Structural Clarification Questions for FW Amendment 7, February 16, 2024 Submittal

1. Provide additional justification that the MPC-32ML and MPC-37-CBS fuel baskets, both analyzed for the tipover accident condition using an “enhanced” LS-DYNA finite element analysis (FEA) model in a Version E overpack, bound the stress analysis results of the remaining fuel basket/overpack pairings currently presented in the SAR.

   In order to demonstrate that the presented basket/overpack selection criteria consistently selects the basket that produces the maximum stresses, the applicant is requested to 1) perform additional studies, by employing the “enhanced” FEA model on a targeted sample of basket/overpack pairings, to validate that the “Beta” parameter consistently determines/correlates to the magnitude of basket stresses, and 2) create a new method, to replace the basket permanent deflection value, of indicating the dynamic response of the basket used to choose the overpack pairing. Alternatively, the applicant may analyze all basket/overpack pairings using the “enhanced” FEA model to determine the resulting stresses without attempting to develop a methodology for selecting the bounding baskets for stress analysis.

   In SAR section 2.2.8, the applicant introduced a “Beta” parameter for all baskets in the FW system, as tabulated in Table 2.2.15, which is intended to predict the basket that will produce the most limiting stress results. Although it is not specifically stated in the SAR, the LS-DYNA model employed to produce the limiting basket stress results is actually an “enhanced” model that incorporates three major changes to the chosen basket models, as described in section G.2 of report HI-2200503, revision 8. The “Beta” parameter is based on basket-specific geometry and static fuel assembly weight. Therefore, the effects of the dynamic response of the basket in specific overpack pairings is not addressed in this method of determination of the “bounding” fuel baskets. Furthermore, there is no indication of what action is to be taken for the introduction of a revised or new overpack.

   In response to NRC staff concerns raised after the January 26 coordination meeting regarding the “Beta” parameter not addressing the dynamic response of the fuel basket in different overpacks, the applicant indicated that the magnitudes of basket maximum permanent deflection results are indicative of the basket dynamic response in different overpacks, where a higher permanent deflection value would reflect a higher dynamic energy input. Therefore, presumably based on this assumption, the applicant chose to reanalyze the baskets with higher permanent deflection values in the Version E overpack.

   As a means of validating the applicant’s statement, the staff reviewed the basket deflection and stress results as well as the associated deceleration results for all basket/overpack pairings submitted by the applicant in November 2023. The staff has summarized the following observations, which should be addressed in justifying the bounding fuel basket determination.

   a. The baskets with the 10 highest maximum stress results are not associated with the MPC-32ML and MPC-37-CBS baskets, which Holtec chose as limiting based on the “Beta” value. Therefore, there does not appear to be a direct correlation between the magnitude of the “Beta” parameter and the resulting basket stresses.

b. The two largest maximum permanent deflection values do appear to correspond to the two baskets chosen as limiting, however, there does not appear to be a direct correlation between these deflection values and the maximum reported stresses.

c. The maximum deceleration values for the lids of the Version E overpack system appear to range from 48 to 69 g's, whereas those of the Version UVH appear to range from 86 to 90 g's, and those of the Standard version fall somewhere in between. It is noted that the maximum deceleration of the MPC-37-CBS basket in the Version E overpack, chosen as the limiting CBS-type fuel basket for stress determination, is 48 g's. Although the staff recognizes that the dynamic response of any one component of a more complex structural system is not intuitively predictable, the magnitude of the dynamic impact energy input to each unique cask system via the overpack during the tipover event is generally indicative of the impact energy levels imparted to the internal cask components, including the fuel baskets. Therefore, the magnitudes of the dynamic impact for each basket/overpack pairing should be further considered in choosing any limiting cask system for stress analysis. Additionally, the applicant should add explicit instructions regarding the analytical requirements for the introduction of a new or revised overpack paired with an existing or new fuel basket.

Based on the items listed above, the staff concludes that the applicant has not provided sufficient justification to conclude that the basket/overpack pairings chosen by the "Beta" factor and maximum permanent deflection criteria reliably produce the most limiting stress results.

This information is needed to determine compliance with the regulatory requirements in 10 CFR 72.236(b).

2. Justify how the methodology for selecting the bounding baskets for detailed stress analysis accounts for changes to components of the storage system (e.g., the overpack) other than the basket panel slenderness and fuel assembly weight.

In SAR section 2.2.8, the applicant introduced a methodology for selecting the bounding baskets for detailed stress analysis. There are currently two screening criteria that determine if a basket is bounding and whether a detailed stress analysis must be performed using an enhanced FEA model. After discussing the screening criteria, the SAR then states that this detailed stress analysis "shall be performed for the storage overpack that caused the maximum permanent deflection of fuel baskets." The staff is concerned that the overpack could affect which baskets experience the most critical stresses, and thus the overpack should be considered in determining which baskets are bounding. By accounting for the overpack after determining the bounding basket, the applicant could be neglecting to analyze a basket and overpack combination that results in the most critical stress results.

For each basket/overpack pairing, an LS-DYNA model must be constructed and analyzed for the tipover condition to verify that the design criteria for the overpack, MPC, and fuel basket permanent deflection limit is met. It appears to staff that once this FEA model is created, the determination of the resulting basket stresses for each basket/overpack pairing *would be readily available* and provide a much more direct and accurate indication of which pairing produces the maximum basket stress than the maximum permanent deflection results (as discussed in Question 1). These maximum stress results would then provide a direct comparison with the design acceptance criteria of 90% of true ultimate strength. If the

stress criterion is not met in this initial FEA model, the fuel basket would be analyzed using the “enhanced” model, as described in section G.2 of Report HI-2200503, revision 8.

This information is needed to determine compliance with the regulatory requirements in 10 CFR 72.236(b).

3. Describe the “enhanced” FEA model and the selection of the bounding basket in a prominent place in the SAR and calculations, presenting only the new analysis models used for the determination of basket stress results. Also, since some legacy figures of the original FEA model must remain to support the existing presented permanent deflection results, these must be labeled appropriately to distinguish them from any new figures.

   Currently, the statements of intent in sections 2.2.8, 3.4.4.1.4, and 3.I of the latest revision of the SAR that rely on the current stress results of the limiting baskets, MPC-32ML and MPC-37-CBS, do not clearly convey that the existing stress (and strain) results for other baskets presented in previous SAR revisions are superseded by those of the limiting baskets. To eliminate confusion for current and future users of the SAR, this new information must be prominently and clearly communicated, and further clarifying language should be added to explain that the existing FEA models for all baskets are still used as the basis for reported permanent deflection results.

   New figures depicting the basket temperature zones associated with the “enhanced” FEA model must be added to the SAR, and the existing ones supporting the legacy permanent deflection results must be clearly labeled to distinguish between them. The previous basket stress contours that are no longer valid must be removed from the SAR, and any tables presenting basket strain results must be corrected to remove these results, as they are no longer pertinent or valid (e.g., table 3.I.3.9).

   Similarly, the design reports supporting the basket tipover designs must be revised for clarification purposes. Currently, only the report for the Version E overpack tipover analysis, HI-2200503, is revised and submitted to add appendix G. The other appendices of this report as well as the other design reports documenting the standard and Version UVH overpack tipover analyses (i.e., HI-2094353, HI-2166998, and HI-2210313) must also be revised to communicate the change in the method of basket stress determination, as well as remove existing erroneous and superseded results. Current examples of portions of HI-2200503 that require further revision are the main body and appendices C, D and F.

   These requested clarifications serve to prevent any confusion as to which tipover models and results form the licensing basis.

   This information is needed to determine compliance with the regulatory requirements in 10 CFR 72.11(a).

4. Correct or justify the true stress-strain curve values determined for Metamic-HT basket material at 180 °C.

   Appendix B of report HI-2200503, revision 8, presents the determination of true stress-strain curves for the Metamic-HT basket material for use in the LS-DYNA model. For the material at 180 °C, it is stated that the input parameters are interpolated from the minimum guaranteed values presented in the Metamic-HT Source Book for 200 °C and ambient

temperature. In Appendix B, ambient is defined as 30 °C, while the Source Book states that ambient is 40 °C.

This information is needed to determine compliance with the regulatory requirements in 10 CFR 72.236(l).

5. Administrative errors that warrant attention, but are not necessary for the staff to make a regulatory finding:

   a. Provide a copy of the revised DS-331 document for staff review. SAR reference 2.2.12 indicates that the current revision of this document is Revision 2. However, Revision 3 was submitted for staff review in August 2023. In December 2023, the staff advised that several errors were present in this revision, specifically the definition of the true ultimate strength values for Metamic-HT. Please correct these errors and resubmit for review, as well as updating reference 2.2.12 to the correct revision number.

   b. In Table 2.2.5, the “w” value of 10.81 lbf/in entered for the MPC-32ML fuel basket should be 11.22 lbf/in.