

## Request for Supplemental Information

**Docket No. 72-1032**  
**Certificate of Compliance No. 1032**  
**Amendment No. 4 to the HI-STORM Flood/Wind (FW) Multipurpose Canister Storage System**

### Chapter 3 – Structural Evaluation

- 3-1 Provide Holtec Report HI-2094353, Revision 10, “Analysis of the Non-mechanistic Tipover Event of the Loaded HI-STORM FW Storage Cask.”

Reference 28, of the Attachment 8, to the Holtec Letter 5018043 refers to the above mentioned Holtec report. The staff needs this report to verify the relevance of this report to the current tipover analysis submitted by the applicant, “Holtec Report No: HI-2166998, Rev. 0 for the HI-STORM FW Cask loaded with MPC-32ML and MPC-31C.

This information is needed to verify compliance with 10 CFR 72.236(b).

#### Holtec Response:

Attachment 5 to this letter contains Holtec Report HI-2094353 Revision 10 for the staff's information. The intent of the reference in Holtec Report HI-2166998 Revision 0 to the previous report is to indicate that Holtec has followed the same methodology for qualifying the new MPC designs as the original, previously approved MPC designs.

### Chapter 4 – Thermal Evaluation

- 4-1 Provide a detailed description of the HI-STORM FW thermal models for MPC-32ML and MPC-31C.

The application did not provide a detailed description of the model configuration. Section 4.5.4.1 of NUREG-1536 states that any model used in the thermal evaluation should be clearly described. The staff needs this information to determine the adequacy of the developed thermal models to predict applicable thermal limits.

This information is necessary to verify compliance with 10 CFR 72.236(a) and (f).

#### Holtec Response:

Specific modeling details for MPC-31C and MPC-32ML were provided in Paragraph 4.4.1.1 of the FSAR with the original submittal of HI-STORM FW Amendment 4. In order to provide further clarification on the thermal models and methodology, paragraphs (iv) and (v) have been included in Section 4.4.1.1 of the HI-STORM FW FSAR Proposed Revision 5.B included with this submittal.

## Chapter 5 – Shielding Evaluation

- 5-1 Provide a shielding analysis for the new fuel types (16x16D, V10A, V10B fuel assemblies) and their corresponding canisters (MPC-32ML and MPC-31C) to be stored in the HI-STORM FW System.

In the amendment application, the applicant requests to authorize storage of 16x16D assemblies in the MPC-32ML canister, and V10A/V10B assemblies in the MPC-31C canister. The applicant states that the shielding evaluations will be performed on a site-specific basis; therefore, no change to Chapter 5 of the HI-STORM FW FSAR is required. However, 10 CFR 72.236(d) requires the applicant to demonstrate that the radiation shielding and confinement features of the cask system are sufficient to meet the requirements of 10 CFR 72.104 and 72.106. The applicant has not provided any information that demonstrates compliance with 72.236(d) for the new fuel types and their corresponding basket and canister types. In addition, the applicant should update the occupational dose estimate analyses to address the new fuel and canister types.

This information is needed to verify compliance with 10 CFR 72.236(d).

### Holtec Response:

The design basis Zircaloy clad fuel Westinghouse 17x17 in the MPC-37 canister is used for calculating the dose rates presented in Chapter 5 for PWR fuel types.

In the amendment application, new fuel types 16x16D in the MPC-32ML canister, and V10A/V10B assemblies in the MPC-31C canister are requested to be added.

Holtec compared source terms to show similarities of the design basis fuel to the new fuel types. Table 1 shows that the total gamma and neutron source terms for the entire basket filled with proposed fuel assemblies are within approximately 10% of the design basis assembly source terms. The basket materials for the three different canister designs are the same, thus resulting in similar shielding properties of the HI-STORM FW system. The rest of the HI-STORM FW system is not affected by adding these new fuel types.

Chapter 5 dose rates for normal conditions are calculated for an average burnup and cooling time values shown in Table 5.0.1. These values are based on a total heat loads. Similarly, to meet the heat load limits for fuel with the higher source term, the cooling time may need to be extended, depending on site specific requirements. The small variation of the source term discussed above will not negatively affect satisfying 10 CFR 72.104 in site specific analyses. For the accident conditions, it is recognized that the bounding accident condition is the loss of water in the HI-TRAC VW. The upper bound burnup and lower bound cooling time are selected to maximize the source term. The resulting burnup and cooling times values for accidents are listed in Table 5.0.2. A significant margin to 10 CFR 72.106 limit is shown in Table 5.1.9. Therefore, the bounding source term provides sufficient margin to 10 CFR 72.106 dose limit even with a small variation in the source term discussed above.

Occupational dose depends on the cask source terms and loading operations sequence. Since the loading operation remains the same and the new cask source terms are similar to the design basis source terms, the dose estimates for the design basis fuel remain representative of loading HI-STORM FW system.

**Table 1 [PROPRIETARY INFORMATION WITHHELD PER 10CF2.390]**

## Chapter 6 – Criticality Safety Evaluation

- 6-1 Provide a specific definition for the term “partial gadolinium credit” and a detailed description of the method used for BWR burnup credit analysis.

The applicant states that it used “partial gadolinium credit” for the MPC-89 BWR fuel cask criticality safety design of the HI-STORM FW system. However, the applicant provided neither a specific definition for the term “partial gadolinium credit”, nor a detailed description for how this method works. The applicant needs to provide a specific definition for the term “partial gadolinium credit.” The applicant also needs to provide a detailed explanation on how this partial gadolinium credit is determined, the technical bases, and justification that it is conservatively applied.

This information is needed to verify compliance with 10 CFR 72.124.

### Holtec Response:

To clarify the background and a specific definition for the term “partial gadolinium credit” the Subsection 6.4.10 has been revised and the following discussion has been included:

“Traditionally, criticality safety calculations for dry storage and transport of BWR fuel have been performed assuming fresh fuel, and neglecting any burnable absorbers in the fuel. With respect to burnable absorbers, modern BWR fuel assemblies rely solely on integral neutron absorbers in the fuel assemblies for long term reactivity control in the reactor. As a result, every modern BWR fuel assembly contains a substantial amount of burnable absorbers, in the form of Gadolinia ( $Gd_2O_3$ ) mixed into the  $UO_2$  for a number of the fuel rods, hereinafter referred to as Gd rods. This is in contrast to PWR fuel which primarily utilizes soluble boron in the water for long term reactivity control, optionally supported by removable and/or integral burnable poison. Hence not all PWR assemblies contain any integral burnable absorbers, and even if they do, the amount is not as significant as in BWR assemblies. In the past, credit for burnable poison, or for burnup for that matter, was generally not necessary for BWR dry storage and transportation system, since the enrichment limits resulting from the criticality safety evaluations were high enough to encompass a large fraction of the fuel inventories (For modern 10x10 BWR assemblies the enrichment limit is about 4.6 to 4.8 wt%, depending on the assembly type). However, by now assemblies exceed those values. And, if after the shutdown of a nuclear plant the entire inventory of spent fuel is moved into dry storage, it is no longer sufficient to cover just a substantial fraction of assemblies, all assemblies need to be qualified.

By now, gadolinium credit methodologies are available, and supported by regulatory guidance documents (NUREG/CR-7194 [6.4.2]), to increase the permissible initial enrichment for dry storage and transportation. One of the complications in such methodologies is the fact that the typically large amount of gadolinium results in a “peak reactivity” condition, where the most reactive condition is no longer the fresh condition, but the condition at a burnup where the poison is burned out, typically at burnups around 10 to 15 GWd/mtU. This then requires a depletion calculation of the fuel in order to identify the most reactive condition of the fuel assembly. However, for the MPC-89, only a limited reactivity benefit is needed from the gadolinium, since the qualified enrichment (see Table 6.1.2) even without such credit is already very close to the maximum

enrichment of 5 wt%. This allows a significant simplification of the gadolinium credit: only a small fraction of the gadolinium needs to be credited, and in this case the “peak reactivity” condition is not applicable, i.e. the fresh condition is the most reactive condition. And since only a small fraction of the available amount of gadolinium in the fuel assembly is credited, this methodology is characterized as the “partial gadolinium credit”.

[

PROPRIETARY INFORMATION WITHHELD PER 10CFR2.390

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## OBSERVATIONS

1. Provide addition code benchmarking analyses for the HI-STORM 100 with the VVER fuel content.

The applicant selected some critical experiments to benchmark the computer code it used to perform criticality safety analyses for the HI-STORM FW system design for the VVER reactor fuel designs, which have a hexagonal shape. However, it appears that only six of the selected critical experiments are in hexagonal geometry. As such, it is not clear if the set of selected critical experiments are sufficient to support a reliable and accurate bias and uncertainty analysis, including the trends of the  $k_{\text{eff}}$  value with respect to the key parameters, as identified in NUREG/CR-6361.

### Holtec Response:

We recognize that six critical experiments are somewhat insufficient to perform an extensive benchmark of the computer code. However, the basic assumption was that the computer code and cross-section library are already benchmarked using the base set of the critical experiments and the conclusions are directly applicable to the extended set of experiments (including the hexagonal fuel lattices). This response provides additional descriptions and arguments that hopefully will help to support the approach used for analysis of the MPC-31C basket.

As discussed in Section 6.5 and Appendix 6.A, the most important parameters are the enrichment, cell spacing and  $^{10}\text{B}$  loading of the neutron absorber panels; other parameters, within the normal range of fuel designs, have a smaller effect. It should be noted that the geometric and material characteristics of commercial VVER fuel (important for criticality) are similar or enclosed by the characteristics of PWR fuel, as shown in the following table:

Parameter	PWR	VVER
Pellet OD (in.)	0.3088 – 0.440	0.298 – 0.299
Fuel Material	UO <sub>2</sub>	UO <sub>2</sub>
Fuel Density, g/cc	10.686	10.686
Clad ID (in.)	0.315 – 0.388	0.304
Clad OD (in.)	0.360 – 0.440	0.358
Clad Material	Zr-based	Zr-based
Fuel Rod Pitch (in.)	0.496 – 0.580	0.502
Active Fuel Length (in.)	150 - 170	138.98 – 144.88
Enrichment, wt% <sup>235</sup> U	≤ 5.0	≤ 5.0
Fuel Lattice	Square	Hexagonal

As a matter of fact, the only substantial difference between VVER and PWR fuel is the configuration of the fuel rods in the lattice, i.e. hexagonal and square lattice, respectively. Nevertheless, taking into account the comparable fuel rod pitch, fuel pellet and cladding dimensions, which produce the conforming hydrogen-to-fissile ratio, a similar degree of thermalization of the fissile system is expected for both fuel designs. To verify the accuracy of calculations for the hexagonal lattice experiments with the Monte Carlo code MCNP5, an approach of representing the data through a spectrum index that incorporates all of the variations in parameters, i.e. energy of the average lethargy causing fission (EALF), is utilized. Figure below shows the calculated  $k_{\text{eff}}$  for the benchmark critical experiments documented in Appendix 6.A as a function of EALF values for MCNP5-1.40. As expected, no substantial difference between the square and hexagonal lattice experiments is observed; the calculated  $k_{\text{eff}}$  values tend to criticality and there is no significant correlation with EALF.

[REMAINDER OF RESPONSE IS PROPRIETARY INFORMATION WITHHELD PER 10CFR2.390 ]