Discussion Points from June 25, 2018 Holtec-NRC Call on HI-STORM FW Amd. 4

Discussion Point 1: CRITICALITY

Clarify the number of rods to be loaded into a DFC or demonstrate the 676 rods will fit into a DFC and revise the operating procedures to ensure that this operation will not cause further damages to the already damaged fuel rods.

On page 6-57 of Report HI-2114830, Rev. 5D, the applicant states: “The number of rods are varied between 16 (4x4) and 324 (18x18) for BWR fuel, and between 64 (8x8) and 576 (24x24) for PWR fuel, and between 289 (17x17) and 676 (26x26) for 16x16D.” Also, Table 6.4.11 of the SAR, Rev. 5D, indicates that the number of bare rods in a DFC of a MPC-32ML can range from 17x17 to 26x26. This leads the staff to believe that the 26x26 array on page 6-57 is not a typo.

Drawing 10457 shows that the minimum basket cell opening is 9.53 inches. Table 2.1.2 shows that the minimum outside diameter of the 16x16D fuel, which is to be stored in the MPC-32ML, is 0.423 inches. Thus, the minimal size of DFC to fit the 26 rods in a rod is 10.998 inches. If the rods are inserted in the DFC with tight fit, then, the distance between two rods is D*con (30^{o}) = 0.423*($\sqrt{3}$/2) = 9.525. This will be a very tight fit. Explain how the 26x26 array of fuel will fit into the DFC and provide operating procedure to ensure that this operation will not cause further damages to the already damaged fuel rods.

If the applicant plans to put bare rods in a triangle array inside the fuel basket cell, demonstrate that the criticality safety analyses for square pitch rod array is applicable to the triangle pitch array.

Holtec’s Response to Discussion Point 1

Holtec confirms that the 26x26 array on page 6-57 is not a typo. However, note that various arrays of fuel rods that have been evaluated in the damaged fuel/fuel debris model are hypothetical, and they are just used in criticality analysis to determine the bounding optimum condition for damaged fuel/fuel debris, regardless of its radial/axial configuration in the DFC. However, per fuel assembly limits in Table 2.1.1 (repeated in the CoC), there is a maximum allowable fuel assembly weight (including DFC), which limits the actual amount of fuel in the basket cell for each MPC. Hence a physical loading of large arrays of fuel rods (e.g. 26x26) into a DFC of a MPC-32ML is prohibited. Editorial changes are also made to HI-STORM FW FSAR Proposed Rev. 5E, Paragraph 6.4.4.1 to state that various arrays of fuel rods that have been evaluated are hypothetical but not actual content of the casks.

Discussion Point 2: SHIELDING

RAI 5-4 requested information for the staff to verify that the source term chosen to represent the decay heat is bounding for all possible fuel and fuel loadings or provide loading limits in terms of maximum assembly burnup, minimum enrichment and minimum cooling time for the two new Baskets and new fuel types. The applicant updated the SAR and provided Table 5.4.9 which includes 11 sets of burnup, enrichment, cooling time combination for loading 16x16D fuel assemblies in MPC-32ML. The applicant also indicated that these combinations sufficiently bound all fuel loadings.

Demonstrate via calculated sources that the 16x16D in MPC-32ML produces the bounding source terms (both source strengths and spectra) with respect to combinations of maximum burnup, minimal enrichment, and minimal cooling time within the ranges of these parameters for all proposed new contents.

Holtec's Response to Discussion Point 2

Additional information on the bounding source term with respect to maximum burnup, minimal enrichment, and minimal cooling time is added in HI-STORM FSAR Section 5.4.6 (Proposed Rev. 5E).

Discussion Point 3: MATERIALS

CILC (Crud or Copper Induced Localized Corrosion) fuels should be undamaged fuel. Similar to other Holtec casks, make a note to confirm CILC fuels are undamaged (e.g., based on sipping record).

Holtec's Response to Discussion Point 3

The definition of Undamaged Fuel in HI-STORM FW FSAR (Proposed Rev. 5E) Glossary is updated to align with the definitions in FW CoC Appendix A and Table 2.1.3 (Note 14) of the FW FSAR, which includes some low-enriched BWR fuel without known or suspected grossly breached spent fuel rods. Also, a "caution note" is added to HI-STORM FW FSAR Section 9.2.3 (MPC Fuel Loading) that states low-enriched fuel must be shown to be without known or suspected grossly breached rods via review of records, fuel sipping, or other method.

Discussion Point 4: MATERIALS

The performance of Metamic-HT has been updated for other Holtec casks. This is based on new data on fracture toughness which Holtec established and subsequently NRC analyzed. FW Amendment 4 should also use the new evaluation on Metamic-HT (the latest version of Metamic-HT Source Book).

Holtec's Response to Discussion Point 4

Section 3.4 and Section 1.2.1.4.1 of the HI-STORM FW FSAR (Proposed Rev. 5E) is revised to reflect the new fracture toughness evaluation for Metamic-HT per the latest version of the Metamic-HT sourcebook.

Discussion Point 5: MATERIALS

For information: ISG-22 describes the method to handle the potential oxidation. The staff is evaluating potential fuel pellet oxidation with a Holtec transportation package. Generally, Option 1 in ISG-22 is valid; one Holtec transportation Case is considering Option 2 or other options.

Holtec's Response to Discussion Point 5

A "caution note" is added to HI-STORM FW FSAR Proposed Rev. 5E, Section 9.2.1 (Overview of Loading Operations) that states fuel cladding is not exposed to air during loading operations, and inert gas must be used any time the fuel is not covered with water.

Discussion Point 6: STRUCTURAL

On Page 7 of Attachment 5 to Holtec Letter 5018058, it states that "All HI-STORM FW MPCs have an identical enclosure vessel…" Provide technical justifications on how the structural performance of the MPC-32ML bounds performance of MPC-37 and MPC-89.

Holtec's Response to Discussion Point 6

The above referenced statement means that all three MPC types (MPC-37, MPC-89, MPC-32ML) that are utilized with the HI-STORM FW System have identical enclosure vessel designs, as shown in the Licensing Drawing Package. The enclosure vessel, which serves as the confinement boundary, consists of the MPC base plate, the MPC shell and the MPC closure lid. The stress analyses of the MPC enclosure vessel described in Paragraph 3.4.3.2 and Subparagraphs 3.4.4.1.5 through 3.4.4.1.7 of the HI-STORM FW FSAR are applicable to all three MPC types since they consider the bounding MPC loaded weight per FSAR Table 3.2.8 and the maximum design pressures per FSAR Table 2.2.1.

Discussion Point 7: STRUCTURAL

On Page 16 of Attachment 6 to Holtec Letter 5018058, the maximum calculated plastic strain of the fuel basket is same as the failure plastic strain of 0.197, which means it is about to fail. It also indicates that this maximum plastic strain occurred at a point near the bottom of the basket. Explain physical phenomena of why and how this plastic strain occurs near the bottom of the basket as to occurring at the bottom of the basket.

Holtec's Response to Discussion Point 7

The maximum plastic strain occurs along the vertical symmetry plane near the bottom of the fuel basket, where two orthogonal Metamic-HT panels intersect. Also, the maximum strain occurs on the side of the fuel basket that is opposite from the impact surface (i.e., ISFSI pad surface). Likewise, there is one additional element on the basket vertical panel, interlocking with the bottom most horizontal basket panel, which realizes a maximum strain equal to 0.197. This result is clearly a numerical artifact which is a consequence of the local structural discontinuity associated with the interlocking tabs on the Metamic-HT panels. If local strain result in these two isolated elements is ignored, the maximum plastic strain anywhere else in the fuel basket is less than 0.194.

Discussion Point 8: STRUCTURAL

Following the previous question, provide the modeling of the structural components in the LS-DYNA analysis:

(a) How the fuel assembly is modeled in the fuel basket?
(b) How the weld with the accompanying heat-affected zone between the cladding and the end plug is modeled?

(c) A plot of the finite element mesh in the heat-affected zone.
(d) The LS-DYNA output files for the fuel rod and basket analyses.

<u>Holtec's Response to Discussion Point 8</u>

(a) As shown in FSAR Figure 3.4.13, the fuel assemblies are individually modelled in LS-DYNA as solid rectangular prisms with enveloping dimensions and mass properties that accord with the maximum fuel parameters in Table 2.1.1 of the HI-STORM FW FSAR. This LS-DYNA modelling approach is consistent with other Holtec cask licensing applications, including HI-STAR 60, 180, 180D, 190. More detailed information is provided in Holtec calculation package HI-2094353 [3.4.11].

(b) The purpose of the non-mechanistic tipover analysis is to characterize the response of the HI-STORM FW overpack and the MPC inside. It is not meant to predict the stress and strain response of fuel assembly cladding. Thus, the fuel assemblies are modelled as solid rectangular prisms. Moreover, the confinement evaluation for the HI-STORM FW system takes no credit for fuel cladding integrity in satisfying the regulatory confinement requirement. Therefore, no specific analysis or test results are required to demonstrate cladding integrity. This is further discussed in Section 3.5 of the HI-STORM FW FSAR.

(c) See response to part (b) above.

(d) The LS-DYNA input and output files associated with the non-mechanistic tipover analysis of the HI-STORM FW cask loaded with the MPC-32ML fuel basket were previously provided along with Holtec letter 5018058 (Attachment 6).