UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

SAFETY EVALUATION REPORT
Docket No. 71-9325
Model No. HI-STAR 180 Package
Certificate of Compliance No. 9325
Revision No. 4

SUMMARY

By letter dated June 1, 2021, Holtec International (Holtec or the applicant) submitted an amendment request (ADAMS Accession No. ML21152A264) for Certificate of Compliance (CoC) No. 9325 for the Model No. HI-STAR 180 package. The applicant made several changes to the design of the packaging, including:

Revision of the packaging and impact limiter licensing drawings to incorporate tolerances to dimensions for components which are considered important to safety (ITS) and for non-important to safety (NITS) components that may have an impact on the safety analysis.

Revisions or additions of Notes to drawings, e.g., (i) using shims between any two monolithic shield cylinders to close gaps that may result during installation of the cylinders onto the cask containment shell, (ii) closing gaps between any two stacked monolithic shield cylinders to the extent practicable, (iii) allowing a local reduction in neutron shield pocket thickness less than 70mm, provided that an average of 70mm is maintained.

Proposing restrictions, for partially loaded casks, for empty basket locations and the use of dummy fuel assemblies.

Classification of all dummy fuel assemblies as ITS due to the self-shielding provided by dummy fuel assemblies in certain locations and loading patterns.

Adding a new shielding evaluation for empty basket cells and basket cells with dummy assemblies.

Revision of the surface finish requirement for sealing surfaces for the outer lid access port plug seal.

Deletion of the requirement to perform a volumetric examination of each bolt, as not required either by the ASME Code or Part 71 regulations.

Deletion of a previous requirement to keep, for documentation purposes, welded coupons from the Metamic-HT production panels used for manufacturing a fuel basket because the procedure qualification records for Metamic-HT friction stir welding already have to meet the essential variables as required by ASME section IX.

Based on the statements and representations in the application, and the conditions listed in the CoC, the U.S. Nuclear Regulatory Commission staff (the staff) concludes that the package meets the requirements of Title 10 of the *Code of Federal Regulations* (10 CFR) Part 71.

EVALUATION

1.0 GENERAL INFORMATION

The Model No. HI-STAR 180 package is designed for transportation of undamaged irradiated Uranium Oxide (UO_2) and Mixed Oxide (MOX) fuel assemblies in baskets, or of individual UO_2 fuel rods in quivers. Two interchangeable fuel basket models, designated F-32 and F-37 contain either 32 or 37 Pressurized Water Reactor (PWR) fuel assemblies respectively, in regionalized and uniform loading patterns. The outer diameter of the HI-STAR 180 packaging is approximately 2700 mm without impact limiters and approximately 3250 mm with impact limiters. The maximum gross weight of the loaded package is 140 Metric Tons.

Subsection 1.2.2 of the application has been revised to refer to Table 1.2.3a for the safety categorization of the dummy fuel assemblies, as follows:

a. to specify the safety categorization of the dummy fuel assembly.
b. to specify the loading requirements for the F-32 Basket for Regions 4 and 7.
c. to specify the loading requirements for the F-37 Basket for Regions 5 and 8.
d. to specify the characteristics of the dummy fuel assembly to support the shielding analysis.

Two licensing drawings were revised, i.e., Drawing No. 4845, “HI-STAR 180 Cask” and Drawing No. 5062, “HI-STAR 180 Impact Limiter.” The proposed changes are included in Revision 15 of the cask drawing and in Revision 8 of the impact limiter drawing.

The NRC staff reviewed the proposed changes to the licensing drawings by comparing the proposed revisions to the most recent approved versions of the drawings. The proposed revision of the cask drawing includes changes to the notes regarding the use of shims to close gaps for shielding components. The staff identified that the most recent approved version of the cask drawing allows the use of shims to close gaps between the shield cylinders and interior components. The proposed revision includes an addition to the notes to also allow use of shims to close gaps in between the stacked shield cylinder segments and specifies that these gaps are to be reduced to the extent practical to enhance shielding effectiveness. Based on reviewing the application, the staff confirmed that these shims are categorized as NITS components, and they are not relied upon in the shielding analyses to support the safety function of the shield cylinders. The staff determined that the proposed change regarding the use of these shims is appropriate to help further reduce radiation streaming to as low as is reasonably achievable (ALARA). The proposed change to the impact limiter drawing adds tolerances to the dimensions for the ITS components. The staff confirmed that the tolerances are appropriately identified for the ITS components in the impact limiter drawing.

The staff verified that with the incorporation of the subject changes, the licensing drawings provide an adequate description of the components, safety categorizations, materials of construction, dimensions, tolerances, fabrication (welding) specifications, and post fabrication nondestructive examination (NDE) techniques. With the incorporation of the proposed changes, the staff finds the licensing drawings contain sufficient information regarding the components and associated materials used for the construction of the HI-STAR 180 package.

The packaging is now constructed and assembled in accordance with the following Holtec International Drawings Numbers:

(a) HI-STAR 180 Cask	Drawing No. 4845, Sheets 1-7, Rev. 15
(b) F-37 Fuel Basket	Drawing No. 4847, Sheets 1-4, Rev. 9
(c) F-32 Fuel Basket	Drawing No. 4848, Sheets 1-4, Rev. 9
(d) HI-STAR 180 Impact Limiter	Drawing No. 5062, Sheets 1-5, Rev.8

2.0 MATERIALS EVALUATION

The NRC staff performed its materials evaluation for the HI-STAR 180 amendment application by following the guidance in NUREG-2216, "Standard Review Plan for Transportation Packages for Spent Fuel and Radioactive Material," August 2020 (ADAMS Accession No. ML20234A651). The objective of the NRC staff's materials evaluation is to verify that the applicant has adequately evaluated the changes affecting the materials performance of the HI-STAR 180 transportation package under normal conditions of transport and hypothetical accident conditions to meet the requirements of 10 CFR Part 71.

Based on the guidance in NUREG-2216, the NRC staff identified the proposed changes that are relevant to the staff's materials evaluation. These changes include the following:

- Several changes to the licensing drawings, as explained in Section 1 of the Safety Evaluation Report (SER);
- A change to the friction stir welding procedure qualification criteria for joining Metamic-HT neutron absorber panels for the Type F-32 and F-37 fuel baskets;
- Elimination of the requirement to perform ultrasonic testing (UT) of the containment boundary bolts; and
- A change to a containment seal specification.

That staff confirmed there are no material-related changes that would affect compliance with applicable codes and standards, mechanical properties of materials, thermal properties of materials, radiation shielding, corrosion resistance, protective coatings, content reactions, radiation effects, package contents, fresh (unirradiated) fuel cladding, and spent nuclear fuel.

2.1 Weld Design and Inspection

The application includes one change to the welding procedure qualification criteria for friction stir welding of Metamic-HT neutron absorber panels, which form the Type F-32 and F-37 fuel baskets. Procedure qualification criteria for friction stir welding of Metamic-HT panels are described in Section 8.1.5.5 of the application. This section states that the welding procedure qualification record (PQR) and welding procedure specification (WPS) shall meet applicable essential variable requirements in the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (BPVC), Section IX. As addressed in Section 8.1.5.5, procedure qualification is accomplished through verification of weld soundness by radiography, visual exams, and bend testing of weld coupons per the ASME BPVC Section IX. The proposed change to Section 8.1.5.5 deletes language stating that at least one welded test coupon from

the population of Metamic-HT production panels used for manufacturing each type of fuel basket (Type F-32 and F-37) must pass the welding procedure qualification test criteria. It should be noted that the change does not affect procedure qualification as defined in the ASME BPVC Section IX. In addition, it should be noted that the applicable ASME BPVC Section III NDE requirement for acceptance of Metamic-HT production welds is not impacted by this change.

The NRC staff reviewed the proposed change to the Metamic-HT friction stir welding procedure qualification criteria by considering the ASME BPVC Section IX essential variable requirements for the PQR and WPS. The essential variable requirements for weld procedure qualification include factors such as joint design, base metals, post weld heat treatment, shielding gas, and welding technique. Qualification of the welding procedure, based on these essential variables in accordance with the ASME BPVC Section IX, is necessary to ensure that the welding procedure will produce welds that meet their design criteria. The staff compared the F-32 and F-37 fuel basket designs and confirmed that there is no difference in the design of the friction stir welded joints for these two basket types. Therefore, the differences between the F-32 and F-37 fuel baskets do not affect the essential variables for qualification of the welding procedure.

Based on a review of the ASME BPVC Section IX essential variables for qualification of the welding procedure, the staff determined that eliminating the requirement to test at least one welded coupon from the population of Metamic-HT production panels used for manufacturing a fuel basket type will not result in the procedure qualification being out of compliance with the applicable PQR and WPS requirements of the ASME BPVC Section IX.

Accordingly, the staff finds that the applicant's proposed change to the friction stir welding procedure qualification criteria for joining Metamic-HT panels in the F-32 and F-37 fuel baskets is acceptable.

2.2 Criticality Control

As addressed above in Section 2.1 of this SER, there is one change to the procedure qualification criteria for friction stir welding of Metamic-HT neutron absorber panels, which form the Type F-32 and F-37 fuel baskets. The NRC staff's evaluation in SER Section 2.1 determined that this change will have no impact on the essential variables for qualification of the welding procedure, as set forth in the applicable requirements of the ASME BPVC Section IX.

Since there is no impact on the qualification of the welding procedure, the staff determined that this change will not affect the integrity of the welded joints and thus will not affect the criticality control function of the Type F-32 and F-37 fuel baskets. Accordingly, the NRC staff finds that this change is acceptable with respect to criticality control.

2.3 Containment Bolting Material

Chapter 2 of the application includes one change to the NDE methods that are specified for acceptance of containment boundary bolting. Section 2.1.2.2(i) in the current approved version of the application requires that each closure lid bolt receive a volumetric examination to ensure the absence of voids. The proposed change to Section 2.1.2.2(i) of the application deletes the language requiring volumetric examination of the containment boundary bolts on the basis that volumetric examination of the bolts is not required by Section III of the ASME BPVC.

The NRC staff reviewed this change by considering the ASME BPVC, Section III, NB-2380 requirements for NDE of containment boundary bolting. The staff noted that NB-2581 requires

volumetric examination of bolts by ultrasonic testing (UT) only if the bolting is of a nominal size greater than 2 inches. The staff reviewed the dimensional specifications for closure lid bolting and identified that the closure lid bolting is of a nominal size less than 2 inches. Therefore, since the containment boundary bolting for the HI-STAR 180 package is less than 2 inches, volumetric examination of bolting is not needed to meet the NDE requirements for bolting in NB-2580.

The staff notes that volumetric examination of pressure-retaining bolting is not required for smaller bolt diameters (i.e., no larger than 2 inches) since the code recognizes that such bolting is not significantly prone to formation of interior defects during fabrication that could compromise bolting integrity. Accordingly, the staff finds that the applicant's proposed change to eliminate the volumetric examination requirement for containment boundary bolting is acceptable.

In addition to the elimination of the volumetric examination requirement for bolting, the NRC staff notes that there is also a proposed change to delete language in Section 2.1.2.2(i) of the application stating that bolts are generally not considered susceptible to brittle fracture based on NUREG/CR-1815, "Recommendations for Protecting Against Failure by Brittle Fracture in Ferritic Steel Shipping Containers Up to Four Inches Thick," August 1981. The NRC staff reviewed this change and determined that the deletion of this language in Section 2.1.2.2(i) is appropriate since the statement that bolts are generally not considered susceptible to brittle fracture is not a valid statement, and NUREG/CR-1815 does not indicate this. Therefore, the staff finds that the deletion of this language is acceptable.

2.4 Containment Seals

Appendix 4.A of the application includes a change to the sealing surface finish requirement for a manufacturer of the outer lid access port plug seals. The applicant indicated that this change is needed to accommodate a revised seal design from the manufacturer, and the change brings the sealing surface finish specification into compliance with the supplier's recommendation.

The NRC staff reviewed the proposed change and confirmed that it is appropriately described in the application, and the need for the change is reasonably justified. Therefore, the staff finds that this change is acceptable.

2.5 Evaluation Findings

- The staff has reviewed the package and concludes that the applicant has met the requirements of 10 CFR 71.33. The applicant described the materials used in the transportation package in sufficient detail to support the staff's evaluation.

- The staff has reviewed the package and concludes that the applicant has met the requirements of 10 CFR 71.31(c). The applicant identified the applicable codes and standards for the design, fabrication, testing, and maintenance of the package and, in the absence of codes and standards, has adequately described controls for material qualification and fabrication.

- The staff has reviewed the package and concludes that the applicant has met the requirements of 10 CFR 71.43(f) and 10 CFR 71.51(a). The applicant demonstrated effective materials performance of packaging components under normal conditions of transport and hypothetical accident conditions.

- The staff has reviewed the package and concludes that the applicant has met the requirements of 10 CFR 71.85(a). The applicant has determined that there are no cracks, pinholes, uncontrolled voids, or other defects that could significantly reduce the effectiveness of the packaging.

- The staff has reviewed the package and concludes that the applicant has met the requirements of 10 CFR 71.43(d), 10 CFR 71.85(a), and 10 CFR 71.87(b) and (g). The applicant has demonstrated that there will be no significant corrosion, chemical reactions, or radiation effects that could impair the effectiveness of the packaging. In addition, the package will be inspected before each shipment to verify its condition.

- The staff has reviewed the package and concludes that the applicant has met the requirements of 10 CFR 71.43(f) and 10 CFR 71.51(a) for Type B packages and 10 CFR 71.55(d)(2) for fissile packages. The applicant has demonstrated that the package will be designed and constructed such that the analyzed geometric form of its contents will not be substantially altered and there will be no loss or dispersal of the contents under the tests for normal conditions of transport.

Based on review of the statements and representations in the application, the NRC staff concludes that the materials used in the transportation package design have been adequately described and evaluated and that the package meets the requirements of 10 CFR Part 71.

3.0 THERMAL EVALUATION

The objective of the review is to verify that the thermal performance of the Model No. HI-STAR 180 package has been adequately evaluated for the tests specified under normal conditions of transportation (NCT) and that the package design satisfies the thermal requirements of 10 CFR Part 71.

Within this license amendment request, the proposed changes that pertains to thermal performance are for partially loaded casks, new restrictions are proposed on the presence of empty basket locations and the use of dummy fuel assemblies. Section 3.3.7 of the application addresses this proposed change from a thermal standpoint.

3.1 Contents Decay Heat

In Section 3.1.2 of the application, the applicant stated that the package's heat decay limits are conservatively limited to limit radiation doses. The applicant ensures this conservatism by requiring the decay heat and burnup limits to comply with Tables 1.2.8 and 1.2.9 of the application. This package is designed to allow fuel loading under both uniform and regionalized loadings. The design heat loads for the cask and assembly are stated in Tables 1.2.8 and 1.2.9 of the application. In addition, these tables provide the permissible heat load patterns/arrangements for both the F-32 and F-37 baskets. Lastly, Table 1.2.3a provides the aggregate cask heat load, Qd, and the quadrant heat load under all storage configurations.

Staff reviewed the decay heat and the loads mentioned in this section and determined that these values are acceptable and will remain within their respective allowable values or criteria for normal conditions of transport (NCT), as required in 10 CFR Part 71.

3.2 Confirmatory Analyses

Staff performed the following actions regarding confirmatory analyses for this package:

- Reviewed the applicant's thermal models,
- Checked the code input in the calculation packages,
- Confirmed the use of the material properties and boundary conditions,
- Drawings were reviewed to verify the proper geometry dimensions, and
- Verified the material properties in the application that they were referenced and used correctly.

3.3 Thermal Evaluation under Normal Conditions of Transport

In Section 3.3.7, the applicant stated that the fuel baskets listed in Table 1.2.3a are permitted to load with empty fuel storage locations, with restrictions. In addition, these fuel baskets may also be loaded with dummy fuel. The applicant also stated that partially loaded casks (for the F-32 and F-37 baskets) are bounded thermally by the full cask under design basis thermal payloads as the empty cells do not produce heat or add an additional thermal burden to the fuel basket.

Based on the review of these proposed changes and evaluation and results provided by the applicant in Chapter 3 of the SAR, the staff concludes the proposed changes do not impact this section and the package meets the requirements of 10 CFR Part 71.

3.4 Evaluation Findings

The staff reviewed the package description, the material properties, the 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 prepared for shipment, and found reasonable assurance that the temperatures comply with 10 CFR 71.43(g) for packages transported by exclusive-use vehicle. The staff reviewed the package preparations for shipment and found reasonable assurance 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-term limits during hypothetical accident conditions (HAC), consistent with the tests specified in 10 CFR Part 71.73.

4.0 CONTAINMENT EVALUATION

The evaluation is unchanged from the one performed for Revision No. 3 of the CoC.

5.0 SHIELDING EVALUATION

5.1 Review Objective

The objective of this review is to verify that the shielding design of the Model No. HI-STAR 180 package, with the proposed changes for this amendment request, continues to provide adequate protection against direct radiation from its contents and that the package design meets the external radiation limits of 10 CFR Part 71 under NCT and HAC.

The package is designed as an exclusive use package in accordance with the regulatory requirements of 10 CFR, Subparagraph 71.47(b).

The staff reviewed the application and performed its review following the guidance provided in NUREG-2216. The staff's evaluation of the proposed changes and their impacts on radiation shielding of the package is documented in following sections of this SER.

5.2 Description of the Shielding Design

5.2.1 Design Features

The proposed changes related to the shielding design of the package include the allowable empty basket cell locations and basket cells needing dummy fuel assemblies. The applicant requested these changes because loading patterns with empty basket cells may result in increased dose rates and, therefore, further limitations are necessary.

The applicant states that all dummy fuel assemblies are now classified as ITS since the locations and loading patterns to provide self-shielding are credited to ensure dose rate limits are met. The staff found this approach acceptable since these dummy fuel assembly structures, including their dimensions, tolerances, and densities of material for neutron and gamma shielding, are considered in the shielding evaluation. Also, the shielding evaluation performed by the applicant found that the restrictions in the allowable contents including the dummy fuel assemblies meet regulatory dose limits with an adequate margin.

The staff reviewed the application related to the shielding design of the package with the proposed changes on the allowable empty basket cell locations and basket cells needing dummy fuel assemblies and staff found that the applicant has provided a detailed description for the proposed shielding design change and the description of the shielding design features meets the regulatory requirement of 10 CFR 71.33.

5.2.2 Summary of Maximum Radiation Levels

This application does not propose any changes in the contents to be transported in the package with respect to fuel designs, including fuel types and configurations, e.g., PWR 15x15, 17x17. However, the applicant requested the use of empty basket cells and dummy fuel assemblies.

Loading dummy fuel assemblies into basket cells will result in lower dose rates since the total source term is reduced, while the reduction in self-shielding, compared to self-shielding of spent fuel assemblies, is relatively small. The staff reviewed the input and output files submitted by the applicant and noticed that the applicant used the source terms with dummy fuel assemblies in the package.

Loading patterns with empty basket cells may result in increased dose rates considering the self-shielding is decreased significantly while the total source term is also reduced. To determine the effect of empty basket cells on dose rates, the applicant performed calculations for both the F-32 and F-37 baskets, as discussed in Appendix M of HI-2073655-R14, "Shielding Analysis for the HI-STAR 180" report. The staff reviewed 204 input and output files as part of the application where the applicant calculated dose rates for multiples configurations using empty cells and dummy fuels assemblies. The staff found these calculations acceptable since the applicant covered a lot of the cases impacting the dose rates when empty cells were in place.

In Appendix M of HI-2073655-R14, the applicant evaluated cases with empty basket regions for the F-32 and F-37 baskets. For each empty basket region, fuel assemblies were removed from all cells of the basket region. In these cases, fuel assemblies were removed from inner or outer basket regions, making sure the effect of the empty basket cells on dose rates is appropriately determined. The staff review of these analyses, as it applies to the shielding performance of the package, is provided in Section 5.5 of this Safety Evaluation report.

The applicant provided a summary of the maximum dose rates in Tables 5.1.1 to 5.1.8 of the application for the package under NCT and HAC.

The maximum dose rate on the surface of the package with the F-32 Basket is 90.3 mrem/hr under NCT. The maximum dose rate on the surface of the package with the F-37 Basket is 90.4 mrem/hr under NCT. These calculated dose rates are below the regulatory limit of 200 mrem/hr under NCT.

The maximum dose rate at 2 meters from the package with the F-32 Basket is 9.27 mrem/hr under NCT. The maximum dose rate at 2 meters from the package with the F-37 Basket is 9.09 mrem/hr under NCT. These calculated dose rates are below the regulatory limit of 10 mrem/hr under NCT.

The maximum dose rate in the vehicle cab for the package with the F-32 Basket is 1.76 mrem/hr under NCT. The maximum dose rate in the vehicle cab for the package with the F-37 Basket is 1.76 mrem/hr under NCT. These calculated dose rates are below the regulatory limit of 2 mrem/hr under NCT.

For HAC, the maximum dose rates at 1 meter from the package with the F-32 Basket is 905.0 mrem/hr and at 1 meter from the package with the F-37 Basket is 942.0 mrem/hr. These calculated dose rates are below the regulatory limit of 1000 mrem/hour under HAC.

The staff reviewed the dose rates presented in these tables and finds that the applicant has correctly identified the location of the maximum dose rates for the package under NCT and HAC pursuant to the regulatory requirements of 10 CFR 71.47 and 71.51.

5.3 Source Specifications

There is no change in the source terms for the spent fuel assemblies to be loaded into the baskets. The staff verified the fuel qualification tables and confirmed that there is no change in the spent fuel characteristic parameters. Therefore, the staff did not perform any further review of the source terms calculated by the applicant.

5.4 Shielding Model

5.4.1 Methods

Section 5.4.8 of the application states that the applicant determined the effect of empty basket cells on dose rates. The applicant states that, after several cases were ran using the Monte Carlo N-Particle code (MCNP), the surface dose rates increased for a few cases at the 2 meters, compared to the reference case surface dose rates at 2 meters. However, overall, the effect is relatively small considering the margin to the dose rate limit, except when the F-37 empty basket region is either region 5 or 8.

There was a significant increase in dose rates when the F-32 empty basket region is either region 4 or 7, and when the F-37 empty basket region is either region 5 or 8. The effect is small for other cases, considering the margin to the dose rate limit. A dose rate analysis was performed using MCNP5, Version 1.51, for both the F-32 and F-37 baskets. This version of MCNP is a newer version than MCNP4A, previously used in this application report. MCNP5 has more accurate cross section libraries than MCNP4A.

The evaluated cases with empty basket regions for F-32 and F-37 are provided in Table M.1 and Table M.2 of the HI-2073655-R14 report, respectively. For each empty basket region, fuel assemblies are removed from all cells of the basket region. In these cases, fuel assemblies are removed from the inner or outer basket regions, making sure the effect of the empty basket cells on dose rates is appropriately determined. All empty spaces in and around the cask are represented by voids in the model. The staff found this approach acceptable because the absorption and scattering in the air will reduce the dose rates on the surfaces and away from the surface of the package under NCT or HAC.

5.4.2 Material Properties

The dummy fuel assembly refers to a dummy weight ancillary that emulates the weight and exterior dimensions of a fuel assembly and is made of stainless steel. The safety categorization of the dummy fuel assembly is specified in Table 1.2.3a of the Application. Dummy fuel assemblies (if used) must be classified as ITS.

5.4.3 Flux-to-Dose-Rate Conversion

The applicant used MCNP to calculate dose rates at the various desired locations. MCNP calculates neutron or photon fluxes and these values can be converted into dose using dose response functions. This is done internally in MCNP and the dose response functions are listed in the input file. The response functions used in these calculations are listed in Table 5.4.1 (b) of the SAR and were taken from ANSI/ANS 6.1.1-1977 standard.

5.5 Shielding Evaluation

The applicant calculated dose rates at the package surface and at 2-meter from the package for 204 different configurations with empty cells and dummy fuel assemblies in different regions. In Appendix M from the Holtec Report No: 2073655, Rev.14, the applicant described the process that was used to address the basket cells with loaded dummy fuel assemblies or empty cells.

The MCNP5 code, a continuous energy, three-dimensional, coupled neutron-photon-electron Monte Carlo transport code, was used for all of the shielding analyses. For the dose rates analysis, the applicant removed all fuel assemblies from all cells of the basket region. In these cases, fuel assemblies were removed from inner or outer basket regions, making sure the effect of the empty basket cells on dose rates is appropriately determined.

For loading patterns with empty basket cells, an increase around 14% of dose rates considering no self-shielding from the empty cells. However, the staff noticed that the effect is relatively small considering the margin to the dose rate limit. Based on the applicant analysis, the staff agreed that empty basket cells in F-32 Regions 4 or 7 cells are not allowed.

Fuel assemblies or important-to-safety dummy fuel assemblies must be loaded into these region cells, and F-37 Regions 5 or 8 empty cells are not allowed. Fuel assemblies or important-to-safety dummy fuel assemblies must be loaded into these region cells.

Partially loaded casks must not have more than 12 empty storage locations with contents evenly spread to the extent practicable. Dummy fuel assemblies may be used to achieve the required mass.

Also, based on this analysis, the dummy fuel assemblies should have these specifications:

- A minimum effective density of 3.807 g/cm3,
- A minimum area of 19.768 cm x 19.768 cm, and with the height that covers the whole active fuel.

With these conditions mentioned above, the dose rates with the regulatory limits for all dose point locations on the surface of the package and at 2 m from the package were calculated for all the basket cells with loaded dummy fuel assemblies or empty cells as specified in Appendix M from the Holtec Report No: 2073655, Rev.14.

The highest dose rates from all tally locations are reported and compared with the regulatory limits in Table M-1 and M-2 of the Holtec Report No: 2073655, Rev.14. The table shows that the regulatory limits are satisfied at all dose point locations for both normal and accident conditions for all basket cells with loaded dummy fuel assemblies or empty cells patterns.

The staff reviewed the shielding analysis provided by the applicant, which provided the sensitivity studied of the source terms, MCNP modeling parameters, and dose rates and found them acceptable since the dose rates were calculated from all basket regions to obtain the fuel loading that result in the highest dose rate at that tally point location.

The staff also calculated the average density of the homogenized stainless-steel tube and air and got an average density of 3.836751 g/cm3. This density meets the assumed density as specified in Table 1.2.3a of the SAR which states: “Minimum effective density of 3.807 g/cm3.”

The staff found acceptable the proposed use of empty basket cell locations and basket cells with dummy fuel assemblies. The use of dummy fuel was previously approved by NRC in Revision 3 of the Certificate of Compliance No. 9325 (ML20122A228). Dummy fuel assemblies are fabricated to emulate the weight and exterior dimensions of a fuel assembly. Based on the calculation of the maximum number of empty basket cells and the description of the proposed dummy fuel assemblies, the staff finds the use of empty cells of the HI-STAR 180 package and the use of dummy fuel assemblies acceptable.

The applicant used the 1977 edition of the ANSI/ANS 6.1.1 standard for flux-to-dose rate conversion factors in its shielding analyses. This is consistent with the recommendation of NURE-2216. On this basis, the staff finds that the applicant’s flux-to-dose rate conversion factors are adequate and acceptable.

5.6 Conclusion

Based on its review of the statements and representations provided in the application, the staff has reasonable assurance that the shielding evaluation is consistent with the appropriate codes and standards for shielding analyses and NRC guidance. On this basis, the staff finds that the revised HI-STAR 180 package design meets dose rate limits of 10 CFR Part 71 with the following conditions:

1. F-32 Regions 4 or 7 cells are not allowed as empty cells. Fuel assemblies or important-to-safety dummy fuel assemblies must be loaded into these region cells, and
2. F-37 Regions 5 or 8 empty cells are not allowed. Fuel assemblies or important-to-safety dummy fuel assemblies must be loaded into these region cells.

3. Dummy fuel assemblies should have these specifications:

   - All dummy fuel assemblies shall now classified as important to safety,
   - The minimum effective density of 3.807 g/cm3,
   - The minimum area of 19.768 cm x 19.768 cm, and
   - Height that covers the whole active fuel.

4. Loading patterns for F-32 should explicitly identify what? for Regions 4 or 7 and loading patterns for F-37 should explicitly identify what? for Regions 5 and 8 for the F-37 basket.

CONDITIONS

The following changes were made to the certificate:

Item No. 3(b) identifies the latest application dated June 1, 2021.

Condition No. 5(a)(2) was revised to add a description of the dummy fuel assemblies which may be used to provide supplemental shielding and/or supplemental weight.

Condition No. 5(a)(3) has been modified to include the new revisions of the cask licensing drawings (Revision No. 15), and impact limiter licensing drawings (Revision No. 8).

Condition Nos. 5(b)(1)(a) and (b) have been revised to include a reference to the new Table 1.c and add new conditions 5(b)(1)(m) and (n). Conditions 5(b)(1)(o) and (p) have been renumbered.

Table 1.c has been added to specify characteristics of the dummy fuel assemblies as ITS component with a shielding function.

Condition Nos. 5(b)(m) and (n) have been added to specific that all basket cells in regions 4 and 7 of a partially loaded cask with the F-32 basket (or regions 5 and 8 of a partially loaded cask with the F-37 basket) shall contain either fuel assemblies or dummy fuel assemblies.

Condition No. 11 was renumbered 12. Condition No. 11 extends the validity of the previous revision of the certificate by approximately one year. Condition No. 12 does not change the expiration date of the certificate.

The References section of the certificate was updated to reference the latest application.

CONCLUSION

Based on the statements and representations in the application, the staff finds that these changes do not affect the ability of the package to meet the requirements of 10 CFR Part 71.

Issued with CoC No. 9325, Revision No. 4.