CERTIFICATE OF COMPLIANCE
FOR RADIOACTIVE MATERIAL PACKAGES

1. a. CERTIFICATE NUMBER	b. REVISION NUMBER	c. DOCKET NUMBER	d. PACKAGE IDENTIFICATION NUMBER	PAGE		PAGES
9373	1	71-9373	USA/9373/B(U)F-96	1	OF	5

2. PREAMBLE

a. This certificate is issued to certify that the package (packaging and contents) described in Item 5 below meets the applicable safety standards set forth in Title 10, Code of Federal Regulations, Part 71, “Packaging and Transportation of Radioactive Material.”

b. This certificate does not relieve the consignor from compliance with any requirement of the regulations of the U.S. Department of Transportation or other applicable regulatory agencies, including the government of any country through or into which the package will be transported.

3. THIS CERTIFICATE IS ISSUED ON THE BASIS OF A SAFETY ANALYSIS REPORT OF THE PACKAGE DESIGN OR APPLICATION

a. ISSUED TO *(Name and Address)*

Holtec International
1 Holtec Blvd.
Camden, NJ 08104

b. TITLE AND IDENTIFICATION OF REPORT OR APPLICATION

Holtec International Report No. HI-2146214.*Safety Analysis Report on the HI-STAR 190 Package,* Revision 3, dated November 2, 2018

4. CONDITIONS

This certificate is conditional upon fulfilling the requirements of 10 CFR Part 71, as applicable, and the conditions specified below.

5.

(a) Packaging

(1) Model No.: HI-STAR 190

(2) Description

The HI-STAR 190 packaging consists of five major components: the overpack, the multi-purpose canister (MPC), the MPC spacer, the impact limiters, and the personnel barrier.

The overpack is a right circular cylinder featuring a containment vessel formed by a nickel steel shell welded to a nickel steel baseplate and to a nickel steel top forging. The overpack also features collapsible trunnions. The top forging has a bolted closure lid with two machined concentric grooves for elastomeric seals. The outer surface of the overpack inner shell is buttressed with a layered combination of lead, steel and neutron shielding material. The overpack provides the containment boundary, the helium retention boundary, gamma and neutron radiation shielding, and heat rejection capability of the package. The containment system consists of the overpack inner shell, bottom plate, top flange, top closure plate, top closure inner O-ring seal, vent port plug and seal, and drain port plug and seal. The overpack is approximately 320 inches long, with an inside diameter of 76 inches, and an outer diameter of approximately 106.5 inches without impact limiters and 128 inches with impact limiters.

The MPC models, designated as MPC-37 and MPC-89, are welded cylindrical structures with flat ends and have identical exterior dimensions, i.e., outer diameter and cylindrical height. Each MPC consists of a honeycombed fuel basket made from panels of Metamic-HT, baseplate, canister shell, lid, and closure ring.

5.(a)(2) Description (continued)

The MPC steel spacers, made of a cylindrical steel shell with flat ends and positioned at both ends of the MPC, may be used to transport MPCs of various lengths to restrict axial movements and control the center of gravity of the package.

Two identical impact limiters, fabricated of aluminum honeycomb completely enclosed by an all-welded austenitic stainless steel skin, are attached to the top and bottom of the overpack with 16 bolts.

The personnel barrier, placed over the package lying in a horizontal orientation during transport, is a packaging component when in use. It provides a physical barrier to prevent access to hot areas of the package.

The HI-STAR 190 packaging includes two versions, SL for a standard cavity length of 190 3/16 inches or XL for an extended cavity length of 213 5/16 inches, to accommodate all canisters. The SL version weighs approximately 238,944 pounds and the XL version weighs 260, 567 pounds. The closure lid sub-assembly weighs the same, 12,987 pounds, in each configuration. The maximum gross weight for transportation (including the overpack, the MPC, the contents, and the impact limiters) is nominally 417,000 pounds.

(3) Drawings

(a) HI-STAR 190 Cask Assembly Drawing 9841, Sheets 1-5, Rev. 1

(b) MPC-37 Enclosure Vessel Drawing 6505, Sheets 1-4, Rev. 19

(c) MPC-37 Fuel Basket Drawing 6506, Sheet 1, Rev. 13

(d) MPC-89 Fuel Basket Drawing 6507, Sheet 1, Rev. 12

(e) MPC-89 Enclosure Vessel Drawing 6512, Sheets 1-3, Rev. 20

(f) HI-STAR 190 Impact Limiter Drawing 9848, Sheets 1-3, Rev. 1

(g) Damaged Fuel Container (DFC) Drawing 10234, Sheets 1-5, Rev. 0

(h) Enhanced Damaged Fuel Container Drawing 11107, Sheets 1-2, Rev. 1

(i) HI-STAR 190 MPC Spacer Ring Drawing 9849, Sheet 1, Rev. 0

(b) Contents

(1) Type and form of material

(a) PWR and BWR fuel assemblies with the characteristics listed in Tables 7.C.1, 7.C.2, and 7.C.3 of the application, and with fuel assembly cross section characteristics as defined in Section 6.D.5 of the application.

5(b) Contents (Continued)

(b) Damaged fuel assemblies and fuel debris meeting the configurations described in Table 7.C.5 for PWR fuel assemblies and Table 7.C.6 for BWR fuel assemblies.

(2) Maximum quantity of material per package:

37 Pressurized Water Reactor (PWR) fuel assemblies in the MPC-37.

89 Boiling Water Reactor (BWR) fuel assemblies in the MPC-89.

6. The Criticality Safety Index (CSI) is 0.0.

7. In addition to the requirements of Subpart G of 10 CFR Part 71:

(a) The package shall be prepared for shipment and operated in accordance with the Operating Procedures in Chapter 7 of the application; and

(b) The package must meet the Acceptance Tests and Maintenance Program of Chapter 8 of the application.

8. Additional operating requirements of the Model No. HI-STAR 190 package include:

(a) Verification that the fuel assemblies to be placed in the MPC meet the post-irradiation minimum cooling time, maximum burnup, maximum decay heat load, and minimum initial enrichment per assembly, as listed in Tables 7.C.8 and 7.C.10 for the MPC-37 and the MPC-89, respectively.

(b) For burnup values not listed in Tables 7.C.8(a), 7.C.8(b), and 7.C.10, minimum enrichment and minimum cooling time can be determined by linear interpolation, except for the bottom two lines, between 45,000 and 60,000 MWd/MTU, of Table 7.C.8(b). Interpolations are only permitted between values within a single column (same heat load) and only if the cooling time increases with burnup.

(c) Verification of the burnup of PWR spent fuel assemblies that need to meet the burnup requirements specified in Table 7.C.4(a) of the application, in accordance with Appendix 7.D of the application.

(d) Verification of the allowable heat load patterns for loading, as identified in Table 7.C.7 for the MPC-37 and Table 7.C.9 for the MPC-89, with cell identifications shown in Figures 7.C.1 and 7.C.2 respectively.

(e) Undamaged PWR or BWR fuel assemblies may have missing fuel rods, provided they are replaced with a dummy rod that displaces an equal or greater volume of water than the fuel rod.

8. Additional operating requirements of the Model No. HI-STAR 190 package (continued)

   (f) Low-enriched, channeled BWR fuel, for which the cladding condition is indeterminable, may be transported in the MPC-89 canister. For this fuel, the channel must be attached to the fuel assembly, must be essentially undamaged, and the maximum planar average initial enrichment of the assembly must be less than or equal to 3.3 weight percent ^{235}U. When present in the canister, all intact fuel is also limited to 3.3 weight percent ^{235}U initial maximum planar average enrichment.

9. Additional acceptance test requirements of the Model No. HI-STAR 190 package include:

   (a) In addition to the radial points described (three cross sectional planes through the radial shield and at four points along each plane's circumference) in Section 8.1.6 and 8.2.3.2 for the shielding effectiveness tests and the periodic neutron shield tests respectively, points on the axial bottom of the package (impact limiter) shall also be included. For the package to be acceptable for use, the measured dose rates must not exceed the calculated dose rates. Measurements that exceed the calculated dose rates will require appropriate corrective actions to be taken.

   (b) For the shielding effectiveness tests, as described in Section 8.1.6 of the application, measurements of radiation levels of both gamma and neutrons shall be performed.

   (c) Prior to transport of MPCs containing high burnup fuel previously in dry storage for periods exceeding 5 years, a minimum of 20% of the MPCs to be shipped shall be subject to eddy current testing (ECT) capable of identifying surface defects (flaws) of depth, per the criteria in Table 8.1.13 of the application, anywhere on the external cylindrical surface of the MPC enclosure vessel. Any MPC identified to have a surface defect exceeding the maximum allowable flaw depth specified in Table 8.1.13 is not acceptable for transport, and shall require the remaining 80% of the MPCs to be shipped to undergo ECT. ECT inspections for a given shipment shall not be credited for future shipments.

10. The personnel barrier shall be installed and remain installed during transport, if necessary to meet package surface temperature and/or package dose rates requirements.

11. Transport of fissile material by air is not authorized.

12. The package authorized by this certificate is hereby approved for use under the general license provisions of 10 CFR 71.17.

13. Revision 0 of this certificate may be used until November 30, 2019.

14. Expiration date: August 31, 2022.

REFERENCES

Holtec International Report No. HI-2146214, *Safety Analysis Report on the HI-STAR 190 Cask System*, Revision 3, dated November 2, 2018.

FOR THE U.S. NUCLEAR REGULATORY COMMISSION

John McKirgan, Chief
Spent Fuel Licensing Branch
Division of Spent Fuel Management
Office of Nuclear Material Safety
and Safeguards

Date: November 27, 2018.

SAFETY EVALUATION REPORT
Docket No. 71-9373
Model No. HI-STAR 190 Package
Certificate of Compliance No. 9373
Revision No. 1

TABLE OF CONTENTS

SAFETY EVALUATION REPORT
Model No. HI-STAR 190 Package
Certificate of Compliance No. 9373
Revision No. 1

SUMMARY

By letter dated January 24, 2018, Holtec International submitted an application to revise the Certificate of Compliance (CoC) No. 9373 for the Model No. HI-STAR 190 package, as follows:

Revision of one of the loading configurations for the MPC-37 to provide more flexibility for allowable contents for transportation, including 2 Damaged Fuel Containers (DFCs) containing fuel debris (up to 37 rods per DFC), 10 DFCs containing damaged fuel and 25 undamaged fuel assemblies, 1 DFC loaded with fuel debris (up to 57 fuel rods), 11 DFCs containing damaged fuel and 25 undamaged fuel assemblies, and 12 DFCs containing fuel debris (up to 11 rods per DFC) and 25 undamaged fuel assemblies.

Addition of Guide Tube Anchors (GTAs) as Non-Fuel Hardware (NFH) to expand options for NFH to be allowed for transportation in the HI-STAR 190.

Addition of a new heat load pattern for the MPC-37 to cover damaged fuel assemblies with decay heat up to 1.1 kW/assembly, instead of 0.84 kW, to provide additional loading flexibility for the MPC-37.

Reduction of the minimum cooling time requirements for Neutron Source Assemblies (NSAs) from a current maximum of 14 years to a 7-year cooling time, independent of NSA burnup, for a package loaded with CE 16x16 fuel assemblies, in order to increase higher burnups NSAs available for transport in the HI-STAR 190.

Increase of the allowable activity limit for Axial Power Shaping Rods (APSRs) loaded with CE 16x16 fuel assemblies with higher Cobalt-60 activity.

Providing adequate justifications for the deletion of Condition No. 8(d) from the CoC to allow insertion of control rods that exceed 8 inches for CE 16x16 fuel assemblies to expand the permissible content conditions for the MPC-37 and increase the number of loaded fuel assemblies for transport in the HI-STAR190.

Adding a new DFC design, with a wider opening, to facilitate assembly insertion.

Making corrections to Charpy absorbed energy and lateral expansion impact testing values to align impact testing acceptance criteria with ASME Code Section III Subsection NF.

Revising a previous requirement to meet the minimum high burnup fuel (HBF) cladding temperature limit, since there is indeed no minimum cladding temperature limit in Chapter 8, with a new criterion to measure the cask surface temperatures and cask surface dose rates, before and after shipment.

The application was supplemented on July 31, 2018, in response to the staff's request for information dated June 13, 2018. Revision No. 3 of the application, dated November 2, 2018, superseded in its entirety the application dated January 24, 2018.

NRC staff reviewed the application using the guidance in "Standard Review Plan for Transportation Packages for Spent Nuclear Fuel," NUREG-1617, March 2000.

Based on the statements and representations in the application, and the conditions listed in the certificate of compliance, the staff concludes that the package meets the requirements of 10 CFR Part 71.

References

Holtec International "Safety Analysis Report on the HI-STAR 190 Package," Holtec Report No. HI-2146214, Revision No. 3, dated November 2, 2018.

1.0 GENERAL INFORMATION

1.1 Packaging

The HI-STAR 190 packaging consists of the following major components: the packaging body, the fuel baskets, the non-fuel waste basket, the impact limiters, and the personnel barrier.

The design of the packaging was not modified in this amendment request. The packaging body is comprised of a nickel steel shell welded to a stainless steel lower forging at the bottom and a stainless steel forging at the top. The closure system consists of two stainless steel closure lids, and the inner seal of each lid ensures both the containment and moderator exclusion functions of the package.

1.2 Contents

The contents for the Model No. HI-STAR 190 package were not changed for this amendment request although the applicant revised the definition of NFH by adding Instrument Tube Tie Rods (ITTRs) and GTAs, to expand the transportation options for NFH.

Higher burnups NSAs are also now available for transport in the Model No. HI-STAR 190 package. The allowable activity limit for APSRs loaded with CE 16x16 fuel assemblies has also been increased with higher Cobalt-60 activity.

1.3 Drawings

The drawing list was revised to add Drawing No. 11107, Sheets 1-2, Rev. 1, for the enhanced Damaged Fuel Canister (DFC) design, to enable loading of smaller sizes of fuel assemblies.

The other previously approved licensing drawings, i.e., HI-STAR 190 Cask Assembly Drawing 9841, Sheets 1-5, Rev. 1, MPC-37 Enclosure Vessel Drawing 6505, Sheets 1-4, Rev. 19, MPC-37 Fuel Basket Drawing 6506, Sheet 1, Rev. 13, MPC-89 Fuel Basket Drawing 6507,Sheet 1, Rev. 12, MPC-89 Enclosure Vessel Drawing 6512, Sheets 1-3, Rev. 20, HI-STAR 190 Impact Limiter Drawing 9848, Sheets 1-3, Rev. 1, Damaged Fuel Container (DFC) Drawing 10234, Sheets 1-5, Rev. 0, and HI-STAR 190 MPC Spacer Ring Drawing 9849, Sheet 1, Rev. 0 were not modified.

1.4 Evaluation Findings

A general description of the Model No. HI-STAR 190 package is presented in chapter 1 of the package application, with special attention to design and operating characteristics and principal safety considerations. Drawings for structures, systems and components important to safety are all included in the application.

The staff concludes that the information presented in this section of the application provides an adequate basis for the evaluation of the Model No. HI-STAR 190 package against 10 CFR Part 71 requirements for each technical discipline.

2.0 STRUCTURAL REVIEW

The scope of the structural review was limited to the evaluation of clarifications related to the Charpy absorbed energy and lateral expansion impact testing values proposed by the applicant and to additional clarifications related to bounding loads in the structural evaluations as a result of the response to staff's request for additional information. Such additional changes are contained in Sections 2.5, 2.6, 2.7 and 2.12 of the application.

In Section 2.1.2, "Design Criteria", the applicant corrects a number of typographical errors and provides additional clarifications regarding the Charpy absorbed energy and the Charpy lateral expansion requirements. The applicant refers to ASME Section III Code, Subsection NF 2.1.14, Figure NF-2331(a)-2) for guidance, and Table 8.1.8 of the application for a summary of test requirements. The staff reviewed the aforementioned ASME guidance and other appropriate sections of the application to conclude that the new text included in Section 2.1.2 further clarifies the Charpy impact testing acceptance criteria requirements per the ASME Code Section III Subsection NF impact testing.

Revision 3 of the application includes additional clarifying text in Sections 2.1, 2.5, 2.6 and 2.7. The added text refers to clarifications related to the statement from the applicant that all proposed fuel loading configurations, heat load patterns, and cooling times discussed in Chapter 7, "Package Operations," are enveloped by the structural evaluations in Section 2.5. Subsection 2.5.5 "Structural Integrity of Damaged Fuel Containers (DFCs)" was also added to provide additional clarifications related to the structural integrity of the DFCs. In the aforementioned subsection, the applicant explained the criteria needed to demonstrate compliance of the DFC. The staff reviewed the aforementioned inclusions and associated structural analyses of the DFC and concludes that the new information provides the necessary further clarifications to ascertain the structural adequacy of the package

Based on the review of the statements and representations in the application, the NRC staff concludes that the structural design has been adequately described and evaluated and that the package has adequate structural integrity and continues to meet the requirements of 10 CFR Part 71.

3.0 THERMAL REVIEW

The objective of the review is to verify that the thermal performance of the Model No. HI-STAR 190 package has been adequately evaluated for the tests specified under both normal conditions of transport (NCT) and hypothetical accident conditions (HAC) of transport and that the package design satisfies the thermal requirements of 10 CFR Part 71. This case is also reviewed to determine whether the package fulfills the acceptance criteria listed in Section 3 of NUREG-1617, "Standard Review Plan for Transportation Packages for Spent Nuclear Fuel," as well as associated Interim Staff Guidance (ISG) documents.

This amendment request was evaluated for the following changes that may affect the package thermal performance:

The applicant:

- (i) revised loading configuration 3 (Table 7.C.5) for the MPC-37,
- (ii) added GTAs as Non-Fuel Hardware (NFH) to Appendix 7.C,
- (iii) revised definition of NFH with the addition of Instrument Tube Tie Rods (ITTRs) and GTAs,
- (iv) added new heat load pattern 7 to Table 7.C.7 of the application for the MPC-37 that covers damaged fuel assemblies with an increased decay heat,
- (v) reduced the minimum cooling time requirements for NNSAs (Table 7.C.8(b)),

(vi) included additional restrictions on number and types of NFH devices and/or loading patterns,
(vii) increased the allowable activity limit for APSRs loaded with CE 16x16 fuel assemblies with higher cobalt-60 activity,
(viii) added Appendix 7.C to the application to provide a basis for staff to delete Condition 8(d) from the CoC, and
(ix) added a new DFC design to the application.

The applicant stated that all changes are bounded by previous design basis thermal analyses. When necessary, the applicant provided additional analysis to justify this statement. The staff reviewed the changes included in the application, and the additional thermal analysis provided by the applicant, and concluded that the thermal evaluation under normal conditions of transport, the thermal evaluation for short term operations, and the thermal evaluation under hypothetical accident conditions continued to be bounded by the design basis thermal analysis and results provided in the application.

These analyses were previously reviewed and evaluated by the staff and were found acceptable. Therefore, the staff finds the overall analysis approach and assumptions acceptable for the HI-STAR 190 thermal design because the description and provided analyses and results are consistent with NUREG-1617.

The staff reviewed the package description, the material properties, component specifications and the methods, used in the thermal evaluation, and found reasonable assurance that they are sufficient to provide a basis for evaluation of the package against the thermal requirements of 10 CFR Part 71.

The staff reviewed the accessible surface temperatures of the package as it will be prepared for shipment and concludes that the temperatures satisfy 10 CFR 71.43(g) for packages transported by exclusive-use vehicle.

The staff reviewed the package preparations for shipment and concludes that the package material and component temperatures will not extend beyond the specified allowable limits during normal conditions of transport, consistent with the tests specified in 10 CFR 71.71.

The staff also found reasonable assurance that the package material and component temperatures will not exceed the specified allowable short-time limits during hypothetical accident conditions, consistent with the tests specified in 10 CFR Part 71.73.

4.0 CONTAINMENT REVIEW

No change was made to the containment of the package.

5.0 SHIELDING REVIEW

The scope of the shielding review was limited to the evaluation of the changes proposed by the applicant to determine if the package still meets the regulatory requirements in 10 CFR Part 71.

In conducting its review, the staff referred to NUREG-1617, “Standard Review Plan for Transportation Packages for Spent Nuclear Fuel”, Division of Spent Fuel Storage and Transportation Interim Staff Guidance - 1, Revision 2, “Classifying the Condition of Spent

Nuclear Fuel for Interim Storage and Transportation Based on Function," the report HI-2167524, "HI-STAR 190 Source Terms and Loading Patterns using SCALE 6.2.1," Agencywide Documents Access and Management System (ADAMS) Accession No. ML18030A804), the report HI-951322, "HI-STAR 100 Shielding Design and Analysis for Transport and Storage," Revision 25, Holtec International (ADAMS Accession No. ML18242A094), the report HI-2002444, Revision 12, "Final Safety Analysis Report for the HI-STORM 100 Cask System, Page 5.0-1 through End (Non-Proprietary)." March 2014 (ADAMS Accession No. ML14086A414), Appendix 2E of DOE/RW-0184, "Characteristics of Spent Fuel, High-Level Waste, and Other Radioactive Wastes Which May Require Long-Term Isolation." December 1987, PNL-6906 Vol. 1, "Spent Fuel Assembly Hardware: Characterization and 10 CFR 61 Classification for Waste Disposal," June 1989, and NUREG/CR-6802, "Recommendations for Shielding Evaluations for Transport & Storage Packages," May 2003.

5.1 Changes to Configuration 3 for Loading Damaged Assemblies for Class 16x16

The applicant proposes to change the assemblies and locations that are allowed to contain damaged fuel and fuel debris. Currently, damaged fuel is allowed in the HI-STAR 190 within the MPC-37 in the 12 outer locations (Region 3) (Configuration 3), and for the 16x16A these 12 outer locations may also contain fuel debris (Configuration 1). The applicant has removed the allowance of fuel debris in the 12 outer locations for 16x16A assemblies and proposed several different loading options for fuel debris for the 16x16C fuel assembly class. As stated in the application, these are (i) 2 opposite cells can be loaded with fuel debris up to 37 rods or less per DFC, (ii) a single corner cell can be loaded with fuel debris up to 57 rods or less per DFC, or (iii) 12 outer cells can be loaded with fuel debris up to 11 fuel rods or less. These three options are for the outermost region of the MPC-37 (Region 3).

The applicant stated that this proposed change was bounded by the design basis dose rate analysis. The staff reviewed the information in the application which discusses how the applicant addresses damaged fuel in the shielding evaluation. The staff does not necessarily agree that the analyses referenced for the HI-TRAC or the HI-STAR 100 are applicable to the HI-STAR 190; however, the staff does find that the HAC reconfiguration scenario for high burn-up (HBF), discussed in the application, bounds that for the damaged fuel and fuel debris allowed in the MPC-37 for Configuration 3.

The staff did not find that this is applicable for normal conditions and, as shown in the application, the limiting dose rate is at 2 meters under NCT. Based on the information in ISG-1 Rev. 2, and the definition of damaged fuel within the glossary of the application, the staff does not agree with the statement in the application, which states that: "Damaged fuel assemblies under normal conditions, for the most part, resemble intact fuel assemblies from a shielding perspective."

The reconfiguration analysis discussed in the application shows, under NCT, that the scenarios most applicable to that of the proposed changes is Scenario 2, where the applicant assumed 3% of all HBF fuel collapsed in all cells. This scenario was considered in the bounding cases used to establish loading limits.

Although this scenario is not directly applicable to the changes proposed by the applicant (i.e. only applied to HBF fuel), the staff still has reasonable assurance that the transportation of the damaged fuel and fuel debris would not affect the package's ability to meet regulatory external dose rate limits based on the following qualitative reasons:

(1) Damaged fuel and fuel debris would be stored in DFCs which provide additional shielding,

(2) Even though scenario 2 is applicable to HBF fuel only, the applicant applied this scenario to all fuel within the MPC-37 (Regions 1, 2 and 3) for the shielding evaluation. With the exception of Pattern 7, the allowable decay heat loading patterns in the application require that assemblies on the periphery, i.e. those that would contain damaged fuel and fuel debris, have a lower decay heat, which generally correlates to lower source term. In regard to Pattern 7, half of the outer (Region 3) assemblies are allowed to have a higher heat load than the rest of the assemblies within the MPC-37, and damaged fuel and fuel debris are only allowed in 3 of these higher heat load cells.

(3) The amount of fuel debris allowed is significantly less than a full assembly.

Based on the discussion above, the staff found the applicant's proposed changes to the application, with respect to transporting damaged fuel and fuel debris, would not affect the ability of the HI-STAR 190 to meet regulatory dose rate limits.

5.2 Add Guide Tube Anchors (GTAs) as Non-Fuel Hardware (NFH) to Appendix 7.C.

The applicant states that GTAs are non-irradiated non-fuel hardware installed in the guide tubes post irradiation in the nuclear reactor. Because these are installed post-irradiation, there will be no appreciable source term included with these components and their presence, if anything, may act as additional shielding. There is some possibility that, if they are made of steel, there could be an increase in secondary gammas generated in the steel; however, due to these being within the guide tubes of the assembly, they are likely to interact with higher energy neutrons and therefore have a lower possibility of generating a secondary gamma.

Any secondary gammas would also likely be shielded by the fuel surrounding the guide tubes. The staff finds the inclusion of the GTA's within the application to be acceptable.

5.3 New heat load Pattern 7 to the application for MPC-37 that covers damaged fuel assemblies with decay heat up to 1.1 kW/assembly.

The applicant uses the decay heat patterns to develop the source terms used within the shielding evaluation. The allowable contents for each decay heat value are defined in the application. The applicant finds the bounding source term out of these allowable contents.

The loading patterns, used to perform the source term evaluations, are in Table 7.C.7 and the dose rates from Pattern 7 (the new pattern) are bounded by dose rates from other patterns reported in the application. Although the applicant is placing some higher decay heat assemblies on the periphery of the MPC-37, generally equating to a higher dose rate, the applicant is limiting this to half of the periphery locations; therefore, the other half would include relatively lower dose rate assemblies, thus balancing this increase. Also since fuel loading is limited to the fuel specifications in the application, the allowable decay heat is not of a significant consequence to the dose rate except for assigning allowable fuel specifications for each loading pattern.

The staff reviewed the allowable fuel specifications (burnup/enrichment/cooling time combinations) for the new pattern and determined that the changes to the burnup/enrichment/cooling times are either appropriately balanced (a non-conservative increase/decrease in a parameter is balanced by a conservative increase/decrease in another parameter) or are conservative, as compared to the previously approved fuel specifications. Thus, the staff finds that the calculated dose rate should be comparable. Since the applicant found the maximum dose rate of the new pattern to be below the regulatory limits, the staff found the addition of the new heat load pattern to be acceptable.

5.4 Reduce Cooling Time Requirements for NSAs and APSRs

The applicant proposed alternative fuel specifications and options within the loading tables for the 16x16 A, B, and C assembly types so that it could ship high activity APSRs and/or NSAs, as compared to the design basis APSR and NSA. One NSA is allowed to be shipped within the MPC-37.

> In option 1, NFH is allowed per the application, which is the NFH currently approved for loading, with the exception of thimble plug devices (TPDs), water displacement guide tube plugs, and orifice rod assemblies, which are not allowed. Burnable poison rod assemblies (BPRAs), wet annular burnable absorbers (WABAs), and vibration suppressor inserts require a minimum cooling time of 25 years. As stated in the application, dose rate evaluations include the presence of NFH and, after 25 years, the dose rate contribution from the BPRAs will be much less significant. Therefore, the staff found the inclusion of BPRAs that have decayed beyond 25 years, regardless of burnup, acceptable.
>
> In options 2 and 3, NFH is not allowed in Regions 1 and 3 (Region 1 is the innermost region, Region 3 is the outermost region) of the MPC-37 basket. The NFH allowed in Region 2 are: APSRs, control components, ITTRs, GTAs and one NSA. This option requires these components to have a cooling time of 7 years and burnup up to 630,000 MWD/MTU, with the exception of GTAs and ITTRs, which have no cooling time requirement. These options allow 12 APSRs/CRAs to be transported in Region 2. Option 2 allows 1 NSA to be included and the SNF is restricted to loading patterns 4, 5, and 6. Option 3 is available for all loading patterns in the application, and the SNF burnup is limited to 60,000 MWD/MTU.

The applicant discusses the source term assumed for the higher activity NSA and the APSRs/CRAs. The staff reviewed the assumptions used to establish the source term for the APSRs (including CRAs) and NSAs and verified that they are appropriate for the new limits (7 years cooling time regardless of burnup).

Regarding the activation modeling assumptions for the APSRs and CRAs, the applicant states that the source term from the APSRs bound that of the CRAs and therefore models the APSRs to represent both CRAs and APSRs. The applicant states that Configuration 1, with 10% insertion of CRAs and APSRs during operation, is bounding or similar to other configurations that were analyzed. There are no in-core insertion requirements on the APSRs allowed to be shipped in this option for the HI-STAR 190; therefore, the staff reviewed the modeling assumptions to determine if the 10% insertion is a conservative assumption versus assuming a fully inserted APSR. The staff reviewed information which does show that Configuration 1 (10% insertion) and Configuration 3 (fully inserted) result in similar dose rates. This is based on the model for the HI-TRAC (transfer cask for the HI-STORM 100) where the applicant assumed a BPRA present in the central 12 locations. The staff found that it was acceptable to model Configuration 1 (10% insertion) for the HI-STAR 190 based on the lid being a non-limiting location. The maximum dose rates [Tables 5.1.1 and 5.1.3 of Ref. 1] for the HI-STAR 190 show that the dose rates at the top of the package are significantly lower than the dose rate at the bounding location. Therefore, the staff found that the increase in dose rate at this location would be insignificant.

The staff reviewed the amount of Co-60 Ci/kg used by the applicant for the APSRs (and CRAs). The applicant calculated the curies/kg of Co-60 for a burnup range from 40,000 MWD/MTU up to 630,000 MWD/MTU. The value used by the applicant corresponds to the maximum curies/kg of Co-60 within this range: therefore, the staff found the analytical assumptions for the BPRAs for this option acceptable.

Regarding the physical modeling assumptions for the various kinds of CRAs and APSRs, the applicant states that the bounding material for the CRAs are the AgInCd due to the activation of Ag. For the two types of APSRs, gray and black, the applicant states that the gray APSRs produce a more bounding source term because of the activation of the Inconel produces more Co-60 than the black. Based on a review of the APSRs, which shows that the gray APSRs have more inconel than the black, the staff agrees with the applicant’s assessments and found that its selection of bounding types of CRAs and APSRs is acceptable. The application shows that, for the same conditions, the APSR source term bounds that of the CRAs. Therefore, the staff found it acceptable to represent the CRAs as APSRs. The applicant assumed 4.7 g/kg Co-59 impurity for the Inconel and 0.8 g/kg for the steel. The staff found these values to be conservative. The staff reviewed the assumptions used for the mass of the steel and Inconel for the APSRs and found them to be acceptable.

The applicant used SAS2H and ORIGEN-S to calculate the activation of the APSRs (and CRAs). The staff found the use of this code acceptable for this purpose.

The staff reviewed the activation modeling assumptions for NSAs as well as the gamma contribution from the NSAs. The applicant calculated the curies for Co-60 for a burnup range from 40,000 MWD/MTU up to 630,000 MWD/MTU. The value used by the applicant corresponds to the maximum curies of Co-60 within this range; therefore, the staff found the assumptions used to calculate the amount of Co-60 for the NSA acceptable.

The staff reviewed the steel and Inconel masses of the NSA within the application and found them acceptable, as consistent with the masses previously referenced. The applicant assumed the same Co-59 impurity for the Inconel and steel as the BPRAs (discussed above) and the staff also found this acceptable for the NSAs. The applicant used the amount of steel and Inconel. This is conservative and therefore found acceptable by the staff.

The staff reviewed the neutron contributions from the NSAs within the application and found the source strength reasonable. The energy assumed is approximately representative of that from an actinide/Be source or a Cf-252 source. The staff notes that these sources produce neutrons with an energy spectrum with a maximum energy higher than that assumed within the analysis; however, considering that the energy assumed by the applicant is representative of the average and there is only one neutron source allowed within the 37 assemblies of the MPC-37, the staff still found the representation to be reasonable.

5.5 Allow transport of CE 16x16 fuel assemblies that have experienced insertion of control rods that exceed 8 inches

The evaluation to calculate dose rates for the HI-STAR 190 currently does not assume that fuel assemblies are burned with a control rod present. The neutron spectra that the assembly experiences when a control rod is present is different than that when a control rod is not present, as the control rod absorbs much of the thermal neutrons that may otherwise cause a fission reaction. This changes the SNF nuclides generated in an assembly, as compared to one burned to the same burnup without the presence of a control rod.

The applicant performed an evaluation and presented results to show the uncertainty in the change in dose rates for the HI-STAR 80 when assuming control rods are present during irradiation. The results show that assuming control rods are present during irradiation either produces a lower source term or a negligible increase. Although this analysis was performed for the Model No. HI-STAR 80, and not the Model No. HI-STAR 190, it is the staff's judgment that the overall behavior would be similar. Therefore, the staff found that including transport of CE 16x16 fuel assemblies that have been burned with control rods inserted more than 8 inches within the Model No. HI-STAR 190 package is acceptable.

5.6 Add New DFC Design Drawing

The applicant neglected the DFCs within the shielding evaluation**.**

5.7 Other Changes:

The applicant proposed to remove a note, pertaining to the allowable contents for the MPC-89, that stated: "The lowest maximum allowable enrichment of any fuel assembly loaded in an MPC-89, based on fuel array class and fuel classification, is the maximum allowable enrichment for the remainder of the assemblies loaded in that MPC." The staff finds that removing this note is inconsequential with respect to meeting regulatory dose rates.

The minimum enrichments used within the dose rate evaluations in Chapter 5 to demonstrate that the package meets regulatory dose rate limits are from Table 7.C.8, and the staff finds that this table is sufficient to define the minimum enrichment needed to ensure that regulatory dose rate limits are met.

6.0 CRITICALITY REVIEW

Of the changes proposed by the applicant for this amendment request, only two have any effect on the criticality safety analysis of the system. The staff reviewed the criticality safety analyses of the HI-STAR 190 package with these modifications to determine whether the package still meets the regulatory requirements in 10 CFR Part 71.

In conducting its review, the staff referred to NUREG-1617, "Standard Review Plan for Transportation Packages for Spent Nuclear Fuel", and Interim Staff Guidance (ISG) No. 8, Revision 3, "Burnup Credit in the Criticality Safety Analyses of PWR Spent Fuel in Transportation and Storage Casks". This section summarizes the staff's criticality safety findings for the HI-STAR 190 package with the new configurations.

The applicant did not request any changes to the packaging design features for this revision. However, in conducting its review, the staff considered the criticality safety-relevant design features of the HI-STAR 190 packaging as part of its review, notably, the seal-welded enclosure vessel of the Multi-Purpose Canister (MPC), which is credited as an additional barrier for moderator exclusion when transporting high burnup fuel, and the fuel basket honeycomb within the MPC, which is composed entirely of Metamic-HT extruded borated metal matrix composite plates in a fixed geometry.

6.1 Changes to Configuration 3 for Loading Class 16x16 Damaged Fuel Assemblies

The applicant proposes amending its current CoC to add new options to loading configuration 3 for fuel assembly class 16x16C that will allow loading of fuel debris in different configurations within the MPC-37. The applicant refers to the fuel material to be transported in this configuration as "light-sized fuel debris", which is described in the application as consisting mainly of individual fuel rods and rod segments from the 16x16C fuel assembly along with a limited number of total fuel rods (up to 57 rods per DFC). Out of the 12 DFC cells that can be loaded with spent damaged fuel assemblies (per Configuration 3), several DFCs may be loaded with light-sized fuel debris; the allowed combinations of spent fuel rods per DFC and total numbers of DFCs that can be loaded with light-sized fuel debris are tabulated in Table 6.2.8 of the application.

To qualify the alternative loading patterns for configuration 3 for MPC-37 baskets containing light-sized fuel debris, undamaged fuel assemblies, and damaged fuel assemblies, the applicant used a range of enrichments and the combined polynomial function in Table 6.B.1 for the regionalized configuration of 16x16 assemblies. The light-sized fuel debris was modeled using a rectangular 14x14 array of bare 16x16C fuel rods containing fresh UO_2. The applicant determined that this array size is the most reactive in the previously approved analysis supporting failed fuel configurations for configuration 4.

The applicant shortened the active length of these rods such that they still contain the total amount of fuel consistent with the values listed in Table 6.2.8 and are located in the top axial portion of the DFC. The remainder of the DFC was flooded. This modeling approach is conservative, as the fuel debris, while modeled shorter than a full length fuel assembly, will be axially located adjacent to the most reactive ends of the intact and damaged fuel assemblies loaded in the remaining basket locations. The applicant considered the three loading patterns from Table 6.2.8:

- Loading Pattern 1: Two (2) DFCs with light-sized fuel debris with up to 37 fuel rods each
- Loading Pattern 2: One (1) DFC with light-sized fuel debris with up to 57 fuel rods
- Loading Pattern 3: Twelve (12) DFCs with light-sized fuel debris with up to 11 fuel rods each

The staff finds that the applicant adequately applied burnup credit techniques for both major actinides and all credited isotopes required in ISG-8, Revision 3 (with the exception of Eu-151, which was conservatively neglected).

For Loading Pattern 1, two sub-cases were evaluated: both DFCs adjacent to each other in the fuel basket or located opposite to each other in the fuel basket. Though the k_{eff} for the case in which both DFCs were adjacent to each other was still below the regulatory limit of 0.95, for added conservatism, the applicant is requiring that 2 DFCs containing light-sized fuel debris with up to 37 fuel rods each be loaded opposite each other in the basket. The staff finds that this provides an adequately conservative criticality safety margin for Loading Pattern 1.

For Loading Patterns 2 and 3, the calculated k_{eff} values are lower than the values for Loading Pattern 1. The table below lists the maximum k_{eff} values calculated for each Loading Pattern, taken from Table 6.B.28 of the SAR.

Loading Pattern #	Description	Enrichment, Percent	Maximum k_{eff}
1a	16x16C assembly, 2 *adjacent* DFCs with 37 fuel rods each	5.0	0.9499
1b	16x16C assembly, 2 *opposite* DFCs with 37 fuel rods each	5.0	0.9427
2	16x16C assembly, 1 DFC with light-sized debris with 57 fuel rods	5.0	0.9476
3	16x16C assembly, 12 DFCs with light-sized debris with 11 fuel rods	5.0	0.9175

Based on the discussion above, the staff found the applicant's proposed changes to the CoC, with respect to transporting damaged fuel and light-sized fuel debris, would not affect the ability of the HI-STAR 190 to meet the criticality safety requirements of 10 CFR Part 71.

6.2 Allow transport of CE 16x16 fuel assemblies that have experienced insertion of control rods that exceed 8 inches

The applicant proposes modifying Condition 8(d) of the current CoC to allow fuel assemblies exposed to insertion of control rods that exceed 8 inches for CE 16x16 fuel assemblies in the

MPC-37, deleting this modified condition from the CoC, and adding it to Appendix 7.C (Table 7.C.5 Note 2) of the application.

The applicant modified the application to include, as allowed contents for transport, “control rod-affected” assemblies, which are CE 16x16 assemblies in which part-length control rods have been inserted up to 41.7 inches from the top of the active fuel length during part or all of a fuel assembly’s irradiation history. Part-length control rods consist of predominantly solid Inconel over the bottom section of the rod, with Inconel tube above that and boron carbide (B_4C) absorber in the top section of the rod. The applicant also considered 16x16 fuel assemblies in which full-length control rods were inserted up to 33.3 inches from the top of the active fuel during irradiation. Current condition No. 8(d) of the HI-STAR 190 CoC limits full-length control rod exposure to eight inches from the top of the active fuel. The applicant provides criticality analyses for control rod-affected assemblies to demonstrate that the multiplication factor remains below 0.95.

In order to validate the loading curves for transportation of control rod-affected assemblies, the applicant performed calculations for CE 16x16A and 16x16B assembly classes having a range of enrichments and burnups that were calculated from the polynomial function tabulated in Table 6.B.1 of the application. Only the regionalized MPC-37 basket loading configurations (i.e., configurations 2-4) in conjunction with the combined loading curve for these three configurations were used, and the applicant evaluated two loading cases:

- Case 1: Assemblies that were located under a full-length control rod bank that was permitted to be inserted during full power operations but did not exceed 33.3 inches from the top of the active fuel length based on operating records. These assemblies are loaded into nine (9) regular cells in the center of the basket for a given regionalized loading configuration, and design-basis spent undamaged fuel assemblies are loaded into the remaining cells.

- Case 2: Assemblies that were located under a part-length control rod bank that was permitted to be inserted during full power operations but never exceeded 41.7 inches from the top of the active fuel length based on operating records. In this case, the assemblies are loaded into all regular cells of a regionalized loading configuration.

The maximum k_{eff} values calculated for these two cases are 0.9478 and 0.9452 for cases 1 and 2, respectively, and are lower than the 0.95 regulatory limit. The staff finds the applicant’s calculational approach acceptable and consistent with the approach recommended in ISG-8, Revision 3.

In addition, the applicant states that, since the part-length rod exposure case bounds that for full-length rod exposure, only 9 assemblies per basket can be loaded in an MPC when a mixture of assemblies that have been irradiated by full- and part-length control rods will be loaded. The staff finds this restriction conservative.

Based on the discussion above, the staff found the applicant’s proposed changes to the CoC, with respect to transporting fuel exposed to full- or partial-length control rods during irradiation, would not affect the ability of the HI-STAR 190 to meet the criticality safety requirements of 10 CFR Part 71.

7.0 PACKAGE OPERATIONS

No significant modifications were made to this chapter.

8.0 ACCEPTANCE TESTS AND MAINTENANCE

No significant modifications were made to this chapter.

CONDITIONS

The following changes were made to the Certificate of Compliance:

Item No. 3.b was revised to reference the revision No. 3 of the application, dated November 2, 2018.

Condition No. 5(a)(2) was edited for a typographical error.

Condition No. 5(a)(3) was revised to add a new licensing drawing for the Enhanced Damaged Fuel Container, Drawing No. 11107, Sheets 1-2, Rev. 1.

Condition No. 8(d) was deleted and the subsequent conditions were renumbered.

Condition No. 13 now extends the use of the CoC revision No. 0 for approximately one year and the previous Condition No. 13 has been renumbered No. 14. The expiration date of the certificate was not changed.

The References section of the certificate was revised to include the Holtec International Report No. HI-2146214 "*Safety Analysis Report on the HI-STAR 190 Cask System*" Revision 3, dated November 2, 2018.

CONCLUSION

Based on the statements and representations contained in the application, and the conditions listed above, the staff concludes that the Model No. HI-STAR 190 package has been adequately described and evaluated and that the package meets the requirements of 10 CFR Part 71.

Issued with Certificate of Compliance No. 9373, Revision No. 1,
on November 27, 2018.