Request for Supplemental Information
Holtec International
Docket No. 71-9373
HI-STAR 190 Transportation Package

By letter dated August 7, 2015, Holtec International (Holtec) submitted an application for the Model No. HI-STAR 190 Package.

This request for supplemental information (RSI) identifies information needed by the U.S. Nuclear Regulatory Commission staff (the staff) in connection with its acceptance review of the Model No. HI-STAR 190 package application to confirm whether the applicant has submitted a complete application in compliance with regulatory requirements.

The requested information is listed by chapter number and title in the package application. NUREG-1617, “Standard Review Plan for Transportation Packages for Spent Nuclear Fuel,” was used for this review.

Chapter 1 – General Information

1-1 Provide the “Metamic-HT Qualification Sourcebook” (Reference 1.2.3), and ensure it includes the materials properties used in support of the analyses in Section 2.1.2.2 (ii) Fuel Basket.

Reference 1.2.3 in the application, “Metamic-HT Qualification Sourcebook,” Holtec Report N. HI-2084122, Latest Revision, (Holtec Proprietary), is cited several times in the application. The staff requires the referenced document to review the material properties used in the analyses of the Model No. HI-STAR 190.

This information is required to determine compliance with 10 CFR 71.31(c).

Licensing Drawings

1-2 Revise Drawing No. 9841 and Figure 2.3.4, as appropriate, to delineate the location and the design details of the lower trunnion support structure of the package.

Figure 2.3.4, “Lower Trunnion Support Structure” indicates that, along the neutron shield rib, the lower trunnion support structure is aligned, in the cask axial direction, with the upper trunnion support structure. As such, there appears to be no consideration for introducing an offset for placement of the lower trunnion support from the cask symmetry plane to facilitate the cask down-ending operations. Also, the design details for the lower support structure should be presented on the drawing.

This information is required to determine compliance with 10 CFR 71.33(a)(5)(iii) and 10 CFR 71.45(a).

1-3 Revise note No. 28 of Drawing Nos. 6505 and 6512, on the cited Subsection 3.4.3.2 of the application for which the 8X 1-3/4 5UNC threaded holes are provided for the single-failure-proof MPC loading operations, as depicted in Figure 1.2.5.

The erroneously cited subsection appears to be that associated with the MPC-37 and MPC-89 storage configurations. On this note, a review of the Drawing No. 6512, Rev. 4, of Docket No. 72-1032 for HI-STORM FW storage suggests that only four (4), in lieu of eight (8), threaded holes, are available for lifting the loaded MPCs.

This information is required to determine compliance with 10 CFR 71.33(a)(5)(iii).

1-4 Provide tolerances in the package drawings on dimensions of components relied on for shielding.

The package drawings should include tolerances on those package components that are included in the shielding analysis. Package tolerances are necessary to understand the package design and ensure the analysis is appropriate for the package design. Tolerances can have a significant impact on the shielding analysis.

This information is required to determine compliance with 10 CFR 71.47 and 71.51.

Chapter 2 – Structural and Materials Evaluation

2-1 Revise the misrepresented description of the upper lifting trunnions to recognize that the trunnions are not attached to the containment vessel flange as noted in the HI-STAR 190 application, Section 1.2.1.7, "Lifting and Tie-down Devices." Revise, as appropriate, the statement, "[T]he bottom trunnions may be slightly off-center to facilitate the rotation direction of the cask," or Drawing No. 5024 which does not display the off-center location for the lower trunnion support structure.

Contrary to the statement, "Lifting trunnions are attached to the containment vessel flange," both Figure 2.3.4 and Drawing No. 5024 show that the upper trunnions are attached to the vertical neutron shield ribs instead. Also, it appears there is no design provision to allow an off-center alignment between the upper and lower trunnion support structures.

This information is required to determine compliance with 10 CFR 71.33(a)(5)(iii) and 71.45(a).

2-2 Revise the application to define the bounding oxide thickness and hydride rim values used to calculate the effective thickness for the high-burnup fuel cladding. Provide valid references for these values, as described in ISG-11, Rev. 3.

Section 2.11 of the application states: "… the high burn-up fuel (i.e., fuel with burnups generally exceeding 45 GWd/MTU) may have cladding walls that have become relatively thin from in-reactor formation of oxides or zirconium hydride. The analysis thus considers the effective cladding thickness, per the guidance from ISG-11, to account for any loss of thickness from oxidation."

ISG-11, Rev. 3, further states: "For design basis accidents, where the structural integrity of the cladding is evaluated, the applicant should specify the maximum cladding oxide thickness and the expected thickness of the hydride layer (or rim). Cladding stress calculations should use an effective cladding thickness that is reduced by those amounts. The reviewer should verify that the applicant has used a value of cladding oxide thickness that is justified by the use of oxide thickness measurements, computer codes validated using experimentally measured oxide thickness data, or other means that the staff finds appropriate. Note that oxidation may not be of a uniform thickness along the axial length of the fuel rods."

Table 2.6.8 identifies a "cladding thickness considering thinning due to in-reactor oxidation" but does not identify the bounding oxide thickness and hydride rim values used to calculate this value. The application also does not provide valid references for the assumed values, per the guidance in ISG-11, Rev. 3.

This information is required to determine compliance with 10 CFR 71.85(a).

2-3 Revise the discussion in Section 2.11 to:

1. Clearly define the specific zirconium cladding alloys in the proposed contents (e.g., Zircaloy-2 or Zircaloy-4, or both).
2. Clarify that Zirlo™ and M5® are not cladding alloys in the allowed contents.
3. Address the following when determining bounding mechanical property data for all cladding alloys in the proposed contents:

    a. maximum hydrogen in the cladding and distribution (for burnups 45-68.2 GWD/MTU),
    b. radial hydride fraction (for "load-and-go" and post-storage scenarios),
    c. fabrication process (recrystallized annealed, cold work stress relieved annealed), and,
    d. thermal history (accounting for annealing of dislocation loops/hydrogen traps during an initial storage period prior to transport).

Revise the assumed bounding yield stress and elastic moduli, as appropriate, upon consideration of the above variables.

Section 2.11 of the application states that the fuel cladding for the HI-STAR 190 design bases fuel is "zircaloy," similar to that analyzed in Reference 2.11.4, and therefore concludes that the mechanical properties used in that study are adequate. However, Reference 2.11.4 states that "the material properties used in the analyses were based on expert judgment and included uncertainties. Ongoing experimental programs will reduce the uncertainties." Therefore, the use of these mechanical properties should be adequately justified in the application.

Section 2.11 further states that Reference 2.11.8 ("PNNL Stress/Strain Correlation for Zircaloy", PNNL-17700) shows a minimum elastic modulus of 9.61×10^6 psi and a minimum yield strength of 76,870 psi for the high burnup fuel cladding. These minimum cladding properties were determined from Figure 22 in Reference 2.11.8 for a bounding temperature of 673K (400°C) with a fast fluence of 11.7×10^{25} n/m^2, nominal hydrogen concentration of 360 ppm and 50% cold worked. Reference 2.11.8 states that the models described in that reference apply *only* to cladding with circumferential hydrides and do not apply to cladding with radial hydrides or significant hydride blisters or spalling.

The applicant states (Section 2.11) that the referenced EPRI Report 1015048 considered the interaction between radial and circumferential hydrides in that it "essentially predicts the minimum properties described above." The application does not reference any figure or specific data or discussion on this report that would serve as confirmation that the data in Figure 22 in Reference 2.11.8 is indeed bounding for all claddings in the allowed contents. The data in Figure 22 is based on cladding with a nominal hydrogen concentration of 360 ppm, which are not representative for the requested maximum burnup (68.2 GWd/MTU). Hydrogen concentrations exceeding 600 ppm are observed for discharge burnups in the range of 60-65 GWd/MTU. The radial hydride fractions for Zircaloy-2 and Zircaloy-4 are also expected to be different, as Zircaloy-4 is generally cold work stress relieved annealed (elongated grains and a high density of dislocations) whereas Zircaloy-2 may be recrystallized annealed (more susceptible to radial hydride formation) and may contain an alloyed or pure Zr liner affecting hydride precipitation over long-term storage. The thermal history of the fuel is also expected to affect the resultant radial hydride fraction and the available hydrogen to precipitate, therefore the mechanical properties will be dependent on when the fuel is transferred following an initial storage period. The application needs to address all these variables prior to assuming bounding a given set of values for elastic moduli and yield strength.

This information is required to determine compliance with 10 CFR 71.43(f), and 71.51(a).

2-4 Revise the application to clarify if Carboguard 890 will be used as a coating for interior *or* for exterior surfaces. Clarify if the Carboguard 890 and Carboline 890 coatings are equivalent. Clarify if any of the Carboline® coatings (Thermaline® 450 or equivalent, and Carboline 890 or equivalent) used to coat the interior/exterior steel surfaces of the HI-STAR 190 package are important to safety. Clarify if any of the other proposed surface passivation coatings in Section 2.2.1.2.5 (aluminum oxide or alternate) are important to safety. If the coatings are important to safety, revise Section 8.2.3.3 "Components and Materials Tests," to ensure these coatings are properly maintained.

Section 2.2.1.2.4 states that: "The HI-STAR 190 cask's *internal* surfaces are coated with a conventional surface preservative such as Carboguard® 890 (see www.carboline.com for product data sheet) and/or equivalent surface preservative." However, notes 13 and 9 of drawings 9841 and 9848, respectively, state: "All carbon steel *external* surfaces (except for threaded holes or sealing surfaces) to be coated with Carboline 890 or equivalent." It is unclear if Section 2.2.1.2.4 should be referring to external surfaces instead of internal surfaces.

In addition, Sections 2.2.1.2.4, 2.2.1.2.5 and Drawing Nos. 9841 and 9848 do not identify if the Carboline® coatings used for coating the interior/interior surfaces of the cask are important to safety. Section 2.2.1.2.5 further does not define the alternate surface passivation coatings (aluminum oxide or equivalent) as important to safety. Therefore, the staff cannot verify if the acceptance criteria in Section 8.2.3.3 for "Component and Materials Tests" is adequate.

This information is required to determine compliance with 10 CFR 71.31(c).

Observations

2-5 Provide clarification, as appropriate, on how the fuel deceleration attenuator (FDA) is implemented in the package design for closure of the gap between the stored fuel assemblies and the closure lid.

The staff is unable to locate the subject hardware in the drawings.

This information is required to determine compliance with 10 CFR 71.33(a)(5)(iii).

2-6 Provide an evaluation of the engagement depth for the threaded holes for the MPC lifting operations.

A review of Drawing No. 6512, Rev. 4, for the HI-STORM FW application suggests that only four (4), in lieu of eight (8), threaded holes, are available for lifting the loaded MPCs.

This information is required to determine compliance with 10 CFR 71.33(a)(5)(iii).

2-7 Provide an evaluation of the closure lid-to-flange joint configuration with respect to the interface clearance between the closure lid and the containment top flange.

The applicant should demonstrate that closure lid bolts need not to be evaluated for the average shear and tension plus shear stresses, per ASME Section III, Appendix F, for the 30-ft free-drop accidents. On the basis of the evaluation results, revise, accordingly, Table 2.1.3, "Stress Limits for Lid Closure Bolts (Elastic Analysis per NB-3230)," as appropriate.

Table 2.1.3 does not provide the basis for not considering stress other than the average bolt tensile stress for bolt stress evaluation. The staff notes that the Drawing No. 9841 provides no closure lid design details, including the difference in diameters between the lid and the containment closure flange, in which the lid appears to be in close proximity to the flange, which would allow the former, and thus the lid bolts, to be subject to shear force during a side drop accident.

This information is required to determine compliance with 10 CFR 71.33(a)(5)(iii) and 10 CFR 71.73(c)(1).

2-8 Ascertain that the containment shell stress intensity results are consistently reported and evaluated.

The maximum stresses based on the fringe plots are seen different from those noted in the captions of Figures 2.7.12 and 2.7.15. For instance, in Figure 2.7.12, a maximum shear stress of 20.16 ksi, which is different from that of 25.04 ksi displayed in the fringe plot, is used for calculating the maximum primary stress intensity of 40.32 ksi (20.16 x 2 = 40.32). It appears that the stress intensity should have been calculated as 50.08 ksi (25.04 x 2 = 50.08) instead.

This information is required to determine compliance with 10 CFR 71.33(a)(5)(iii) and 71.73(c)(1).

2-9 Provide the following references:

(i) "Development and Discussion of Design Code for Baskets Made of Aluminum Alloys and Borated Aluminum Alloys for Transport/Storage Packagings," by M. Hirose, T. Saegusa, K. Miyata, T. Nakatani, H. Akamatsu, and T. Yamamoto, Proceedings of the 15th International Symposium on the Packaging and Transportation of Radioactive Materials. PATRAM 2007, Miami, Florida.

(ii) Source for S_y, S_u, E, and % Elongation values in "Properties of Aluminum Alloys, Tensile, Creep, and Fatigue Data at High and Low Temperatures, ASM International, November 2006," page 82.

This information is required to determine compliance with 10 CFR 71.31(c).

Chapter 5 – Shielding Evaluation

5-1 Provide the following information regarding the assembly hardware and non-fuel hardware shielding analysis:

(i) Cobalt impurity level assumed for assembly hardware and non-fuel hardware, both for the steel and Inconel components, and provide the basis for the assumed impurity level.

(ii) AgInCd gamma source spectrum for axial power shaping rods (in Table 5.2.13).

This information is an important part of the analysis of the contributions to dose rates from the assembly hardware and the non-fuel hardware.

This information is required to determine compliance with 10 CFR 71.47 and 71.51.

5-2 Provide the following specifications for the proposed contents in Appendix 7.C.

(a) Maximum uranium loading in MTU per assembly,

(b) Clear specifications for maximum irradiation exposures, in terms of MWd/MTU, and minimum decay times for the different types of proposed non-fuel hardware contents,

(c) Material specifications for guide and instrument tubes, water rods, and BWR channels.

These specifications appear to be missing from the application's description of the proposed contents given in Appendix 7.C of the application. Thus, the description is not adequate to explain the package contents or to evaluate the adequacy of the shielding analysis in addressing the proposed package contents.

This information is required to determine compliance with 10 CFR 71.33(b), 71.47, and 71.51.

5-3 Include a shielding analysis to address transportation of damaged fuel and fuel debris for both PWR and BWR spent fuel contents.

Appendix 7.C, Table 7.C.1, indicates that the proposed contents include damaged fuel and fuel debris. However, the shielding analysis appears to only address undamaged fuel for spent fuel at burnups less than 45 GWd/MTU. The staff recognizes that specific reconfiguration cases have been analyzed for spent fuel with burnups greater than 45 GWd/MTU (i.e., high burnup fuel, or HBF). However, these reconfiguration cases do not address the proposed HBF contents that are loaded as damaged fuel or fuel debris. Damaged fuel and fuel debris will be in a degraded condition for both NCT and HAC and will not necessarily fit the specific reconfiguration cases considered in the shielding analysis.

This information is required to determine compliance with 10 CFR 71.47 and 71.51.

Observations:

5-4 Provide the basis for the amount of reconfiguration assumed in NCT (and HAC) shielding analyses.

5-5 Clarify how the shielding analysis addresses MPCs of different lengths; the analysis should include the MPC/package configuration that results in maximum dose rates.

5-6 Demonstrate that analysis conservatisms adequately compensate for analysis uncertainties (from using source term code above its validated range, assumptions/simplifications in the models, etc.).

5-7 Provide the design basis source terms for both PWR and BWR spent fuel contents, including for other fuel types evaluated (i.e., W 17x17, GE 10x10, B&W 15x15, and GE 7x7 assembly types).

5-8 Describe whether the proposed TPD and NSA contents include TPD and NSA types that have absorber rodlets and how the shielding analysis addresses these types of TPDs and NSAs.

5-9 Describe how the shielding analysis supports the distinct specifications for 8x8F assemblies in Table 7.C.1 versus the other BWR assemblies in the proposed contents.

5-10 Clarify whether the proposed contents include assemblies with axial blankets and how the shielding analysis includes assemblies with axial blankets.

The information from Observations 5-4 through 5-10 is required to determine compliance with 10 CFR 71.47 and 71.51.

Chapter 6 – Criticality Evaluation

6-1 Revise the application to specify the minimum required 10B areal density in the Metamic HT neutron absorber panels for the MPC-37 and MPC-89 canisters.

The minimum 10B areal density for the Metamic HT absorber panels does not appear to be specified on the HI-STAR 190 licensing drawings, or in the criticality safety chapter of the application.

This information is required to determine compliance with 10 CFR 71.55 and 71.59.

6-2 Revise the application to consider preferential flooding of the damaged fuel cans in configurations where they are present.

Section 6.3.4.4 addresses preferential flooding, and concludes that an explicit analysis is not required, as the basket is designed with drain holes at the top and bottom of the neutron absorber panels, and the damaged fuel cans have mesh screens at the top and bottom for water drainage. However, for damaged fuel can configurations, the drain rate (or fill rate, in the case of reflooding) of the damaged fuel cans will be lower than that of the rest of the canister, and could potentially be much lower if fuel debris were to partially block the lower screen. Therefore, the canister could exist for some time with different water levels in the damaged fuel cans than is in the rest of the canister, during draining or reflooding.

This information is required to determine compliance with 10 CFR 71.55.

Observation:

6-3 Appendix 7.D, for Method A of burnup verification, states: "For each assembly in the F-37 where burnup credit is required, the minimum burnup is determined from the burnup requirement applicable to the configuration chosen for the cask (see Table 7.D.6)." Table 7.D.6 does not appear to be part of the application. Provide this table or revise the text to reference the appropriate existing table in the application.

This information is required to determine compliance with 10 CFR 71.55.

Chapter 7 – Operating Procedures

7.1 Provide package operations descriptions in Chapter 7, "Package Operations," for loading spent fuel contents into the MPCs for 'load and go' transport.

Operations for 'load and go' transport do not fall under the jurisdiction of 10 CFR Part 72 operations since the MPC is not stored for any duration of time at a 10 CFR Part 72 independent spent fuel storage installation.

The loading operations in this scenario are to directly transport the spent fuel from the spent fuel pool to some off-site location. Thus, these loading operations are under the jurisdiction of 10 CFR Part 71 and the essential elements of these operations should be described in the package operations part of the application to ensure that the package is operated in a manner consistent with the analyses submitted in the application.

This information is required to determine compliance with 10 CFR 71.87.

Chapter 8 – Maintenance Procedures

8-1 Provide the minimum B_4C content specifications for the neutron shielding material in Chapter 8 of the application (in Table 8.1.9) and an acceptance test for ensuring material compliance with this specification.

The B_4C content is an important component of the neutron shield material that is part of the shielding analysis. Without this specification, the description of the critical characteristics of the package's neutron shielding is not complete, and it is unclear that the shielding analysis uses the appropriate material information.

This information is required to determine compliance with 10 CFR 71.47 and 71.51.

8-2 Revise the application to describe procedures and acceptance criteria for pre-transport inspections for ensuring that MPCs loaded during their initial storage period or during a renewed period will be free of corrosion pits, partial through-wall cracks, uncontrolled voids or other defects that could significantly reduce the effectiveness of the packaging, and compromise compliance with the proposed approach consistent with ISG-19. The proposed acceptance criteria should be justified by ensuring the MPC configuration analyzed in the application is valid for all shipments.

Section 8.2.2 states: "A pre-shipment leakage rate test of cask containment seals and MPC containment boundary (See Appendix 8.A for applicability) is performed following fuel loading per Subsection 8.1.4. This pre-shipment leakage rate test is valid for 1 year. If the pre-shipment leakage rate test expires, a periodic leakage rate test of the containment seals must be performed prior to transport. This periodic leakage rate test is valid for 1 year."

Section 8.2.1 further states: "The MPC maintenance program under the aegis of the HI-STORM FW FSAR (Docket # 72-1032) or the HI-STORM UMAX FSAR (Docket # 72-1040) shall include an aging management program (applicable to storage durations longer than the initial storage license life) that ensures continued radiological safety of the MPC and verifies that the MPC pressure and/or containment boundary (as applicable) is free of cracks, pinholes, uncontrolled voids or other defects that could significantly reduce the effectiveness of the packaging."

Section 1.A.2 further states: "The MPC is already designed, manufactured and field-welded to be completely leak-tight. However, since a leak test directly after loading the MPC is not feasible, the MPCs are not formally leak-tight per ANSI 14.5, they are simply described as a system where leakage is not credible. The leakage test of the MPC after loading it into the HI-STAR 190 will serve now as the formal proof that the MPC is leak-tight in compliance with the ANSI standard."

The statement in Section 8.2.2 appears to be only applicable to the "load-and-go" configuration, as defined in page 1.0-1 of the application. The statement in Section 8.2.1 suggests that the licensee would rely on the aging management program for verifying the confinement of the MPC has not been breached. However, it is unclear if an additional acceptance inspection will be performed prior to transport of an MPC during its renewed storage period (i.e., >20 years).

Moreover, it is unclear if MPCs in their initial storage period (i.e., <20 years) will be subject to any pre-transport acceptance inspection, since these canisters would not be subject to an aging management program. Table 8.A.1 and the statement in Section 1.A.2 suggest that such pre-transport inspections are not a requirement. If so, the application should address the procedures and acceptance criteria to determine that the pressure and/or containment boundary is free of corrosion pits, partial through-wall cracks, uncontrolled voids, or other defects due to age-related degradation (e.g., stress corrosion cracking) that could reduce the effectiveness of the package and compromise compliance with the proposed approach consistent with ISG-19.

The staff notes that, although aging management programs start at year 20, age-related degradation starts at the time the MPC is placed on the pad. The acceptance criteria for the pre-transport inspections should be properly justified in the discussions by providing reasonable assurance that the configuration analyzed in the application is valid for all shipments.

This information is required to determine compliance with 10 CFR 71.85(a).

Observation:

8-3 Modify the Chapter 8 acceptance tests and maintenance program information to address MPCs which are used in a ‘load and go’ fashion (i.e., not stored at a Part 72 ISFSI prior to transport under Part 71); such MPCs are subject only to Part 71 requirements and the Part 71 CoC conditions and not to Part 72 CoC or license.

This information is required to determine compliance with 10 CFR 71.47, 71.51, and 71.85.