RAI Responses

CHAPTER 6 CRITICALITY REVIEW

6-1 Justify that the parametric studies performed for the HI-STAR 190 are applicable to the HI-STAR 100MB package or provide separate analyses.

On page 6.0-2 of the application, in the discussion of the reactivity impact of various parameters such as the geometries of fuel rod, assembly design and fuel basket design, the applicant concludes that there is no need to perform parametric studies for the HI-STAR 100MB. The studies performed for the HI-STAR 190 are applicable to the HI-STAR 100MB because: "*PWR fuel is always undermoderated. Any variations that cause an increase in the amount of water without decreasing the amount of fuel will increase reactivity.*"

The staff notes that, for the HI-STAR 190 results, these studies appeared to be based on fresh fuel at the maximum enrichment (5% U-235). While this conclusion is true for fresh fuel, it may not be the case for a spent fuel package that takes burnup credit. Based on the staff's own calculations, the fissile material present in a Westinghouse 17x17 fuel assembly with an initial enrichment of 5 w.t.% U-235 and 60 GWd/MTU burnup is roughly $1.6x10^4$ grams of fissile materials (U-235+Pu-239+Pu-241) per metric ton of uranium (MTU). This is roughly equivalent to a 1.6% U-235 enrichment, neglecting the slight difference between U-235 and Pu-239/Pu-241 for their contributions to reactivity. With consideration of the presence of fission products and other absorber actinides in the spent fuel, the spent fuel package flooded with fresh water could become over-moderated. As such, the applicant's parametric studies for the HI-STAR 190 may not be applicable to the HI-STAR 100MB that takes burnup credit.

This information is required by the staff to determine compliance with 10 CFR 71.55(b), 71.55(d), 71.55(e), and 71.59.

Holtec Response to RAI 6-1:

All studies and calculations in the application have now been performed directly for the HI-STAR 100MB, instead of including corresponding results from the HI-STAR 190. Hence there is no reliance in the application anymore on results calculated for the HI-STAR 190 system. Tables, references and discussions have been updated accordingly. This also addresses RAIs 6-2, 6-4, 6-5, and 6-8, and parts of RAIs 6-6 and 6-7.

6-2 Demonstrate that the studies on the impact of basket tolerances on the system's reactivity for the HI-STAR 190 package are applicable to the HI-STAR 100MB package design.

On page 6.0-2 of the application, the applicant states: "*Studies regarding the basket tolerances and deflections have historically shown to be reliant solely upon basket structure (flux trap vs. no flux trap). Decreasing the cell ID for each basket cell reduces the distance between fuel assemblies; however, increasing the cell ID for each basket cell increases moderation for those fuel assemblies. In the case where flux traps are not* *present in the basket structure, reducing the distance between fuel assemblies increases reactivity of the system much more than the reduction in reactivity due to decreased moderation. In the case where flux traps are present in the basket structure, increasing the amount of water within a cell increases the reactivity of the system much more than the reduction of reactivity due to increased distance between fuel assemblies. Therefore, this study, performed for MPC-37 of the HI-STAR 190 SAR, is not necessary to repeat and its results apply to the MPC-32M and F-32M fuel packages*."

However, the staff notes that the HI-STAR 100MB and the HI-STAR 190 have different fuel basket configurations and sizes: the MPC-37 basket in the HI-STAR 190, with 37 PWR fuel assemblies, is much larger than the MPC-32M and F-32M fuel baskets and hence has a much smaller geometric buckling. Consequently, the neutron flux and neutron importance distributions will be different.

Because neutronic sensitivities highly depend on the neutron flux and neutron importance, the sensitivity studies performed for the HI-STAR 190 may not be directly applicable. The staff needs this information to determine if the results and conclusion are directly applicable to the HI-STAR 100MB package design that takes burnup credit.

This information is required by the staff to determine compliance with 10 CFR 71.55(b), 71.55(d), 71.55(e), and 71.59.

Holtec Response to RAI 6-2:

See response to RAI 6-1.

6-3 Provide the bounding fuel assembly (FA) design used in the criticality safety analyses for an array of packages under normal conditions of transport and hypothetical accident conditions.

In Tables 6.1.1 and 6.1.2, the applicant identified the bounding k_{eff} values for the package containing the MPC-32M canister, the F-32M, or the F-24M basket. Table 6.1.1 indicates that the package containing the 16x16 FA design in the MPC-32M canister or the F-32M basket has the maximum k_{eff} and Table 6.1.2 indicates that the package containing the 17x17A FA design in the F-24M basket gives the highest k_{eff}.

In Table 6.1.3 of the SAR, the applicant provides a summary of the criticality safety analyses for a single package, as well as, an array of packages that contain the MPC-32M canister or F-32M or F-24 basket to demonstrate compliance with the regulatory requirements of 10 CFR 71.55 and 71.59. However, the staff notes that the FA class 15x15B is used in these analyses. This is not the bounding FA as identified in Table 6.1.1 and 6.1.2 of the application.

This information is required by the staff to determine compliance with 10 CFR 71.55(b), 71.55(d), 71.55(e), and 71.59.

Holtec Response to RAI 6-3:

Minor Adjustments were made to the loading curves for the MPC-32M and F-32M. With that, the assembly class 15x15B is bounding, which justifies its use as the design basis assembly for those baskets.
For the F-24M, the assembly class 17x17A remains bounding, and results in various tables are now presented for that class.

6-4 Justify that the various sensitivity studies performed for the HI-STAR 190 are applicable to the criticality safety of the HI-STAR 100MB package containing the MPC-32M canister, F-32M basket, or the F-24M basket.

The applicant provides studies on various factors, such as moderator density, partial flooding, preferential flooding, and eccentric positioning of the FAs for the HI-STAR 190 and claims that these studies are applicable to the HI-STAR 100MB package. From the data presented in the tables of the HI-STAR 190 application (Table 6.3.7, 6.3.12(a), 6.3.12(b), etc.), it appears that these studies are based on a single burnup, enrichment, and cooling time combination.

However, the equations provided in Table 7.7.3(a) (i.e., the loading curve) of the HI-STAR 100MB application indicate that the required minimum burnup is a function of the enrichment and the enrichment can vary from 2.25% to 5.0% with a cooling time of 3 years. The applicant provides no specific justification for the applicability of these studies to the HI-STAR 100MB package. Without a clear justification, the staff cannot determine the applicability of the various sensitivity studies performed for the HI-STAR 190 to the criticality safety analyses of the HI-STAR 100MB package containing the MPC-32M canister, F-32M basket, or the F-24M basket. The staff is particularly concerned with the applicability of these studies to the F-24M basket because the package containing the F-24M basket does not take burnup credit.

This information is required by the staff to determine compliance with 10 CFR 71.55(b), 71.55(d), 71.55(e), and 71.59.

Holtec Response to RAI 6-4:

See response to RAI 6-1.

6-5 Demonstrate that the loading curve developed for the HI-STAR 190 package containing the MPC-37 canister is appropriate for the HI-STAR 100MB package containing the MPC-32M canister or F-32M basket.

On page 6.B-1 of the application, the applicant states: “*The same loading curve developed for MPC-37 of HI-STAR 190 is used for the MPC-32M and F-32M fuel packages. As discussed in Subsection 6.0.1, the results of benchmark evaluations for MPC-37 of HI-STAR 190 are applied to HI-STAR 100MB, i.e. the total bias and bias uncertainty determined for fresh (MPC-89) and spent fuel (MPC-37) in Table 6.B.14* *have been used for F-24M and MPC-32M/F-32M, respectively. This is acceptable due to the similarities between the HI-STAR 100MB and HI-STAR 190 characteristics, such as considered materials, fuel assembly and fuel basket geometry, etc. (see Subsection 6.0.1) and evaluation methodologies, including the same codes for depletion and criticality calculations*."

The staff notes that the design and contents of the two packages are significantly different. The HI-STAR 190 package contains 37 PWR fuel assemblies whereas the HI-STAR 100MB contains only 32 PWR fuel assemblies. As such, the fuel basket sizes are significantly different, resulting in significantly different geometric buckling (the geometric buckling of the MPC-37 is 0.000715574, the geometric buckling of MPC-32 is 0.000832485 assuming a typical 144 inches active fuel length) that impact the system's reactivity. Consequently, the same fuel assembly will have a different reactivity worth and the loading curves may be significantly different between these two packages.

This information is required by the staff to determine compliance with 10 CFR 71.55(b), 71.55(d), 71.55(e), and 71.59.

Holtec Response to RAI 6-5:

See response to RAI 6-1.

6-6 Demonstrate that the total bias and bias uncertainty determined for fresh (MPC-89) and spent fuel (MPC-37) in Table 6.B.14 can be used for F-24M and MPC-32M/F-32M.

On page 6.B-1 of the application, the applicant concludes that the results of benchmark evaluations for MPC-37 of HI-STAR 190 are applied to the HI-STAR 100MB, i.e. the total bias and bias uncertainty determined for fresh (MPC-89) and spent fuel (MPC-37) in Table 6.B.14 have been used for F-24M and MPC-32M/F-32M, respectively. The applicant further determines that the bias and bias uncertainty are acceptable due to the similarities between the HI-STAR 100MB and HI-STAR 190 characteristics.

The staff notes that the design and contents of the two packages are significantly different in three aspects: (1) the capacity of the HI-STAR 190 is 37 PWR assemblies and the capacity of the HI-STAR 100MB with MPC-32M or F-32M basket is 32 PWR assemblies; (2) both the MPC-89 and F-24M assume fresh fuel but the MPC-89 is a BWR basket whereas the F-24M is a PWR basket; and (3) the F-24M includes flux traps while the MPC-89 does not.

With these significant differences in these two package designs, it is not clear why the total bias and bias uncertainty determined for the MPC-89 basket (fresh fuel) can be used for the F-24M and the total bias and bias uncertainty determined for the MPC-37 (spent fuel) can be used for the MPC-32M or F-32M basket.

This information is required by the staff to determine compliance with 10 CFR 71.55(b), 71.55(d), 71.55(e), and 71.59.

Holtec Response to RAI 6-6:

See response to RAI 6-1. Table 6.B.13 is now specifically for the HI-STAR 100MB, without any reliance on the HI-STAR 190. For the applicability of the selected benchmarking experiments to the F-24M, an additional discussion is provided in Appendix 6.A.

6-7 Demonstrate that the Interim Staff Guidance 8 (ISG-8) revision 3 (ISG-8, Rev.3), applicability conditions for treating the bias and bias uncertainty of the minor actinides and fission products (MAFP) is applicable to the HI-STAR 100MB package design.

On page 6.0-2 of the application, the applicant concludes that the results of benchmark evaluations for the MPC-37 of HI-STAR 190 are applied to all HI-STAR 100MB fuel packages. The results of the burnup credit analysis and verification of assembly burnup evaluated for MPC-37 of HI-STAR 190 are directly applied to the MPC-32M and F-32M fuel packages. The staff notes that the burnup credit analyses for the HI-STAR 190 used the recommendation of ISG-8, Rev. 3. The ISG sets the conditions for using the recommendation as:

- "uses the SCALE code system with the ENDF/B-V, ENDF/B-VI, or ENDF/B-VII cross section libraries,
- can justify that its design is similar to the hypothetical GBC-32 system design used as the basis for the NUREG/CR-7109 criticality validation, and
- demonstrates that the credited minor actinide and fission product worth is no greater than 0.1 in k_{eff}."

In addition, the applicant performed some analyses to compare the similarities between the GBC-32 cask and the HI-STAR 100MB cask containing the MPC-32M canister and the F-32M basket. The applicant concludes that overall the evaluations show that the HI-STAR 100MB is sufficiently similar to the GBC-32 cask to justify the applicability of the method (Appendix 6.C, "6.C.1 Comparison of GBC-32 and MPC-32M, F-32M Fuel Baskets").

The staff reviewed the applicant's comparison of the cask design and the neutronic characteristics between the GBC-32 and the HI-STAR 100 MB and notes:

1. the applicant used CASMO code in its spent fuel material composition analyses and the CASMO code is not capable of tracking the ingrowth of Gd-155 as a fission product. Therefore, the use of the CASMO code does not meet the condition of using the recommendation of ISG-8, Revision 3.

2. the basket designs of the HI-STAR 100 MB and the GBC-32, including the basket and fuel cell geometric dimensions, poison plates, are significantly different.

3. The fuel types to be loaded are different. GBC-32 contains only 17x17 fuel assembly whereas the MPC-32M/F-32M is designed to load both 17x17, 14x14, 15x15 and 16x16 fuel assemblies and many subtypes of these assemblies.

4. The active fuel region length of the fuel assemblies in the MCP-32M/F-32M is 6 inches longer than that of the GBC-32 fuel assembly (150 vs 144 inches). Consequently, MPC-32M/F-32M contains more fuel.

5. The 16x16 fuel class contains Er_2O_3 burnable poison in the fuel pellet. The applicant did not perform any study on the bias and bias uncertainty of the criticality safety analysis code associated with the fuel poisoned with Er_2O_3.

Based on the above comparisons, it appears that the fuels and basket designs of the MPC-32M canister or F-32M basket are significantly different from that of the GBC-32 cask. The staff needs specific justification for the applicability of the recommendation from ISG-8, Rev. 3 on the bias and bias uncertainty for the criticality code benchmarking for MAFPs is appropriate.

This information is required by the staff to determine compliance with 10 CFR 71.55(b), 71.55(d), 71.55(e), and 71.59.

Holtec Response to RAI 6-7:

The overall approach addressing the MAFP bias is consistent with previous applications, namely for the HI-STAR 100 in Amendment 10 [1] and for the HI-STAR 190 [2]. Specifically, Appendix 6.C contains the comparison between the HI-STAR 100MB and the GBC-32, including consideration for two different assembly types in the HI-STAR 100 MB, and shows all those are neutronically equivalent.

Further Note that the MAFP bias has only a rather small effect on the overall evaluation. This bias is only of the order of 0.0015 delta-k, which is a small fraction of the overall bias and bias uncertainties (which is about 0.0246), and an even smaller fraction of the expected margin (more than 0.04 based on the best estimate calculation in Section 6.B.6).

6-8 Demonstrate that the results of the misload analyses performed for the HI-STAR 190 are applicable to the HI-STAR 100MB package.

On page 6.E-1 of Appendix E of the application, the applicant asserts that the results of the misload analysis for the HI-STAR 190 is used for the HI-STAR 100MB. The applicant concludes that the same loading curve developed for the MPC-37 of the HI-STAR 190 is used for the MPC-32M and F-32M fuel packages and the results of the misloading condition in MPC-37 will have a similar result for a misloading condition in the MPC-32M or F-32M because of the baskets nearly identical geometry and materials.

The staff, however, notes that the two packages have significant differences in fuel basket geometry and total fuel load. The HI-STAR 190 fuel basket is loaded with 37 PWR fuel assemblies while the HI-STAR 100MB can hold only 32 PWR fuel assemblies. Thus, a misload of the fuel assembly in these two packages will have different reactivity insertions because the neutron leakage and neutron importance distribution in these two packages are different.

The applicant is requested to demonstrate that the misload analyses performed for the HI-STAR 190 package bound the reactivity insertion in the HI-STAR 100MB package.

This information is required by the staff to determine compliance with 10 CFR 71.55(b), 71.55(d), and 71.55(e).

Holtec Response to RAI 6-8:

See response to RAI 6-1.

References:

[1] Letter to R.Ngwayah, "re: Certificate of Compliance No. 9261, Revision No. 10, for the Model No. HI-STAR 100 package", USNRC, ADAMS Accession No. ML18290A533, October 16, 2018.

[2] Letter to R.Ngwayah, "re: Certificate of Compliance No. 9373, Revision No. 1, for the Model No. HI-STAR 190 package", USNRC, ADAMS Accession No. ML18332A028, December 4, 2018.