NRC RAI 4-1

Provide thermal results for the new MPC-31C and MPC-32L canisters under normal storage conditions.

Section 4.4.1.5 of the FSAR states that to evaluate the storage scenario, 3-D FLUENT screening models of the HI-STORM FW cask are constructed and that peak cladding temperatures (PCT) are computed and tabulated in Table 4.4.2 of the FSAR. However, it is not clear if the screening results provided in FSAR Table 4.4.2 are the final thermal results for the MPCs. The staff needs this information to verify that the predicted temperatures for the new canisters are below the recommended limits.

This information is needed to determine compliance with 10 CFR 72.236(b), and 72.236(f).

Holtec Response

Holtec withdraws MPC-31C canister from this license amendment. FSAR has been modified to remove discussions related to MPC-31C.

We regret the confusion caused by peak cladding temperature (PCT) reported in Table 4.4.2 of the FSAR. To avoid confusion, the computed PCT result for MPC-32ML canister has been removed from Table 4.4.2 of the FSAR. The computed PCT and other component temperatures for MPC-32ML canister are now added to Table 4.4.3 of the FSAR. Thermal evaluations of MPC-32ML were performed using a mesh with similar mesh density as that previously approved by NRC and presented in Section 4.4.1.6 of the FSAR. The results presented in Table 4.4.3 are the final thermal results for this canister.

Table 4.4.2 now only contains the PCT results for MPC-37 and MPC-89. As explained in Note 2 of this table, the results therein are from screening evaluations of MPC-37 and MPC-89 canisters using a reference coarse mesh. The table now is exactly the same as that previously approved revisions of the FSAR.

NRC RAI 4-2

Provide the thermal analysis discretization error for the normal conditions of storage by calculating the grid convergence index (GCI) for the new MPC-31C and MPC-32ML canisters.

The applicant did not perform grid sensitivity studies to obtain the discretization error for the new canisters. Given the screening results provided in FSAR Table 4.4.2 that show the predicted temperatures are very similar, the applicant should obtain the discretization error by calculating the GCI. The staff has accepted GCI calculations which are based on procedures described in American Society of Mechanical Engineers Verification and Validation 20-2009 (ASME V&V 20-2009), "Standard for Verification and Validation in Computational Fluid Dynamics and Heat Transfer". The staff needs this information to assure predicted temperatures for the new canisters are in fact bounded by previous analysis.

This information is needed to determine compliance with 10 CFR 72.236(b), and 72.236(f).

Holtec Response

Holtec withdraws MPC-31C canister from this license amendment. FSAR has been modified to remove discussions related to MPC-31C.

The computed PCT for MPC-32ML is provided in Table 4.4.3 of the FSAR. The results of the calculations conclude that the computed temperatures for MPC-32ML are substantially lower than the licensing basis results for MPC-37 (also tabulated in Table 4.4.3). Therefore, MPC-37 with pattern A is the most limiting thermal scenario and adopted in the FSAR for all licensing basis evaluations. The discretization error for the normal conditions of storage by calculating the grid convergence index (GCI) was performed for the most limiting thermal scenario of MPC-37 and presented in Section 4.4.1.6 of the FSAR. Additionally, it must be noted that the thermal evaluations of MPC-32ML were performed using a mesh with similar mesh density as the licensing basis converged mesh for MPC-37 (Section 4.4.1.6 of the FSAR). A clarification is added to Section 4.4.1.6 of the FSAR. Therefore, no additional mesh sensitivity studies are performed for MPC-32ML canister.

NRC RAI 4-3

Clarify the difference between the screening results reported in Table 4.4.2 of the FSAR and the results obtained from grid convergence studies reported on page 4-68 of the FSAR.

FSAR Table 4.4.2 summarizes the screening results to determine the bounding canister. However, it is not clear why the temperatures reported in this table are significantly lower than the results provided on page 4-68 of the FSAR. The staff needs to have a clear understanding of the thermal results for the different canisters to determine the adequacy of the thermal design and to determine predicted temperatures are below the allowable limits.

This information is needed to determine compliance with 10 CFR 72.236(b), and 72.236(f).

Holtec Response

The results reported in Table 4.4.2 of the FSAR are based on screening calculations for normal long-term storage condition of canisters in HI-STORM FW overpack. Whereas, the results reported on page 4-68 of the FSAR (Holtec Letter 5018043, Dated March 11, 2016) are based on mesh sensitivity studies for MPC-37 in HI-TRAC during normal onsite transfer. Since Table 4.4.2 is for long-term storage and table on page 4-68 is for normal onsite transfer, the reported PCT results are different. It must be noted that no changes are made to the table on page 4-68 in this amendment.

NRC RAI 4-4

Provide vacuum drying time limits for the MPC-31C canister.

Section 4.5.2.3 of the FSAR states that fuel drying in MPC-31C generating greater than threshold heat loads require implementation of site-specific vacuum drying time limits. The FSAR should provide the time limits for a typical vacuum drying cycle and the threshold heat loads described in the FSAR. Design basis heat loads along with adequate thermal analysis and the results need to be provided in the FSAR for normal and loading conditions. The staff needs this information to verify that the predicted temperatures for the new canisters are below the recommended limits under normal, loading, off-normal, and accident scenarios.

This information is needed to determine compliance with 10 CFR 72.236(b), and 72.236(f).

Holtec Response

Holtec withdraws MPC-31C canister from this license amendment. FSAR has been modified to remove discussions related to MPC-31C.

NRC RAI 4-5

Provide thermal results for the new MPC-31C and MPC-32ML canisters under off-normal and accident scenarios.

Section 4.4.1.5 of the FSAR states that fuel storage in the minimum height MPC-37 is limiting (produces the highest peak cladding temperature). However, the applicant did not determine the GCI for the new canisters. Given the small differences in the predicted temperatures for the different canisters, the applicant needs to obtain the discretization error for the new canisters (see RAI 2) and if necessary, perform thermal analysis under off-normal and accident conditions. The staff needs this information to verify that predicted temperatures for the new canister are below the recommended limits under off-normal and accident scenarios.

This information is needed to determine compliance with 10 CFR 72.236(b), and 72.236(f).

Holtec Response

Holtec withdraws MPC-31C canister from this license amendment. FSAR has been modified to remove discussions related to MPC-31C.

The computed PCT for MPC-32ML is provided in Table 4.4.3 of the FSAR. The results of the calculations conclude that the computed temperatures for MPC-32ML are substantially lower than the licensing basis results for minimum height MPC-37 (also tabulated in Table 4.4.3). Therefore, MPC-37 with pattern A is the most limiting thermal scenario and adopted in the FSAR for all off-normal and accident scenarios. Safety evaluations of all off-normal and accident conditions in Section 4.6 of the FSAR are bounding.

NRC RAI 5-1

Provide a shielding analysis for the new fuel types (16x16D, V10A, V10B fuel assemblies) and canister (MPC-31C) to be stored in the HI-STORM FW System.

In the amendment application, the applicant request to authorize storage of 16x16D, V10A, and V10B fuel types and storage of V10A and V10B in the new MPC-31C canister. The applicant states that the shielding evaluations will be performed on a site-specific basis; therefore, no change to the Chapter 5 of the HI-STORM FW FSAR is required. However, 10CFR72.236(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 sufficient information to demonstrate compliance with 10 CFR 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) and 72.24.

Holtec Response

Shielding analysis for adjacent and 1-m dose rates for HI-STORM FW System with MPC-32ML loaded with 16x16D fuel assemblies are added to Chapter 5, to show the radiation shielding features of the cask system is enough to meet the requirements of 10CFR72.104 and 72.106. Additionally, a source term analysis is performed and documented in Chapter 5.

Furthermore, an example of the site boundary dose for normal condition of storage of casks with MPC-32ML is added to the shielding calc package (HI-2094431 R13). Since it shows similar result to that of MPC-37, the result is not added to Chapter 5.

Please also note that the application for the new fuel types V10A, V10B is withdrawn.

A summary of changes made to Chapter 5 are included at the end of shielding RAIs.

NRC RAI 5-2

Provide the bounding source term for the 16x16D, V10A, V10B fuel assemblies.

In response to the staff's request for supplemental information in the shielding section, the applicant provided the source terms for 16x16D, V10A, V10B fuel assemblies and comparison to DBA WE 17x17 fuel assembly. However, the response appears to show that the source terms for the proposed fuels are not bounded by the source terms of the DBA fuel. The staff also notes that in previous amendments (100U or FW), the B&W 15x15 was used as DBA fuel assembly.

This information is needed to verify compliance with 10CFR72.236(d) and 72.24.

Holtec Response

A more detailed source term analysis, along with shielding analysis, is added to Chapter 5.

Regarding the use of B&W 15x15 fuel in HI-STORM 100 and few other applications, it should be noted that the DBA fuel for MPC-37 in HI-STORM FW FSAR is W17x17 since currently this is the fuel widely used throughout the industry.

Please also note that the application for the new fuel types V10A, V10B is withdrawn.

A summary of changes made to Chapter 5 are included at the end of shielding RAIs.

NRC RAI 5-3

Justify the burnup profile and source term for V10A and V10B (MPC-31C) fuel assemblies

The V10A and V10B fuels have 6" blankets at both ends of the fuel pins. The blanketed fuel will drive the burnup profile to further peak in the middle part of burnup profile. Accordingly, the source term for fuel with 6" blankets will be larger than that of fuel without 6" blankets. The increased burnup in the middle of the fuel assembly will increase both neutron and gamma sources and result in higher dose rates.

This information is needed to verify compliance with 10CFR72.104, 72.106, and 72.236(d).

Holtec Response

The application for the new fuel types V10A, V10B is withdrawn.

NRC RAI 5-4

Provide information to allow 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 proposed technical specifications for the HI-STORM FW Amendment No. 4 contains two new basket design and three new fuel types. The applicant uses only decay heat to evaluate the radiation source term for external dose rate evaluations. Decay heat alone does not adequately characterize the spent fuel specifications, as there is an infinite number of burnup, enrichment, and cooling time combinations that would produce the same decay heat, but different radiation source terms. Also the same combination of these parameters does not necessarily result in bounding dose rates or doses for all conditions and all relevant locations around the cask system (at least at the cask surface), whether for the transfer cask or the storage overpack.

The evaluated dose rates are also needed to show the estimated doses to workers in the radiation protection section of the safety analysis report (SAR).

This information is needed for the staff to evaluate the capability of the cask system to meet dose limits in 10CFR72.104 and 72.106 and to evaluate compliance with 72.236(d).

Holtec Response

Shielding analysis for adjacent and 1-m dose rates for HI-STORM FW System with MPC-32ML loaded with 16x16D fuel assemblies discussed above was performed considering a wide range of conservative combinations of burnups, enrichments and cooling times. These combinations sufficiently bound all possible fuel loadings.

For additional discussion please also see the responses to RAIs 5-1 and 5-2.

Summary of the main changes made to Chapter 5 Rev.5D:

- Removed any discussion on MPC-31C.
- Section 5.0: Added a summary of the analyses performed on MPC-32ML.
- Section 5.1:
    - Specified 16x16D as the design basis fuel assembly for MPC-32ML.
    - Discussed evaluated loading patterns for MPC-32ML.
    - Updated Tables 5.0.1 and 5.0.2 for MPC-32ML.
    - Added a discussion on dose rates for HI-TRAC VW with MPC-32ML in Subsection 5.1.1.
    - Discussed shielding evaluation requirement for site-specific accident condition of MPC-32ML in Subsection 5.1.2.

  - Added Tables 5.1.10 and 5.1.11.
- Section 5.2:
  - Added discussions on source terms for design basis fuel in MPC-32ML
  - Added Tables 5.2.17 through 5.2.22.
- Section 5.3:
  - Updated the text for MPC-32ML.
  - Updated Tables 5.3.1 and 5.3.2 for MPC-32ML.
- Section 5.4: Added Subsection 5.4.6, and Tables 5.4.9 through 5.4.11.

NRC RAI 6-1

Demonstrate that all parametric studies performed for the MPC-37 canister are directly applicable to MPC-32ML canister.

On page 6-32 of the SAR, in referring to the parametric studies performed for the MPC-37 canister, the applicant states: "The MPC-32ML basket design is very similar to the MPC-37 basket; the only major difference is the increased cell ID and, consequently, the number of storage locations is reduced. The applicant then states, "Therefore, all studies performed for MPC-37 are directly applicable to MPC-32ML […]". The applicant, however, did not provide detailed comparison of the similarities between the two canister designs and their corresponding contents. The staff notes from the application that the reason for increasing the cell ID is to accommodate the 16x16D fuel assembly which has a larger size compared to other 16x16 class fuel assemblies previously approved for storage in the MPC-37 canister. The staff also notes that the fuel assembly length, fuel rod outer diameter, and assembly pitch for the 16x16D class are all larger than the previously approved assembly designs for storage in the MPC-37 canister. Therefore, it is not clear to the staff why the parametric study performed for the MPC-37 is applicable to the MPC-32ML canister. The applicant needs to demonstrate that all parametric studies performed for the MPC-37 are directly applicable to the MPC-32ML design by a comparison of the neutronic characteristics of these two canister designs.

The staff needs this information to determine if the HI-STORM FW system design with the new types of fuel assemblies proposed for storage meet the regulatory requirements of 10CFR72.124(b).

Holtec Response

Additional MPC-32ML basket specific studies are performed and the results are presented in HI-STORM FW FSAR, see Tables 6.3.1, 6.3.2, 6.3.5, 6.3.6, 6.4.1, 6.4.2, 6.4.4 and 6.4.5 of the FSAR for the results of the additional parametric studies for the MPC-32ML canister. The results confirm that, as expected, since the MPC-32ML basket design is very similar to the MPC-37 basket, the same behavior (reactivity effect) are shown for the two canister designs.

NRC RAI 6-2

Provide justification that the code benchmarking analysis is appropriate for use in evaluating the criticality safety of the HI-STORM FW with the MPC-31C canister, or revise the benchmarking analysis to include additional critical experiments that reflect the features and parameters of the MPC-31C canister for the VVER fuel.

The applicant selected critical experiments to benchmark the computer code it used to perform criticality safety analyses for the HI-STORM FW spent fuel dry storage cask system design for the VVER reactor fuel designs whose fuel assemblies are in a hexagonal shape. However, it appears that the selected set of critical experiments contains only a few configurations that are in hexagonal shape. The applicant needs to provide justification that the code benchmarking analysis is appropriate for the HI-STORM FW with the MPC-31C canister containing the VVER fuel or revise the benchmarking analyses to include additional critical experiments that are appropriate for the VVER fuel.

The staff needs this information to determine if the HI-STORM FW system design with the VVER fuel assemblies proposed for storage meet the regulatory requirements of 10CFR72.124(b).

Holtec Response

MPC-31C canister for the VVER fuel is removed from Amendment No. 4 of the HI-STORM FW CoC.

NRC RAI 6-3

Provide a detailed description of the method used BWR partial gadolinia credit analysis.

The applicant states that it used "partial gadolinia credit" for the MPC-89 BWR fuel cask criticality safety design of the HI-STORM FW system. However, the applicant did not provide a detailed description for this method in the SAR. The applicant needs to provide a detailed explanation on how partial gadolinia credit is determined, the technical bases, and justification that it is conservatively applied. Specifically, the applicant needs to:

1. Explain the technical basis of this method. The technical basis should include a clear definition of the term "partial gadolinia credit," i.e., partial credit interms of what the full credit is, and why this method can assure the credit taken is appropriate;

2. Discuss the strategy used to determine the maximum allowable fraction of the poison to be included in the criticality safety analyses, and;

3. Determine the safety margin in terms of reactivity for criticality safety using this approach.

The staff needs this information to determine if the HI-STORM FW system design for the canister containing BWR fuel assemblies with enrichment exceeding 4.8% meet the regulatory requirements of 10CFR72.124(b).

Holtec Response

BWR partial gadolinia credit analysis is removed from Amendment No. 4 of the HI-STORM FW CoC.

NRC RAI 6-4

Demonstrate that the scenarios studied bound all intended BWR fuel assembly designs in these 10x10 classes or limit the fuel assembly designs to the configurations as analyzed.

The applicant performed sensitivity analyses to identify reactivity differences between fresh fuel with gadolinium and burned fuel to demonstrate that there is no peak in reactivity during the entire life of the fuel, and show that the fresh fuel with limited gadolinium loading cases are bounding for all fuel types to be stored. The applicant performed representative cases with the gadolinia-poisoned fuel rod loading configurations for assembly types whose number of water holes and their locations in the assembly vary. However, it is not clear whether these scenarios will bound all intended BWR fuel assembly designs in these classes, because BWR fuel assembly designs may include large variations in fuel enrichment, poison loading (typically in terms of percentage of fuel, number of poisoned fuel rods and their locations), axial fuel enrichment, water holes (also called water rods). The staff also notes that partial length rods are widely used in modern BWR fuel designs and there are wide range of partial length rod patterns. However, it is not clear from the application if the intended BWR fuel classes include the combination of all or some of the features. The applicant needs to clarify if the 10x10 fuel assembly classes intended for storage include only the variation of number of poisoned rods as analyzed and there is no other special design features besides those as defined in Table 6.4.13 of the revised SAR. The applicant needs to either demonstrate that the scenarios studied bound all intended 10x10 BWR fuel assembly designs in these classes or limit the fuel assembly designs to configurations as analyzed. If a bounding configuration is to be used, the applicant needs to perform a systematic study on all of the potential combinations of these design features of the 10x10 BWR fuel class.

The staff needs this information to determine if the HI-STORM FW system design for the canister containing BWR fuel assemblies with enrichment exceeding 4.8% meet the regulatory requirements of 10CFR72.124(b).

Holtec Response

BWR partial gadolinia credit analysis is removed from Amendment No. 4 of the HI-STORM FW CoC.

NRC RAI 6-5

Demonstrate that the two dimensional CASMO code is appropriate or bounding for modeling the BWR fuel assemblies with highly heterogeneous three dimensional features such as various partial length rods.

On page 6-66 of the SAR, in reference to the reactivity behavior of the fuel for which partial gadolinia credit is sought, the applicant states that: "[…] the amount of gadolinium used in the partial credit analysis is not sufficient to achieve such a peak reactivity effect. To verify this conclusion, CASMO-4, a two dimensional transport theory code discussed in Section 6.1, is used for qualitative calculations to determine the direction of the reactivity change with fuel irradiation." However, it is not cle.ar how the applicant applies the two dimensional CASMO code for modeling BWR fuel assemblies with various partial length rods and/or variations in axial enrichment such as natural or low enrichment uranium blankets to determine the reactivity of the fuel assembly as a function of burnup. The applicant needs to discuss how the two dimensional CASMO code is appropriate or bounding for modeling the BWR fuel assemblies with highly heterogeneous considerations in three dimensions (such as partial length rods and axial enrichment and void fraction variations).

The staff needs this information to determine if the HI-STORM FW system design for the canister containing BWR fuel assemblies with enrichment exceeding 4.8% meet the regulatory requirements of 10CFR72.124(b).

Holtec Response

BWR partial gadolinia credit analysis is removed from Amendment No. 4 of the HI-STORM FW CoC.

NRC RAI 6-6

Pertaining to the code benchmarking analyses for the MCNP code used in criticality safety analyses for the MPC-89 canister:

1. Explain how the code benchmarking was performed, i.e., together with other BWR and PWR fuel classes or if it is done for this fuel class only and justify that the performed code benchmarking analysis is adequate for the MPC-89 canister design criticality safety analyses that take partial gadolinia credit, or;

2. Provide separate code benchmarking analyses and determine the bias and bias uncertainty for the computer code and cross section used for the MPC-89 canister criticality safety analyses that take partial gadolinia credit.

The applicant performed code benchmarking analyses for the computer code and cross sections it used for criticality safety for the HI-STORM FW system design. However, it is not clear if the code benchmarking was done together with other BWR and PWR fuel designs or not. If code benchmarking was done together with other BWR and PWR fuel designs, the applicant needs to provide a justification for the adequacy of the approach. The justification needs to consider the fact that the modeling strategy uses one, two, or three gadolinia poisoned fuel rods per assembly. The selected critical experiments must represent the system to be analyzed per the requirement of Area of Applicability as specified in ANSI/ANS-8.17. Alternatively, the applicant may consider performing a separate set code benchmarking analyses to determine the bias and bias uncertainty of the code for the MPC-89 canister design that takes partial gadolinia credit.

The staff needs this information to determine if the HI-STORM FW system design for the canister containing BWR fuel assemblies with enrichment exceeding 4.8% meet the regulatory requirements of 10CFR72124(b).

Holtec Response

BWR partial gadolinia credit analysis is removed from Amendment No. 4 of the HI-STORM FW CoC.

NRC RAI 6-7

Justify that assuming fewer than the actual poisoned fuel rods (from 1 to 3 per assembly in the models does not produce under-estimated keff values for partial gadolinia credit or provide a means to prevent this from occurring.

The applicant takes "partial gadolinia credit" in its criticality safety analyses for the MPC-89 canister loaded with gadolinia poisoned fuel rods. The applicant calculated the reactivity of the system with up to 3 gadolinia-poisoned fuel rods per fuel assembly at various burnups. However, the modeling assumption of only one, two, or three poisoned rods per assembly could result in under-estimated k_{eff} values for the system. If the analysis assumes fewer poisoned rods than the actual poisoned load (i.e., 1,2, r 3 vs 10 to 20 poison rods, based on NUREG/CR-7194), it may arbitrarily neglect the competing absorption of neutrons from the additional poison rods that actually exist in a fuel assembly. As a result, the estimated absorption from the assumed poisoned rods may be magnified, which may underestimate the system's reactivity and prevent the detection of a potential reactivity peak during irradiation. The applicant needs to justify that assuming one, two, or three poisoned fuel rods per assembly in the models does not produce under-estimate k_{eff} values for partial gadolinia credit or provide an adjustment to the calculated k_{eff} to compensate the possible overestimate.

The staff needs this information to determine if the HI-STORM FW system design for the canister containing BWR fuel assemblies with enrichment exceeding 4.8% meet the regulatory requirements of 10CFR72.124(b).

Holtec Response

BWR partial gadolinia credit analysis is removed from Amendment No. 4 of the HI-STORM FW CoC.

NRC RAI 6-8

Demonstrate that the selected gadolinia-poisoned rods locations in the models will always have the highest neutron flux (particularly thermal neutron flux) in the fuel assembly so that the most rapid depletion of gadolinium is assured throughout its entire irradiation history.

On page 6-67 of the SAR, the applicant states: "Gd rods are located in the fuel assembly region with highest neutron flux, i.e. in the radial center of the fuel assembly. In this case, the most rapid depletion of gadolinium is expected." However, the neutron flux, particularly the thermal neutron flux, in a fuel assembly with heavy gadolinia poison load is typically deeply depressed because of the heavy absorption from the gadolinia. Also, the flux distributions are significantly influenced by the characteristics of the neighboring fuel assemblies in a reactor. As such, the thermal neutron flux distribution may not be dominated by the locations of the poisoned rods alone. The influence from neighboring fuel assemblies must be considered in determining the location where the highest neutron flux is expected. The applicant needs to demonstrate that the selected gadolinia-poisoned rods locations in the models will always have the highest neutron flux (particularly thermal neutron flux) in the fuel assembly so that the most rapid depletion of gadolinium is assured throughout its entire irradiation history.

The staff needs this information to determine the HI-STORM FW system designs for the canister containing BWR fuel assemblies with enrichment exceeding 4.8% meet the regulatory requirements 10CFR72.124(b).

Holtec Response

BWR partial gadolinia credit analysis is removed from Amendment No. 4 of the HI-STORM FW CoC.

NRC RAI 6-9

Demonstrate that the method used to determine the reactivity trajectory for a poised BWR fuel assembly is always conservative for all possible fuel configurations, gadolinium loadings, and irradiation conditions.

The applicant performed depletion calculations for three different assembly classes with the minimum allowable number of gadolinium rods and two different layouts of the gadolinium rod locations and shows the results in Figure 6.4.2 of the SAR. This figure shows the difference in reactivity from the fresh fuel case as these fuel assemblies are burned (up to 25 GWd/MTU). For these cases, the applicant shows that the difference in reactivity is always negative (i.e. the fresh fuel case is always more reactive) and demonstrating that there is no peak in reactivity.

Based on the information published in NUREG/CR-7194 (Reference 1), fuel with light gadolinium loading may experience a higher reactivity peak than heavy gadolinium loading. Although there are figures within Reference 2 showing that fewer gadolinium rods does not necessarily produce a peak in reactivity, the same report also shows that lower gadolinium loadings (weight percent) produce a more pronounced peak. The applicant needs to provide additional information to demonstrate that there is no peak in reactivity for all possible fuel assemblies allowed for loading within the HI-STORM FW with gadolinium credit. Per the information provided in References 1 and 2, te applicant should discuss factors that are known to affect the peak reactivity such as gadolinium loading patterns, void fraction, control blade insertion, lattice modeling (full or part-length rods) etc. to justify that its analyses are bounding. In addition, the demonstration should include an allowance for consideration of uncertainties such as those related to the depletion code's ability to calculate accurately the reactivity of the fuel assembly.

Alternatively, or in conjunction with some of the above requested information, the applicant may propose restrictions on fuel assemblies with gadolinium credit such as a more conservative minimum gadolinium loadings or a minimum burnup value. The applicant needs to provide appropriate justifications for the selected values.

The staff needs this information to determine the HI-STORM FW system designs for the canister containing BWR fuel assemblies with enrichment exceeding 4.8% meet the regulatory requirements of 10CFR72.124(b).

References:

1. NUREG/CR-7194, "Technical Basis for Peak Reactivity Burnup Credit for BWR Spent Nuclear Fuel in Storage and Transportation Systems," April 2015 (ADAMS Accession No. ML15097A186)

2. M. Tardy, S. Kitsos, L. Picard, L. Milet, M. Lein, G. Grassi, "Gadolinium Credit Application for Transport and Storage Casks Loaded with BWR UO2 Spent Fuel Assemblies," Proceedings of the 17th International Symposium on the Packaging and Transportation of Radioactive

Materials (PATRAM 2013), August 18-23, San Francisco, CA, USA.

Holtec Response

BWR partial gadolinia credit analysis is removed from Amendment No. 4 of the HI-STORM FW CoC.