEL ASSEMBLIES as authorized contents in the MPC-68 contents.
    e. Revise item III.B.5 from "Up to one (1) Dresden Unit 1 Thoria Rod Canister" to "Up to one (1) Dresden Unit 1 Thoria Rod Canister loaded toward the basket periphery (i.e., away from the hot central core of the fuel basket)."
    f. Add Table 1.1-1, item IV. A. for MPC-32 allowable contents.
9. Revise Table 1.1-2, "PWR Fuel Assembly Characteristics.".
10. Revise Table 1.1-4 to include the MPC-32.
11. Incorporate change 1 for MPC-32, above, by revising Table 1.1-5, "Fuel Assembly Cooling and Average Burnup," to include the MPC-32.
12. Revise Table 1.3-1, "List of ASME Code Exceptions for the HI-STAR 100 Cask System," to include additional components.

This revised CoC, when codified through rulemaking, will be denoted as Amendment No. 3 to CoC No. 1008.

This safety evaluation report (SER) documents the review and evaluation of the proposed amendment. The staff followed the guidance of NUREG-1536, Revision 1, "Standard Review Plan for Spent Fuel Dry Storage Systems at a General License Facility" (ADAMS Accession No. ML101040620), ISG-11, and ISG-18 during its review.

The staff's evaluation is based on a review of Holtec's application and supplemental information, and whether it meets the applicable requirements of 10 CFR Part 72 for independent storage of spent fuel. The staff's evaluation focused only on modifications requested in the amendment as supported by the revised SAR and did not reassess previously approved portions of the FSAR or CoCs through Amendment No. 2.

The NRC staff also reviewed editorial changes requested by the applicant and found them to be acceptable.

1.0 GENERAL DESCRIPTION

The objective of this chapter is to review the requested design changes made to CoC No. 1008, Amendment No. 3 to ensure that Holtec has provided a description that is adequate to familiarize reviewers and other interested parties with the pertinent features of the system, including the requested changes. The specific changes are described and evaluated in later sections of this SER.

1.1 Findings

F1.1 The staff concludes that the information presented in the proposed FSAR pages satisfies the requirements for the general description under 10 CFR Part 72. This finding is reached on the basis of a review that considered the regulation itself, Regulatory Guide (RG) 3.61, "Standard Format and Content for a Topical Safety Analysis Report for a Spent Fuel Dry Storage Cask" (ADAMS Accession No. ML003739511), and accepted practices. The staff concludes that the applicant's information is sufficiently detailed to allow reviewers to familiarize themselves with the pertinent features of the system and the changes requested.

2.0 PRINCIPAL DESIGN CRITERIA

The applicant proposed changes to the principal design criteria in Chapter 2 of the SAR and corresponding changes to the CoC, as applicable. These changes are described in detail in the application, as supplemented. The Holtec staff revised the principal design criteria for the HI-STAR 100 to:

- be consistent with the principal design criteria for other Holtec storage systems, except for the maximum decay since that is directly tied to the HI-STAR 100 overpack heat transfer capability;
- add design criteria for the MPC-32, including its contents;
- add design criteria for metamic neutron poison; and
- add changes for the soluble boron concentrations.

These changes are supported by the analyses in the following chapters. Based on the information provided below, the staff has reviewed these changes and finds them acceptable. These changes have no adverse impact on the design and operation of the cask and will not affect the ability of the cask to meet the requirements of 10 CFR Part 72.

The staff concludes that the revisions to the principal design criteria for the HI-STAR 100 are acceptable based on a review that considered the applicable regulations, regulatory guides, codes and standards, and accepted engineering practices. A description of the staff evaluation of the design criteria and an assessment of compliance with those criteria are presented in Chapters 3 through 14 of this SER.

3.0 STRUCTURAL EVALUATION

3.1 Background

In this amendment, the applicant proposed four changes related to the structural design of the storage system:

- Include the MPC-32 for storage of PWR spent fuel into the HI-STAR 100 storage system;
- Make the pocket trunnions optional in the HI-STAR 100 design;
- Allow horizontal storage of the casks; and
- Include the structural requirements to designate a cask transporter as single failure-proof.

3.2 Evaluation

3.2.1 Include the MPC-32 for PWR Spent Fuel Storage into the HI-STAR 100 Storage System

3.2.1.1 Structural Design and Design Criteria

The applicant stated that similar MPC structures (i.e., MPC-24 and MPC-68) were previously reviewed and approved by the NRC for the HI-STAR 100 Cask System. The staff reviewed the applicant's submittals and the previous SERs issued for HI-STAR 100 (Amendment No. 0 SER ADAMS Accession No. ML070260547, Amendment No. 1 SER ADAMS Accession No. ML003780760, and Amendment No. 2 SER ADAMS Accession No. ML011500507) and HI-STORM 100 (Amendment No. 1 SER ADAMS Accession No. ML011500507) to determine whether the MPC-32 can be included into the HI-STAR 100 storage system. From the review, the staff determines that the MPC-32 structural design is very similar to the previously approved MPC-24 and MPC-68. The structural dimensions of all three MPCs (MPC-24, MPC-32 and MPC-68) are almost identical. The weight of MPC-32 and the weights of MPC-24 and MPC-68 are enveloped by the maximum design weight of 90,000 lbs. The center of gravity location of the MPC-32 is almost same as those for MPC-24 and MPC-68.

The staff also determines that the structural design criteria for all three MPCs (MPC-24, MPC-32 and MPC-68) under normal, off-normal, accident, and natural phenomena events are identical and are based on the ASME B&PV Code, Section III for which the NRC approves its use for spent fuel storage systems.

3.2.1.2 Normal Operating and Off-Normal Conditions

All three MPCs (MPC-24, MPC-32 and MPC-68) were structurally evaluated for the handling operations under normal operating conditions. A normal handling operation is a vertical lift of a fully-loaded MPC by the lifting bolts installed in threaded holes in the MPC top lid. The strength requirements of the lifting bolts and the embedment length were evaluated using NUREG-0612 with a safety factor of 6 for material yield strength and 10 for the ultimate strength. From the review, the staff finds that the calculated stresses under the normal operating condition are less than 1/6 of the yield stress and 1/10 of the ultimate stress and meet the minimum factor safety of 1.0 consistent with NUREG-0612. It is noted that a separate evaluation for the MPCs under the off-normal condition was not needed because this cask only has off-normal conditions, as defined by NUREG-1536, Rev. 1, related to the thermal evaluation. Therefore, off-normal conditions structural loads are identical to the normal condition.

3.2.1.3 Accident Conditions

All three MPCs (MPC-24, MPC-32 and MPC-68) were structurally evaluated for accident conditions. Each MPC (fuel basket and enclosure vessel) was evaluated by using a finite element (FE) method for structural analyses. An FE model of each MPC model was used to

assess the effects of the accident loads. Table 3.4.1 of the SAR presented the results of the FE analyses of each of the three MPC models. The NRC previously reviewed and approved the FE structural analyses for the MPC-24 and MPC-68, (ADAMS Accession No. ML070260547).

The FE models were 1-inch thick cross sections of the relevant MPC. They were two-dimensional structural models that included the fuel basket, the basket support structures, and the enclosure shell. The analysis considered two impact orientations (one 0-degree and one 45-degree) of the fuel basket for the accident side drop. The design-basis deceleration of 60g was used to perform a quasi-static structural analysis using the ANSYS computer code. The weights of the fuel assemblies were applied to the basket fuel cell as a uniformly distributed pressure load. The weight of fuel assemblies, the basket and the enclosure shell were all amplified by the design-basis deceleration of 60g for the side drop accident.

The resulting stresses were compared with the allowable stresses and the safety factors were computed. The results of the analyses were provided in Tables 3.4.3 through 3.4.19 of the SAR. The staff reviewed the resulting stresses, which came from the FE analyses, and finds that all resulting stresses are bounded by the allowable stresses. In addition, the staff finds that all computed factors of safety are larger than the minimum required factor of safety of 1.0. Therefore, the staff approves the FE structural analysis for the MPC-32 and concludes that all three MPCs (MPC-24, MPC-32 and MPC-68) are safe under the accident condition loads.

3.2.1.4 Conclusion

The staff confirmed that the MPC-32 has almost identical structural dimensions and weight to the dimensions and weights of the MPC-24 and MPC-68. All three MPCs (MPC-24, MPC-32 and MPC-68) were designed based on the same design criteria specified in the ASME B&PV Code, Section III, for which the NRC approved its use for spent fuel storage systems. In addition, the staff reviewed the analysis results and finds that that the calculated stresses and factors of safety for all three MPCs are bounded by the required values in the ASME B&PV Code. Therefore, the staff concludes that the applicant’s proposed inclusion of the MPC-32 in the HI-STAR 100 storage application is acceptable.

3.2.2 Optional Pocket Trunnions in the HI-STAR 100 Design

The applicant proposed an amendment request to make the pocket trunnions optional in the HI-STAR 100 system. The applicant provided a justification of the proposed change with the following statement: “The pocket trunnions are eliminated from the HI-STAR 100 design. Early loading experience indicated the pocket trunnion locations to be a localized dose accretor. The pocket trunnions are already optional under the HI-STAR 100 transportation license.”

The pocket trunnions are part of the lifting devices and are welded to the lower side of the overpack to provide a pivoting axis for rotation. The function of the pocket trunnions is to ensure the proper rotational direction of the overpack during a lifting operation. The NRC previously reviewed the applicant’s analysis of fracture toughness criteria for the pocket trunnions for the HI-STAR 100 transport package (SER for CoC No. 9261, Revision No. 0, ADAMS Accession No. ML023260089) and approved the use of the pocket trunnions as an optional part of the package. The staff determined that the pocket trunnions are consistent with RGs 7.11 and 7.12, “Fracture Toughness Criteria of Base Material for Ferritic Steel Shipping Cask Containment Vessels with a Maximum Wall Thickness of 4 Inches (0.1 m),” and “Fracture Toughness Criteria of Base Material for Ferritic Steel Shipping Cask Containment Vessels with a Wall Thickness Greater than 4 Inches (0.1 m) But Not Exceeding 12 Inches (0.3 m),”

respectively (ADAMS Accession Nos. ML003739413 and ML003739424, respectively). Therefore, the staff finds the proposed use of the same pocket trunnions to be optional in the HI-STAR 100 storage system acceptable because the function of the pocket trunnions, which is to ensure the proper rotation direction of the overpack, is identical in both HI-STAR 100 storage cask and HI-STAR 100 transport package.

3.2.3 Allow Horizontal Storage of the Casks

The applicant proposed to allow the storage casks in the horizontal orientation. The applicant evaluated the HI-STAR 100 in the horizontal orientation for normal, off-normal, and accident conditions.

3.2.3.1 Normal Operating and Off-Normal Conditions

The applicant performed evaluations for the HI-STAR 100 overpack under normal and off-normal conditions. In the evaluations, the applicant considered: (i) temperatures for both storage orientations (horizontal and vertical), (ii) stress calculations for the MPC fuel basket and enclosure in both storage orientations, and (iii) lifting operations for the HI-STAR lifting trunnion, pocket trunnions and the various lid lifting points for both storage orientations. The applicant presented the calculated component temperatures in Tables 3.4.10, 3.4.17, and 3.4.18 of the HI-STAR 100 SAR. The applicant compared the calculated temperatures with the design temperatures listed in Table 2.2.3 of the HI-STAR 100 FSAR and demonstrated that the calculated temperatures are bounded by the design temperatures. Based on the results of the evaluations, the applicant concluded that the structural evaluations that were originally performed for the vertically oriented HI-STAR 100 overpack are bounding for the HI-STAR 100 overpack when stored horizontally under normal and off-normal conditions.

3.2.3.2 Accident Load Conditions

The applicant performed evaluations for the HI-STAR 100 storage cask under accident load conditions. In the evaluations, the applicant evaluated the storage cask loads in the horizontal orientation for the following accident events: (i) tip-over, (ii) handling accident, (iii) flood, (iv) explosion, (v) tornado, (vi) earthquake, and (vii) lightning. Based on the results of the evaluations, the applicant concluded that the storage of the HI-STAR 100 overpack in a horizontal orientation meets structural performance criteria under credible accident conditions.

3.2.3.3 Conclusion

The staff reviewed the applicant’s evaluations in accordance with the guidance in NUREG-1536. The staff confirmed that the applicant applied the same design criteria for the evaluations of the HI-STAR 100 overpack in both horizontal and vertical orientations. The staff also confirmed that the design criteria were consistent with the guidance and criteria specified in the ASME B&PV Code, Section III, for which the NRC approved its use for spent fuel storage systems. In addition, the staff reviewed the analysis results provided in the SAR and RAI responses and finds that that the calculated stresses and factors of safety for the HI-STAR 100 overpack in both horizontal and vertical orientations are bounded by the criteria in the NUREG-1536 and the requirements in the ASME B&PV Code. Therefore, the staff concludes that the applicant’s proposed emplacement of the HI-STAR 100 Storage in a horizontal orientation is acceptable.

3.2.4 Designate Cask Lifting Devices as Single Failure-Proof

The applicant proposed that the cask transporter is single failure-proof in the SAR and to add an optional requirement that cask lifting devices be single failure-proof in TS 2.1.3(b). The applicant justified the request for the proposed inclusion of the single failure-proof structural requirement by noting it was approved in the HI-STORM FW docket (72-1032). The original approval for single failure-proof handling devices was documented in the SER for HI-STORM FW Amendment No. 0, published July 14, 2011 (ADAMS Accession No. ML111950325).

The staff reviewed the SER for the HI-STORM FW Amendment No. 0 and finds that the NRC previously reviewed and approved the structural requirements to designate cask lifting devices as single failure-proof because it is consistent with the guidance of NUREG-0612. The staff finds that the previous finding continues to be valid and, therefore, finds the designation of cask lifting devices as single failure-proof to be acceptable.

3.3 Evaluation Findings

F3.1 The staff finds that the applicant's inclusion of the MPC-32 in the HI-STAR 100 storage application is acceptable because: (i) the MPC-32 has almost identical structural dimensions, weight, and center of gravity to those of the MPC-24 and MPC-68, (ii) all three MPCs (MPC-24, MPC-32 and MPC-68) were designed based on the design criteria specified in the ASME B&PV Code, Section III, for which the NRC approved its use for spent fuel storage systems, and (iii) the applicant demonstrated that the MPC-32 meets the design criteria for its intended structural functions under all credible conditions in the HI-STAR 100 storage system.

F3.2 The staff finds that the change of the pocket trunnions to be optional in the HI-STAR 100 storage system is acceptable because: (i) the staff previously determined that the pocket trunnions were consistent with RGs 7.11 and 7.12 when finding use for the HI-STAR transport package, (ii) this requested change is bounded by the staff's previous review and approval in the HI-STAR 100 transport package, and (iii) the function and loadings of the pocket trunnions is identical in both the HI-STAR 100 Storage and Transportation.

F3.3 The staff finds that the applicant's proposed emplacement of the HI-STAR 100 storage system in a horizontal orientation is acceptable because the analysis results provided in the SAR and RAI responses show that the calculated stresses and factors of safety for the HI-STAR 100 overpack in both horizontal and vertical orientations are bounded by the values of the ASME Code.

F3.4 The staff finds that the applicant's proposed inclusion of the cask transporter as single failure-proof in the SAR and the optional requirement in the TS that cask lifting devices be single failure-proof is acceptable because: (i) the NRC previously reviewed and approved the same designation for HI-STORM FW Amendment No. 0, and (ii) the cask lifting devices are designed consistent with the guidance in NUREG-0612.

The staff reviewed the amendment requests and the proposed changes for the HI-STAR 100 storage system. Based on the statements in the application and representations contained in the proposed SAR changes and the conditions in the CoC, the staff concludes that the HI-STAR 100 Cask System meets the requirements of 10 CFR Part 72.

4.0 THERMAL EVALUATION

The changes in the HI-STAR 100 Amendment No. 3 application that involve thermal consideration include: (i) inclusion of the MPC-32, (ii) use of Metamic neutron absorber for the MPC-24, MPC-32, and MPC-68, (iii) incorporation of the FHD system, (iv) horizontal storage of casks, and (v) change of the fuel cladding temperature limits to be consistent with ISG 11 Rev. 3.

4.1 Inclusion of the MPC-32

The applicant requested to include the MPC-32 in the HI-STAR 100 storage cask, relying on thermal analyses previously provided to the staff in the HI-STAR 100 transportation SAR, Holtec Report HI-951251, Revision 15, Chapter 3, Docket No. 71-9261 (ADAMS Accession No. ML17129A499) for the horizontal orientation. The thermal evaluation of the MPC-32 in the HI-STAR 100 storage cask in the horizontal orientation is discussed in Section 4.4, “Horizontal storage of casks,” of this SER.

The applicant provided thermal analysis results in Table 4.4.12 of the application, “HI-2012610 HI-STAR 100 FSAR Proposed Rev. 4B,” for the MPC-32 in the HI-STAR 100 storage cask in vertical orientation for normal conditions of storage. The applicant provided ANSYS/FLUENT models for the MPC-32 for the fuel basket in-plane thermal conductivity, neutron absorber/sheathing/box wall effective thermal conductivity, and the fuel assembly effective thermal conductivity.

4.1.1 Normal Conditions of Storage

From Table 1.2.2 of the application, the decay heat for the MPC-32 (18.5 kW) is equal to the decay heat for the MPC-68 in the vertical orientation. The maximum normal condition temperatures in the vertical orientation for the MPC-68 and MPC-32 are provided in Tables 4.4.11 and 4.4.12 of the application, respectively. The applicant concluded in Section 4.4.2.1, “Maximum Temperatures Under Normal Storage Conditions,” of the application, that the temperature results for the applicant’s analysis of the MPC-68 bound the applicant’s analysis of the MPC-32 in the vertical orientation, based on comparing the maximum fuel cladding and the bounding confinement boundary component temperature (that of the MPC Shell), shown in Table 4.4.11 for the MPC-68, to the temperatures in Table 4.4.12 for the MPC-32 of the application. The staff noted that in Table 4.4.12 the overpack bottom plate maximum temperature is higher for the MPC-32 compared to the MPC-68, and therefore the staff concludes the applicant’s analysis results for the MPC-68 do not necessarily bound the applicant’s analysis results for the MPC-32. However, the calculated maximum temperature for the MPC-32 overpack bottom plate is below the normal conditions allowable temperature limit in Table 4.4.12 of the application. Therefore, the staff concludes the temperature results from the applicant’s analysis provided in Tables 4.4.11 and 4.4.12 of the application are below the normal condition design temperature limits in Tables 4.4.11 and 4.4.12, respectively, of the application, and therefore are acceptable.

4.1.2 Off-Normal and Accident Conditions

The applicant performed an analysis, described below, for off-normal and accident conditions, based on the applicant’s assumption that MPC-24 temperatures bound those of the MPC-32 for normal conditions of storage in the HI-STAR 100 storage cask. The staff compared the temperature results provided by the applicant for the MPC-32 in the vertical orientation from

Table 4.4.12 of the application to the temperatures provided for the MPC-24 in vertical orientation, at the same decay heat, from Table 4.4.18 of the HI-STAR 100 storage FSAR, Holtec Report HI-2012610, Revision 3, Docket No. 72-1008 (ADAMS Accession No. ML13297A198). The staff's comparison demonstrated that the MPC-32 temperature results provided by the applicant are higher than the temperature results reported for the MPC-24. For example, the maximum fuel cladding temperature reported is 697 °F for the MPC-24, and 710 °F for the MPC-32.

To determine the maximum temperatures for off-normal conditions, the applicant added 20 °F to the maximum normal condition temperatures to account for the 20 °F increase of the temperature of the environment from normal to off-normal conditions. The resultant normal and off-normal conditions temperatures are located in Table 11.1.1 of the application for vertically oriented systems. The maximum temperatures presented in Table 11.1.1 are below the off-normal condition design temperature limits in Table 11.11.1.

The applicant evaluated two different thermal accidents, extreme environmental condition temperature of 125 °F and the fire accident. The extreme environmental accident condition temperatures are shown in Table 11.2.6 of the application for the vertically oriented MPC-24 and MPC-68, where the applicant added 45 °F to the maximum normal condition temperatures, to account for the environmental temperature increase from 80 °F to 125 °F.

The maximum temperatures presented in Tables 11.2.2 and 11.2.6, for the fire evaluation and extreme environmental conditions, respectively, are below the accident condition design temperature limits in Tables 11.2.2 and 11.2.6, except for the neutron shield inner surface. The applicant calculated the maximum temperatures of the neutron shield to be 314 °F and 319 °F, for the fire and extreme environmental conditions, respectively, compared to the 300 °F limit. The applicant described, in Sections 11.2.3.3 and 11.2.13.3, "Fire Dose Calculations," and "Extreme environmental temperature dose calculations," of the FSAR, that localized regions of the neutron shielding may exceed the design temperature limit for short periods of time, but for conservatism the post-accident shielding evaluations take no credit for the presence of the neutron shield material. In addition, the applicant described, in Section 11.2.13.4, "Extreme environmental temperature corrective action," of the FSAR, that upon detection of an extreme environmental temperature accident, the cask shall be inspected for any damage.

The staff reviewed Sections 11.2.13.3 and 11.2.13.4 of the application. Based on its review of the dose calculations and monitoring after an accident included in these sections, the staff finds it is acceptable for the MPC-32 neutron shield to exceed its temperature limit.

Based on comparing the applicant's off-normal and accident temperatures as well as the off-normal and accident allowable temperature limits—all in in Tables 11.1.1, 11.2.2, and 11.2.6 of the application—with the off-normal and accident design temperature limits also in Table 2.2.3 of the FSAR, the staff determines that there is acceptable margin (for example, at least 272 °F of margin for the fuel cladding). Therefore, the analysis provided by the applicant for the MPC-24, while not bounding compared to the MPC-32, is sufficient for this amendment request because there is acceptable margin to the maximum allowable temperature limits.

4.1.3 Pressure

Table 4.4.15 of the application presented the maximum gas pressures for normal conditions as well as with 1%, 10%, and 100% fuel rod rupture for the MPC-24, MPC-68, and MPC-32, in the

vertical orientation, and demonstrated that the values remain below the MPC design pressure in Table 2.2.1 of the application.

The initial backfill pressure (20.3 psig) in Table 4.4.15 of the application, for the MPC-32 is lower than initial backfill pressure in Table 2-1 of the TS (22.2 psig). Based on the staff's review of the margin between the applicant's calculated pressures in Table 4.4.15 of the application and the design pressures shown in Table 2.2.1 of the application, the staff concludes that the calculated pressures would continue to remain below the MPC design pressures shown in Table 2.2.1 of the application even if the higher technical specification initial backfill pressure were considered in the pressure calculations, and therefore finds the applicant-calculated pressure to be acceptable.

Section 11.1.1.3, "Analysis of Effects and Consequences of Off-Normal Pressure," of the application presented calculations for the off-normal pressure (61.9 psig) for vertically oriented casks and demonstrated that it remains below normal condition MPC design pressure (100 psig). The applicant calculated the maximum fire accident condition pressure (133.5 psig) in Section 11.2.3.2, "Fire Analysis," of the application which includes the pressure from rupture of 100% of the fuel rods. The applicant demonstrated, in Table 11.2.3 of the application, that the accident pressure did not exceed the accident condition design basis limit (200 psig). The staff reviewed the applicant-provided fire accident pressures in Table 11.2.3 of the application and finds the pressures are below the accident condition design basis limit in Table 11.2.3 of the application, and therefore finds the applicant-calculated pressure to be acceptable.

While Table 2.2.1 of the application presented the accident design pressure as 125 psig, the applicant's response to the staff's first round RAI (ADAMS Accession No. ML16133A509), confirmed (in response to RAI 4-7) that the accident design pressure limit is 200 psig. The staff reviewed the response to RAI 4-7 and finds the accident design pressure limit of 200 psig to be accurate and therefore acceptable.

In Section 11.2.12.2, "Burial Under Debris Analysis," of the application, based on a vertically-oriented cask containing an MPC-68 having the highest steady-state fuel cladding temperature, the applicant calculated a pressure of 117.8 psig for burial of the cask system under debris, which is below the accident MPC internal design pressure. The staff reviewed Section 11.2.12.2 of the application and finds the applicant calculated pressure of 117.8 psig for burial of the cask system under debris to be below the accident MPC internal design pressure (200 psig) the applicant presented in Section 11.2.12.2 of the application, and therefore finds the applicant-calculated pressure to be acceptable.

Confinement boundary temperatures are provided in Table 4.4.22 of the application for normal storage conditions for the MPC-24 and MPC-68 vertically-oriented casks, and in Table 4.4.12 of the application for the MPC-32 in the vertical orientation. Section 4.4.5, "Maximum Thermal Stresses," of the application described that the structural evaluation, in Section 3.4.4, "Heat," of the application, referenced these temperature results to demonstrate confinement boundary integrity. The staff reviewed the confinement boundary temperatures in Table 4.4.22 of the application and found the applicant-provided temperatures had not changed from the previous revision of the FSAR. The staff reviewed the applicant-provided MPC-32 confinement boundary temperature (the MPC shell, 315 °F) in response to the second-round RAI 4-1, and finds that it is similar to and less than the applicant-provided MPC-68 MPC shell maximum temperature (331 °F); therefore, the staff concludes the confinement boundary integrity will not be affected by thermal stresses. Therefore, the staff finds the confinement boundary integrity acceptable.

4.1.4 Cask Arrays

The applicant stated, in Section 1.4, “Generic Cask Arrays”, of the application, that the HI-STAR 100 system may be stored in either vertical or horizontal orientations and that vertically-oriented and horizontally-oriented casks will not be combined within an array. The center-to-center spacing, or pitch, between casks stored in the vertical orientation was stated to be 12 feet in both orthogonal directions, as shown in Figure 1.4.1, “HI-STAR 100 Typical ISFSI Storage Pattern for Vertical Storage,” of the application. The applicant concluded, that the center-to-center spacing between casks in vertical orientation has not changed and therefore remains applicable with the inclusion of the MPC-32. Based on its review of this information, the staff concludes that center-to-center spacing between casks in vertical orientation is applicable because it is the same as the spacing previously reviewed and approved by the NRC in Table 1.4.1, “Cask Layout Minimum Pitch Data Based on Thermal Evaluation,” of Revision 3 of the HI-STAR 100 FSAR (ADAMS Accession No. ML13337A382), and therefore is acceptable. The staff’s review of the horizontal orientation center-to-center spacing is provided in Section 4.4.6 of this SER.

4.1.5 MPC-32 Conclusion

Based the staff’s review of the calculated temperatures and pressures reported by the applicant being below the normal, off-normal, and accident allowable limits, the staff finds the inclusion of the MPC-32 acceptable for storage in the vertical orientation. The thermal evaluation of the MPC-32 stored in the horizontal orientation in the HI-STAR 100 is addressed in Section 4.4, “Horizontal storage of casks,” of this SER.

4.2 Use of Metamic Neutron Absorber for the MPC-24, MPC-32, and MPC-68

The applicant stated, in Table 1.0.3 of the application, that Metamic has been approved for use in Holtec fuel baskets in the HI-STAR 100 transportation system (Docket No. 71-9261) by the NRC. The applicant also stated, in Section 4.2, “Summary of thermal properties of materials,” of the application, that the thermal conductivity of the original neutron absorber (Boral) in the HI-STAR 100 storage system and Metamic are virtually identical. The applicant continued to use the thermal conductivity of Boral in the thermal analysis.

The staff confirmed that the thermal conductivity values of a composite fuel basket wall with Metamic are higher than the thermal conductivity values of a composite fuel basket wall with Boral for the same temperature range. Therefore, the staff concludes that the applicant’s use of the Boral thermal conductivity values bound the use of Metamic basket material. Based on the review of the thermal conductivity values of a composite fuel basket wall with Metamic compared to Boral and the prior approval by the NRC in the HI-STAR 100 transportation package, the staff finds the use of the Metamic neutron absorber acceptable in the MPC-24, MPC-32, and MPC-68 in the HI-STAR 100 storage application.

4.3 Incorporation of the Forced Helium Dehydrator

The applicant stated, in Table 1.0.3 of the application, that the use of FHD has been approved for the HI-STAR 100 transportation system by the NRC. The applicant described, in Section 4.4.1.1.12, “MPC temperature distribution under drying conditions,” and Appendix 4.A, “The FHD system,” of the application, the use of FHD to reduce moisture levels, as well as the design and operation of FHD. The staff reviewed the information in Section 4.4.1.1.12 and Appendix 4.A of the application—where the applicant addressed the FHD system overview, design

criteria, analysis requirements, and acceptance testing—and compared it with Section 3.4.1.1.16, “MPC temperature distribution under vacuum conditions,” and Appendix 3.B, “The forced helium dehydration (FHD) system,” respectively of the HI-STAR 100 transportation SAR. The staff finds that, apart from editorial changes, the relevant sections and appendices were consistent and accordingly finds the applicant’s inclusion of the FHD in the HI-STAR 100 storage application to be acceptable. The staff also confirmed that the applicant included FHD in the Technical Specification 2.1.1 Table 2-1 for this application to ensure that the MPC will be dry and helium-filled. This provides adequate heat transfer and an inert atmosphere to ensure cladding integrity. Therefore, based on the staff’s review of Section 4.4.1.1.12 and Appendix 4.A of the application, the staff’s review of Section 3.4.1.1.16 and Appendix 3.B of the HI-STAR 100 transportation SAR, the applicant’s inclusion of FHD in Technical Specification 2.1.1 Table 2-1, and the prior approval by the NRC in the HI-STAR 100 transportation package, the staff finds that the incorporation of the FHD in the HI-STAR 100 storage application is acceptable.

4.4 Horizontal Storage of Casks

4.4.1 Description of the Horizontal Emplacement Structure

The applicant stated, in Section 1.2.1.6, “Support structure for horizontal casks,” of the application, that HI-STAR 100 casks in the horizontal storage configuration are supported by saddle-type supports located near the cask’s extremities, as shown in Figure 1.2.13 of the application. Steel tie-down straps wrap around the remainder of the circumference at the same axial locations to secure the cask to the saddles. The applicant provided basic dimensions of the saddle supports and tie-down straps in Table 1.2.7 of the application and stated these saddle dimensions shall be used whenever the HI-STAR 100 cask is stored horizontally.

4.4.2 Normal Conditions of Storage

The applicant stated, in Section 4.4.2.1, “Maximum temperatures under normal storage conditions,” that the maximum fuel cladding and structures, systems, and components (SSC) temperatures in horizontally-oriented casks are listed in Tables 3.4.10 and 3.4.11 of the HI-STAR 100 transportation SAR for normal conditions of transport. From Table 1.2.2 of the application, the decay heat for the MPC-24 (20 kilowatts (kW)), MPC-32 (20 kW), and MPC-68 (18.5 kW) in horizontal orientation is equal to the decay heat for the MPC-24 (20 kW), MPC-32 (20 kW), and MPC-68 (18.5 kW) in Table 1.2.3 of the HI-STAR 100 transportation SAR.

In Section 4.4.2.1 of the application, the applicant compared the fuel cladding temperatures and the temperatures of the bounding confinement boundary component (the MPC shell) in Tables 3.4.10 and 3.4.11 of the HI-STAR 100 transportation SAR and concluded that the MPC-68 thermally bounds the MPC-32 in horizontal casks.

The applicant also stated, in Section 4.4.2.1 of the application, that, as shown in Table 4.4.26 of the application, “Comparison of transportation results incorporated by reference with normal horizontal storage on support structure,” the horizontal support structure for storage provides the same or more favorable thermal conditions when compared to the transport conditions (referenced in Table 4.0.1 of the application) thus the applicant concluded, conservatively representing the thermal performance under horizontal, normal storage conditions.

The applicant stated in Table 4.4.26 of the application that the maximum fuel cladding temperature, the MPC shell temperature, and the MPC cavity pressure under normal conditions in the horizontal orientation, remain below the normal allowable storage limits for BWR and

PWR canisters, also listed in Table 4.4.26 of the application. The staff reviewed Table 4.4.26 of the application and concludes the temperatures and MPC cavity pressure are below the allowable limits in Table 4.4.26 of the application.

In response to the staff's second RAI, the applicant (in response to RAI 4-2) provided the fuel cladding temperature, MPC shell temperature, and MPC cavity pressure for the MPC-68 and MPC-32 in the HI-STAR 100 cask while on the horizontal emplacement structure described in Section 1.2.1.6, "Support structure for horizontal casks," of the application. The applicant demonstrated, based on the results in Table 4-2.2 (in response to RAI 4-2) for the BWR canister and Table 4-2.3 for the PWR canister, that the normal horizontal transport results bound the normal horizontal storage results for the BWR and PWR canisters.

However, where the applicant concluded the MPC-68 thermally bounds the MPC-32 in horizontal orientation, Tables 4-2.2 and 4-2.3 of the RAI 4-2 response show that the HI-STAR 100 cask with the PWR canister on the horizontal structure bounds the results with the HI-STAR 100 cask with the BWR canister on the horizontal structure.

The applicant demonstrated that the applicant-provided temperature and pressure results in Tables 4-2.2 and 4-2.3 remain below the normal storage allowable temperature and pressure limits for the normal horizontal transport temperatures incorporated from Tables 3.4.10 and 3.4.11 of the HI-STAR 100 transportation SAR and the normal storage of the HI-STAR 100 on the horizontal support structure. The staff reviewed the applicant-provided temperature and pressure results in Tables 4-2.2 and 4-2.3 of the RAI 4-2 response and concludes the temperatures and MPC cavity pressure are below the allowing limits that are also in Tables 4-2.2 and 4-2.3, respectively, of the response to RAI 4-2. Therefore, while the MPC-68 does not thermally bound the MPC-32, MPC-32's temperatures are still below the allowable limits, and, accordingly, are acceptable.

The applicant stated, in Section 4.4.2.1 of the application, that the effects of array blocking for an array of horizontally-oriented casks were evaluated and temperatures were compared to the transportation thermal performance incorporated by reference from the HI-STAR 100 transportation SAR in Table 4.4.27 of the application. The staff reviewed the applicant-provided results and the normal allowable storage limits, both found in Table 4.4.27 of the application. Basedo n this review, the staff concludes the applicant demonstrated, in Table 4.4.27 of the application, that the maximum fuel cladding temperature, the MPC shell temperature, and the MPC cavity pressure—under normal conditions of storage in the horizontal orientation—remain below the normal allowable storage limits. Accordingly, because these values will remain below allowable limits, the staff finds the normal conditions for storage acceptable.

4.4.3 Off-normal Conditions

The applicant stated, in Section 11.1.2.3, "Analysis of effects and consequences of off-normal environmental temperatures," of the application, that for horizontally-oriented systems, Chapter 3 of the HI-STAR 100 transport SAR considers 100 °F (38 °Celsius (°C)) as the normal condition ambient temperature. The staff concludes the 100 °F ambient temperature used under normal conditions of transport bounds the 80 °F ambient temperature used under normal conditions of storage. The applicant increased component temperatures, under normal conditions of transport, by 20 °F to account for the off-normal conditions of storage, reporting those component temperatures in Table 11.1.1 of the application. While Table 11.1.1 of the application is for vertically-oriented casks, the staff confirmed the reported component temperatures in Table 11.1.1 are higher than if 20 °F were added to the applicant's response to

the staff's second RAI that included temperatures for normal conditions of storage while in horizontal orientation. This demonstrated that the component temperatures are below the allowable limits. In addition, in response to the staff's second RAI, the applicant (in response to RAI 4-2) described adding 20 °F to the fuel cladding, MPC shell, MPC baseplate, and MPC lid based on the horizontal storage analysis of a HI-STAR 100 on a saddle support. The staff reviewed this response and concludes that the results in Table 4-2.4 of the response to RAI 4-2 demonstrated acceptable margin to the temperature limits.

4.4.4 Accident Conditions

The accident condition extreme environmental temperatures presented in Table 11.2.6 of the application for the horizontal orientation were calculated based on the normal condition temperatures of the MPC-68 and PWR MPCs from Tables 3.4.10 and 3.4.11 of the HI-STAR 100 transportation SAR. In addition, in response to the staff's second-round RAI, the applicant (in response to RAI 4-2) described adding 45 °F to the fuel cladding, MPC shell, MPC baseplate, and MPC lid based on the normal storage analysis of a HI-STAR 100 on a saddle support. The staff reviewed this response and concludes that the results in Table 4-2.4 of the response to RAI 4-2 demonstrated sufficient margin to the temperature limits.

The applicant demonstrated that the component temperatures in Table 11.2.6 are below their allowable limits with the exception of the neutron shield inner surface. The neutron shield inner surface peak transient temperature is slightly higher than the 300 °F long-term limit. The applicant stated, in Section 11.2.13.3, "Extreme environmental temperature dose calculations," of the FSAR, that the bulk of the shield material away from these hot spots will remain within the normal temperature limits and degraded function of the neutron shielding material is not expected. In Section 11.2.13.4, "Extreme environmental temperature corrective action," of the FSAR, the applicant also stated that upon detection of an extreme environmental temperature accident the cask shall be radiologically inspected for any damage. The staff reviewed Sections 11.2.13.3 and 11.2.13.4 of the application. Based on its review of the statements in Sections 11.2.13.3 and 11.2.13.4 of the application the staff finds this to be acceptable because upon detection of an extreme environmental temperature accident, the cask shall be radiologically inspected for any damage.

In response to the staff's second RAI, the applicant (in response to RAI 4-2) stated that the fire event for storage assumes the same flame temperature and fully engulfing nature as is required by 10 CFR Part 71, and the hypothetical accident condition fire for transportation is of longer duration than the storage fire. In addition, the applicant stated in the second RAI response to RAI 4-2 that the storage fire event can be reasonably assumed to be bounded by the transportation condition safety analysis reported in Section 3.5, "Hypothetical accident thermal evaluation," of the HI-STAR 100 transportation SAR. Specifically, in Table 3.5.4, the applicant demonstrated that there is margin when comparing the transportation fire and post-fire component temperatures to the accident temperature limits. The applicant also stated, in Section 11.2.3.2, "Fire analysis," of the application, that the neutron shield inner surface peak transient temperature is slightly higher than the 300 °F long-term temperature limit, and described this temperature excursion as, "not expected to significantly degrade the neutron shield materials shielding function at this location." For conservatism, the applicant described, in Section 11.2.3.2 of the application, that the post-fire shielding evaluation takes no credit for the neutron shield material. In addition, the applicant stated, in the second-round RAI response to RAI 4-2, that all site-specific fire events that are not bounded by the FSAR will require a site-specific 10 CFR 72.212 evaluation. The staff reviewed the statements above from Section 11.2.3.2 of the application. Based on its review of these statements, the staff finds this to be

acceptable considering the applicant's post-fire shielding evaluation takes no credit for the neutron shield material and all site-specific fire events that are not bounded by the FSAR will require a site-specific 10 CFR 72.212 evaluation.

The applicant stated, in Section 11.2.3.2 of the application, that the fire duration is calculated for a vertically-oriented cask, which bounds the fire duration for a horizontally-oriented cask because the diameter of the cask is less than its length. The applicant concluded, in Section 11.2.3.2, that a vertically-oriented cask results in a significantly smaller fuel puddle which maximizes the puddle depth and corresponding fire duration. Therefore, the applicant evaluated the temperature response of the vertically-oriented cask in Table 11.2.2 of the application. The staff reviewed this information and confirmed the support structure footprint is shown in Figure 1.2.13 of the application and the footprint is larger than the footprint of a vertically-oriented cask to ensure the vertically-oriented cask fire duration bounds the horizontally-oriented cask fire duration.

4.4.5 Pressure

Section 4.4.4, "Maximum internal pressure," of the application described that Table 3.4.15 of the HI-STAR 100 transportation SAR included the maximum gas pressure under normal conditions in the horizontal orientation (89.3 psig) and demonstrated that the maximum gas pressure remained below the normal condition MPC design pressure (100 psig). Section 11.1.1.3, "Analysis of effects and consequences of off-normal pressure," of the application provided calculations for the off-normal pressure (93 psig) for horizontally-oriented casks and showed it remains below normal condition MPC design pressure (100 psig). The applicant calculated the maximum fire pressure (133.5 psig) in Section 11.2.3.2, "Fire analysis," of the application, described in Section 11.2.8.2, "100% fuel rod rupture analysis," of the application that 100% fuel rod rupture was included in the calculation, and demonstrated in Table 11.2.3 of the application that it did not exceed the accident condition design basis limit (200 psig).

The staff reviewed the applicant-provided results in Section 4.4.4 and applicant-provided pressure calculations in Section 11.1.1.3 of the application. The Staff also performed confirmatory calculations. Based on its review of the applicant-provided results and the confirmatory calculations, the staff finds that the applicant-provided pressures are below the respective design pressure limits shown in Table 2.2.1 of the application for normal and off-normal conditions. The staff also reviewed the results in Section 11.2.3.2 of the application. Based on its review of the results, staff determined that the applicant's provided pressure with a maximum value of 133.5 psig for the MPC-32, listed in Table 11.2.3 of the application, is below the 200 psig accident design pressure limit described in the applicant's response to the staff's first round RAI, (in response to RAI 4-7) for accident conditions; and therefore finds the applicant-calculated pressure acceptable. While Table 2.2.1 of the application presented the accident design pressure as 125 psig, the applicant's response to the staff's first round RAI, stated (in response to RAI 4-7) that the accident design pressure limit is 200 psig. The staff reviewed the response to RAI 4-7 and finds the accident design pressure limit of 200 psig to be accurate and therefore acceptable.

The applicant also stated, in Section 11.2.8.2 of the application, that given the extreme environmental temperature of 125 °F ambient, generated temperatures are bounded by the fire accident condition's temperature and, therefore, internal pressure of the fire accident condition is also bounding. The staff also performed confirmatory calculations of the pressure calculated under burial conditions. In Section 11.2.12.2, "Burial under debris analysis," of the application, based on a vertically-oriented cask containing an MPC-68 having the highest steady-state fuel

cladding temperature, the applicant calculated a burial under debris pressure of 117.8 psig which is below the accident MPC internal design pressure. Section 4.4.5, "Maximum thermal stresses," of the application described that temperatures for the helium-retention boundary components are provided in Table 3.4.24 of the HI-STAR 100 transportation SAR for horizontal orientation of the MPC-68 and PWR MPCs for normal conditions. Section 4.4.5 of the application described that the structural evaluation, in Section 3.4.4, "Heat," of the application, referenced these temperature results to demonstrate confinement boundary integrity. The staff reviewed Section 11.2.12.2 of the application and based on its review and confirmatory calculations, the staff concludes the calculated pressure for the burial under debris analysis is below the applicant-provided accident design pressure limit provided in response to staff first round RAI 4-7, and therefore is acceptable.

4.4.6 Horizontal Casks in an Array

The applicant provided, in Figure 1.4.2 of the application, a typical layout for the horizontal-orientation ISFSI storage pattern and described a design-basis lateral distance between cask centerlines of 18 feet to provide access for handling equipment. The design-basis cask clearance of 5 feet is also shown. The applicant described, in Section 1.4, "Generic cask arrays," of the application, that site-specific layouts for arrays of casks will be evaluated pursuant to 10 CFR 72.212. The applicant also stated that vertically- and horizontally-oriented casks will not be combined within an array, because the applicant did not provide analysis results for an array combining vertically- and horizontally-oriented casks. In the applicant's response to the staff's second round RAI 4-4, the applicant provided thermal evaluations of a horizontal HI-STAR 100 cask positioned on the horizontal emplacement structure in the proposed array configuration. The applicant provided Tables 4-4.1 and 4-4.2 that show the BWR canister and PWR canister, respectively, have maximum fuel cladding and MPC confinement boundary component temperatures that are below the normal storage allowable limits also provided in Tables 4-4.1 and 4-4.2. Tables 4-4.1 and 4-4.2 also show that the applicant-provided MPC cavity pressure is below the normal storage design pressure limit also in Tables 4-4.1 and 4-4.2. Based on the staff's review of the applicant-provided temperatures and pressures in Tables 4-4.1 and 4-4.2 of the response to the staff's second round RAI 4-4 and given that the applicant described that site-specific layouts for arrays of casks will be evaluated pursuant to 10 CFR 72.212, the staff finds the horizontal cask array spacing acceptable.

4.4.7 Horizontal Storage of Casks Conclusion

Based on staff's review of the applicant's evaluations and the applicant-provided calculated temperatures and pressures, that are below the normal, off-normal, and accident allowable limits as described in Section 4.4, "Horizontal storage of casks," of this SER, the staff finds the inclusion of the MPC-24, MPC-32, and MPC-68 acceptable for storage in the horizontal orientation in the HI-STAR 100 cask with the emplacement structure as described in Section 1.2.1.6, "Support structure for horizontal casks," and as designed shown in Figure 1.2.13 of the application with the dimensions in Table 1.2.7 of the application. Based on the staff's review of the applicant-provided temperatures and pressures in Tables 4-4.1 and 4-4.2 of the response to the staff's second round RAI 4-4, and given that the applicant described that site-specific layouts for arrays of casks will be evaluated pursuant to 10 CFR 72.212, the staff finds the horizontal cask array spacing acceptable.

4.5 Change of the Fuel Cladding Temperature Limits to Meet Interim Staff Guidance No. 11 Revision 3

The applicant provided fuel cladding temperature limits in Tables 2.2.3 and 4.3.1 of the application. The staff reviewed this information using guidance provided in ISG 11 Rev 3. The ISG 11 Rev. 3 provides guidance to the staff to show that the licensee will be in compliance with 10 CFR 72.122(h)(1), which describes that the spent fuel cladding must be protected during storage against degradation that leads to gross ruptures. The applicant states the maximum fuel cladding temperature limit is 752 °F for normal conditions of storage, and 752 °F for short-term loading operations of high burn-up fuel (high burn-up fuel was not requested as contents and is not authorized as contents). Based on its review, the staff confirmed that the fuel cladding temperature limits provided by the applicant are consistent with the temperature limits provided in ISG 11 Rev. 3, and, therefore, are acceptable. The ISG 11 Rev. 3 also states that during loading operations, repeated thermal cycling should be limited to less than 10 cycles, with cladding temperature variations less than 117 °F (65 °C). Based on its review, the staff confirmed Section 2.0.1, “MPC Design Criteria” of the FSAR is consistent with this guidance, and, therefore, is acceptable.

4.6 Evaluation Findings

F4.1 SSCs important to safety are described in sufficient detail in the SAR to enable an evaluation of their thermal effectiveness. Cask SSCs important to safety remain within their operating temperature ranges.

F4.2 The HI-STAR 100 is designed with a heat-removal capability having verifiability and reliability consistent with its importance to safety. The cask is designed to provide adequate heat removal capacity without active cooling systems.

F4.3 The spent fuel cladding is protected against degradation leading to gross ruptures by maintaining the cladding temperature below maximum allowable limits in a helium gas environment in the cask cavity under normal, off-normal, and accidental storage conditions for the HI-STAR 100 cask reviewed for this application. Protection of the cladding against degradation is expected to allow ready retrieval of spent fuel for further processing or disposal.

F4.4 The staff concludes that the thermal design of the HI-STAR 100 continues to be in compliance with 10 CFR Part 72, and that the applicable design and acceptance criteria have been satisfied. The evaluation of the thermal design provides reasonable assurance that the HI-STAR 100 will allow safe storage of spent fuel for a licensed life of 20 years. This finding is reached on the basis of a review that considered the regulation itself, appropriate RGs, applicable codes and standards, and accepted engineering practices.

5.0 CONFINEMENT EVALUATION

The objective of the confinement review of the HI-STAR 100 Cask System 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-STAR 100 Cask System, proposed by this amendment request. The applicant requested

several changes to the HI-STAR 100 Cask System design and CoC. The staff reviewed proposed Amendment No. 3 of the HI-STAR 100 Cask System confinement analyses to ensure that credible normal, off-normal, and accident conditions have been identified and their potential consequences considered, such that the HI-STAR 100 Cask System continues to meet the regulatory requirements of 10 CFR 72.236.

5.1 Confinement Design Characteristics

The applicant proposed to include the MPC-32 in the HI-STAR 100 storage docket to align the MPCs allowed in the HI-STAR 100 storage overpack with those (e.g., MPC-24 and MPC-68) previously licensed for transportation in the HI-STAR 100.

The HI-STAR 100 is a dual weld design canister and the confinement boundary of the MPC design for all applicable MPCs (including the MPC-32) includes the following: MPC shell and bottom baseplate; MPC lids, MPC vent, and drain port cover plates; and MPC closure ring and associated welds. Penetrations to the confinement boundary consist of two penetrations, the MPC vent and drain ports. All components of the confinement boundary are important to safety, Category A, as specified in the applicant's proposed SAR Table 2.2.6. The MPC confinement boundary is designed, fabricated, inspected, and tested in accordance with ASME B&PV Code, Section III, Subsection NB. The NRC-staff approved alternatives to the ASME B&PV Code are identified in Table 2.2.15 of the SAR.

The applicant proposed to revise the confinement boundary criterion to be leaktight, consistent with ISG-18, "The Design and Testing of Lid Welds on Austenitic Stainless Steel Canisters as the Confinement Boundary for Spent Fuel Storage", to ensure consistency across all Holtec storage dockets and consistency with the most up-to-date NRC guidance. The purpose of ISG-18 is to address the design and testing of the various closure welds (i.e. dual lid welds) associated with the redundant closure (i.e. dual lid design) of all-welded austenitic stainless steel canisters, such as the HI-STAR 100. The ISG-18 does not serve as a regulatory requirement. Instead, it provides guidance to the staff on an acceptable method for applicants to meet the applicable regulatory requirements in 10 CFR 72.236.

The change to the confinement boundary criterion requested in this amendment affects the inspection and leak testing of the lid-to-shell structural weld. The ISG-18 states that any weld that is part of the confinement boundary should be helium leak tested and also provides an alternative method the applicant can use to exercise the option to eliminate the helium leak test normally required of the structural-lid-to-shell weld. Under the guidance, the helium leak test can be eliminated if (among other requirements): 1) the weld is a multi-pass weld consisting of three or more distinct weld layers; 2) a flaw tolerance analysis for that weld has been performed consistent with the guidance of ISG-15; and 3) the weld is liquid penetrant examined. With respect to the third criterion, the guidance provides that the weld should be liquid penetrant examined for a minimum of three different liquid penetrant examinations: 1) after the root pass; 2) after each time a weld deposit depth is applied that does not exceed the dimension of the flaw tolerance analysis; and 3) after the final pass is completed. Table 7.1.4 of the SAR provides a comparison of the Holtec MPC design with the ISG-18 guidance, demonstrating the applicant's structural weld testing is consistent with the criteria for eliminating a helium leak test of the lid-to-shell weld under ISG-18, as stated above. The staff finds that the applicant has conformed to the guidance of ISG-18 and that this change to the confinement boundary criterion will not affect the confinement system's ability to reasonably maintain confinement of radioactive material under normal, off-normal, and credible accident conditions. For the remaining welds in the confinement boundary, as stated in SAR Section 7.1.1 and Table 9.1.1, a helium leak test in

accordance with the "leaktight" criteria of ANSI N14.5-1997, “American National Standard for Radioactive Materials - Leakage Tests on Packages for Shipment,“ is performed at fabrication.

The MPC-32 was previously approved by NRC in 2006 in the HI-STAR transportation package. Since the MPC-32 confinement boundary is the same as the MPC-24 and -68 already approved for the HI-STAR 100 storage CoC, the staff finds there will be no changes to the confinement by adding the MPC-32 to the HI-STAR 100 storage CoC. Therefore all MPC designs will conform to the proposed revision of the confinement boundary criteria as described above.

The staff finds that the addition of MPC-32 to the HI-STAR 100 storage CoC and the revision of the confinement boundary criteria to be leak tight consistent with ISG-18 is acceptable.

5.2 Evaluation Findings

Based on the NRC staff’s review of information provided in the HI-STAR 100 Cask System amendment request, the staff finds the following:

F5.1 Chapter 7 of the SAR describes confinement structures, systems, and components important to safety in sufficient detail to permit evaluation of their effectiveness.

F5.2 The design of the HI-STAR 100 Cask System adequately protects the spent fuel cladding against degradation that might otherwise lead to gross ruptures. Section 4 of this SER discusses the relevant temperature considerations.

F5.3 The design of the HI-STAR 100 Cask System provides redundant sealing of the confinement system closure joints by using dual welds on the MPC lid and the MPC closure ring.

F5.4 The MPC has no bolted closures or mechanical seals. The confinement boundary contains no external penetrations for pressure monitoring or overpressure protections. No instrumentation is required to maintain operational under accident conditions. Because the MPC uses an entirely welded redundant closure system, no direct monitoring of the closure is required.

F5.5 The confinement system has been evaluated by analysis. Based on successful completion of specified testing and examination procedures—described in FSAR Chapters 7, 8 and 9—the staff concludes that the confinement system will reasonably maintain confinement of radioactive material under normal, off-normal, and credible accident conditions.

F5.6 The staff concludes that the design of the confinement system of the HI-STAR 100 Cask System, as changed and updated by the applicant in the FSAR, is in compliance with 10 CFR Part 72 and that the applicable design and acceptance criteria have been satisfied. The evaluation of the confinement system design provides reasonable assurance that the HI-STAR 100 Cask System will allow safe storage of spent fuel. This finding considered the regulation itself, the appropriate RGs, applicable codes and standards, the applicant’s analysis, the staff’s confirmatory review, and acceptable engineering practices.

6.0 SHIELDING EVALUATION

The staff reviewed the application for the addition of the MPC-32 canister as an approved canister for storage in the HI-STAR 100 storage cask system, including 6x6B and 7x7A fuel assemblies. The review included evaluating the cask shielding design under normal, off-normal, and design-basis accident conditions as required in 10 CFR 72.236(d). Also, the application was evaluated to determine whether the cask evaluation is consistent with acceptance criteria listed in Chapter 6, "Shielding Evaluation," of NUREG-1536. Because the dose requirements in 10 CFR Part 72 for members of the public include direct radiation, effluent releases, and radiation from other uranium fuel cycle operations, the NRC staff documents its overall assessment of compliance with the regulatory limits in Chapter 11 of this SER on radiation protection of the SER.

The shielding review in Chapter 6 of this SER evaluates dose rates for normal, off-normal, and accident conditions from both direct gamma and neutron radiation at locations near the HI-STAR 100. Chapter 11 of the SAR discusses the estimated occupational exposures and offsite dose rates that are based on the dose rates calculated in Chapter 6 of the SAR.

6.1 Description of the Shielding Design

6.1.1 Packaging Design Features

The HI-STAR 100 System is designed to accommodate different MPC designs in a single overpack. Currently approved MPC designs include the MPC-24 and the MPC-68. Each MPC is identified by the maximum number of fuel assemblies it is capable of accommodating. The current application is for addition of the MPC-32. The construction features of the PWR and BWR MPCs are similar and have identical exterior dimensions.

The MPC-32 is designed to store a maximum of 32 intact, zircaloy-clad PWR fuel assemblies in array/classes 14x14A, B, C, and D; 15x15A, B, C, D, E, F, G, and H; 16x16A; and 17x17A, B, and C, as specified in Table 2.1.3 of the SAR. The MPC-32 is constructed and assembled in accordance with Drawing No. 3927, Sheets 1-5, Rev. 16 in the SAR. The maximum burnup levels and minimum cooling times for the MPC-32 are listed in Table 2.1.15 of the SAR. The fuel assembly parameters and enrichment specifications for the zircaloy clad fuel are listed in Table 5.2.24 of the SAR. The MPC-32 is not authorized to transport damaged fuel assemblies or fuel debris.

The fuel basket structure is built from inter-welded intersecting plates and neutron poison panels attached to the fuel storage cell walls. Shielding of gamma radiation is provided by the steel structure of the MPC and overpack. The overpack's inner, intermediate, and enclosure shells provide gamma shielding with additional axial shielding provided by the bottom plate and the top closure plate.

The staff reviewed the description of cask design features in Chapter 5 of the SAR related to the amendment request and compared the description against the drawings in Chapter 1. The description of the shielding design features is consistent with the drawings of the storage cask, therefore, the staff finds the description of the design features is acceptable.

6.2 Source Specification

The applicant calculated the design basis source terms for the burnup and cooling time requested in the amendment using the SAS2H and ORIGEN-S modules of the SCALE 4.3 system. The applicant's method used to calculate the source terms for the MPC-32 is the same as for the MPC-24, which NRC reviewed in the initial issuance of the certificate. In the evaluation of the MPC-24, the applicant determined that the Babcock & Wilcox 15x15 fuel assembly, which has the largest UO_2 mass per assembly, including the newly added 6x6B and 7x7A fuel assemblies, has the highest radiation source term of the zircaloy-clad fuel assembly classes evaluated in Table 5.2.24. This fuel assembly was used to evaluate the MPC-32.

The source terms for the MPC-32 were calculated for two burnup and cooling time combinations: 40,000 megawatt-days/metric ton of uranium [MWd/MTU] and minimum cooling time of 8 years; and 45,000 MWd/MTU and a minimum cooling time of 11 years. The staff determined these combinations to be conservative combinations since they bound the maximum burnup levels and minimum cooling times in Table 1.1-5 of Appendix B to the TS. The minimum cooling times proposed by the applicant for 40,000 MWd/MTU and 45,000 MWd/MTU are greater than 14 years and greater than or equal to 20 years, respectively. The calculated MPC-32 PWR fuel gamma source per assembly, Co-60 source per assembly, and neutron source per assembly are listed in Tables 5.2.4, 5.2.9, 5.2.12 of the SAR.

The applicant performed a source term evaluation for stainless steel and inconel in-core grid spacers. The applicant developed separate burnup and cooling times for PWR fuel assemblies containing zircaloy and non-zircaloy incore spacers, as shown in Table 1.1-5 of Appendix B to the TS. Stainless steel has a lower cobalt impurity level than inconel, therefore the source term from zircaloy-clad PWR assemblies with stainless steel grid spacers is bounded by source term from PWR fuel assemblies containing inconel grid spacers. The applicant used a mass of 4.9 kilogram (kg) for the inconel grid spacers, with a Co-59 impurity level of 4.7 g Co-59/kg inconel.

The staff evaluated the source term methodology for determining design-basis fuel types and found it acceptable for the following reasons. In this application, the applicant compared the source terms for the 6x6A and 7x7B fuel assemblies and determined that the 15x15 fuel assemblies are still the bounding fuel assembly for use in the dose rate calculations, since they have the highest uranium loading. Since the methodology is the same as previously approved, the fuel assemblies are light-water reactor fuel assemblies, and will have a similar flux spectrum as other light-water reactor fuel assemblies, the staff finds that the methodology used to determine the neutron and gamma sources for the new fuel assemblies is acceptable. Therefore, the NRC staff finds that the source terms for the new fuel assemblies and the source terms used to calculate the dose rates from the new MPC-32 canister are conservative, and therefore acceptable for use in the shielding analysis.

6.3 Model Specification

6.3.1 Configuration of Source and Shielding

The applicant used a modeling approach for the MPC-32 canister that is the same as the approach used for the MPC-24, which was previously approved by NRC in the initial issuance of the certificate. The applicant used Monte Carlo N-Particle Transport (MCNP) Version 4A and the ENDF/B-V cross-section library to calculate the dose rates for the different fuel conditions. The MCNP models are the same as those previously approved by NRC for the MPC-24, except for the MPC. The applicant's shielding geometry of the MPC-32 is based on the new design of

the basket cells. The difference between the normal conditions shielding model and the accident conditions models is that the applicant's accident condition shielding model replaced the entire volume of the neutron shield with a void.

The staff evaluated the SAR shielding model and found it acceptable becausethe dimensions used in the shielding model appropriately represent the dimensions on the drawings for the MPC-32. The staff determines that the applicant's shielding analyses, and design basis assumptions adequately represent the HI-STAR 100 containing an MPC-32 and are consistent with the criteria in NUREG-1536, Section 6.4.3.

6.3.2. Material properties

The composition and densities of the material used in the shielding analysis to support this amendment are presented in Tables 5.3.2 and 5.3.3 of the SAR. Table 5.2.24 provides further detailed information about material properties and dimensions. The applicant submitted a supplementary propriety report which contained actual MCNP input files. Figures 5.3.1, 5.3.4, 5.3.7 and 5.3.10 of the SAR provide additional design details on all dimensions.

The staff reviewed the materials properties and found them acceptable because the materials used in the analysis for the storage cask are the same as those previously approved in Revision No. 2 of CoC No. 1008 (ADAMS Accession No. ML011500504), and adequately represent the materials in the storage cask. The staff reviewed the materials for the MPC-32 canister, basket, and spent fuel contents and compared the material specifications against the drawings for the MPC-32 canister and basket. The staff reviewed the material specifications for the spent fuel and determines they adequately represent the homogenized fuel assembly.

The staff determines the materials and dimensions used in the models accurately represent the storage system and that the shielding analysis adequately modeled the new MPC-32 in the HI-STAR 100 storage cask.

6.4 Shielding Evaluation

The applicant calculated the maximum dose rates adjacent to the overpack during normal, off-normal, and design basis accident conditions for the MPC-32 canister. The dose rates for the three radiation sources under normal conditions for the MPC-32 in the HI-STAR 100 overpack for each of the burnup levels and cooling times evaluated are listed in Tables 5.4.18 – 5.4.20 of the SAR. Table 5.4.21 of the SAR lists the total dose rate for both burnups and cooling time combinations that the applicant evaluated for the MPC-32.

With the exception of the dose rates on the lid and bottom plate, the dose rates presented in the SAR for the MPC-32 for a burnup of 40,000 MWd/MTU and 8-year cooling time are less than those for the previously NRC-approved MPC-24 PWR canister. In the case of a design-basis accident, the applicant assumes the neutron shield to be completely lost and the corresponding dose rates adjacent to the overpack are provided in Tables 5.1.9 and 5.4-24 of the SAR, for 1 meter from the cask surface and on the cask surface. The applicant evaluated the storage cask containing an MPC-32 for accident conditions. These dose rates are bounded by the accident condition dose rates for the MPC-24.

In Table 5.4-24, the applicant compares the dose rates from actual fuel assembly combinations in Table 1.1-5 of Appendix B to the TS with the dose rates from the design-basis source term for normal conditions on the surface of the cask and 1 meter from the cask and accident conditions.

For all locations and conditions, the design-basis fuel assembly dose rates are higher than the dose rates for the actual burnup and cool time combinations, which include fuel assemblies with non-zircaloy grid spacers. Staff finds this acceptable because the dose rates for the MPC-32 are bounded by the does rates for the MPC-24, which the NRC already approved in the initial issuance of the certificate (ADAMS Accession No. ML011500507).

6.5 Evaluation Findings

F6.1 The SAR sufficiently describes shielding design features and design criteria for the SSCs important to safety in sufficient detail to allow evaluation of their effectiveness.

F6.2 As discussed in Chapter 11, the radiation shielding features are sufficient to meet the radiation protection requirements of 10 CFR Part 20, 10 CFR 72.236(d).

The NRC staff reviewed the information provided by the applicant to support this amendment and determines that it provides reasonable and appropriate information, including dose rates, to enable evaluations to determine the ability of the storage system to meet the radiation protection requirements in 10 CFR 72.236(d), and 10 CFR Part 20. This finding considered the regulation itself (10 CFR 72.236, and 10 CFR Part 20), appropriate regulatory guidance (NUREG-1536), applicable codes and standards, and accepted engineering practices.

7.0 CRITICALITY EVALUATION

The staff evaluated Holtec's application for the addition of the MPC-32 as an allowed content for storage in the HI-STAR 100 storage cask system in order to bring the HI-STAR 100 into alignment with the HI-STAR 100 transportation cask and the HI-STORM 100 storage cask system, which are both currently authorized to use this canister type. The applicant also requested the use of Metamic neutron absorber for the MPC-24, MPC-32 and MPC-68 configurations, as well as the use of soluble boron credit when performing pool loading and unloading operations of the MPC-24 and MPC-32 PWR canisters. The applicant also requested changes to the TS to allow 7x7A and 6x6B fuel assembly array/classes and to PWR fuel characteristics to allow annular fuel pellets. Staff evaluated the criticality safety design of the HI-STAR 100 storage cask system to verify that the changes proposed in this amendment continue to meet the requirements of 10 CFR Part 72.

7.1 Description of the Criticality Design

The HI-STAR 100 storage cask system loaded with an MPC-32 canister relies on the use of neutron absorber plates, number of fuel assemblies loaded, configuration control, and minimum burnup as a function of initial enrichment to determine the allowable fuel assemblies that can be safely stored. The HI-STAR 100 system also relies on the minimum soluble boron concentration in the pool water for loading and unloading operations in the MPC-24 and MPC-32. No burnup credit is taken for this amendment. The MPC-32 is similar in design to the MPC-24 and has the same exterior dimensions, with the main difference being the number of PWR fuel assemblies contained within that boundary (i.e., 24 versus 32 PWR assemblies).

Up to 32 intact zircaloy-clad PWR fuel assemblies can be loaded into the MPC-32 and may consist of various fuel types as specified in Table 2.1.3 of the SAR. The allowable fuel types are found in Table 2.1.15 of the SAR, and the fuel assembly specifications and enrichment are found in Table 6.2.2 of the SAR. The interior fuel basket is constructed of intersecting plates

and neutron poison panels composed of either Boral or Metamic in the MPC-24, MPC-32, and MPC-68 configurations.

The staff evaluated the proposed changes in this amendment application and reviewed it against the SAR for completeness of information, description of the package design features, parameters, and dimensions, and finds them to be sufficient to perform their review.

7.2 Spent Fuel Specification

As specified in Table 2.1.3 of the SAR, the applicant has requested authorization to store up to 32 intact PWR fuel assemblies in an MPC-32 in each HI-STAR cask. The uranium dioxide [UO_2] fuel assemblies contain the following arrays/classes of fuel: 14x14A, B, C, and D; 15x15A, B, C, D, E, F, G and H; 16x16A; and 17x17A, B, and C. These contents are identical to those approved in the transportation evaluation of the HI-STAR 100, Revision 5 and those approved for storage in the HI-STORM 100, Amendment No. 1. The PWR fuel rods may have up to 8 inches of annular pellets in the top and bottom of PWR fuel rods.

The applicant performed criticality safety analyses for each assembly class in order to identify the bounding assembly based on the maximum active fuel length, maximum fuel pellet diameter, minimum cladding outside diameter, maximum cladding inside diameter, and minimum guide tube/water rod thickness. The applicant performed parametric studies for the PWR assemblies in the MPC-24 and MPC-32 configurations both with and without soluble boron flooding the MPC during loading/unloading operations.

For the MPC-24 without soluble boron in the water, the maximum enrichment remains at 4.1 wt% ^{235}U. With a minimum soluble boron concentration of 400 parts per million (ppm), the maximum allowable enrichment in the MPC-24 is 5.0 wt% ^{235}U for all assembly classes. When loading the MPC-32 with a maximum enrichment 4.1 wt% ^{235}U, a minimum soluble boron concentration is always required during loading and unloading operations by the TS, and can vary between 1300-1900 ppm, depending on the assembly class as specified in the SAR. At a maximum enrichment of 5.0 wt% ^{235}U, a minimum soluble boron concentration between 1900-2600 ppm is required by the TS, based on assembly class. Both of these minimum concentration loading limits are identified in Tables 6.1.5 and 6.1.6 in the SAR.

BWR fuel assembly types stored in the HI-STAR 100 cask are unchanged from the previously approved amendment, including the 7x7A and 6x6B fuel designations, and continue to be bounded by the 10x10A assembly class analysis, and also include Thoria Rod Canisters as an allowable content in the MPC-68. The NRC compared the analyses performed by the applicant in the previous approval for HI-STAR 100 Amendment No. 0 (SER ADAMS Accession No. ML070260547), which demonstrated that the reactivity was bounded by the 10x10A assembly classes, with the fuel specificatioms for the HI-STAR 100 cask. The staff finds that the HI-STAR 100 Amendment No. 0 analyses are conservative for application in the HI-STAR 100 cask, and therefore acceptable for use in this amendment.

7.3 Model Specification

The applicant used the similar model specifications and material properties that were previously approved for the HI-STAR 100 transportation package as well as the previously approved HI-STORM 100 storage system for both the MPC-24 and MPC-32 configurations. As such, the applicant evaluated a single package and package arrays for both normal and hypothetical accident conditions for the configurations as shown in Figures 6.3.1 through 6.3.7 of the SAR.

The calculational models explicitly define the fuel, cladding, neutron absorber panels, guide tubes and water gaps. For the fully flooded cases, the applicant conservatively modeled fresh water both above and below the MPC in all instances where borated water was assumed to be in the cask during loading and unloading operations, and performed parametric studies of the various boron concentrations to determine the reactivity effect in order to determine the most conservative models to be used in the analysis.

The applicant also assessed the off-center positioning of assemblies within the fuel storage locations, which had not been done in previous revisions to this SAR, to determine the maximum effective multiplication factor (k_{eff}) values. Three different configurations were analyzed to bound any potential configuration of the fuel assemblies: center configuration (as was previously approved); basket center configuration (where assemblies are shifted toward the center of the basket); and basket periphery configuration (where assemblies are shifted away from the center of the basket). The results of the most reactive configurations are shown in Table 6.3.6 and indicate that the basket center configuration for the MPC-32 is slightly more reactive than the baseline case and as a result this configuration is used as the basis for the remainder of the criticality analysis performed by the applicant.

7.4 Criticality Analysis

The applicant utilized the MCNP4a Monte Carlo code with continuous energy cross-section data based on ENDF/B-V data library to perform its criticality analyses. The applicant used NITAWL-KENO5a with the 238-group cross-section library which is also based on ENDF/B-V data library to perform independent verification calculations in their criticality analyses. The applicant also used the CASMO-3 code to determine small incremental reactivity effects based on manufacturing tolerances, the results of which were used to establish the magnitude of tolerances for input into the MCNP4a calculations.

The applicant utilized the analyses performed for the approved HI-STAR 100 transportation package, CoC No. 9261, Rev. 5 (ADAMS Accession No. ML023240007) and those analyses performed for the approved HI-STORM 100, Amendment No. 1 (ADAMS Accession No. ML003748023) storage system as applicable to the revisions requested in this amendment to the HI-STAR 100 storage cask. The applicant relied on the technical justifications, calculations, and methodologies performed in these NRC-reviewed and approved documents, and did not perform additional analyses. Rather, the applicant integrated these already approved analyses into the SAR where applicable to address the additions proposed in this amendment; namely, the addition of the MPC-32 configuration, Metamic neutron absorber, and soluble boron for loading/unloading operations for both the MPC-24 and MPC-32.

The applicant also looked at the effects of PWR assemblies with annular fuel pellets located in the top and bottom of fuel rods. These pellets alter the fuel to moderator ratio in these areas and could impact reactivity. The applicant evaluated up to 12 inches of annular fuel pellets in the top and bottom with varying inner diameters and found that due to the increased neutron leakage at the top and bottom of the assemblies, there was no discernable effect on reactivity over solid pellets, and therefore fuel rods in the top and bottom 8 inches would be bounded by the solid pellet analysis.

The NRC staff reviewed the SAR sections added to allow the additions presented in this amendment request, and the integration of this information into the existing licensing basis for the HI-STAR 100 storage cask. The staff also referenced the two supporting SARs that were utilized in this alignment effort to ensure the applicability of these analyses to this storage

certificate and found the application of these SARs acceptable for use in this amendment. In all instances, the maximum k_{eff} values, including all uncertainties and biases for the analyzed configurations remain adequately subcritical, consistent with the previously approved k_{eff} limits for the HI-STAR 100 cask system.

7.5 Burnup Credit

The applicant did not request any changes to this amendment of the HI-STAR 100 storage cask that would allow for burnup credit.

7.6 Evaluation Findings

F7.1 SSCs important to criticality safety are described in sufficient detail in the SAR to enable an evaluation of their effectiveness.

F7.2 The cask and its spent fuel transfer systems are designed to be subcritical under all credible conditions.

F7.3 The criticality design is based on favorable geometry, fixed neutron poisons, and soluble poisons of the spent fuel pool [as applicable]. An appraisal of the fixed neutron poisons has shown that they will remain effective for the term requested in the CoC application and there is no credible way for the fixed neutron poisons to significantly degrade during the requested term in the CoC application as found in F8.2 of this SER; therefore, there is no need to provide a positive means to verify their continued efficacy as required by 10 CFR 72.124(b).

F7.4 The analysis and evaluation of the criticality design and performance have demonstrated that the cask will enable the storage of spent fuel for the term requested in the CoC application.

The staff concludes that the criticality design features for the HI-STAR 100 continue to be in compliance with 10 CFR Part 72, and that the applicable design and acceptance criteria have been satisfied. The evaluation of the criticality design provides reasonable assurance that the HI-STAR 100 will continue to allow for the safe storage of spent fuel with the modifications proposed by this amendment. This finding is reached on the basis of a review that considered the regulation itself, appropriate RGs, applicable codes and standards, and accepted engineering practices.

8.0 MATERIALS EVALUATION

8.1 General

The applicant describes multiple changes for the HI-STAR 100 Amendment No. 3 storage system. The primary change related to the materials review is the addition of the MPC-32. Other changes in the application include:

1. Use of the Metamic neutron absorber for MPC-32, MPC-24 and MPC-68.
2. Incorporation of FHD System.
3. Horizontal storage of casks.
4. Updated fuel cladding temperature limits.

5. Revised definitions of damaged fuel assembly, DFC, and ZR (any zirconium-based fuel cladding or fuel channel material authorized for use in a commercial nuclear power reactor).
6. Revised vacuum drying conditions.
7. Included ASME B&PV Code Section II and the following ASME Code Exceptions in Subsection NCA, NB-1100, NB-3100, NG-3100, NF-3100, NB-3350, NB-2000, NB-1130, NB-4120, NG-4120, NF-4120, NB-4220, NF-4220, NB-4220, NG-4220, NB-5239
8. Revised drawings.

With the new addition of MPC-32, the materials review followed ISG-15, “Materials Evaluation,” including other changes made.

8.2 Materials Selection

The MPC Alloy X materials (for various types of stainless steel) are provided in the ASME Code Section II. The ASME Code only provides allowable stress values to -20 ˚F (-29 ˚C). For the design temperature of the MPC (-40 ˚F (-40 ˚C) to 725 ˚F (385 ˚C)), material strength properties become increasingly favorable as the temperature drops. The applicant conservatively assumed in its assessment that temperatures will reach -40 ˚F (-40 ˚C) throughout the structure. All structural analyses are performed at the design-basis temperature of material strength, which is set higher than the component would experience with the design basis heat load under normal conditions. Assuming the system at -40 ˚F (-40 ˚C) would only serve to increase the safety margins as the material strength increases with decreasing temperature. The thermal conductivity decreases with the decreasing temperature. The thermal conductivity value for -40 ˚F (-40 ˚C) is linearly extrapolated by the applicant from the 70 ˚F (21 ˚C) value using the difference from 70 ˚F (21 ˚C) to 100 ˚F (38 ˚C), as data are not available. The staff reviewed this information and determines that these practices were approved by the NRC in HI-STAR 100 Amendment No. 2 (ADAMS Accession No. ML011500503). They are applicable here because the MPC-32 is constructed of the same materials as previous MPCs, and, therefore, are acceptable.

Cryogenic brittle fracture properties of Alloy X are presented at the lowest service temperature. Stainless steel does not undergo a ductile-brittle transition in the minimum temperature range of the HI-STAR 100 system. The staff reviewed RG 7.8, “Load Combinations for the Structural Analysis of Shipping Casks for Radioactive Material” (ADAMS Accession No. ML003739501), NUREG/CR-3826, “Recommendations for Protecting Against Failure by Brittle Fracture in Ferritic Steel Shipping Containers Greater than Four Inches Thick,” and ASME Code Section III, Subsection NF, for ductile-brittle transition for stainless steels. The application is consistent with these guides and standards and, therefore, the applicant’s assessment of brittle fracture is acceptable.

The applicant presented a list of adopted ASME B&PV Code exceptions (as listed in item 7, above in Section 8.1) and the addition of Section II of the ASME B&PV Code, to approve the additional MPC-32. The staff reviewed ASME B&PV Code Exceptions used for other Holtec storage casks (e.g., HI-STORM 100), and determined that the exceptions, justifications and compensatory measures provided by Holtec are acceptable. The ASME B&PV Code Section II has been used in storage cases to determine material properties and, therefore, its use is acceptable.

Non-structural materials used in this amendment include the neutron shield, neutron absorber and aluminum conduction inserts. The staff notes that Holtite (neutron shield), Boral, and

Metamic (neutron absorber) properties were approved in Amendment No. 2 to the HI-STAR 100 CoC (ADAMS Accession No. ML011500503) previous applications within the same temperature conditions for the HI-STAR 100 Cask System Amendment No. 3. Therefore, the staff finds that the Holtite, Boral, and Metamic properties are acceptable. Recently, Holtec reanalyzed aluminum thermal aging over time in various applications or submittals for different aluminum alloy series. The staff notes that in this application of HI-STAR 100 Cask System Amendment No. 3, thermal aging aluminum properties for 1100 series was taken from "Aluminum Standards and Data 2003 (The Aluminum Association, 2003)." Based on the staff's independent review of the data (The Aluminum Association, 2003), the staff determined that the data provided by the applicant are sufficient to determine that the mechanical properties of the precipitation hardened aluminum alloy are acceptable because the assessment of thermal aging is acceptable.

Non-code materials must have adequate controls for their application and fabrication because no standards are applicable. Proprietary materials or alternative codes and standards should have adequate material specifications/requirements and quality control information. For non-code welds, the applicant follows the provisions of either ASME B&PV Code Section IX or American Welding Society [AWS]. For non-code materials, the applicant uses Alloy X or other equivalent material. Appendix 1.C provides non-code miscellaneous material data. The staff determines the data of non-code miscellaneous material are acceptable, based on the staff's review of manufactures' data in literature.

The horizontally-oriented casks are supported by a structure that holds the casks and prevents their movement during design-basis events. The thermal performance (i.e., temperature) of the cask under horizontal storage conditions while mounted in the support structure is the same as or superior to the horizontal transport conditions (details in SER Chapter 4).

Editorial changes were made in the drawings, including options of the use of (i) SA 350 LF steel for inner shell and (ii) fillet welding of inner shell and bottom plate. The applicant complies with the ASME BPVC Section II, NB, for the use of SA 350 LF steel, and the fillet welding was previously used. The staff finds the use of the ASME BPVC consensus standard acceptable.

8.3 Chemical and Galvanic Reactions

Carbon steel is not in contact with water, and the internal and external steel surfaces of the overpacks are coated to prevent corrosion (SAR Section 3.4.1). Accordingly, staff did not conduct further analysis of chemical and galvanic reactions.

8.4 Spent Fuel Cladding Integrity

The applicant proposed revisions to the definitions of damaged fuel assembly, damaged fuel canister and ZR. The staff reviewed the proposed changes and determined that they are consistent with ISG-1, Rev. 2 and the ASME B&PV Code. The staff also determined that the proposed changes to the definitions of non-fuel hardware are consistent with the definitions previously approved for MPC-24, which is applicable for MPC-32. Therefore, the staff finds these changes acceptable.

The temperature limits of cladding under normal, off-normal, and accident conditions are consistent with the recommendations in ISG-11, Rev. 3. The burnable poison rod assembly (BPRA) fuels were previously authorized in Amendment No. 2 to for the MPC-24. The BPRA control element and thimble plugs were previously approved in MPC-24. The staff finds the cooling time and burnup are the same as previously approved, therefore, the use of non-fuel

hardware (BPRA control element and thimble plugs) are acceptable for use in the MPC-32. BPRA control elements may release more gas pressure (e.g., helium). The applicant studied the conditions of 1, 10 and 100% cladding failure on thermal, structural, confinement, shielding and criticality. The staff finds the applicant's studies acceptable concluding that no safety issues were identified from these practices.

Pacific Northwest National Laboratory (PNNL) data, PNNL-17722, "PNNL Stress/Strain Correlation for Zircaloy," on mechanical properties can be used on the cladding mechanical properties. The staff finds the use of PNNL data acceptable based on the staff's use of the data in Amendment No. 2 to CoC No. 1008 for the MPC-24.

In drying fuels, both the free volume of the MPCs and the annulus (Figures 1.1.2 and 1.2.1) between the external surface of the MPC and the inside surface of the overpack are inerted with commercially pure helium gas during the fuel loading operations. The helium purity is 99.99% and, therefore, it is compatible with 3 torr criteria during vacuuming, as recommended in American Society for Testing and Materials (ASTM) Guide. Therefore, the staff finds the vacuum procedure acceptable.

A method of fuel drying, such as accepted FHD, is used if the cladding temperature limits are not met during operations. Although the FHD System is monitored during its operation, stoppage of FHD operations does not require actions to restore forced cooling for adequate heat dissipation. The condition of natural convection cooling shows from model calculations that the fuel temperatures remain below off-normal limits. An FHD malfunction is detected by operator response to control panel visual displays and alarms. The staff finds the use of FHD acceptable when the cladding temperature limits are met with the detailed operational procedures described.

8.5 Evaluation Findings

F.8.1. The staff has reasonable assurance that the SSCs important to safety for the MPC-32 and the horizontal emplacement structure are described in sufficient detail in the SAR. The staff has reasonable assurance that the material changes made in MPC-24 and MPC-68 described are in sufficient detail in the SAR. The materials properties are consistent with RG 7.8 and NUREG-3826, and ASME B&PV Code exceptions.

F.8.2. Non-structural materials used in this amendment include the neutron shield, neutron absorber, and aluminum conduction inserts. Holtite (neutron shield), Boral, and Metamic (neutron absorber) properties were approved in previous applications within the same temperature conditions for the HI-STAR 100 Cask System Amendment No. 3. The staff has assurance that aging of aluminum alloys is within the acceptable limit.

F.8.3 The staff has reasonable assurance that non-code materials have adequate material/requirements and quality control information. For non-code welds, ASME B&PV Codes, ASW standards, or open literature data are used.

F.8.4. The applicant has met the requirements of 10 CFR 72.122(h)(1) and 236(h). The design of the dry cask storage system and selection of materials adequately protects the spent fuel cladding against degradation that might otherwise lead to gross rupture of the cladding. The temperature limits are met and drying procedures are adequate. No galvanic reactions are expected.

F.8.5. The applicant has met the requirements of 10 CFR 72.236(h) and 236(m). The material of construction for SSCs important to safety will be maintained during normal, off-normal, and accident conditions of operation so the spent fuel can be readily retrieved without posing operational safety problems.

F.8.6. The applicant has met the requirements of 10 CFR 72.236(g). The materials of construction for SCCs important to safety will be maintained during all conditions of operation so the spent fuel can be stored for a minimum of 20 years and maintenance can be conducted as required.

F.8.7 The applicant has met the requirements of 10 CFR 72.236(h). The HI-STAR 100 Cask System employs materials compatible with wet and dry spent fuel loading and unloading operations and facilities. These materials should not degrade over time or react with one another during any conditions of storage.

8.6 References

The Aluminum Association, "Aluminum Standards and Data 2003," 2003.

ASTM Guide, C 1553-08, "Standard Guide for Drying of Spent Nuclear Fuel."

Geelhood, K.J., C.E. Beyer and W.G. Luscher, "PNNL Stress/Strain Correlation for Zircaloy," PNNL-17700, Pacific Northwest National Laboratory, 2008. NRC Interim Staff Guidance (ISG) – 11, Revision 3, "Cladding Considerations for the Transportation and Storage of Spent Fuel."

9.0 OPERATING PROCEDURES EVALUATION

The operating procedures review ensures that the applicant's SAR presents acceptable operating sequences, guidance, and generic procedures for identified key operations. The applicant updated the operating procedures to revise the procedures for MPC cavity reflooding and to make editorial changes to the procedures, for constancy with other Holtec storage cask operating procedures.

Staff reviewed the changes to the operating procedures that incorporate the changes to TS 2.1.4, "MPC Cavity Reflooding," which replaced the existing helium exit temperature requirement with a requirement on the MPC cavity pressure. Based on the staff's review of the proposed changes to TS 2.1.4 and comparing them to the same changes made in HI-STORM 100 Amendment No. 3 in TS 3.1.3 (ADAMS Accession No. ML071500376), the staff found that the technical evaluation for the HI-STORM 100 is applicable to the HI-STAR 100, and therefore finds the proposed change acceptable.

F9.1 The technical bases for the changes to the operating procedures described in the SAR are adequate to protect health and minimize danger to life and property. Detailed procedures will need to be developed and evaluated on a site-specific basis.

The staff concludes that the generic procedures and guidance for operation of the HI-STAR 100 storage system are in compliance with 10 CFR Part 72 and that the applicable acceptance criteria have been satisfied. The evaluation of the operating procedure descriptions provided in the SAR offers reasonable assurance that the system will enable safe storage of spent fuel. This finding is based on a review that considered the regulations, appropriate RGs, applicable codes and standards, and acceptable practices.

10.0 ACCEPTANCE TESTS AND MAINTENANCE PROGRAM EVALUATION

The objective of the acceptance tests and maintenance program review ensures that the applicant's SAR includes the appropriate acceptance tests and maintenance programs for the system.

The applicant made editorial changes to the acceptance tests and maintenance program and included, as appropriate, acceptance tests and maintenance program items included in this amendment. These items are discussed in Chapters 3 through 8 of this SER.

11.0 RADIATION PROTECTION EVALUATION

The objective of the review of this section is to determine whether the radiation protection design features, design criteria, and operating procedures, as appropriate, of the HI-STAR 100 storage cask meet regulatory dose requirements for the MPC-32. The regulatory requirements for providing adequate radiation protection to site licensee personnel and members of the public include 10 CFR Part 20 and 10 CFR 72.236(d).

11.1 Radiation Protection

Since the operational exposure estimates are based on the MPC-24, which is bounding for most dose rates around the HI-STAR 100 (see section 6.4, above), the applicant did not revise the dose estimates to workers. While the MPC-24 dose rate on the top of the cask when drained of water is not bounding, none of the dose rate estimates to workers use the dose rate in the radial center of the storage cask lid or bottom. Therefore, since all dose rates used to calculate worker dose are bounding, the MPC-24 dose estimates to workers is representative of the MPC-32.

The applicant replaced the figure showing the location for dose rate measurements with a description of the same locations. The staff reviewed the description and determined that the locations of dose rate measurements have been adequately described.

11.2 Dose at the Controlled Area Boundary

In Chapter 5, the applicant determined the dose rates for the HI-STAR 100 containing the MPC-32. The applicant provided revised calculations to estimate the dose to a real individual beyond the controlled area boundary for the MPC-32. The applicant also calculated the doses to a real individual for several different array variations from a single cask to a 2×5 array of casks. In the dose calculations, the applicant assumed that an individual is located at the distance to the controlled area boundary shown in Table 5.1-7 for the various arrays for an entire year (8760 hours).

As shown in Table 5.1-7, the off-site dose rates to a real individual for various arrays of the MPC-32 inside of a HI-STAR 100 overpack is bounded by the corresponding dose rates for the MPC-24, which was approved in the initial issuance of the HI-STAR 100 certificate. In addition, the applicant calculated the distance to controlled area boundary for each array. The distance to the controlled area boundary is the same for the MPC-32 as for the MPC-24.

The applicant had demonstrated that—with the addition of the MPC-32—the radiation shielding and confinement features are sufficient to meet the radiation protection requirements of 10 CFR Part 20 and 10 CFR 72.236.

The staff reviewed the applicant's evaluation of offsite dose estimates from direct radiation and found them acceptable. Chapters 5 and 6 of this SER present the staff's evaluation of the confinement and shielding analyses. Since the storage cask is leaktight, in accordance with ANSI N14.5, the staff concludes any calculated dose rates from design-basis confinement releases would be insignificant compared to the dose rates from direct radiation. Therefore, direct radiation (including skyshine) would be the primary dose pathway to individuals beyond the controlled area during normal and off-normal conditions. As expected, since the dose rates from the MPC-32 canister on the majority of the surface area of the cask are bounded by the dose rates from the MPC-24, the offsite dose rates for the MPC-32 are bounded by the dose rates from the MPC-24. Therefore, the staff has reasonable assurance that the storage cask will meet the regulatory dose criteria in 10 CFR 72.236(d).

12.0 ACCIDENT ANALYSES

The applicant made editorial changes to the accident analysis to incorporate information from other Holtec dockets for consistency and updated the chapter to include changes evaluated for this amendment. These items are discussed in Chapters 3 through 8 of this SER. Since the MPC-32 dose rates are bounded by the MPC-24 dose rates and the MPC-32 maximum weight is less than the design weight evaluated for issuance of the initial CoC, there were no new dose analyses performed.

13.0 TECHNICAL SPECIFICATIONS AND OPERATING CONTROLS AND LIMITS EVALUATION

13.1 Review Objective

The objectives of this review were to ensure that the changes to the operating controls and limits or the TS in CoC No. 1008 Amendment No. 3, continue to meet the requirements of 10 CFR Part 72. The evaluation is based on information provided by the applicant in this revision request, a review of the SAR, and consideration of accepted practices.

All of the proposed changes listed above in the summary, including those listed as TS changes were evaluated in the previous sections of this SER, except for the change in location of the dose rate measurements and deletion of duplicative definitions, TS 3.1, 3.2, and 3.3, in Appendix B.

13.2 Revision of Dose Rate Measurement Location

The Holtec staff revises Technical Specification A2.2.1, "OVERPACK Average Surface Dose Rates" to delete the figure showing the locations for measuring dose rates and replace it with a description of the locations. The locations specified in Surveillance Requirement 2.2.1.1 specify the same locations as the figure and are the same as the descriptions used for the HI-STORM 100 storage cask (Docket No. 72-1014). The NRC reviewed the descriptions of the locations for dose rate measurement and determined that they adequately describe the same locations for dose rate measurements that was previously depicted in Figure 2.2.1-1.

13.3 Deletion of Duplicative Definitions and Technical Specification 3.1, 3.2, and 3.3

The Holtec staff proposed deletion of all the definitions in Appendix B to the TS and added a reference to the definitions in Appendix A. Since all the definitions in Appendix B were duplicated in Appendix A, staff finds that these items have not changed and agrees that the change is editorial.

The staff reviewed the proposed change and compared it to the applicable regulatory guidance and requirements in NUREG-1745, "Standard Format and Content for TS for 10 CFR Part 72 Cask Certificates of Compliance" (ADAMS Accession No. ML011940387), and 10 CFR Part 72, respectively. Staff noted that 10 CFR 72.44(b)(4) requires licensees (both general and specific) to have an NRC-approved program in effect that covers the training and certification of personnel operating important to safety equipment and controls. Staff also noted that NUREG-1745, which provides guidance for the standard format and content of the TS, does not include a training program provision. Therefore, the staff finds the proposal to remove TS 3.1 for a training program acceptable because 1) 10 CFR Part 72 already requires a training program and 2) it is consistent with the guidance in NUREG-1745.

Technical Specifications 3.2, and 3.3, "Pre-Operational Testing and Training Exercise," and "Special Requirements for First Systems in Place," respectively, were moved to the certificate in Condition Nos. 9 and 10. Neither of the requirements were changed.

13.4 Findings

F13.1 The staff finds that CoC No. 1008, continues to identify necessary TS to satisfy 10 CFR Part 72 and that the applicable criteria of 10 CFR 72.236 have been satisfied. The proposed TS changes provide assurance that the HI-STAR 100 Cask System will continue to allow safe storage of spent nuclear fuel.

14.0 QUALITY ASSURANCE EVALUATION

The applicant proposed changes to the quality assurance program applied to safety significant activities that included excerpts from the HI-STORM UMAX docket. Since these changes were already approved by NRC under the UMAX Amendment No. 0 SER dated April 2, 2015 (ADAMS Accession No. ML15093A498), the Staff finds them to be acceptable. The licensee's description of the quality assurance program continues to be in compliance with applicable NRC regulations and industry standards.

15.0 CONCLUSIONS

Based on its review of the revision request to CoC No. 1008, Amendment No. 3, the staff determines that there is reasonable assurance that: (i) the activities authorized by the amended certificate can be conducted without endangering the health and safety of the public and (ii) these activities will be conducted in compliance with the applicable regulations of 10 CFR Part 72. Therefore, the amendment should be approved.