UNITED STATES
NUCLEAR REGULATORY COMMISSION
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FINAL SAFETY EVALUATION REPORT

DOCKET NO. 72-1042
TN AMERICAS LLC
CERTIFICATE OF COMPLIANCE NO. 1042
NUHOMS® EOS SYSTEM
AMENDMENT NO. 2

SUMMARY

This safety evaluation report (SER) documents the U.S. Nuclear Regulatory Commission (NRC) staff's review and evaluation of the amendment request to amend Certificate of Compliance (CoC) No. 1042 for the NUHOMS® EOS system. By letter dated April 18, 2019 (Agencywide Documents Access and Management System (ADAMS) Accession Number ML19114A227), as supplemented on August 5, 2019 (ADAMS Accession Number ML19225C845), October 2, 2019 (ADAMS Accession Number ML19282A518), October 29, 2019 (ADAMS Accession Number ML19311C551), June 30, 2020 (ADAMS Accession Number ML20190A135), October 29, 2020 (ADAMS Accession Number ML20315A417), and January 27, 2021 (ADAMS Accession Number ML21027A324), TN Americas LLC, from here on referred to as the "applicant", requested that NRC amend the CoC to include the following changes:

Change No. 1:
Add the 61BTH Type 2 dry shielded canister (DSC) transferred in the OS197 Transfer Cask (TC) for storage in the NUHOMS® MATRIX (HSM-MX) design approved in Amendment 1 to CoC No. 1042. The 61BTH Type 2 DSC design included in this amendment is approved in CoC No. 1004 Amendment 15. The associated design change to the HSM-MX included in this amendment is the addition of spacer blocks at the front and rear DSC supports to maintain the centerline of the DSC in line with the horizontal storage module (HSM) door centerline.

Change No. 2:
For the EOS-37PTH DSC, add two new heat load zone configurations (HLZCs) for the EOS-37PTH for higher heat load assemblies, up to 3.5 kW/assembly, that also allow for damaged and failed fuel storage.

Change No. 3:
For the EOS-37PTH DSC, add basket type 4H, previously introduced in CoC No. 1042 Amendment 1, for HLZCs 1, 4, 5, 6, 8, and 9.

Change No. 4:
For the EOS-TC108 TC System with the EOS-37PTH DSC, add HLZCs 4 through 9 for the 4H basket and reduce the minimum cooling times to 2 years (HLZC 2 through 9).

Change No. 5:
For the EOS-37PTH DSC, increase the control component source terms to better address potential control component sources from various shutdown plants.

Enclosure

Change No. 6:
Certain CoC and Technical Specification (TS) items are revised for consistency and clarity.

In addition to the six changes requested by applicant in their letter dated April 18, 2019, the applicant requested additional changes not associated with its responses to the request for additional information (RAI) in the letters dated June 30, 2020, and October 29, 2020, including the following:

Additional Changes not associated with the RAI

Additional Change No. 1:
Move TS Table 3 relating to control component (CC) Co-60 from the TS to the Updated Final Safety Analysis Report (UFSAR) as Table 6-37a as part of continued application of the graded approach. *Note: On October 29, 2020, the applicant withdrew this change. Therefore, there is no evaluation of this change needed in the SER.*

Additional Change No. 2:
Add description of methodology on Co-60 equivalence to UFSAR Section 6.2.4, Control Components, to clarify methodology for CCs.

Additional Change No. 3:
Add description to UFSAR Section 1.2.1.1 for EOS-37PTH and Section 1.2.1.2 for EOS-89BTH to clarify the option of using a shield plug integrated with the inner top cover plate.

Additional Change No. 4:
Update UFSAR Section 2.4.3 to clarify the methodology to reduce the maximum allowable heat load based on the fuel assembly type.

Additional Change No. 5:
Replace the phrase “28 days” with “which may be tested up to 56 days” in Paragraph 4.4.4 of the TS to clarify whether concrete testing is required based on HSM component temperatures.

The amended CoC, when codified through rulemaking, will be denoted as Amendment No. 2 to CoC No. 1042. This SER documents the staff’s review and evaluation of the proposed amendment. The staff followed the guidance of NUREG-1536, Revision 1, “Standard Review Plan for Spent Fuel Dry Storage Systems at a General License Facility,” and ISG-23, “Application of ASTM Standard Practice C1671-07,” when performing technical reviews of spent fuel storage and transportation packaging licensing actions.

The staff's evaluation is based on a review of the applicant’s application and whether it meets the applicable requirements of 10 CFR Part 72 for dry storage of spent nuclear fuel. The staff’s evaluation focused only on modifications to the CoC and Technical Specifications (TS) requested in the amendment as supported by the submitted revised UFSAR (see ADAMS Accession Nos. ML19114A107, ML19225C810, ML19282A512, ML19311C557, ML20190A142, ML20315A424 and ML21027A324) and did not reassess previous revisions of the UFSAR nor previous amendments to the CoC.

1.0 GENERAL DESCRIPTION

The objective of this chapter is to review the changes requested to CoC No. 1042 for the NUHOMS® EOS system to ensure that the applicant provided an adequate description of the pertinent features of the storage system and the changes requested in the application. The specific changes requested by the applicant are described and evaluated in the following sections of this SER.

2.0 PRINCIPAL DESIGN CRITERIA EVALUATION

The staff's objective in reviewing the principal design criteria related to the structures, systems and components (SSCs) important to safety is to ensure that they comply with the relevant general criteria established in 10 CFR Part 72. The staff reviewed and evaluated the information provided by the applicant requested in Amendment No. 2. The specific changes evaluated in this section include:

Change No. 1:
Add the 61BTH Type 2 DSC transferred in the OS197 TC for storage in the HSM-MX design approved in Amendment 1 to CoC No. 1042. The 61BTH Type 2 DSC design included in this amendment is approved in CoC No. 1004 Amendment 15. The associated design changes to the HSM-MX include the addition of spacer blocks at the front and rear DSC supports to maintain the centerline of the DSC in line with the HSM door centerline.

SSCs Important to Safety

The applicant added Appendix B to the UFSAR to include the 61BTH Type 2 DSC and the OS197 TC into the NUHOMS® EOS system. The applicant stated that the OS197 TC includes the OS197, OS197H, OS197HFC-B and OS197FC-B TC variants. The applicant stated that Table B.2-1 provides safety classification of major 61BTH Type 2 DSC components as either important to safety or not important to safety. For the OS197 TC and yoke, the applicant states that there was no change from Section 3.4.4.1, "Transfer Cask and Yoke," of Standardized NUHOMS® system UFSAR Revision 18 related to CoC No. 1004 Amendment 15. The applicant stated that there were no changes to safety classification of the NUHOMS® EOS HSM-MX, ISFSI basemat and approach slabs, other transfer equipment or auxiliary equipment.

The staff reviewed the changes to the NUHOMS® EOS system including the addition of the 61BTH Type 2 DSC and the OS197 TC and determined that the safety classifications were acceptable because they are based on the guidance in NUREG/CR-6407, INEL-95/0551, "Classification of Transportation Packaging and Dry Spent Fuel Storage System Components According to Importance to Safety," issued February 1996.

Spent Fuel to Be Stored in the 61BTH Type 2 DSC

The applicant described the spent fuel to be stored in the 61BTH Type 2 DSC in UFSAR Section B.2.2. The 61BTH Type 2 DSC is designed to store intact (including reconstituted), damaged, and failed BWR fuel assemblies as specified in Section 2.3 of the TS. The 61BTH Type 2 DSC is also authorized to store fuel assemblies containing blended low enriched uranium (BLEU) fuel material. The 61BTH Type 2 DSC can also accommodate up to a maximum of 61 damaged fuel assemblies placed in the fuel compartments located in accordance with TS Figure 5. When used with the top grid assembly (Alternate 1) design, the 61BTH Type 2 DSC is also able to accommodate up to a maximum of four failed fuel assemblies encapsulated in individual failed fuel canisters (FFC) and placed in cells located at the outer edge of the DSC as shown in TS Figure 5.

Evaluation Findings

The staff concludes that the principal design criteria for the NUHOMS® EOS system are in compliance with 10 CFR Part 72, and that the applicable design and acceptance criteria have been satisfied. The evaluation of the principal design provides reasonable assurance that the NUHOMS® EOS system will allow safe storage of spent fuel. This finding is reached on the basis of a review that considered the regulation itself, appropriate regulatory guides, applicable codes and standards, and accepted engineering practices. Some of the key findings from the staff's review of Amendment 2 include:

F2.1 The UFSAR and docketed materials adequately identify and characterize the SNF to be stored in the DSS in conformance with the requirements given in 10 CFR 72.236.

F2.2 The UFSAR and docketed materials relating to the design bases and criteria for structures categorized as important to safety meet the requirements given in 10 CFR 72.236.

F2.3 The UFSAR and docketed materials relating to the design bases and criteria for criticality safety meet the regulatory requirements as given in 10 CFR 72.124(a) and (b).

F2.4 The UFSAR and docketed materials relating to the design bases and criteria for retrievability meet the regulatory requirements as given in 10 CFR 72.236(m).

F2.5 The UFSAR and docketed materials relating to the design bases and criteria for other SSCs not important to safety but subject to NRC approval meet the general regulatory requirements as given in 10 CFR Part 72: Subpart L, "Approval of Spent Fuel Storage Casks."

3.0 STRUCTURAL EVALUATION

The staff reviewed the information provided by the applicant and found two changes requested in Amendment No. 2 that required structural evaluation:

Change No. 1:
Add the 61BTH Type 2 DSC transferred in the OS197 TC for storage in the HSM-MX design approved in Amendment 1 to CoC No. 1042.

Change No. 6:
Certain CoC and TS items are revised for consistency and clarity.

This section of the SER documents the staff's review and conclusions with respect to structural safety.

Change No. 1: Addition of 61BTH Type 2 DSC and OS197 TC to HSM-MX

The 61BTH Type 2 DSC and OS197 TC are currently approved for use under the CoC No. 1004, and the applicant is proposing to add the 61BTH Type 2 DSC and OS197 TC to the HSM-MX as part of the NUHOMS® MATRIX storage system. As a result, the applicant only addressed the important-to-safety (ITS) aspects of the 61BTH Type 2 DSC and OS197 TC to the HSM-MX in Appendix B of the NUHOMS® EOS UFSAR, where the structural evaluations of the 61BTH Type 2 DSC and OS197 TC are provided in Appendix B.3 - Structural Evaluation. Therefore, the staff only evaluated the safety aspects of structural performance of the 61BTH Type 2 DSC and OS197 TC in the HSM-MX system under normal, off-normal, and accident conditions.

61BTH Type 2 DSC: The applicant used the finite element (FE) method for structural analysis of the 61BTH Type 2 DSC in the HSM-MX, where the method of evaluation (MOE) was previously reviewed and accepted by the staff. The applicant used the commercially available FE software program, ANSYS, and developed a three-dimensional (3-D) 180° half-symmetric FE model for the computer-based analysis of the 61BTH Type 2 DSC in the HSM-MX. Each of the 61BTH Type 2 DSC shell assembly components was modeled using a 3-D solid element (ANSYS SOLID185).

Figures B.3.9.1-1 through B.3.9.1-5 of the UFSAR present the ANSYS FE model used for the structural analysis of the 61BTH Type 2 DSC in the HSM-MX. Tables B.3.9.1-1 and B.3.9.1-2 of the UFSAR list the dimensional inputs used for the 61BTH Type 2 DSC model and the material designations of each modeled DSC component, respectively. The staff confirmed that all aspects of the applicant's computer-based FE model were consistent with standard practices described in NUREG-1536, Revision 1.

The applicant presented the results of the FE structural analysis of the 61BTH Type 2 DSC in the HSM-MX under the normal, off-normal, and accident conditions in Table B.3.9.1-5 of the UFSAR. In this table, the applicant reported: (i) the calculated stress intensity, (ii) the ASME Code allowable stress, and (iii) a stress ratio, defined as a ratio of the calculated stress (demand) with respect to the ASME Code allowable stress (capacity) in that structural member of the 61BTH Type 2 DSC.

The staff reviewed the results of the structural analysis in Table B.3.9.1-5 for the various load combinations considered and finds that the design of the structural components of the 61BTH Type 2 DSC in the HSM-MX is adequate based on the calculated stresses. The staff finds that the applicant's analysis results are acceptable because, under all load combinations, all stress ratios remain less than 1.0, which indicates that the load-carrying capacities of all structural members of the 61BTH Type 2 DSC in the HSM-MX are greater than the maximum induced stresses under the various load combinations applied, and therefore the staff concludes that the

61BTH Type 2 DSC in the HSM-MX will perform its intended function under the normal, off-normal, and accident load conditions.

The applicant also presented the results of the stress analysis for the closure welds of the 61BTH Type 2 DSC shell to the inner top cover plate (ITCP) in the HSM-MX in Table B.3.9.1-7 under the normal, off-normal, and accident conditions. As was the case of the stress analysis for the DSC structural members presented above, the staff reviewed the results of the weld stress FE analysis and found that the design of the closure welds between the 61BTH Type 2 DSC shell to the ITCP in the HSM-MX is adequate based on the calculated stresses. The staff finds that the reported results are acceptable because, under all load combinations, the calculated stress ratios remain less than 1.0. These stress ratios indicate that the load carrying capacity of the closure welds in the 61BTH Type 2 DSC shell to the ITCP is greater than the maximum induced stress under the load combinations applied.

Based on the results of the structural analysis for the 61BTH Type 2 DSC in the HSM-MX under the normal, off-normal, and accident conditions, the staff concludes that the 61BTH Type 2 DSC in the HSM-MX is structurally adequate and will perform its intended function under all anticipated load conditions for service during the transfer and storage in the HSM-MX.

OS197 TC: The applicant stated that there is no change to the evaluation of the OS197 TC structural analysis documented in Sections T.3.6.1.9 and T.3.7 of the Standardized NUHOMS® system UFSAR for the normal, off-normal, and accident load conditions when the OS197 TC is used in the HSM-MX because the design loads on the OS197 TC in the Standardized NUHOMS® system are same as those in the HSM-MX system. Thus, there is no change to the previous evaluation.

The staff confirmed that the structural performance of the OS197 TC under all required load conditions was evaluated when it was used for Standardized NUHOMS® System. Since the design loads required to impose on the OS197 TC in the Standardized NUHOMS® system are same as those in the HSM-MX system, there is no additional structural evaluation required, therefore, the applicant's structural evaluation is acceptable.

Change No. 6: Revisions of Technical Specification

The staff reviewed the Technical Specification (TS) Sections 1.0 - Use and Application and 4.0 Design Features, where the 61BTH Type 2 DSC, OS197 TC, and HSM-MX structural system were described. Based on the staff's review of Sections 1.0 and 4.0 in the TS, the staff finds that the information provided in the TS regarding the 61BTH Type 2 DSC, OS197 TC, and HSM-MX is consistent with the information provided in Appendix B.3 - Structural Evaluation and Appendices B.3.9.1 through B.3.9.7 for the structural analysis, and therefore is acceptable.

Evaluation Findings

The staff concludes that the structural performance of the 61BTH Type 2 DSC and OS197 TC to the HSM-MX storage system is in compliance with 10 CFR Part 72, and that the applicable design and acceptance criteria in Section 3.4 of NUREG-1536, Revision 1, have been satisfied. The evaluation of structural performance provides reasonable assurance that the NUHOMS®

EOS dry storage system will allow for the safe storage of spent nuclear fuel for the licensed period. This finding is reached on the basis of a review that considered the regulation itself, appropriate regulatory guides, standard review plans, applicable Codes and Standards, and accepted engineering practices. Some of the key findings from the staff's review of Amendment 2 include:

F3.1 On the basis of the review of the statements and representations in the application, the staff finds that the UFSAR adequately describes the 61BTH Type 2 DSC and OS197 TC to the HSM-MX in Appendix B.3 - Structural Evaluation and Appendices B.3.9.1 through B.3.9.7 for the structural analysis in the UFSAR to enable evaluations of the structural performance and effectiveness.

F3.2 The staff finds that the applicant has met the requirements of 10 CFR 72.236(b). The 61BTH Type 2 DSC and OS197 TC to the HSM-MX are designed to accommodate the combined loads of the normal, off-normal, and accident conditions with an adequate margin of safety. Stresses at various locations of the 61BTH Type 2 DSC and OS197 TC under various design loads are determined by the FE analysis. Total calculated stresses under the combined loads of the normal, off-normal, and accident conditions are acceptable and are found to be within the limits given in the applicable Codes.

4.0 THERMAL EVALUATION

The staff reviewed the information provided by the applicant and the following six changes are applicable to the thermal evaluation:

Change No. 1:
Add the 61BTH Type 2 DSC transferred in the OS197 TC for storage in the HSM-MX design approved in Amendment 1 to CoC No. 1042.

Change No. 2:
For the EOS-37PTH DSC, add two new heat load zone configurations (HLZCs) for the EOS-37PTH for higher heat load assemblies, up to 3.5 kW/assembly, that also allow for damaged and failed fuel storage.

Change No. 3:
For the EOS-37PTH DSC, add basket type 4H, previously introduced in CoC No. 1042 Amendment 1, for HLZCs 1, 4, 5, 6, 8, and 9.

Change No. 4:
For the EOS-TC108 TC System with the EOS-37PTH DSC, add HLZCs 4 through 9 for the 4H basket and reduce the minimum cooling times to 2 years (HLZC 2 through 9).

Change No. 6:
Certain CoC and Technical Specification (TS) items are revised for consistency and clarity.

Additional Change No. 4 not associated with the RAI:
Update UFSAR Section 2.4.3 to clarify the methodology to reduce the maximum allowable heat load based on the fuel assembly type.

This section of the SER documents the staff's review and conclusions with respect to thermal safety. In addition, the staff notes according to Revision 0 of the Amendment 2 UFSAR provided in the initial application submittal and subsequent list of change pages (Enclosure 5 List of Changed UFSAR Pages dated June 30, 2020, Enclosure 4 List of Changed UFSAR Pages dated 10/30/2020), that the change pages of Chapter 4's main section (comprising pages 4-1 to 4-220) associated with the amendment's thermal-related design were pages 4-1, 4-2, 4-3, 4-5, 4-27, 4-28, 4-89, 4-109, 4-141; it also is noted that there were no change pages to the thermal-related issues in Section 9.1.3 (steps 1 through 27) and Section 9.1.4 (steps 1 through 9).

Change No. 1: Addition of 61BTH Type 2 DSC transferred in the OS197 TC for storage in the HSM-MX

Change No. 1 was described as follows: "Add the 61BTH Type 2 dry shielded canister (DSC) transferred in the OS197 Transfer Cask (TC) for storage in the NUHOMS® MATRIX (HSM-MX) design submitted under Amendment 1 to COC No. 1042. The 61 BTH Type 2 DSC design included in this amendment is from the previously approved CoC No. 1004 Amendment 15. The associated design changes to the HSM-MX include the addition of spacer blocks at the front and rear DSC supports to maintain the centerline of the DSC in line with the HSM door centerline."

The applicant's analysis to demonstrate that the 61BTH Type 2 DSC can be loaded inside the OS197 transfer cask (TC) for transfer operations and stored within the HSM-MX for normal, off-normal, and accident conditions while maintaining temperatures and pressures within regulatory limits was presented in UFSAR Appendix B.4. Specifically, UFSAR Appendix B.4 provided the HSM-MX storage analyses. The UFSAR indicated that most of the analyses for transferring the 61BTH Type 2 DSC inside the OS197 transfer cask were previously presented in Appendix T.4 of the Standardized NUHOMS® system UFSAR. UFSAR Section B.4.5.6 presented the thermal analysis demonstrating the minimum duration of forced air circulation once initiated and the subsequent time limit to complete the transfer process, either in the HSM-MX storage module or returning the DSC back to the fuel handling building with subsequent refilling of the TC/DSC annulus with water.

The ten HLZCs, maximum heat load, type of neutron absorber material, type of transfer cask, and type of storage module associated with the 61BTH Type 2 DSC are listed in the table below (as presented in UFSAR Appendix B.4, page B.4-1). According to UFSAR Section B.4, the maximum heat load per assembly is 1.2 kW.

DSC Type	Basket Assembly Type or Heat Load Zone Configuration (HLZC)	Max. Heat Load (kW)	Neutron Absorber Material	Transfer Cask	Time Limit for Transfer Operation	Storage Module
61BTH Type 2	1, 2, 9	22.0	Borated Aluminum or BORAL® or MMC	OS197 or OS197H or OS197FC-B	No	NUHOMS® MATRIX (HSM-MX)
	3, 4	19.4				
	8	27.4		OS197FC-B	Yes	
	5, 6, 7, 10	31.2	Borated Aluminum or MMC			

NOTE: The 61BTH Type 2 DSC and the OS197 TCs (OS197, OS197H, or OS197FC-B) are licensed under Revision 18 of the UFSAR of CoC 1004 in Appendix T [B.4-2] and no changes are considered.

UFSAR Appendix B.4 indicated that the details associated with the ten HLZCs and the location of the damaged and failed fuel assemblies inside the 61BTH Type 2 DSC were found in Figures 4A through 4J and Figure 5, respectively, of the proposed Technical Specifications. It was mentioned that the placement of the damaged and failed fuel assemblies is the same as those in the Standardized NUHOMS® system UFSAR, Revision 18. It was noted on UFSAR page B.4-4 that there were no restrictions for storage of the 61BTH Type 2 DSC regarding placement in the upper or lower compartment of the HSM-MX because the 31.2 kW heat load was less than the 41.8 kW heat load value that would warrant a placement restriction, as described in Section A.4.4 of Appendix A.4, from an earlier NUHOMS® EOS amendment.

Decay Heat Removal

UFSAR Section B.4.1 noted that the fuel assemblies were modeled as homogenized materials in the basket's fuel compartments. The lowest effective properties of the applicable fuel assemblies were used when generating the thermal model. Heat transfer within the fuel region was due to conduction and radiation; convection was conservatively not considered. Heat transfer from the fuel assemblies to the basket was based on conduction heat transfer through the basket materials and helium; convection and radiation heat transfer were conservatively not considered. Heat transfer from the DSC through the HSM-MX included conduction through the DSC shell and DSC supports in the HSM-MX, convection of air flowing from the HSM-MX front vent around the DSC to the roof vents, and radiation from the DSC outer surface to the concrete and heat shields in the HSM-MX. As noted earlier, the heat removal system for transfer operations are the same as presented in Appendix T.4 of the Standardized NUHOMS® system UFSAR.

Material and Design Criteria

UFSAR Section B.4.2 noted that the thermal design criteria for the 61BTH Type 2 DSC were identical to those in Appendix T, Section T.4.1 of the Standardized NUHOMS® system UFSAR, Revision 18. In addition, it was noted that the thermal properties for the 61BTH Type 2 DSC and OS197 TC were provided in Appendix T, Section T.4.2 in the Standardized NUHOMS® system UFSAR, Revision 18, and that the thermal properties for the HSM-MX used in the ANSYS FLUENT analysis model were the same as those in UFSAR Section A.4.2 from an earlier NUHOMS® EOS amendment. UFSAR Section B.4.2.2 specified that the neutron absorber thermal conductivity acceptance criteria were provided in Appendix T, Section T.4.3 of the Standardized NUHOMS® system UFSAR, Revision 18. It was noted in UFSAR Section B.4.2.2 that the nominal thickness of the single or paired neutron absorber plate with aluminum sheet in the base model was 0.31 inches and that in order to maintain the thermal performance of the basket, the minimum conductivity “shall be such that the total thermal conductance (sum of conductivity x thickness) of the neutron absorber and aluminum 1100 plate shall be equal to the conductance assumed in the thermal models.”

Environmental Conditions

UFSAR Section B.4.3 presented the environmental conditions for the storage and transfer thermal analyses. The normal ambient temperature was based on a -20 deg F and 100 deg F range, with a 90 deg F average ambient temperature corresponding to a 24-hour period. The off-normal ambient temperature range was -40 deg F to 117 deg F, with a 103 deg F daily average ambient temperature corresponding to a 24-hour period. A wind boundary condition with a range of 0 to 15 mph was considered for the HSM-MX, which was the range of wind speed described in UFSAR Appendix A.4 of an earlier NUHOMS® EOS amendment. Finally, UFSAR Section B.4.3 noted that the transfer ambient conditions were as provided in Appendix T, Table 4-4 and Table 4-5 of the Standardized NUHOMS® system UFSAR, Revision 18. It was noted in UFSAR Section B.4.3 that the ambient temperature ranges for normal transfer and off-normal transfer were 0 to 100 deg F and 0 to 117 deg F, respectively, with an indoor ambient temperature of 120 deg F for fuel loading operations in the fuel building.

Evaluation of the 61BTH Type 2 DSC in HSM-MX Storage Module

UFSAR Section B.4.4.1 indicated that HLZC 7 was the bounding HLZC in the CoC No. 1004 analysis for the 61BTH Type 2 DSC in storage, and therefore, the HLZC 7 would be bounding for the 61BTH Type 2 DSC in storage in HSM-MX. Staff finds that HLZC 7 would be an appropriate HLZC for the HSM-MX analysis because this condition has the highest heat load at 31.2 kW and because the arrangement of the fuel assemblies defined by HLZC 7 has shown to result in bounding thermal results in the NUHOMS® system. UFSAR Section B.4.4.1 also indicated that loading condition LC 1e (and the corresponding fine mesh loading condition LC 1f), with a bounding oriented wind speed worst case, was the bounding thermal condition when a EOS-37PTH DSC was stored in a HSM-MX (as reported in Appendix A.4 Section A.4.4.4.1 and Table A.4-2 of an earlier NUHOMS® EOS amendment), and therefore, would be analyzed for a 61BTH DSC in the HSM-MX. Staff finds that LC 1e would be an appropriate loading condition for the 61BTH DSC/HSM-MX analysis because that wind condition has shown to result in bounding thermal results for a DSC in an HSM-MX. It also was noted that LC2, with a 117 deg F ambient temperature, was the off-normal hot storage condition. Likewise, it was noted that the results from this off-normal condition were the initial conditions for the 32-hour transient accident condition assuming blockage of the inlet vents (LC 3).

A description of the 61BTH Type 2 DSC and the HSM-MX thermal models was presented in UFSAR Section B.4.4.2; it was noted that the half-symmetrical thermal model followed the same methodology as described in UFSAR Section A.4.5.3 of an earlier NUHOMS® EOS amendment. Each fuel assembly was considered as a homogenous region with effective thermal properties calculated in UFSAR Section T.4.8 of the Standardized NUHOMS® system UFSAR, Revision

18. The effects of some gaps were modeled as part of the effective conductivities. In addition, the top grid was conservatively modeled as helium in the current 61BTH Type 2 DSC rather than the higher thermal conductivity stainless steel. The DSC basket plates were modeled as a composite plate with a thickness equal to the sum of the individual plates and with corresponding orthotropic thermal conductivities, and, according to UFSAR Section B.4.4.2.2, these effective conductivities accounted for the gaps associated with the basket plates, rail shims, and compartment wraps. UFSAR Section B.4.4.2.2 also discussed a conservative simplification in the present model whereby homogenized basket plates were considered rather than non-homogenized components. Specifically, UFSAR Section B.4.4.2.2 compared the maximum temperatures of basket and DSC-related components (e.g., cladding, neutron absorber, R45 rail, R90 rail) for the above described "homogenized" model with the non-homogenized model described in Section T.4.6.2 of Standardized NUHOMS® system UFSAR and showed that the "homogenized" basket model resulted in higher component temperatures (i.e., less margin with allowable temperatures) by approximately 5 deg F (cladding and neutron absorber), 10 deg F (R90 rails), and 24 deg F (R45 rails).

According to UFSAR Section B.4.4.2.3, the HSM-MX model and mesh were generated from ANSYS ICEM CFD software using the methodology discussed in UFSAR Section A.4.5.3.1 from an earlier NUHOMS® EOS amendment; details of the thermal model were also discussed in UFSAR Section B.4.4.2.5 and UFSAR Section A.4.5.7.3 of an earlier NUHOMS® EOS amendment. UFSAR Section B.4.4.2.4 indicated that the hexahedral meshes of the HSM-MX and 61 BTH Type 2 DSC were imported and merged into ANSYS FLUENT. According to UFSAR Section B.4.4.3, a GCI calculation (per ASME V&V 20-2009 as described in UFSAR Appendix 4.9.4.8.1) based on coarse and fine mesh models was less than 2 deg F. UFSAR Table B.4-4 summarized convergence parameters and showed that maximum cladding temperature variation for the last 500 iterations, inlet mass flow rate variation for the last 500 iterations, total heat load imbalance, and radiation heat transfer imbalance were less than 1 deg F and approximately 0.5% or less. UFSAR Table B.4-5 indicated that the maximum fuel cladding temperature for LC 1a and LC 3 were 679 deg F and 711 deg F, respectively, which were below the 752 deg F and 1058 deg F allowable temperatures for normal and accident conditions, respectively. Likewise, concrete temperatures were below the 300 deg F temperature limit by more than 75 deg F. For off-normal storage LC2 conditions, the 654 deg F cladding temperature and 204 deg F concrete temperature were below the 1058 deg F and 300 deg F allowable temperatures, respectively. UFSAR Table B.4-6 showed that temperatures of HSM-MX components were below the temperatures reported for the bounding HLZC and DSC (i.e., 50 kW decay heat) in a HSM-MX reported in FSAR Table A.4-33b from a previous NUHOMS® EOS amendment (except for the heat shield that was approximately 30 deg F higher). Based on the above, staff finds that cladding, DSC, and HSM storage components were below allowable temperature limits, and are therefore acceptable.

Evaluation of the 61BTH Type 2 DSC during Transfer

UFSAR Section B.4.5 indicated that the analyses for transferring the 61BTH Type 2 DSC inside the OS197 transfer casks were previously presented in Appendix T, Chapter T.4 of the Standardized NUHOMS® system UFSAR, Revision 18 for the NUHOMS® and that no changes were considered for these thermal evaluations because the 61BTH Type 2 DSC and OS197 TC transfer operations, content decay heat, HLZCs (including placement of damaged/failed fuel assemblies), ambient conditions for transfer operations, and load cases (i.e., normal, off-normal, accident conditions) considered were identical for the NUHOMS® EOS and Standardized NUHOMS® systems. Likewise, according to UFSAR Section B.4.5.5, there were no changes to the thermal evaluations associated with vacuum drying, helium backfill, and unloading operations; UFSAR Sections 9.1.1 through 9.1.4 noted that the annulus between the DSC and transfer cask is to be filled with water during these short-term operations. UFSAR Section B.4.5.1 stated that the OS197 and OS197H transfer casks are used for transfer when the 61BTH Type 2 DSC has decay heat less than or equal to 22.0 kW; the OS197FC-B transfer cask is used when decay heat is greater than 22 kW and less than or equal to 31.2 kW. UFSAR Section B.4.1 indicated that there is a transfer time limit when heat loads are greater than 22 kW in the 61BTH Type 2 DSC. UFSAR Section B.4.5 provided useful summary and description of the previously considered thermal evaluations (Appendix T, Chapter T.4 of the Standardized NUHOMS® system UFSAR, Revision 18) and analysis results indicated that cladding and component temperatures were below allowable values. For example, the response to RAI 4-3 indicated that the Appendix T thermal analyses, which conservatively modeled failed fuel assemblies using the thermal properties of helium (i.e., conservative thermal conductivity and neglecting thermal mass), showed that temperatures for accident transfer conditions with intact fuel assemblies bounded those with failed fuel assemblies.

UFSAR Section B.4.5.6 described the thermal analyses associated with forced air circulation for limited conditions of operation if a situation arises that prevents the DSC from being successfully transferred to an HSM-MX storage module within the 10 hour transfer time limit. According to UFSAR Section B.4.5.6.2, the thermal model, consisting of the OS197FC-B transfer cask and 61BTH Type 2 DSC with HLZC 7 (bounding HLZC according to UFSAR Section B.4.5.6.1), was three-dimensional and half-symmetric and meshed using ANSYS ICEM CFD. The thermal analysis was then performed using ANSYS FLUENT. It was noted in UFSAR Section B.4.5.6.2.6 that a thermal resistance between the DSC and canister rail less than 5 Btu/hr-in2-F was applied to the model. UFSAR Figure B.4-10 showed the cladding temperature profile of a transfer process prior to forced convection initiation, during forced convection (as a limited condition of operation), and after turning off forced convection. UFSAR Table B.4-10 reported the cladding temperatures for the three parts of the transfer process; the maximum temperature of 692 deg F was well below the 752 deg F allowable limit. According to UFSAR Section B.4.5.6.2.2 and Section B.4.5.6.3, the discretization error associated with the model was 7.2 deg F and was determined using the methodology discussed in UFSAR Section A.4.4.2.3.7 from a previous NUHOMS® EOS amendment; the parameters of the GCI calculation also were reported in UFSAR Table B.4-11. The portion of the transient transfer operation that did not rely on forced convection was based on the gap between the transfer cask and DSC being modeled with stagnant air properties. Inlet and outlet boundary conditions were modeled to represent a 400 cfm convection flow through the transfer cask and DSC annulus when considering the forced convection limited condition of operation using the methodology described in UFSAR Section 4.5.2.2.4 from an earlier NUHOMS® EOS amendment. Likewise, radiation heat transfer between the transfer cask and DSC gap used the methodology in Item D of UFSAR Section 4.4.2.3.4 from an earlier NUHOMS® EOS amendment. Regarding the forced circulation thermal analyses presented in UFSAR Section B.4.5.6, it is noted that the application did not provide validation of the Realizable κ-ϵ turbulence model with enhanced wall treatment, which was used for the time periods of the transfer process with and without forced convection. Likewise, there was no explanation for the different DSC heat balance values at the 54,000 second period for the LC1-1 (coarse mesh) and LC2-1 (fine mesh) reported in the DSC heat flux output file. However, staff considers that the two preceding modeling items would not significantly affect findings in the current amendment because there was a 60 deg F margin between the reported cladding temperature and its allowable value. In summary, the model and numerical method described in UFSAR Section B.4.5.6 was used for the 61BTH Type 2 DSC with decay heat no greater than 31.2 kW. In using this methodology, margins with allowable values included 60 deg F for PCT, 10 deg F for the OS197FC-B transfer cask neutron shield, and 17 deg F for the transfer cask's NS-3.

Based on the model described above, UFSAR Section B.4.5.6.4 indicated a 670 deg F cladding temperature after 15 hours of the transfer process without forced convection. It was reported that, in order to have additional margin with the allowable temperatures and to maintain consistency with other transfer operations, there would be a 10 hour transfer time limit with a five hour recovery period. If the 10 hour transfer period is not met, forced convection, as a limited condition of operation recovery action, is to be initiated within one hour and maintained for a minimum of eight hours before it is turned off. The DSC transfer to the storage module must then be completed within four hours. Staff finds that the above-mentioned time limits for the transfer of the 61BTH Type 2 DSC are reasonable because the content and methodology used to model the transfer process were similar to that reported in earlier NUHOMS® EOS amendments, and are therefore acceptable.

Pressure Analysis of the 61BTH Type 2 DSC

UFSAR Section B.4.6 stated that there was no change to the maximum internal pressure evaluation for the 61BTH Type 2 DSC, presented in Appendix T, Chapter T.4 of the Standardized NUHOMS® system UFSAR, Revision 18. The methodology was described in UFSAR Section T.4.6.6.4, T.4.6.7.6, and T.4.6.8.5 for normal, off-normal, and accident conditions. The response to RAI 4-1 stated that the DSC content considered in the Standardized NUHOMS® system UFSAR, Revision 18, resulted in bounding quantity of fission gases relative to the current NUHOMS® EOS amendment; it is noted from the Ideal Gas Law that greater amounts of gas result in a higher pressure. Likewise, UFSAR Section B.4.4.3 stated that the average helium temperature in the 61BTH Type 2 DSC stored in the HSM-MX was lower than in the HSM-H storage module, and therefore, the maximum internal pressure discussed in Section T.4.6.6.4 (USNRC Docket 72-1004) is bounding. In addition, UFSAR Section B.4.5 stated that the 61BTH Type 2 DSC transfer evaluations in the OS197 transfer casks, described in Appendix T, Chapter T.4 of the Standardized NUHOMS® system UFSAR, Revision 18, are applicable because the designs, operations, ambient conditions, load cases, and time limits are unchanged or bounding. UFSAR Appendix B.4.6 stated that DSC pressures were 7.6 psig, 12.1 psig, and 68.7 psig, which were less than the design pressures of 15 psig, 20 psig, and 120 psig for normal, off-normal, and accident conditions, respectively. Staff finds that the 61BTH Type 2 DSC pressures for the current NUHOMS® EOS amendment are less than design values because the content's fission gases and temperatures are bounded by those reported in Standardized NUHOMS® system UFSAR, Revision 18, and because the reported pressure margins range from approximately 7.5 psig for normal and off-normal conditions to 51 psig for accident conditions; therefore, the staff finds this acceptable.

Change No. 2: Addition of HLZC 10 and HLZC 11 to EOS-37PTH DSC (up to 3.5 kW/assembly) that also allows for damaged and failed fuel

Change No. 2 was described as follows: "For the EOS-37PTH DSC, add two new heat load zone configurations (HLZCs) for the EOS-37PTH for higher heat load assemblies, up to 3.5 kW/assembly, that also allow for damaged and failed fuel storage."

The applicant's analysis to demonstrate that the EOS-37PTH DSC (HLZC 10 and HLZC 11) can be loaded inside the EOS-TC125 and EOS-TC135 transfer casks for transfer operations and stored within the relevant EOS-HSM storage module for normal, off-normal, and accident conditions while maintaining temperatures and pressures within regulatory limits, was presented in UFSAR Appendix 4.9.7. In addition, the analysis to demonstrate that the EOS-37PTH DSC with HLZC 11 can be stored in the HSM-MX storage module was presented in UFSAR Appendix A.4.6. The basket type, HLZCs, maximum heat load, type of transfer cask, and type of storage module associated with Change No. 2 are listed in the summary table below (as presented in UFSAR Appendix 4.9.7).

DSC Type	Basket Assembly Type	Heat Load Zone Configuration (HLZC)	Max. Heat Load (kW)	Transfer Cask	Storage Module
EOS-37PTH	4H	10	45.70	EOS-TC125/ EOS-TC135	EOS-HSM/EOS-HSMS EOS-HSM-FPS/ EOS-HSMS-FPS
	4H	11	44.50		EOS-HSM/EOS-HSMS EOS-HSM-FPS/ EOS-HSMS-FPS/ HSM-MX(1)

Note:

1. Thermal evaluation of HLZC 11 for storage operations in HSM-MX is presented in Chapter A.4.

Evaluation of EOS-37PTH Type 4H Basket in HSM-MX Storage Module

Storage of an EOS-37PTH Type 4H basket with HLZC 11 in an HSM-MX storage module was considered in UFSAR Appendix A.4.6. UFSAR Section A.4.6.1 noted that the spent fuel assembly loading pattern for HLZC 11 was defined in Figure 1K of the Technical Specifications. According to Figure 1K, the upper compartment of the HSM-MX is limited to a total DSC decay heat of 41.8 kW and a maximum fuel assembly decay heat of 3 kW in Zone 2 and Zone 4. The lower compartment of the HSM-MX is limited to 44.5 kW and a maximum fuel assembly decay heat of 3.5 kW in Zone 2.

UFSAR Section A.4.6.1 noted that there were no credible accident conditions that could alter the fuel configuration of the damaged fuel assemblies; likewise, the analyses in UFSAR Section 3.9.6.7, from a previous NUHOMS® EOS amendment, showed that there were no changes to the configurations of the damaged fuel assemblies during normal and off-normal conditions. Therefore, the analyses based on intact fuel assemblies of a HLZC 11 would be applicable when there are damaged fuel assemblies. In addition, UFSAR Section A.4.6.1 indicated that the analyses based on intact fuel assemblies of a HLZC 11 was applicable when there are failed fuel assemblies because the decay heat when storing two failed fuel assemblies is reduced to

39.7 kW (DSC in lower compartment) and 37.38 kW (DSC in upper compartment). This conclusion was based on previous analyses from an earlier NUHOMS® EOS amendment (reported in UFSAR Table 4.9.6-10) that showed HLZC 4 with intact fuel assemblies (50 kW decay heat) had bounding cladding temperatures compared to HLZC 6 (44.3 kW) with four failed fuel assemblies. Based on the above, staff finds that the storage thermal analysis based on intact fuel assemblies in HLZC 11, which can have up to 44.5 kW decay heat and result in cladding temperatures with approximately 50 deg F margin from the allowable value (per UFSAR Table A4.-36), would tend to bound the lower decay heat condition of having two failed fuel assemblies.

UFSAR Section A.4.6.2, Section A.4.6.3, Section A.4.6.5, UFSAR Table A.4-16, and UFSAR Table A.4-34 described the bounding load cases, including the storage normal condition LC 1e-S-full-O with a bounding oriented wind speed, based on the HSM-MX analyses in UFSAR Appendix A.4.5 from an earlier NUHOMS® EOS amendment. The CFD thermal model used when analyzing HLZC 11 was the same model described in UFSAR Section A.4.5.7.3; the only change being the decay heat loading pattern described in Figure 1K of the Technical Specifications. According to UFSAR Section A.4.6.4, the thermal model's convergence parameters showed a cladding temperature variation over the last 500 iterations of less than 0.1 deg F, heat transfer flux imbalance less than 0.5%, radiation heat transfer flux imbalance less than 0.05%, and mass flow rate variation over the last 500 iterations less than 1%; grid convergence index values were reported in UFSAR Section A.4.5.4.4 as being approximately 10 deg F.

Based on the above-mentioned boundary conditions and convergence parameters, UFSAR Table A.4-36 reported fuel cladding and concrete temperatures of 699 deg F and 280 deg F, respectively, which are approximately 50 deg F and 20 deg F less than the 752 deg F and 300 deg F temperature limits, respectively. In order to show that HLZC 7 conditions tended to bound HLZC 11, it was shown in UFSAR Table A.4-37 that maximum temperatures of cladding and other DSC components) were less than previously analyzed HLZC 7 temperatures reported in UFSAR Appendix A.4.5 from a previous NUHOMS® EOS amendment, indicating that HLZC 11 off-normal and accident storage condition temperatures also would be lower. Likewise, results showed similar air flow and air temperatures as the HLZC 7 model from a previous NUHOMS® EOS amendment. In addition, the HLZC 11 DSC gas temperature was lower than that reported for HLZC 7 from an earlier NUHOMS® EOS amendment for the bounding LC 1e-S, such that the DSC pressure with HLZC 11 would be less than the maximum pressure reported in UFSAR Table 4-45. Based on the above, staff finds that the EOS-37PTH Type 2 DSC with HLZC 11 within the HSM-MX storage module has temperatures and pressures that are less than the values for the bounding HLZC 7, and are therefore acceptable.

Evaluation of EOS-37PTH Type 4H Basket in EOS-HSM Storage Module

Storage of an EOS-37PTH Type 4H basket in an EOS-HSM storage module (and the relevant optional designs, including EOS-HSM-FPS) was discussed in UFSAR Appendix 4.9.7. It was stated in UFSAR Section 4.9.7.1 that HLZC 10 bounds HLZC 11 because HLZC 10 can have a higher decay heat load within Zone 2 and Zone 4 (3.5 kW/assembly for both zones for HLZC 10 versus HLZC 11's combination of 3.5 kW/assembly and 3.2 kW/assembly), thus resulting in a higher maximum heat load. It was also noted that both HLZC 10 and HLZC 11 can accommodate six damaged fuel assemblies or up to two failed fuel assemblies; the failed fuel assemblies are limited to 0.8 kW. It was stated that damaged fuel assemblies and failed fuel assemblies cannot be stored in the same DSC. According to UFSAR Section 4.9.7.2.1.3, the same thermal model was used as described in UFSAR Section 4.9.5.2 from an earlier EOS amendment. It included wind deflectors for heat loads greater than 41.8 kW per DSC. There were no changes to the mesh, although heat generation rates for the fuel regions were modified to reflect HLZC 10. The FLUENT energy under-relaxation factors were listed in UFSAR Section 4.9.7.2.1.3 and the pressure, density, body forces, momentum, turbulence kinetic energy, turbulence dissipation rate, and turbulent viscosity under-relaxation factor values were listed in UFSAR Section 4.9.5.2.3.2.A from an earlier NUHOMS® EOS amendment. The convergence criteria were listed in UFSAR Section 4.9.5.2.3.2.B and included total heat transfer and radiation heat transfer imbalances within 1% of the heat load such that maximum fuel cladding and concrete temperatures were stabilized. Two load conditions (LC) were modeled; LC1n modeled a 45.7 kW decay heat and included an EOS-HSM with wind deflectors at the outlets whereas LC2n modeled a 41.8 kW decay heat for the EOS-HSM without wind deflectors. These conditions with and without wind deflectors were chosen because they were found to be bounding in storage analyses from an earlier NUHOMS® EOS amendment when modeling HLZC 1 with a 50 kW decay heat. UFSAR Section 4.9.7.2.1.2 noted that the ambient temperature was the same condition (70 deg F) reported in UFSAR Section 4.3.

Based on the above-mentioned boundary conditions, solver parameters, and convergence parameters, thermal results from the above-mentioned HLZC 10 analyses were provided in UFSAR Table 4.9.7-2, UFSAR Figure 4.9.7-1 and UFSAR Figure 4.9.7-2. Fuel cladding temperature for HLZC 10 with LC1n was reported as 698 deg F; this would increase to 715.13 deg F when corrected for the Grid Convergence Index value of 17.13 deg F reported in UFSAR Section 4.9.7.2.1.4. The 715.13 deg F PCT is less than the design basis LC1 condition (HLZC 1 at 50 kW) PCT of 716 deg F reported in UFSAR Table 4.9.7-2 and is approximately 37 deg F below the 752 deg F allowable temperature reported in UFSAR Section 4.9.7.2.1.4. Likewise, fuel cladding for load case LC2n (normal condition without EOS-HSM wind deflectors) was 704.13 deg F and was bounded by load case LC1b (normal condition without wind deflectors) from UFSAR Section 4.9.5 of an earlier NUHOMS® EOS amendment. The 234 deg F (LC 1) and 266 deg F (LC 1b) concrete temperatures associated with the EOS-HSM were below the 300 deg F allowable value (with margins greater than 34 deg F) and were lower than those reported for the design basis load case (LC1) described in UFSAR Section 4.9.5 from an earlier NUHOMS® EOS amendment. UFSAR Section 4.9.7.2.1.4 noted that no evaluations were performed for off-normal and accident conditions with HLZC 10 and HLZC 11 because, as noted in UFSAR Table 4.9.7-2, temperatures for HLZC 10 and HLZC 11 associated with normal conditions were lower than that reported in UFSAR Section 4.9.5 for the design basis LC 1 with HLZC 1 (50 kW decay heat) and, therefore, the off-normal and accident conditions evaluated in UFSAR Section 4.9.5 with HLZC 1 would remain bounding. Staff finds that temperature criteria associated with the EOS-37PTH DSC and EOS-HSM would also be met for off-normal and accident storage conditions for EOS-37PTH DSC with HLZC 10 and HLZC 11 because the fuel assembly heat load pattern and lower decay heat has shown to result in lower temperatures when compared with the previously analyzed design basis EOS-37PTH DSC with HLZC 1.

Evaluation of the EOS-37PTH Type 4H DSC during Transfer

Thermal analyses for transfer operations of an EOS-37PTH Type 4H with HLZC 10 and HLZC 11 using an EOS-TC 125/135 were discussed in UFSAR Section 4.9.7.2.2. It indicated that analyses from an earlier NUHOMS® EOS amendment (UFSAR Section 4.9.6.1.4.1) showed that the EOS-37PTH DSC within an EOS-TC125 transfer cask (and the EOS-TC135 transfer cask because it is bounded by EOS-TC125 according to UFSAR Section 4.5) under normal conditions in a vertical orientation with loading case (LC) 1 condition (defined in UFSAR Section 4.5) resulted in maximum cladding temperatures with the smallest temperature margins. Likewise, it was stated that UFSAR Table 4-23 showed that a steady-state analysis with loss of liquid in the neutron shield and loss of air circulation was the bounding accident transfer condition (LC5). Therefore, UFSAR Section 4.9.7.2.2.1 indicated the above-mentioned load cases were also modeled for HLZC 10 with 45.7 kW inside an EOS-TC125 with the ambient operating conditions described in UFSAR Section 4.5. According to UFSAR Section 4.9.7.2.2.3, the convergence criteria described in UFSAR Section 4.5.2.2.6 were used for the LC 1 and LC 5 analyses. Differences with that model included the changes to the heat generation rates associated with HLZC 10. UFSAR Section 4.9.7.2.2.3 indicated a cladding temperature GCI for the transfer model in the EOS-TC125 that was less than 10 deg F and the response to RAI 4-2 indicated the GCI based on the DSC shell temperature was less than 1 deg F. UFSAR Table 4.9.7-4 showed that component temperatures for LC 1 were less than the design basis evaluation for the EOS-37PTH DSC with HLZC 1. In addition, according to UFSAR Section 4.9.7.2.2.4, the time limits associated with insertion of the DSC into the EOS-HSM for normal and off-normal conditions would be eight hours with an additional five-hour time limit to complete recovery actions. The response to RAI 4-4 indicated that the eight hour transfer period is conservative, considering results for an EOS-37PTH DSC with HLZC 1 (50 kW decay heat) could be 10 hours based on UFSAR Section 4.5.4 from a previous NUHOMS® EOS amendment. Results for the accident condition (LC 5) in UFSAR Table 4.9.7-5 and UFSAR Figure 4.9.7-4 showed that the 877 deg F cladding temperature was 58 deg F below the HLZC 1 design basis condition value of 935 deg F and was 181 deg F below the 1058 deg F allowable value reported in UFSAR Table 4-28. Likewise, UFSAR Table 4.9.7-5 show that the DSC and EOS-TC125 component temperatures were below those reported for the HLZC 1 design basis condition. Based on the above, staff finds that the transfer time limits for HLZC 10 are acceptable and component temperatures would be below allowable values for normal, off-normal, and accident conditions.

Pressure Analysis of the EOS-37PTH Type 4 DSC

UFSAR Section 4.9.7.2.2.4 indicated that the LC1 DSC average helium gas temperature of 492 deg F was below the 557 deg F design basis value, and, therefore, the DSC pressure for normal transfer would be below the design basis internal pressure for normal conditions reported in UFSAR Section 4.7. Likewise, the accident condition (LC5) DSC average helium gas temperature of 660 deg F was below the 716 deg F value reported for the design basis condition in UFSAR Table 4-45 and, therefore, the DSC pressure would be below the design basis accident condition value. Based on the DSC gas temperatures being below design basis values and pressure being linearly proportional with temperature, staff finds that pressure criteria would be met for normal, off-normal, and accident conditions.

Evaluation of Damaged and Failed Fuel Assemblies in EOS-37PTH Type 4 DSC

As mentioned earlier, HLZC 10 and HLZC 11 can accommodate six damaged fuel assemblies or two failed fuel assemblies. UFSAR Section 4.9.7.3.1 noted that the UFSAR Section 4.9.6.1.5.1 analyses from an earlier NUHOMS® EOS amendment, indicated that damaged fuel assemblies did not impact normal, off-normal, and accident storage conditions or normal and off-normal transfer conditions because there is no change in their configuration. Therefore, UFSAR Section 4.9.7.3 stated that only a bounding transfer accident condition with the loss of neutron shield and air circulation (see UFSAR Table 4-28 and Table 4-29) was evaluated for damaged fuel assemblies turning into rubble as a result of an accident. Specifically, the load case (LC) 5 model from an earlier NUHOMS® EOS amendment described in UFSAR Section 4.9.6.1.5.3, with ambient conditions described in UFSAR Section 4.5.1, was used by modifying the model heat generation rates associated with the HLZC 10 fuel assemblies. Results were presented in UFSAR Section 4.9.7.3.4 and UFSAR Table 4.9.7-7, which showed component temperatures of the EOS-37PTH DSC and EOS-TC125. Except for the DSC shell and basket transition rails, component temperatures were less than the design basis condition described in UFSAR Section 4.5. The DSC shell and basket transition rails were 43 deg F and 39 deg F higher, respectively, than those for the design basis condition. This could indicate a local effect when modeling six damaged fuel assemblies as rubble after an accident condition. It was noted that the maximum internal pressure within the DSC with damaged fuel assemblies was bounded by the design basis condition presented in UFSAR Table 4-45. Staff finds that the DSC pressure would be less than the design basis condition (which has a higher decay heat) even when accounting for the damaged fuel assemblies becoming rubble because the average gas temperature in the DSC was reported to be 642 deg F, which is less than the 716 deg F average helium temperature for the bounding condition that assumed 100% rod rupture. Finally, UFSAR Section 4.9.7.4.4 noted that the maximum temperatures with two failed fuel assemblies limited to 0.8 kW/assembly and a 40.3 kW total DSC decay heat would be bounded by the condition with intact fuel assemblies with a 45.7 kW total DSC decay heat. Staff finds that the EOS-37PTH DSC with HLZC 10 and intact fuel assemblies with a 45.7 kW total decay heat would bound HLZC 10 with two failed fuel assemblies and a 40.3 kW total decay heat because the nearly 14% greater decay heat would result in higher component temperatures.

Change No. 3: For EOS-37PTH DSC, adding basket Type 4H for HLZCs 1, 4, 5, 6, 8, and 9 for storage and transfer conditions.

Change No. 3 was described as follows: “For the EOS-37PTH DSC, add basket type 4H, previously introduced in CoC No. 1042 Amendment 1, for HLZCs 1,4,5,6,8 and 9.”

The applicant’s analyses to demonstrate that Basket Type 4H with HLZC 1, 4, 5, 6, 8, and 9 can be included in the EOS-37PTH DSC were presented in UFSAR Section 4.4, UFSAR Appendix A.4, and UFSAR Appendix 4.9.6. According to UFSAR Section 4.9.6.1, Basket Type 4H with HLZC 4, 5, and 6 can be loaded inside the EOS-TC125, EOS-TC135, and EOS-TC108 transfer casks for transfer operations and can be stored in the relevant EOS-HSM storage module. According to UFSAR Appendix A.4 and UFSAR Section 4.9.6.2, Basket Type 4H with HLZC 8 and 9 can be loaded inside the EOS-TC125, EOS-TC135, and EOS-TC108 transfer casks for transfer operations and can be stored in the HSM-MX storage module. The storage and transfer conditions associated with Change No. 3 are presented in the summary tables below according to UFSAR Appendix A.4, UFSAR Section 4.9.6.1, and UFSAR Section 4.9.6.2.

DSC Type	Basket Assembly Type	HLZC	Max. Heat Load (kW)	Transfer Cask	Storage Module
EOS-37PTH	4H	7	50.00	EOS-TC125/ EOS-TC135 *and EOS-TC108*[(3)]	HSM-MX
	4H/4L/5	8[(1)]	46.40[(2)]		
	4H/4L/5	9	37.80		
	4H	*11*	*44.50*	*EOS-TC125/EOS-TC135*	
EOS-89BTH	3	3	34.44	EOS-TC125/EOS-TC108	

Note:

(1) Basket Type 5 can only accommodate Intact FAs. Therefore, damaged or Failed FAs allowed per HLZC 8 shall only be loaded in Basket Type 4L.

(2) The maximum decay heat per DSC is limited to 41.8 kW when a damaged or failed FA is loaded.

(3) Transfer operations in EOS-TC108 are permitted for HLZCs 4 through 9 in EOS-37PTH DSC only with Basket Type 4H.

DSC Type	Basket Assembly Type	Heat Load Zone Configuration (HLZC)	Max. Heat Load (kW)	Transfer Cask	Storage Module
EOS-37PTH	*4H*/4L/5	4	50.00	EOS-TC125/ EOS-TC135 *EOS-TC108*[(1)]	EOS-HSM/ EOS-HSMS/ EOS-HSM-FPS/ EOS-HSMS-FPS
	4H/4L/5	5	41.00		
	4H/4L	6	46.00		

Note 1: Transfer operations in EOS-TC108 are permitted for HLZCs 4 through 6 in EOS-37PTH DSC only with Basket Type 4H.

DSC Type	Basket Assembly Type	Heat Load Zone Configuration (HLZC)	Max. Heat Load (kW)	Transfer Cask	Storage Module
EOS-37PTH	4H	7	50.00	EOS-TC125/ EOS-TC135 *and EOS-TC108*[(3)]	HSM-MX
	4H/4L/5	8[(1)]	46.40[(2)]		
	4H/4L/5	9	37.80		

Note:

1. Basket Type 5 can only accommodate intact FAs. Damaged *FAs* or *FFCs* allowed per HLZC 8 shall only be loaded in Basket Type 4L.
2. The maximum decay heat per DSC is limited to 41.8 kW when a damaged *FA* or failed *fuel* is loaded.
3. *Transfer operations in EOS-TC108 are permitted for HLZCs 7 through 9 in EOS-37PTH DSC only with Basket Type 4H.*

Evaluation of EOS-37PTH Type 4H DSC with HLZC 1

According to UFSAR Section 4 (page 4-2), the thermal evaluations for EOS-37PTH Type 1 baskets (which are defined with a HLZC 1) for EOS-HSM storage conditions in UFSAR Section 4.4 and EOS-TC125/EOS-TC135 transfer conditions in UFSAR Section 4.5 are applicable for

EOS-37PTH Type 4H basket with HLZC 1. It was stated this is because the Type 4H basket has the same steel plate emissivity and poison plate thermal conductivity as the Type 1 basket; likewise, UFSAR Table 1-2 indicated that both Type 1 and Type 4H baskets had high values for steel plate emissivity and poison plate thermal conductivity. In addition, UFSAR Section 4.9.6.1.1 from an earlier NUHOMS® EOS amendment stated that the arrangement of the basket assembly plates does not impact the thermal evaluation of different basket assembly types. Based on the above, staff finds that a Type 4H basket thermal analysis with HLZC 1 would be similar to the Type 1 basket thermal analyses because the thermal aspects of the basket design and thermal properties are similar, thereby tending to have similar temperatures and pressures for a given decay heat arrangement. In addition, staff finds the temperature margins (approximately 28 deg F and 42 deg F for cladding and concrete, respectively, at normal storage and approximately 28 deg F for cladding during normal transfer) and pressure margins (approximately 9.5 psig at normal conditions) that the Type 1 basket (HLZC 1) has relative to the allowable temperature and pressure limits, as described in UFSAR Table 4-5, UFSAR Table 4-24, and UFSAR Table 4-45 from an earlier amendment, provide additional reasonable assurance.

Evaluation of EOS-37PTH Type 4H DSC with HLZCs 4, 5, 6, 8, 9

According to UFSAR Section 4.9.6.1.1 from an earlier NUHOMS® EOS amendment, "… all the thermal evaluations for EOS-37PTH Type 4L/5 baskets for storage and transfer conditions in this Appendix 4.9.6 are also applicable for EOS-37PTH Type 4H baskets" because Type 4H baskets have higher emissivity plates and higher thermal conductivity poison plates than Type 4L/5 baskets. Likewise, according to UFSAR Section A.4.4 of Appendix A.4 from an earlier NUHOMS® EOS amendment, "… all the thermal evaluations for EOS-37PTH Type 4L/5 baskets for storage and transfer conditions in Sections A.4.4.4 and A.4.5.5 are also applicable for EOS-37PTH Type 4H baskets" because Type 4H baskets have higher emissivity steel plates and higher thermal conductivity poison plates than Type 4L/5 baskets. Staff finds that Type 4H baskets would be bounded by the previously considered Type 4L/5 basket thermal analyses because changing a thermal model only by increasing basket emissivity and poison plate thermal conductivity would improve heat transfer, thereby reducing temperatures and pressures. In addition, the cladding temperature margins for storage (e.g., approximately 20 deg F at normal conditions) from UFSAR Section 4.9.6.1.3.5, and transfer (approximately 23 deg F at normal conditions) from UFSAR Section 4.9.6.1.4.4, that the Type 4L/5 baskets with HLZCs 4 through 6 have relative to the allowable cladding temperature (as described in UFSAR Table 4.9.6-3 and UFSAR Table 4.9.6-5), provides additional reasonable assurance that any slight difference between the two baskets would result in the Type 4H basket to be similar or bounded by the Type 4L/5 basket.

It is noted that the storage of Type 4L/5 baskets (and, therefore, Type 4H) with HLZCs 4, 5, 6 in the EOS-HSM (and the relevant optional designs, including EOS-HSM-FPS) storage module was addressed in UFSAR Section Appendix 4.9.6.1.3.1, from an earlier NUHOMS® EOS amendment. Likewise, the transfer of Type 4L/5 baskets (and, therefore, Type 4H baskets) with HLZCs 4, 5, 6 in the EOS-TC125/135 was addressed in UFSAR Section Appendix 4.9.6.1.4, from an earlier NUHOMS® EOS amendment. In addition, the transfer of Type 4L/5 baskets (and, therefore, Type 4H baskets) for HLZC 8 and HLZC 9 in the EOS-TC125/135 was addressed in UFSAR Section 4.9.6.2 from an earlier NUHOMS® EOS amendment. UFSAR

Section A.4.4.4 and Section A.4.5.5 of Appendix A.4, from an earlier NUHOMS® EOS amendment, addressed the storage of Type 4L/5 baskets (and, therefore, Type 4H basket) with HLZCs 8 and 9 in the HSM-MX storage module. UFSAR Section 4.9.6.3 addressed the transfer of Type 4H basket with HLZCs 4, 5, 6, 8, 9 in the EOS-TC108; these thermal analyses are evaluated in the Amendment 2 Change No. 4 discussion, below.

Change No. 4: Transfer operations in EOS-TC108 with EOS-37PTH with Type 4H and HLZCs 4 through 9

Change No. 4 was described as follows: "For the EOS-TC108 TC System with the EOS-37PTH DSC, add HLZCs 4 through 9 for the 4H basket and reduce the minimum cooling times to 2 years (HLZC 2 through 9)." Thermal analyses for this amendment change were presented in UFSAR Section 4.9.6.3 of Appendix 4.9.6.

According to UFSAR Section 4.9.6.3.2, the thermal FLUENT model used to represent the EOS-37PTH Type 4H in the EOS-TC108 was based on the model described in UFSAR Section 4.6.1, from an earlier NUHOMS® EOS amendment, with no changes in the mesh. Likewise, UFSAR Section 4.9.6.1.1 indicated the thermal model previously used for basket assembly Types 1 through 3 was applicable for Type 4H because the arrangement of the basket assembly plates did not affect thermal performance. Differences associated with the previously used model for the current analysis included updates to the heat generation rates and thermal mass properties (density and specific heat) and the representation of the fuel content in an arrangement described for HLZC 4 (bounding HLZC, discussed below) in Figure 1D of the Technical Specifications. According to UFSAR Section 4.9.6.3.1 and UFSAR Table 4.9.6-12, the boundary conditions for the transient thermal analysis were based on 120 deg F ambient, indoor normal condition transfer, with no air circulation; this was designated as load case (LC) 1. According to UFSAR Section 4.9.6.3.1, this load case was found to be the bounding condition for the EOS-TC125 transfer cask with similar content. Likewise, UFSAR Section 4.9.6.3.3 C and the response to RAI 4-6 compared the LC 1 results from UFSAR Table 4.9.6-4 (EOS-TC125) and UFSAR Table 4.9.6-12 (EOS-TC108) to show that temperatures are bounding for transfer in the EOS-TC125. Based on the above, staff finds that the transfer operations of an EOS-37PTH Type 4H DSC with HLZCs 4 through 9 in the EOS-TC108 would be bounded by the EOS-TC125 analyses.

In addition, it was noted in UFSAR Section 4.9.6.3 that HLZC 4 was modeled because, based on earlier NUHOMS® EOS amendment analyses discussed in UFSAR Section 4.9.6.1.4.1 and UFSAR Section 4.9.6.2, it was the bounding decay heat pattern. This was further clarified by comparing the details of the other HLZCs with HLZC 4. For example, UFSAR Section 4.9.6.1.4.4 and UFSAR Table 4.9.6-5 showed that cladding, DSC components, and transfer cask components had higher temperatures when transferring HLZC 4 content, compared to HLZC 5 content. Likewise, UFSAR Section 4.9.6.1.5.1 stated that HLZC 4, with a decay heat of 50 kW, bounded HLZC 6 with a decay heat of 46 kW, including an HLZC 6 with damaged fuel assemblies. UFSAR Section 4.9.6.2 explained that HLZC 4 bounded HLZC 7 because HLZC 4 had higher decay heat in the center of the DSC, which results in higher cladding temperatures. Likewise, HLZC 4, with 50 kW decay heat, bounded HLZC 8, with 46.4 kW decay heat, because of the higher heat load. It was also stated that HLZC 8 with damaged/failed fuel is limited to 41.8 kW and, therefore, its results are also bounded by HLZC 6, which is bounded by HLZC 4, as discussed above. Finally, UFSAR Section 4.9.6.2 explained that HLZC 5, with 41 kW decay heat and with a maximum fuel assembly decay heat of 2.4 kW, had higher decay heat load than HLZC 9, with a 37.8 kW decay heat and with a maximum fuel assembly decay heat of 2 kW, and since HLZC 4 bounds HLZC 5, it would also bound HLZC 9.

Results from the transient analysis of the EOS-TC108 normal transfer condition with HLZC 4 were presented in UFSAR Table 4.9.6-13. The table showed that, except for a 2 deg F and 6 deg F higher gamma shield and neutron shield temperature, respectively, the component temperatures associated with the EOS-37PTH with Type 4H basket in a EOS-TC108 transfer cask were lower than the EOS-37PTH with Type 4L basket in an EOS-TC125 transfer cask that was analyzed in an earlier NUHOMS® EOS amendment. The 2 deg F and 6 deg F higher component shielding temperatures are relatively small considering that UFSAR Table 4.9.6-13 indicated that temperature margins with the temperature limits ranged from 40 deg F for the neutron shield to 52 deg F for the fuel cladding. As mentioned in UFSAR Section 4.9.6.1.1 that was considered in a previous NUHOMS® EOS amendment, the thermal evaluations for EOS-37PTH Type 4L/5 baskets for transfer (and storage) in Appendix 4.9.6 bound EOS-37PTH Type 4H baskets because of the Type 4H basket's higher emissivity steel plates and higher conductivity poison plates (i.e., more thermally efficient). With regards to pressure, the applicant noted in UFSAR Section 4.9.6.3.3 C that the DSC cavity helium gas temperature (used to evaluate internal DSC pressure) for the bounding EOS-108 normal transfer condition with HLZC 4 was 550 K. Staff finds this temperature would result in a DSC pressure lower than the design basis pressure associated with the 565 K cavity gas temperature reported in an earlier NUHOMS® EOS amendment in UFSAR Section 4.7 because pressure is a linear function of temperature, according to the Ideal Gas Law. Finally, UFSAR Section 4.9.6.3 B noted the normal and off-normal transfer time limits provided in UFSAR Table 4.9.6-7 were valid for the EOS-TC108 for HLZCs 4 through 6 and the normal and off-normal transfer time limits in UFSAR Table 4.9.6-11 were valid for EOS-TC108 for HLZCs 7 through 9 because the temperatures for EOS-TC108 with HLZC 4 are bounded by EOS-TC125 with HLZC 4. Based on the above discussion, staff finds that, because DSC pressures and temperatures (except as discussed above) are lower when a EOS-37PTH Type 4H basket with HLZC 4 is transferred using an EOS-TC108 compared to transfer using an EOS-TC125, the normal and off-normal transfer time limits associated with the EOS-37PTH Type 4H basket with HLZC 4 (bounding HLZC) in the EOS-TC125 are acceptable for the EOS-37PTH Type 4H basket with HLZC 4 in the EOS-TC108.

Change No. 6: Technical Specification revisions and considerations

Technical Specification Figure 1J and Figure 1K provided the maximum decay heat per fuel assembly and maximum decay heat within HLZCs 10 and 11 for the EOS-37PTH DSC. Likewise, Technical Specification Figure 4A through Figure 4J provided the maximum decay heat per fuel assembly and maximum decay heat within HLZCs 1 through 10 for the 61BTH Type 2 DSC. These Technical Specification figures were referenced in UFSAR Appendix 4.9.7 for the EOS 37PTH for HLZC 10 and HLZC 11 thermal analyses and UFSAR Appendix B.4 for the 61BTH Type 2 DSC HLZC 1 through 10 thermal analyses. Staff finds that the maximum decay heat indicated in the Appendix 4.9.7 summary table (UFSAR page 4.9.7-1) and Appendix B.4 summary table (UFSAR page B.4-1) were as described in the above-mentioned Technical Specification figures.

Staff reviewed Technical Specifications 3.1.3 and confirmed that the 8-hour time limit for completion of the EOS-37PTH with HLZC 4 through 11 was as described in UFSAR Section 4.9.6.3.3 and UFSAR Section 4.9.7.2.2.4 of the UFSAR thermal analyses. Staff also confirmed that the 23 hour time limit for transfer completion of the 61BTH Type 2 DSC with HLZC 5, 6, and 8 and that the 10 hour time limit for transfer completion of the 61BTH Type 2 DSC with HLZC 7 and 10 were as described in UFSAR Section B.4.5.1 (Appendix B.4) "Thermal Evaluation of OS197 TCs with 61BTH DSC." Staff confirmed that the 1 hour completion time to initiate air circulation (Technical Specification Limited Condition of Operation A.2 required action) and the 5 hour completion time to return the transfer cask to the cask handling area (Technical Specification Limited Condition of Operation A.3 required action) were as described in UFSAR Section B.4.5.1 and UFSAR Section B.4.5.6 (Appendix B.4) "Minimum Duration to Operate Force Air Circulation (FC)".

Finally, the current amendment request included the storage of EOS-37PTH DSCs with Type 4H baskets and with content defined by HLZC 1,4,5,6, and 10, within an EOS-HSM. It is noted that item 3 of Technical Specification 4.5.3 stated that a site's normal ambient temperature associated with an EOS-37PTH DSC (with a heat load greater than 41.8 kW) stored in an EOS-HSM is based on a maximum calculated average yearly temperature of 70 deg F. According to the UFSAR thermal sections (e.g., Section 4.3, Appendix 4.9.7.2.1.2), the thermal analyses associated with these configurations were based on a 70 deg F ambient temperature. However, it is recognized that ambient temperatures at normal conditions can be greater than 70 deg F at a site (e.g., summer seasonal). The applicant provided a discussion, in Enclosure 4 response to RAI 4-9, of component temperatures at high ambient temperatures. In the RAI 4-9 response, it was noted that Load Case 3 (defined in UFSAR Section 4.9.5.4, UFSAR Table 4.9.5-1, UFSAR Table 4.9.5-2 from an earlier NUHOMS® EOS amendment) for HLZC 1 at 50 kW, with a 103 deg F daily average ambient temperature, and stored within an EOS-HSM with the Flat Plate System (FPS) option, would have a PCT of approximately 755 deg F (after adjusting the calculated value reported in UFSAR Table 4.9.5-2 with the grid convergence index correction reported in UFSAR Section 4.9.5.7) and concrete temperature of 266 deg F. Likewise, according to UFSAR Section 4.4.4 and UFSAR Table 4-5, similar conditions for the EOS-HSM without the FPS option resulted in a PCT of approximately 746 deg F (after adjusting the calculated value reported in UFSAR Table 4-5 with the grid convergence index correction reported in UFSAR Section 4.9.3.1.3) and concrete temperature of 272 deg F. Based on the applicant's information presented above, staff finds there is reasonable assurance that daily average ambient temperatures greater than 70 deg F, but suitably lower than 103 deg F, would result in PCT and concrete temperatures lower than the allowable temperatures at normal conditions (752 deg F and 300 deg F, respectively) for the EOS-37PTH DSCs, within an EOS-HSM, for Type 4H baskets with content defined by HLZC 1, 4, 5, 6, and 10.

Additional Change No. 4 not associated with the RAI: Update UFSAR Section 2.4.3 to clarify the methodology to reduce the maximum allowable heat load based on the fuel assembly type.

UFSAR Section 2.4.3 included text stating that the maximum NUHOMS® EOS system allowable heat loads could be reduced based on the methodology described in UFSAR Chapter 4 and UFSAR Appendix A.4 for the fuel assembly types permitted in the EOS-37PTH DSC or the

EOS-89BTH DSC and that the determination of fuel assembly type thermal properties are to be based on the methodology presented in Appendix 4.9.1 of UFSAR Chapter 4. Staff notes that the updated text is a reiteration from Technical Specification Section 2.1 and Section 2.2 and the referenced methodology presented in UFSAR Appendix 4.9.1 was considered in a previously approved amendment.

Evaluation Findings

The staff concludes that the thermal design of the NUHOMS® EOS system is in compliance with 10 CFR Part 72, and that the applicable design and acceptance criteria have been satisfied. The evaluation of the thermal design provides reasonable assurance that the NUHOMS® EOS system will allow safe storage of spent fuel for the certified life of twenty years. This finding is reached on the basis of a review that considered the regulation itself, appropriate regulatory guides, and accepted engineering practices. Some of the key findings from the staff's review of Amendment 2 include:

F4.1 Structures, systems, and components (SSCs) important to safety are described in sufficient detail in Chapter 4, Appendix A.4, and Appendix B.4 of the UFSAR to enable an evaluation of their thermal effectiveness. The NUHOMS® EOS system SSCs important to safety remain within their operating temperature ranges.

F4.2 The NUHOMS® EOS system is designed with a heat-removal capability having verifiability and reliability consistent with its importance to safety. The NUHOMS® EOS system is designed to provide adequate heat removal capacity without active cooling systems.

F4.3 The spent fuel cladding is protected against degradation leading to gross ruptures by maintaining the cladding temperature below maximum allowable limits in a helium environment. Protection of the cladding against degradation is expected to allow ready retrieval of spent fuel for further processing or disposal.

5.0 CONFINEMENT EVALUATION

The staff reviewed the information provided by the applicant and the following two changes are applicable to the confinement evaluation:

Change No. 1:
Add the 61BTH Type 2 DSC transferred in the OS197 TC for storage in the HSM-MX design approved in Amendment 1 to CoC No. 1042.

Change No. 6:
Certain CoC and TS items are revised for consistency and clarity.

This section of the SER documents the staff's review and conclusions with respect to confinement safety.

Change No. 1: 61BTH Type 2 Dry Shielded Canister (DSC)

The applicant described the confinement system of the 61BTH Type 2 DSC in UFSAR Appendix B.2.2 of this application: (a) the fuel compartment and the top and bottom end caps together form the confinement of damaged fuel, (b) if fuel particles are released from the damaged assembly, the top and bottom end caps provide the confinement of gross fuel particles to a known volume, and (c) the failed fuel shall be stored in a failed fuel canister (FFC), with the end caps fit snugly into the top and bottom of the fuel compartment.

The staff reviewed Technical Specifications (TS) Appendix A and UFSAR, including Appendix B.2.2, and confirmed that:

(a) the DSC confinement system, including the confinement welds, is consistent as described in the CoC No. 1004 in which the 61BTH Type 2 DSC was reviewed and approved by the NRC, and

(b) the confinement function of the end caps for the 61BTH Type 2 DSC is consistent with that for the EOS-37PTH DSC, which was reviewed and approved by the NRC in the NUHOMS® EOS Amendment 1 application.

Change No. 6: Revision to Certain CoC and TS Items

The staff reviewed the application and confirmed that (a) the maximum DSC internal pressures for the 61BTH Type 2 DSC at normal, off-normal, and accident conditions are consistent with those provided in the Standardized NUHOMS® system UFSAR, and (b) the pressure and helium leakage rate tests applied to the confinement boundary of the 61BTH Type 2 DSC, including the confinement welds, are consistent with those tests required by the TS Appendix A of CoC No. 1004.

The staff confirmed that the CoC and TS items for the confinement system of the 61BTH Type 2 DSC in this application is consistent with those specified in the CoC and TS of CoC No. 1004, in which the 61BTH Type 2 DSC was approved by the NRC.

Evaluation Findings

The staff concludes that the confinement design features for the NUHOMS® EOS system are in compliance with 10 CFR Part 72, and that the applicable design and acceptance criteria have been satisfied. The evaluation of the confinement design provides reasonable assurance that the NUHOMS® EOS system will allow safe storage of spent fuel. This finding is reached on the basis of a review that considered the regulation itself, appropriate regulatory guides, applicable codes and standards, and accepted engineering practices. Some of the key findings from the staff's review of Amendment 2 include:

F5.1 The cask confinement system of the NUHOMS® EOS system has been evaluated for the proposed changes and demonstrates that it will reasonably maintain confinement of radioactive material under normal, off-normal, and credible accident conditions.

F5.2 On the basis of the review of the statements and representations in the application, addition of the 61BTH Type 2 DSC to the NUHOMS® EOS system continues to meet the confinement requirements of 10 CFR Part 72.

6.0 SHIELDING EVALUATION

The staff reviewed the information provided by the applicant and the following eight changes are applicable to the shielding evaluation:

Change No. 1:
Add the 61BTH Type 2 DSC transferred in the OS197 TC for storage in the HSM-MX design approved in Amendment 1 to CoC No. 1042.

Change No. 2:
For the EOS-37PTH DSC, add two new heat load zone configurations (HLZCs) for the EOS-37PTH for higher heat load assemblies, up to 3.5 kW/assembly, that also allow for damaged and failed fuel storage.

Change No. 3:
For the EOS-37PTH DSC, add basket type 4H, previously introduced in CoC No. 1042 Amendment 1, for HLZCs 1, 4, 5, 6, 8, and 9.

Change No. 4:
For the EOS-TC108 TC System with the EOS-37PTH DSC, add HLZCs 4 through 9 for the 4H basket and reduce the minimum cooling times to 2 years (HLZC 2 through 9).

Change No. 5:
For the EOS-37PTH DSC, increase the control component source terms to better address potential control component sources from various shutdown plants.

Change No. 6:
Certain CoC and Technical Specification (TS) items are revised for consistency and clarity.

Additional Change No. 2 not associated with the RAI:
Add description of methodology on Co-60 equivalence to UFSAR Section 6.2.4, Control Components, to clarify methodology for CCs.

Additional Change No. 3 not associated with the RAI:
Add description to UFSAR Section 1.2.1.1 for EOS-37PTH and Section 1.2.1.2 for EOS-89BTH to clarify the option of using a shield plug integrated with the inner top cover plate.

This section of the SER documents the staff's review and conclusions with respect to shielding safety.

Change No. 1: Add the 61BTH Type 2 dry DSC transferred in the OS197 TC for storage in the new HSM-MX design submitted under Amendment 1 to CoC No. 1042. The 61BTH Type 2 DSC design included in this amendment is from CoC No. 1004 Amendment 15.

The associated design changes to the HSM-MX include the addition of spacer blocks at the front and rear DSC supports to maintain the centerline of the DSC in line with the HSM door centerline.

The 61BTH Type 2 DSC and OS197 or OS200/OS200FC TC design have been approved by the NRC in CoC No. 1004 Amendment 15. The HSM-MX design was previously approved under Amendment 1 to the NUHOMS® EOS system. The applicant proposed to incorporate the 61BTH Type 2 DSC into the HSM-MX design. As was previously approved in CoC No.1004, the 61BTH Type 2 DSC will be transferred to the storage module using the OS197 or OS200/OS200FC TC for storage in the HSM-MX design as specified in the TS for the HSM-MX system within this amendment. Since the OS200/OS200FC are slight variants of the OS197 and the dose rates for these variants are bounded by OS197, the staff will reference all these three TC subtypes as OS197 in this SER unless there is a need for explicit distinction of the subtypes. However, it is important to note that the OS197L transfer cask is not incorporated in the HSM-MX design because OS197L is not authorized to load and unload the 61BTH canister.

The applicant also requested approval of a modification to the HSM-MX to include additional spacer blocks at the front and rear DSC supports to maintain the centerline of the 61BTH Type 2 DSC in line with the HSM-MX door centerline because the 61BTH Type 2 DSC has a diameter smaller than the opening of the storage module. The OS200 or OS200FC is fitted with an aluminum sleeve to accommodate the 61BTH Type 2 DSC for transfer operations. The applicant provided the structural design and dimension information for the 61BTH Type 2 DSC in the Standardized NUHOMS® system UFSAR.

Because the spacer blocks do not provide shielding from radiation of the contents, their only purpose is to keep the DSC in the center of the storage module. Since the structural evaluation has determined that the spacer blocks will be able to maintain their structural integrity, the shielding evaluation assumes that the DSCs will maintain their positions as designed under normal, off-normal, and accident conditions of operation of the HSM-MX system. As such, the shielding analysis and evaluation does not include an explicit discussion about the spacer blocks.

The applicant provided a general description of the 61BTH Type 2 DSC in the Standardized NUHOMS® system UFSAR. Based on the description, there is no design change in the canister itself from what has been approved in CoC No. 1004. The applicant also provided the dimensions and structural layout for the OS197 and a general overview for the TCs in licensing drawing NUH-03-8000-SAR of the UFSAR for this amendment application.

The staff reviewed the information provided by the applicant and found that the applicant has provided detailed descriptions of the canister and the transfer cask design. The staff finds that the description of the 61BTH Type 2 DSC is acceptable. The OS197 design to be used in the HSM-MX system remains the same as approved in CoC No. 1004 design.

When incorporating the 61BTH Type 2 DSC design into the HSM-MX system, the applicant made additional changes that affect the shielding design of the 61BTH DSC. Specifically, these changes include:

- Revised fuel qualification tables in the TS for the fuel allowed to be stored in the 61BTH DSC.
- Revised the TS to add the number of reconstituted fuel assemblies, number of stainless steel rods per reconstituted fuel assembly, and the total number of stainless steel rods per DSC. The reconstituted assemblies may contain up to 10 replacement stainless steel rods per assembly and the maximum number of irradiated stainless steel rods in reconstituted assemblies per DSC is 120.

As such, the 61BTH DSC incorporated into the HSM-MX system is not the same design as certified in CoC No. 1004. Rather, the staff considers this as a modified 61BTH Type 2 DSC because the revised fuel qualification tables (FQTs) are developed using the method approved in amendment 1 of CoC No. 1042. The user of this design should be aware of the differences in the allowable contents.

The applicant added the burnup, enrichment, and cooling time (BECT) combinations in Tables 18 and 19 of the TS for the allowable spent fuel contents of the system. The applicant also added Table 20, in terms of BECTs, for the fuels that are qualified for loading in the peripheral locations as defined in Figure 6 of the TS for the 61BTH Type 2 DSC loading configuration. These tables are also called fuel qualification tables in a sense that the BECTs in these tables are used to define the fuel that has been qualified for loading in the cask for the cask shielding design.

The revised TS for the HSM-MX also added specifications for the number of irradiated stainless steel rods allowed per reconstituted fuel assembly and per DSC. The BECTs and number of irradiated steel rods per fuel assembly are used to determine the bounding gamma and neutron source terms of the spent fuel to be stored in the 61BTH Type 2 DSC. The BECTs and specification for the number of allowable irradiated stainless steel rods per reconstituted fuel assembly and per DSC provide precise definitions for the authorized contents. The staff reviewed these specifications and found that the applicant has provided sufficient information for qualifying the authorized contents. On these bases, the staff found that the specifications for the authorized contents in the 61BTH DSC meet the regulatory requirements of 10 CFR Part 72.236(a) and therefore are acceptable.

Source terms calculations

The applicant calculated the source terms for the spent fuel to be stored in the 61BTH DSC using the ORIGEN-ARP module of the SCALE6.0 code package (ORNL, 2009). The applicant developed sources for the design basis assembly and the BECTs as specified in the TS.

The staff reviewed the applicant's source term calculation. The staff found that the BECTs specified in the TS provide data that can be used to calculate the sources of the spent fuel to be stored in the cask. The staff also found that the SCALE computer code and the ENDF/B-VII cross section library are one of the computer codes and cross section libraries recommended by NUREG-1536 and this code has been used and accepted by the staff in the review of the previously approved Amendments 0 and 1 for the NUHOMS® EOS system. On these bases, the staff found that the computer code and cross section library are appropriate and acceptable.

However, the staff found that the applicant used a power density that is not necessarily bounding based on power plant operation data, as provided by the applicant for the fuel to be stored. Because using a power density lower than the actual value will increase the depletion time for a given total fuel assembly burnup. The increased depletion time further increases the decay time for the radioactive materials in the spent fuel. The increased decay time for the radioactive materials in the spent fuel will produce lower than the actual source terms because of the arbitrarily increased decay times for the radioactive materials in the spent fuel.

In order to assess the impact of the power density used by the applicant, the staff performed a sensitivity study on the impact of a power density on the source terms. The staff found that the power density has a third level of impact on the source terms for the same burnup, enrichment and cooling time. This conclusion is consistent with NUREG/CR-6716, (ORNL 2001). With considerations of other conservatisms in the source terms and shielding calculations, the staff found it to be acceptable for this application. However, using a lower power density is in general not a conservative assumption. Consistent with 10 CFR 72.104 and 72.106, the users need to determine the impact to the dose at the controlled area boundary to ensure it meets the regulatory requirements. The general licenses must evaluate the impact to their radiation protection plans as well when performing the 10 CFR 72.212 evaluation.

The staff performed a confirmatory calculation for the source terms using the ORIGEN-ARP module of the SCALE6.1 code package (ORNL, 2010). The staff used the design basis assembly with burnup of 30 GWd/MTU, 1.5% initial enrichment, and 2 years of cooling time as specified in TS Table 19, “61BTH Type 2 DSC Fuel Qualification Table, All Fuel.” The staff selected this BECT combination because it is on the line that separates acceptable and unacceptable BECTs as shown in Table 19 of the TS. All other BECTs below this line are not acceptable. Therefore, this BECT will likely produce bounding sources. The results confirmed that the source terms are in good agreement with the design basis source terms as presented in the Appendix B of the SAR. In addition, the method has been used in source term calculations in the previously approved Amendments 0 and 1 for the NUHOMS® EOS system. For these reasons, the staff did not perform further verification for other BECT combinations.

Shielding Calculations

The applicant performed shielding analyses for the HSM-MX system with the new 61BTH DSC and the associated transfer cask OS197/OS200 under normal, off-normal, and accident conditions. The shielding analyses include calculations of the dose rates around the transfer cask and the dose as a function of distance from hypothetical arrays of the HSM-MX modules to the controlled area boundary.

Shielding calculations for TC OS197/OS200 and Storage Module with 61BTH Type 2 DSC:

<u>Normal and off-normal conditions of operations</u>

The applicant performed shielding analyses for the storage module with the modified 61BTH Type 2 DSC. Since the applicant includes two new loading zone configurations to this DSC as presented in Figures 4I and 4J of the TS, the total number of HLZCs for the 61BTH Types DSC in the HSM-MX system is ten.

The 61BTH Type 2 DSCs loaded with BWR spent fuel are to be transferred from the reactor pool building to the ISFSI pad using the OS197 TC. The applicant performed shielding analyses for the OS197 transfer cask. The shielding evaluations for loading and transfer configurations documented herein are based on the OS197 TC. This is conservative because the OS200 TC has slightly thicker neutron and gamma shielding layers hence the shielding calculations for OS197 are bounding for the OS200 TC.

The staff reviewed the TC designs for both the OS197 and OS200, and confirmed that the OS200 TC has slightly thicker neutron and gamma shielding layers. Based on basic particle attenuation theory, for the same source, thicker shields will further reduce the radiation level. Therefore, the staff determined that it is conservative and acceptable to use the OS197 in the shielding calculation for the other TCs for the transfer operations of the 61BTH canister.

The applicant calculated the dose rates around the OS197 TC loaded with the 61BTH Type 2 DSC that contains the source terms from the design basis fuel assemblies. The applicant documented its shielding analyses in Appendix B of the UFSAR. The applicant provided its calculated dose rates around the OS197 TC in Table B.11-1, "Occupational Dose Rates, OS197 with 61BTH DSC." The calculated dose rates show that dose rates for transfer of the 61BTH DSC within the OS197 TC are similar to the dose rates for transfer of the EOS-89BTH DSC within the EOS-TC125, as documented in Chapter 6 of the UFSAR, which is approved under Amendment 1 for the NUHOMS® EOS system. Therefore, the exposure estimate for transfer of the 61BTH Type 2 DSC, loaded with the authorized contents as specified in the TS, to the HSM-MX documented in Chapter B.11, is similar to the exposure estimate for the transfer of the EOS-89BTH DSC to the HSM-MX documented in Chapter A.11.

The applicant performed shielding analyses for the transfer cask and storage module containing the 61BTH Type 2 DSC loaded with reconstituted fuel assemblies. The applicant provided the calculated maximum dose rates around the OS197 TC and HSM-MX in Table B.6-19 and Table B.6-20, respectively, for the design basis reconstituted fuel assembly (FA) containing five stainless steel rods at various BECTs. The applicant also analyzed the dose rates for the OS197 TC and HSM-MX with 10 irradiated stainless steel rods per reconstituted FAs as specified in the TS.

The applicant used the same computer code (MCNP5) and cross section library, as well as modeling approach it used in Amendments 0 and 1 to the NUHOMS® EOS system for its shielding analysis. The staff did not perform a detailed review because this computer code and cross section library have been approved in the previous reviews of those amendments. In addition the BECTs for this amendment are within the validated ranges of the computer codes and code and cross section library are ones that are recommended by NUREG-1536, Revision 1, "Standard Review Plan for Spent Fuel Dry Storage Systems at a General License Facility."

The staff reviewed the output files provided by the applicant for the models of the transfer cask and storage module containing design basis fuel assemblies and bounding HLZC. The staff found that the models accurately represent the system and the calculations have properly converged because the results have passed the 10 statistical checks implemented in the

MCNP5 computer code. On this basis, the staff determined that there is reasonable assurance that the shielding calculations performed by the applicant are reliable and acceptable.

The applicant also provided the annual dose as function of distance to the various locations from these two hypothetical ISFSIs containing the 61BTH Type 2 DCSs. The two generic configurations that are considered are: (1) a one row (2x11 back to back) and (2) two separate rows of 1x11 configurations. The results show that the total annual exposure for each configuration is bounded by the same ISFSI configurations containing the 89BTH DSC, which have been approved in Amendment 1 for the NUHOMS® EOS system. This result is expected because only 61 BWR fuel assemblies can be loaded in the 61BTH Type 2 DSC whereas the 89BTH DSC can hold up to 89 BWR fuel assemblies. The results for the hypothetical ISFSIs containing the 89BTH DSC are provided in Table A.11-5 of the UFSAR. The applicant provided the detailed dose rate results as a function of distance in Table A.11-7 and Table A.11-8 for the 2x11 and two 1x11 configurations, respectively. The results show that the HSM-MX system loaded with the design basis fuel will continue to meet the regulatory requirements of 10 CFR 72.104. Based on the calculated results, the staff found that there is reasonable assurance that the HSM-MX system loaded with the 61BTH Type 2 DSC and the authorized contents as specified in the TS for the system will meet the regulatory requirements of 10 CFR 72.104.

Shielding analysis for accident conditions

Consistent with the previously approved Amendments 0 and 1 for the NUHOMS® EOS system, the applicant determined that the only plausible accident condition may involve a drop accident under which the TC would lose the neutron shield and the lead gamma shield will slump under the specified drop impact. Ground and atmospheric air are modeled to account for ground shine and skyshine at large distances.

The applicant considered that all damaged fuel assemblies may reconfigure under accident conditions and that the 61BTH DSC may contain up to 61 damaged fuel assemblies. The staff reviewed this assumption and considered it bounding for all cases because in the worst case scenario, it is almost impossible for all FAs to reconfigure. On this basis, the staff found that the applicant's accident analyses are conservative and acceptable and there is reasonable assurance that the design, as amended, meets the regulatory requirement of 10 CFR 72.106. However, this conclusion is based on an assumption that the accident recovery operations will be completed within eight hours. The general licensees who use this cask design should evaluate the adequacy of this assumption based on their site characteristics.

The staff notes that the 61BTH DSC is no longer the original design as certified in CoC No. 1004 because the new FQTs, as shown in Tables 19 and 20 of the TS, are developed using the new method as approved in amendment 1 to CoC No. 1042. The new FQTs are developed for inner and periphery zones of the HLZCs. For this reason, the allowable spent fuel contents are different with respect to the shielding analysis. The applicant made additional changes that affect the shielding design of the 61BTH when incorporating this DSC design into the HSM-MX system. Specifically, the increased fuel burnup for the same fuel assembly designs and reconstituted fuel assemblies constitute new allowable contents. In addition, the new loading patterns and burnup as specified in the TS are changes to the original 61BTH DSC. Therefore, the staff considered that the 61BTH incorporated in the CoC No. 1042 as a new canister design in terms of the shielding analysis because the shielding design must consider the canister structural design, shielding features, and the allowable contents.

Change No. 2: For the EOS-37PTH DSC, add two new HLZCs for the EOS-37PTH for higher heat load assemblies, up to 3.5 kW/assembly, that also allow for damaged and failed fuel storage.

In the proposed change No. 2, the applicant requested to add two new HLZCs to the EOS-37PTH DSC. These two new HLZCs are No. 10 and No. 11 as shown in Figures 1J and 1K of the TS respectively. There is no change in the structural design of the EOS-HSM or the HSM-MX. The HSM-MX is a stack up design of the EOS-HSM that have been approved under Amendments 0 and 1 for the NUHOMS® EOS system.

The new HLZCs allow for assemblies with heat load up to 3.5 kW per assembly. With the two new HLZCs, the EOS-37PTH DSC will have eleven HLZCs available for loading. The HLZCs are defined in Figure 1A through Figure 2 of the revised TS for the HSM-MX system design. However, HLZC 10 is designed to be loaded in the EOS-HSM model and HLZC 11 is to be used in HSM-MX storage module.

As approved in Amendment 1 for the NUHOMS® EOS system, the EOS HSM system has two configurations, a standard NUHOMS® and a stacked two story (i.e. the HSM-MX) configuration. For the two new HLZCs (i.e., 10 and 11) proposed for the EOS-37PTH DSC, HLZC 10 is for use in the HSM configuration and HLZC 11 is designed for the HSM-MX configuration. The applicant developed the source terms for the fuel to be loaded in each loading zone of the two new HLZCs. The applicant presents the calculated source terms in Section 6.2 of the UFSAR. The applicant compared HLZCs 10 and 11 and demonstrated that the source terms for HLZC 10 bound HLZC 11 in terms of dose rate. Therefore, HLZC 10 sources were used in the shielding analyses for both the HSM and HSM-MX configurations. The staff found the applicant’s bounding source to be conservative to calculate the dose rates for both HLZC 10 and 11. Therefore, the staff found the source term calculations to be acceptable.

The proposed changes will allow damaged and failed fuel in the EOS-37PTH DSC, up to six damaged FAs or two failed fuel cans (FFCs) in HLZC 10 or 11; but damaged and failed fuel shall not be present in the same DSC. In the shielding calculations for the TC and storage module, the applicant treated the damaged fuel and the failed fuel in the FFCs the same as intact fuel. The staff found this assumption acceptable because the damaged fuel, as classified using Interim Staff Guidance-1 (ADAMS Accession No. ML071420268), will retain its geometry and the FFCs will hold the fuel as loaded to retain the geometric distributions of the sources.

The applicant developed fuel qualification tables (FQTs), which are the combinations of BECTs, based on the decay heat load limits in different heat load zones. The FQTs are included in the TS for the purpose of controlling the source terms for shielding calculations. Decay heat cannot uniquely define the allowable spent fuel contents for the purpose of shielding design since there are many different BECT combinations that can produce the same decay heat but different source terms. For this reason, the applicant developed a list of BECTs that can produce the decay heat and source terms. In this way, the allowable spent fuel contents are uniquely defined for both the decay heat limit and source term limits. The decay heat limit is used for thermal analyses and the BECT defines the source terms used for the shielding analyses.

The applicant recalculated the source terms based on the FQTs as defined in the TS for the two new HLZCs using the same method as used in the previously approved Amendments 0 and 1 for the NUHOMS® EOS system. The applicant performed shielding calculations for the HSM-MX system containing the 37PTH canister with the new HLZCs and damaged fuel. The applicant provided a summary of the limiting EOS-HSM dose rates in Table 6-55a of the UFSAR.

The applicant also performed shielding analyses of the accident dose rate for the EOS TC containing the fuel with the two new HLZCs. For accident analyses, the applicant used the same assumptions as it used in the previously approved Amendments 0 and 1 for the NUHOMS® EOS system. The applicant demonstrated that the system will be able to meet the dose limit prescribed in 10 CFR 72.106 (i.e., 5 rem per accident) assuming that accident recovery is within eight hours. Consistent with 72.212(b)(6), the user is required to review the UFSAR and, therefore, should be aware of the assumptions described in the UFSAR for the development of the radiation protection plan based on site specific characteristics and operation procedures. Because the staff has accepted this assumption in the review of Amendment 0 for the NUHOMS® EOS system, and there is no change in the assumption, the staff did not need to re-review the validity of this assumption.

The staff reviewed the applicant's shielding calculation for the system under accident conditions and found that the assumptions and calculated results are the same as those used in the previously approved accident conditions for Amendment 0 for the NUHOMS® EOS system. For this reason, the staff finds that the applicant's shielding analyses for change No. 2 are acceptable and that there is reasonable assurance that the shielding design for the HSM-MX system, as amended, will continue to meet the regulatory requirements of 10 CFR 72.106. .

Change No. 3: For the EOS-37PTH DSC, add basket type 4H, previously introduced in CoC No. 1042 Amendment 1, for HLZCs 1, 4, 5, 6, 8, and 9.

The staff reviewed the proposed addition of the basket type 4H for HLZCs 1, 4, 5, 6, 8, and 9. Because the change in the basket design is just to add a new coating material to the existing basket for improved thermal conductivity, this basket design change has no impact on the shielding design of the HSM-MX system, neither the TC, nor the HSM-MX storage. For this reason, the staff did not perform a detailed shielding review.

Change No. 4: For the EOS-TC108 TC System with the EOS-37PTH DSC, add HLZCs 4 through 9 for the 4H basket and reduce the minimum cooling times to 2 years (HLZC 2 through 9).

The applicant proposed to add HLZCs 4 through 9 to the 4H basket for the EOS-37PTH DSC and reduced minimum cooling times to 2 years for HLZCs 2 through 9 for the DSCs/HLZCs that can be transferred by the EOS-108 TC as specified in the TS.

The applicant calculated the dose rate around the EOS-108 transfer cask with the EOS-37PTH DSC that is to be loaded with fuel in HLZCs 2 through 9 with the new 2-year cooling time fuel as defined in the TS. The addition of the HLZCs 4 to 9 to the type 4H basket has no impact on shielding. However, the reduced cooling time of the spent fuel affects the shielding design and dose rates around the transfer cask and HSM-MX storage module. The reduced cooling time also affects the dose at the control area boundary.

The applicant performed shielding analyses for the system containing the type 4H basket. The applicant provided a summary in Table 6-52 of the UFSAR for the calculated dose rates around the EOS-108 TC containing the 37PTH DSC with the new HLZCs. The results show that the maximum dose rate for the EOS-TC 108 is slightly higher than that of the EOS-TC 125/135 which is approved in Amendments 0 and 1 for the NUHOMS® EOS system. Higher dose rates are expected because the EOS-TC 108 is a lighter cask and has less shielding. The applicant has included the higher radiation levels around the EOS-TC 108 in determining the expected dose for completing the loading operation in the radiation protection chapter of the UFSAR. The shielding analysis results also show that there is no noticeable impact on the dose rate around the storage module and the dose at the controlled area boundary comparing other basket types that contain the same design basis fuel defined by BECT in the TS. The staff found that this result is reasonable because the difference in annual dose at a distance is expected to be small for a small difference in dose rate around the TCs.

The staff reviewed the calculation files provided by the applicant and found that the calculations have properly converged. The staff finds the applicant's calculations to be acceptable and that there is reasonable assurance that the HSM-MX system containing the new 4H basket and reduced cooling time is capable of meeting the regulatory requirements of 10 CFR 72.236(d).

Change No. 5: For the EOS-37PTH DSC, increase the control component source terms to better address potential control component sources from various shutdown plants.

The applicant proposed to modify the TS for the authorized control components (CC) as approved in Amendments 0 and 1 for the NUHOMS® EOS system. The revised TS for CCs provides a total Co-60 equivalent radioactivity limit for the CC radioactivity per canister instead of per region as specified in the TS for Amendments 0 and 1 for the NUHOMS® EOS system. The total Co-60 equivalent activity per canister also increased from 12,107 Ci to 38,327 Ci. This significant increase in total activity of CCs is a result of the decreased cooling time.

The applicant calculated the source terms from the CCs in terms of equivalent Co-60 activity and presented its calculated results in Table 6-37 of the UFSAR. This source term is added to the shielding calculations for determining the dose for a real individual at the controlled boundary and dose rate near the transfer casks to provide information for the radiation protection evaluation of the system design. The calculated dose rates associated with the transfer operations are given in Table 11-1 through Table 11-5 of the UFSAR. The calculated dose as a function of distance is given in Table 11-6 and Table 11-8 of the UFSAR. In Tables 11-9 to 11-10 of the UFSAR, the applicant also provided the radiation level at the various locations around the storage module at different configurations.

The staff reviewed the revised method for specification of the CCs and found it to be acceptable because the limit of the total CC source per canister, together with the decay heat limit per region, provides a clear limit on the regional source limit. This method for specifying the CC load limit requires the general licensee to calculate the decay heat of the CCs that are to be loaded into the canister. However, determining the Co-60 equivalent can be complicated because some of the CCs, such as indium, silver, cadmium and hafnium in control rods, and californium or antimony in the neutron sources, may have very complicated decay chains.

Change No. 6: Revised CoC and TS items for consistency and clarity.

In Section 2.1 of the UFSAR, the applicant provided a list of proposed changes to the CoC TS items. The staff reviewed these changes and found that some of the proposed changes are for clarity and others are related to design changes. For the changes that are for improvements to clarity only, the staff found that they have no impact to safety of this system and are therefore acceptable. For the changes, such as the contents and loading configurations, the staff has provided its evaluations for the proposed design changes in discussing proposed changes No. 1 to No. 5 in the previous sections of this SER. The staff's evaluations of the other additional changes are discussed below.

Additional Change No. 2 not associated with the RAI: Add description of methodology on Co-60 equivalence to UFSAR Section 6.2.4, Control Components, to clarify methodology for CCs.

Control components are authorized contents for the PWR fuel canister heat load zone configurations. Examples of these control components include Burnable Poison Rod Assemblies (BPRAs), Thimble Plug Assemblies (TPAs), Control Rod Assemblies (CRAs), Control Element Assemblies (CEAs) and neutron sources.

In order to provide a simplified way to define the source term limits in the TS for the various allowable control components the applicant developed a method that can convert the source terms of the CCs to a specific radioactivity of an equivalent Co-60 source. In essence, the method relates the dose rates produced by the various CCs to that of an equivalent Co-60 source around the TC. Using this method, the applicant first calculated the dose rate around the transfer casks from the source of a selected CC and then found a Co-60 source that produces the same dose rate around the same TC. This method finds an equivalent Co-60 source for each of the CCs. Based on this new dose rate equivalence method, the allowable CCs in Table 3 of the TS are expressed in terms of "Co-60 equivalent". The applicant shows in Table 6-37a of the UFSAR, "Co-60 Equivalence Method," the equivalent dose rates outside the EOS-TC108, EOS-TC125/135 and the storage module HSM in terms of mrem/hr at different gamma energies for each gram of Co-60 in the control components as listed in the TS.

The staff reviewed the proposed method for determining the equivalent Co-60 source for a given CC. The staff found that the method is acceptable in this instance. However, the calculated equivalent Co-60 source is dependent of (1) the types of the CCs, (2) the cask design, and (3) the cooling time of the CCs because some of the CCs may have very complicated decay chains and therefore many of the daughter elements may contribute significantly to the dose rate. As such, the acceptability of using the Co-60 equivalent may be determined on a case-by-case basis. The users of this dry storage system design should be aware of how the Co-60 equivalent radioactivity limit in the TS is derived from the allowable contents and the specific cask design.

Additional Change No. 3 not associated with the RAI: Add description to UFSAR Section 1.2.1.1 for EOS-37PTH and Section 1.2.1.2 for EOS-89BTH to clarify the option of using a shield plug integrated with the inner top cover plate.

The DSC includes a top shield plug and inner cover plate. The safety function of the shield plug and inner top cover plate is to provide shielding in order to reduce the radiation level in the axial direction of the DSC for radiation protection.

In the current design, the shield plug and the inner top cover plate are two separate round plates and welded to the DSC with two separate welding procedures. The proposed change will integrate the shield plug and inner top cover plate into one piece of round plate and welded on to the DSC in one welding procedure. The applicant provided a new drawing for this new shield plug and material specifications for the new integrated shield plug design in licensing drawings EOS01-1000-SAR, Revision 4B and identified this new design as an alternative to the standard shield plug that has been approved in the previous Amendments 0 and 1 for the NUHOMS® EOS system. This new canister closure lid design is designated as an alternative to the current closure lid design. The applicant also provided the material properties for the new shield plug design in the revised UFSAR. The drawings show that the new alternative shield plug has the same thickness in comparison with the total thickness of the standard shield plug and inner top cover plate designs.

The staff reviewed the proposed change in the shield plug design for the DSCs and finds that the new design does not affect the effectiveness of the shielding of the DSC because the new integrated shield plug has the same thickness compared to the standard shield plug and inner top cover plate designs and the material of the new shield plug is comparable to currently approved design in terms of density and composition which are important to shielding design. Therefore, the new shield plug has the same, or better, shielding capacity as the previously approved design because, for shielding purposes, there will be no change in the shielding capacity as long as the material and thickness are kept the same or better. The staff finds that the proposed change of the shield plug design to be acceptable and that there is reasonable assurance that the HSM-MX loaded with the canister that use the new integrated canister top closure will continue to meet the regulatory requirements of 10 CFR 72.236(d).

Evaluation Findings

The staff reviewed the proposed changes in the amendment application with respect to the shielding design of the HSM-MX system. Based on its review, the staff concludes that the proposed safety design features for the EOS HSM-MX spent fuel dry storage system are in compliance with 10 CFR Part 72 and regulatory requirements for dose rate limits have been met. On these bases, the staff determined that there is reasonable assurance that the shielding design of the EOS HSM-MX, as amended, will allow safe storage of spent fuel. This finding is reached on the basis of a review that considered the regulation itself, appropriate regulatory guides, applicable codes and standards, and accepted engineering practices. Some of the key findings from the staff's review of Amendment 2 include:

F6.1 Structures, systems, and components important to shielding are described in sufficient detail in Chapters 1, 7, B.1.3, and B.7 of the UFSAR to enable an evaluation of their effectiveness.

F6.2 The specifications of spent fuel meet the regulatory requirements of 10 CFR 72.236(a).

F6.3 The transfer cask and storage module consist of neutron shields and gamma shields to provide sufficient shielding for protecting the general public and occupational workers and meets the requirements of 10 CFR 72.236(d).

F6.4 The safety analysis of the shielding design has demonstrated that the cask will enable the storage of spent fuel for the term requested in the application.

References:

1. Oak Ridge National Laboratory, "A Modular Code System for Performing Standardized Computer Analyses for Licensing Evaluation," ORNL/TM-2005/39, Version 6, SCALE, January 2009.

2. Oak Ridge National Laboratory, "A Modular Code System for Performing Standardized Computer Analyses for Licensing Evaluation," ORNL/TM-2005/39, Version 6.1, SCALE, October 2010.

3. Oak Ridge National Laboratory, SCALE Code System, ORNL/TM-2005/39, Version 6.2.1, April 2016.

4. Oak Ridge National Laboratory, NUREG/CR-6716, "Recommendations on Fuel Parameters for Standard Technical Specifications for Spent Fuel Storage Casks," February 2001. https://www.nrc.gov/docs/ML0108/ML010820352.pdf

7.0 CRITICALITY EVALUATION

The staff reviewed the information provided by the applicant and the following three changes are applicable to the criticality evaluation:

Change No. 1:
Add the 61BTH Type 2 DSC transferred in the OS197 TC for storage in the HSM-MX design approved in Amendment 1 to CoC No. 1042.

Change No. 2:
For the EOS-37PTH DSC, add two new HLZCs for the EOS-37PTH for higher heat load assemblies, up to 3.5 kW/assembly, that also allow for damaged and failed fuel storage.

Change No. 3:
For the EOS-37PTH DSC, add basket type 4H, previously introduced in CoC No. 1042 Amendment 1, for HLZCs 1, 4, 5, 6, 8, and 9.

This section of the SER documents the staff's review and conclusions with respect to the criticality safety design of the system.

Change No. 1: 61BTH Type 2 Dry Shielded Canister (DSC)

The applicant proposed to add the 61BTH Type 2 dry shielded canister (DSC) which will be transferred in the OS197 Transfer Cask (TC) for storage in the new NUHOMS® MATRIX (HSM-MX) design. This HSM-MX design was approved under Amendment 1 to the NUHOMS® EOS system. The 61BTH Type 2 DSC design included in this amendment was approved by the NRC in CoC No. 1004 Amendment 10. The applicant has requested associated design changes to the HSM-MX to include the addition of spacer blocks at the front and rear DSC supports to maintain the centerline of the DSC in line with the HSM-MX door centerline.

As described in Section T.2.1 of the Standardized NUHOMS® system UFSAR, the 61BTH Type 2 DSC consists of three allowable poison materials: (a) borated aluminum alloy, (b) boron carbide/aluminum metal matrix composite (MMC), or (c) Boral. The applicant analyzed each material for six different Boron-10 loadings in the neutron poison plates to accommodate the variability of the allowable fuel enrichment levels. The basket configurations are labeled A to F, with A being the lowest Boron-10 loading in the neutron poison plate and F being the highest.

The Type 2 designation refers primarily to the material used for construction of the structural rails on the periphery of the canister internals. The Type 2 canister has aluminum rails versus the Type 1 canister which has steel rails.

The 61BTH Type 2 DSC was first approved for use within CoC No. 1004 as part of Amendment 10 on August 24, 2009 (ADAMS Accession No. ML092290186). It has since been modified in Amendment 14 on March 31, 2017 (ADAMS Accession No. ML17093A261) to allow damaged fuel in all locations and Amendment 15 on December 14, 2018 (ADAMS Accession No. ML18347B333) to allow additional fuel types.

The staff reviewed Drawing NUH61BTH-2002-SAR, "NUHOMS® 61BTH Type 2 Basket Assembly" in Section B.1.3 of the UFSAR (Submitted on April 18, 2019, ADAMS Accession No. ML19112A106) and determined that it is consistent with Drawing NUH61BTH-2002-SAR within the Standardized NUHOMS® system UFSAR as updated to support Amendments 10, 14, and 15 (ADAMS Accession Nos. ML072180229, ML15114A053, and ML17094A714, respectively).

The staff reviewed the allowable contents approved with Amendments 10, 14, and 15 for CoC No. 1004 for the 61BTH, as shown in Table 1-1t of the Standardized NUHOMS® system TS (ADAMS Accession No. ML18347B336) and found it consistent with that for the proposed TS as shown in Section 2.3 of the proposed TS (ADAMS Accession No. ML19282A508). The fuel assembly design characteristics in Table 1-1u of the Standardized NUHOMS® system TS is consistent with Table 13 of the proposed TS Table 13.

The staff determined that the required maximum enrichment and minimum Boron aerial density for the poison plates as specified in Table 1-1v for intact and 1-1w, 1-1w1, and 1-1x for damaged fuel of the Standardized NUHOMS® TS are the same as those in the NUHOMS® EOS system in Tables 9, 10, 11, and 12 respectively. The staff verified that the locations of the damaged assemblies for the 61BTH Type 2 in the Standardized NUHOMS® (Figure 1-25) is consistent with Figure 5 of the NUHOMS® EOS TS. The staff also verified that the restrictions on these tables as documented in the footnotes are the same. The staff verified that the applicant updated Section 4.3.1, “Neutron Absorber Tests,” to include the appropriate requirements for the 61BTH Type 2 DSC.

Although the HSM-MX storage module approved for use in the NUHOMS® EOS system is different from the storage cask used in CoC No. 1004, the reactivity of the system is largely independent of these differences and is primarily based on the basket design and materials internal to the basket. Differences exterior to the basket do not have a significant effect on the reactivity of the system, therefore the staff finds that the criticality safety review, as performed for the 61BTH Type 2 DSC in CoC No. 1004 as documented in staff safety evaluation reports (ADAMS Accession Nos. ML092290329, ML17338A121 and ML18347B337), is applicable to the NUHOMS® EOS system.

Since the allowable contents, criticality controls, and drawings of the 61BTH Type 2 canister within the NUHOMS® EOS are the same as that of the 61BTH Type 2 canister in the Standardized NUHOMS® system, the staff finds the criticality evaluation for the 61BTH Type 2 within the Standardized NUHOMS® system applicable to the NUHOMS® EOS system. In addition, the staff’s conclusions associated with the criticality safety of that canister are applicable to that of the NUHOMS® EOS system design and therefore the staff has reasonable assurance that the canister will meet the requirement in 10 CFR 72.236(c), i.e., the system remains subcritical.

Change No. 2: Two new heat load zone configurations for the HLZC

For the EOS-37PTH DSC, the applicant has proposed adding two new heat load zone configurations (HLZCs) for the EOS-37PTH for higher heat load assemblies, up to 3.5 kW/assembly. These loading patterns also allow for damaged and failed fuel storage.

The new heat load patterns are shown in Figures 1J and 1K of the Technical Specifications (Appendix A). Although the applicant is not increasing the number of allowable damaged and/or failed fuel assemblies, the location for these assemblies is slightly different from what has been previously analyzed and could possibly affect the reactivity of the system. However, the staff found the previous analysis is very conservative and it bounds the new loading patterns based on the following:

- There are fewer damaged/failed fuel locations included in Figures 1J and 1K of the TS (App. A) than what was analyzed by the applicant in Figure 7-24 of the UFSAR. Since damaged/failed fuel is more reactive than intact fuel, this is a conservative assumption.
- The locations of the analyzed damaged/failed fuel in Figure 7-24 of the UFSAR are more concentrated to the basket center and likely have a larger impact on reactivity than the

locations of the damaged/failed fuel in Figures 1J and 1K of the TS (App. A) making the analysis in the UFSAR more conservative than the other allowable loading patterns.

- The applicant assumes fresh fuel within the criticality evaluations. This is a very conservative assumption and bounds the uncertainty when applying the current damaged fuel model to the new fuel loading patterns in Figures 1J and 1K of the TS (App. A).

For these reasons, the staff found that the maximum planar average initial enrichments specified in Table 4 of the TS (App. A) for damaged and/or failed fuel are applicable to the loading patterns in Figures 1J and 1K of the TS (App. A) for the EOS-37PTH design.

The burnup characteristics of the fuel, which determines the heat load zone patterns, does not affect the criticality safety of the NUHOMS® EOS system in this case. This is because the applicant determines the reactivity of the system using a fresh fuel assumption, which is conservative and therefore the burnup characteristics of the fuel are bounded by the criticality evaluation.

Change No. 3: Basket Type 4H

For the EOS-37PTH DSC, the applicant proposed to add basket type 4H. This basket type was previously introduced in CoC No. 1042 Amendment 1, for HLZCs 1, 4, 5, 6, 8, and 9. The staff reviewed the inclusion of the basket type 4L in Amendment 1 to the NUHOMS® EOS system. The Type 4H and 4L baskets have the same geometry design but Type 4H has higher emissivity steel plates and higher conductivity poison plates. However, the minimum B-10 content within the metal matrix composite (MMC) for the poison plates remains the same as that of the Type 4L baskets, as specified in Table 5 of the TS (App. A). Therefore, the staff finds that there is no difference from a criticality safety perspective in implementing the Type 4H basket and found that its inclusion is acceptable, and that the NUHOMS® EOS system will continue to meet the regulatory requirements of 10 CFR 72.236(c).

Evaluation Findings

The staff concludes that the criticality design features for the NUHOMS® EOS system are in compliance with 10 CFR Part 72, and that the applicable design and acceptance criteria have been satisfied. The evaluation of the criticality design provides reasonable assurance that the NUHOMS® EOS system will allow safe storage of spent fuel. This finding is reached on the basis of a review that considered the regulatory requirements, appropriate regulatory guides, applicable codes and standards, and accepted engineering practices. Some of the key findings from the staff's review of Amendment 2 include:

F7.1 Structures, systems, and components important to criticality safety are described in sufficient detail in Chapters 1, 7, B.1.3, and B.7 of the UFSAR to enable an evaluation of their effectiveness.

F7.2 The cask and its spent fuel transfer systems are designed to be subcritical under all credible conditions.

F7.3 The criticality design is based on favorable geometry, fixed neutron poisons, and soluble poisons in the spent fuel pool. An appraisal of the fixed neutron poisons has shown that they will remain effective for the term requested in the application and there is no credible way for the fixed neutron poisons to significantly degrade during the requested term in the application. Therefore, there is no need to provide a positive means to verify their continued efficacy as required by 10 CFR 72.124(b).

F7.4 The analysis and evaluation of the criticality design and performance have demonstrated that the cask will enable the storage of spent fuel for the term requested in the application.

8.0 MATERIALS EVALUATION

The staff reviewed and evaluated the information provided by the applicant requested in Amendment No. 2. The specific changes evaluated in this section include:

Change No. 1:
Add the 61BTH Type 2 DSC transferred in the OS197 TC for storage in the HSM-MX design approved in Amendment 1 to CoC No. 1042. The 61BTH Type 2 DSC design included in this amendment is approved in CoC No. 1004 Amendment 15. The associated design change to the HSM-MX included in this amendment is the addition of spacer blocks at the front and rear DSC supports to maintain the centerline of the DSC in line with the HSM door centerline.

Change No. 2:
For the EOS-37PTH DSC, add two new HLZCs for the EOS-37PTH for higher heat load assemblies, up to 3.5 kW/assembly, that also allow for damaged and failed fuel storage.

Change No. 3:
For the EOS-37PTH DSC, add basket type 4H, previously introduced in CoC No. 1042 Amendment 1, for HLZCs 1, 4, 5, 6, 8, and 9.

Change No. 4: For the EOS-TC108 TC System with the EOS-37PTH DSC, add HLZCs 4 through 9 for the 4H basket and reduce the minimum cooling times to 2 years (HLZC 2 through 9).

Change No. 5: For the EOS-37PTH DSC, increase the control component source terms to better address potential control component sources from various shutdown plants.

Change No. 6: Certain CoC and TS items are revised for consistency and clarity.

Additional change No. 3 not associated with the RAI:
Add description to UFSAR Section 1.2.1.1 for EOS-37PTH and Section 1.2.1.2 for EOS-89BTH to clarify the option of using a shield plug integrated with the inner top cover plate.

Additional change No. 5 not associated with the RAI:
Replace the phrase “28 days” with “which may be tested up to 56 days” in Paragraph 4.4.4 of the TS to clarify whether concrete testing is required based on HSM component temperatures.

The staff reviewed the changes to the UFSAR, CoC and Technical Specifications associated with the application. The staff’s review included the material incorporated by reference from CoC No. 1004. The staff review was conducted using the guidance in Chapter 8 of NUREG-1536, Revision 1, “Standard Review Plan for Spent Fuel Dry Storage Systems at a General License Facility,” to conclude there was adequate materials performance under normal, off-normal, and accident-level conditions.

The areas of review covered in this SER section are described in NUREG-1536, Section 8.2, and included system design, engineering drawings, material selection and material properties, environmental conditions and material compatibility, cladding integrity and fuel condition. The staff also evaluated the changes in the application with respect to the 10 CFR Part 72 regulatory requirements identified in NUREG-1536, Section 8.3, and the review procedures and acceptance criteria identified in Section 8.4 of NUREG-1536.

In addition to the guidance in NUREG-1536, the staff evaluated the engineered drawings and the description of the structures systems and components included in the application using the information provided in NUREG/CR-5502, “Engineering Drawings for 10 CFR Part 71 Package Approval,” and NUREG/CR-6407, “Classification of Transportation Packaging and Dry Spent Fuel Storage System Components According to Importance to Safety.”

Change No. 1: Addition of the 61BTH Type 2 DSC and the OS197 TC

The applicant revised the UFSAR to include the use of the 61BTH Type 2 DSC in the HSM-MX. The applicant stated that the 61BTH Type 2 DSC was from CoC No. 1004 Amendment 15 (ADAMS Accession No. ML18347B333). The applicant made minor revisions to the engineered drawings for the HSM-MX which were included in a new Appendix B of the UFSAR.

The applicant also revised the NUHOMS® EOS CoC and Technical Specifications to address the addition of the 61BTH Type 2 DSC. The changes to the Technical Specifications included revised definitions, allowed fuel specifications, limiting conditions of operation, design features, applicable codes and standards, code alternatives and administrative controls.

In addition, the applicant incorporated the OS197 TC for transfer of the 61BTH Type 2 DSC to the HSM-MX. For CoC No. 1042 Amendment 2, the applicant has incorporated the OS197 TC by reference from the CoC No. 1004 Amendment 15 with no change in the design, materials, drawings, applicable codes or approved contents.

The applicant also revised the NUHOMS® EOS Technical Specifications to address the addition of the OS197 TC for transfer of the 61BTH Type 2 DSC to the HSM-MX. The changes to the Technical Specifications included revised definitions, limiting conditions of operation, applicable codes and standards, code alternatives and administrative controls.

The applicant described the additional structural components that are necessary to transfer the 61BTH Type 2 DSC from the OS197 TC to the HSM-MX. The applicant also described the additional components necessary for storage of the 61BTH Type 2 DSC in the HSM-MX. These components included an adapter to facilitate the transfer of the 61BTH Type 2 DSC from the OS197 TC to the HSM-MX and HSM-MX DSC support components.

The staff reviewed the revisions to the UFSAR, the added Appendix B and the Technical Specifications associated with the addition of the 61BTH Type 2 DSC. The 61BTH Type 2 DSC was originally approved in CoC No. 1004 Amendment 10 (ADAMS Accession Nos. ML090400180 and ML18031A042). The staff determined that the drawings for the 61BTH Type 2 DSC included in the UFSAR Appendix B were acceptable because they included adequate information with respect to the DSC design, materials specifications, dimensions and tolerances, and nondestructive examination (NDE) requirements that follows the guidance in NUREG/CR-5502. The staff determined that the quality category information included with the drawings was acceptable because it follows the guidance identified in NUREG/CR-6407. The staff determined the changes to the 61BTH Type 2 DSC drawings were acceptable because these were minor revisions or corrections and did not result in changes to the design codes, ASME Code exceptions, material specifications, or quality category of the DSC components.

The staff reviewed the revisions to the UFSAR, the added Appendix B and the Technical Specifications associated with the addition of the OS197 TC for transfer of the 61BTH Type 2 DSC. The OS197 TC was originally approved in CoC No. 1004 Amendment 8 (ADAMS Accession Nos. ML053390278 and ML18031A024). The staff determined that the OS197 TC information incorporated by reference from the CoC No. 1004 Amendment 15 is acceptable because it includes the OS197 TC design materials specifications, dimensions and tolerances, and NDE requirements in accordance with the guidance in NUREG/CR-5502 as well as quality category information included with the drawings which follows the guidance identified in NUREG/CR-6407.

The staff reviewed the revisions to the UFSAR and the added Appendix B that describe the transfer adapter and the drawings for the additional structural components that are necessary for storage of the 61BTH Type 2 DSC in the HSM-MX. The staff determined that the classification of the transfer adapter as an item that is not important to safety (NITS) was appropriate because the adapter is not relied on for a specific safety function. The staff determined that the drawings for the components necessary to allow the storage of the 61BTH Type 2 DSC in the HSM-MX were acceptable because they include the adequate information with respect to the design, materials specifications, dimensions and tolerances, and NDE requirements which follows the guidance in NUREG/CR-5502. The staff determined that the quality category information included with the drawings was acceptable because it follows the guidance identified in NUREG/CR-6407.

The staff reviewed the materials of construction and determined that the material properties as a function of temperature provided by the applicant were acceptable because they are consistent with the materials properties information contained in the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel (B&PV) Code Section II, Part D. The staff noted that the bolts that have ASTM specifications did not include material properties as a function of temperature. The applicant provided the estimated maximum temperatures for the bolts used in the additional structural components for storage of the 61BTH Type 2 DSC in the HSM-MX. The staff compared the maximum temperature for the bolts to the information reported by Weigand et al. (2018). The staff determined that the maximum temperature for the bolts is below the minimum temperature where alteration of the material properties of the bolts have been observed. The staff determined that the bolting material specified by the applicant was acceptable because the material properties of the bolts will not be adversely affected by thermal exposures under normal, off-normal and accident conditions.

Change No. 2: New HLZCs for the EOS-37PTH with Damaged and Failed Fuel

The applicant included an additional UFSAR Section A.4.6 to describe the maximum temperatures of fuel cladding and concrete of the HSM-MX and the maximum and average temperatures of key components of the HSM-MX loaded with the EOS-37PTH DSC with HLZC 11. The applicant's analysis showed that the maximum fuel cladding and concrete temperatures are within the temperature limits of 752°F [400°C] and 300°F [149°C], respectively for HLZC 11 with the EOS-37PTH DSC in the HSM-MX. The analysis provided by the applicant showed that the maximum and average temperatures of key components of the HSM-MX loaded with the EOS-37PTH DSC for the storage conditions are similar to or less than the bounding load case.

The applicant provided information in the application to support the new HLZCs for the 37PTH DSC that include heat loads up to 3.5 kW/assembly and allow for damaged and failed fuel storage. The applicant provided UFSAR Appendix 4.9.7 that evaluates the thermal performance of the EOS-37PTH DSC for normal, off-normal, and accident conditions with HLZCs 10 and 11 for both storage and transfer operations. The applicant provided maximum component and content temperatures of EOS-37PTH DSC with 6 damaged fuel assemblies under the bounding accident condition in Table 4.9.7-7. The maximum component temperatures for the new HLZC 10 are compared to the previous load case 5 using HLZC 1 with intact fuel assemblies and a 50 kW heat load.

The results of the analysis and a comparison to the original design basis accident condition were included in UFSAR Table 4.9.7-7. The applicant showed that for a transfer accident with a loss of neutron shield with loss of air circulation the maximum fuel cladding temperature is 884°F (473°C) which the applicant noted is bounded by the original design basis value of 935°F (503°C). For the new HLZC 10, the applicant reported the maximum temperature for fuel rubble is 1135°F [613°C]. The applicant stated that the maximum gamma shield temperature is 565°F (296°C) which is lower than the design basis temperature of 579°F (304°C). The maximum temperature for the basket transition rails is 789°F (420°C) which is higher than the original design basis analysis of 750°F (399°C). The applicant showed that the DSC shell temperature is 717°F (381°C) which was an increase of +43°F (+24°C) from the original design basis value of 674°F (357°C).

The staff reviewed the revisions to the UFSAR that describe the maximum temperatures of fuel cladding and concrete of the HSM-MX and the maximum and average temperatures of key components of the HSM-MX loaded with the EOS-37PTH DSC with HLZC 11. The staff have previously reviewed the 37PTH DSC in NUHOMS® EOS Amendment 0 SER (ADAMS Accession No. ML17116A278). The staff determined that the applicant's analysis in UFSAR

Section A.4.6 is acceptable because the maximum temperatures of fuel cladding and concrete of the HSM-MX are within the temperature limits of 752°F [400°C] and 300°F [149°C], respectively for HLZC 11 with the EOS-37PTH DSC in the HSM-MX.

The staff reviewed the revisions to the UFSAR that address the new HLZC for the EOS-37PTH DSC with damaged and failed fuel. The staff have previously reviewed the 37PTH DSC and the SSCs for the storage of damaged and failed fuel in NUHOMS® EOS Amendment 1 SER (ADAMS Accession No. ML20136A052). The staff determined that the applicant's analysis in UFSAR Appendix 4.9.7 that evaluates the thermal performance of the EOS-37PTH DSC for normal, off-normal, and accident conditions with HLZCs 10 and 11 for storage is acceptable because the maximum temperatures of the concrete for the HSM are within the temperature limits of 300°F [149°C].

The staff reviewed the information provided by the applicant for the maximum temperatures of the intact fuel cladding and the components within the EOS-37PTH DSC and the EOS-TC125 for the bounding transfer accident condition with six damaged fuel assemblies (FAs). The staff noted that the new analysis of the transfer accident condition with six damaged FAs does not result in an increase in the intact fuel cladding temperature. The NRC determined that the applicant's analysis of fuel cladding temperatures for the EOS-37PTH DSC and the EOS-TC125 under the bounding transfer accident condition with six damaged FAs was acceptable because the maximum fuel cladding temperature follows the guidance in NUREG-1536, Section 8.4.17.1, "Cladding Temperature Limits."

The staff reviewed the maximum temperatures for the EOS-37PTH DSC internal components under the bounding transfer accident condition with six damaged fuel assemblies. In response to a RAI (ADAMS Accession No. ML20315A417), the applicant provided the temperature ranges for the EOS-37PTH DSC internal components under the accident conditions. The applicant also provided additional information with respect to the load bearing internal components and temperature of the components under accident conditions. The analysis provided by the applicant showed that the structural function and geometry of the internal components are maintained under the accident conditions. The staff determined that the increased transition rail temperature for the EOS-37PTH DSC and the EOS-TC125 under the bounding transfer accident condition with six damaged fuel assemblies was acceptable based on the design and temperature tolerance of the materials of construction for the EOS-37PTH DSC internal components.

The staff reviewed the maximum DSC shell temperatures for the bounding transfer accident condition with six damaged fuel assemblies. As noted, the applicant showed that the DSC shell temperature is 717°F (381°C), which was an increase of +43°F (+24°C) from the original design basis value of 674°F (357°C). Austenitic stainless steels used for the DSC shell have a maximum allowable temperature of 800°F (427°C). The staff determined that increased temperature under the bounding transfer accident condition with six damaged FAs was acceptable because the DSC shell temperature for an austenitic stainless steel is within the allowable temperatures specified in the ASME B&PV Code Section II Part D Table 2A.

The EOS DSC may also be constructed with Unified Numbering System (UNS) S31803 duplex stainless steel in accordance with ASME Code Case N-673-1, which sets a 600°F (316°C) maximum temperature for continuous use. ASME Code Case N-673-1 does not provide mechanical properties at temperature above the maximum allowable temperature of 600°F (316°C). The staff's determination (ADAMS Accession No. ML17116A278) that the original design bases accident temperature of 674°F (357°C) was acceptable even though it exceeded the ASME allowable temperature was based on the relatively short period of time the DSC shell temperatures are above the material's operating limit of 600°F (316°C). This time is compared with the time necessary for metallurgical changes to result in embrittlement of the alloy at that temperature. In order to assess higher temperatures, the staff requested additional information for the duplex stainless steel including the mechanical properties at temperatures above 600°F (316°C) and the effect of time at temperature on the microstructure and fracture toughness.

The ASME temperature limit is intended to be the maximum allowable temperature for continuous operation. Typical mechanical properties for the duplex stainless steel at higher temperature are available from material suppliers but the values reported are not guaranteed minimum values. In response to a RAI (ADAMS Accession No. ML20315A417), the applicant used reduction factors published by the Steel Construction Institute (2017) for the duplex stainless steel to determine the effect of elevated temperatures above 600°F (316°C) on the yield strength and tensile strength values. The applicant tabulated the yield and tensile strength values in SAR Tables 8-7 and 8-8 for duplex stainless steel UNS S32205 and S31803 respectively. The applicant also compared the yield and tensile strength of the duplex stainless steel using the reduction factors at a temperature of 400°C (752°F) and showed that the corresponding values for 304 stainless steel were lower and therefore limiting. The applicant stated that because 304 stainless steel is the limiting material in the accident load case, the evaluation is performed considering the 304 stainless steel material properties at 750°F, even though shell materials of 304 stainless steel are assumed to maintain structural function through 800°F.

The staff reviewed the yield and tensile strength reduction factors published by the Steel Construction Institute (2017) for the duplex stainless steel. The reduction factors published by the Steel Construction Institute (2017) are applicable to UNS S32205, which has a similar compositional specification and slightly higher minimum mechanical properties compared to UNS S31803, which is allowed for ASME Section III Class 1 components by ASME Code Case N-635-1. Although there are compositional and mechanical property specification differences, it is common for Type 2205 stainless steels to be dual certified to meet the specifications of UNS S32205 and UNS S31803. Using these reduction factors, the staff confirmed that at temperatures up to 752°F (400°C) the calculated values for yield strength, tensile strength and design stress intensity will be greater than the corresponding values for the austenitic stainless steel as stated by the applicant. In addition, the staff determined that the yield and tensile strength reduction factors at temperatures up to 600°F (316°C) published by the Steel Construction Institute resulted in lower calculated values compared to the yield and tensile strength values tabulated for UNS S31803 in ASME Code Case N-635-1. Therefore, the staff concluded that the use of the elevated temperature reduction factors published by the Steel Construction Institute (2017) is conservative for UNS S31803 type 2205 duplex stainless steel. The staff determined that the maximum temperature for a duplex stainless steel EOS-37PTH DSC in the EOS-TC125 under the bounding transfer accident condition with six damaged fuel assemblies is acceptable because the duplex stainless steels retain sufficient mechanical properties at, and considerably above, the maximum accident temperature.

The applicant provided additional information (ADAMS Accession Nos. ML20190A135 and ML20315A417) to support the analysis showing the maximum DSC shell temperatures for the bounding transfer accident condition with six damaged fuel assemblies results in a maximum DSC shell temperature of 717°F (381°C). The applicant indicated that the maximum temperature of the DSC shell would be reached after many hours. The applicant provided an analysis that considered the effects of microstructural changes for the duplex stainless steel that have been shown to result in a reduction of the material toughness. The applicant provided the results of extended duration testing conducted at bounding temperatures where the rate of embrittlement as a result of microstructural changes is known to be maximized. While reduction of the toughness of the ferritic phase occurs as a result of elevated temperature exposure, the austenitic phase is not affected, and the duplex stainless steel retains adequate toughness to preclude brittle fracture even after extended exposures at well above the maximum shell temperature of 717°F (381°C). Based on the analysis provided, the applicant concluded that embrittlement of the DSC shell is not a concern as a result of the accident condition.

The staff reviewed the information provided by the applicant to show that the duplex stainless steel would not be embrittled under accident conditions. The staff conducted an independent analysis based on the information on duplex stainless steels referenced in the original NUHOMS® EOS Amendment 0 SER (ADAMS Accession No. ML17116A278). The staff's analysis shows that spinodal decomposition of the ferritic phase would lead to measurable embrittlement of the duplex stainless steel at a temperature of 717°F (381°C) but would require an extended exposure time greater than the accident duration described by the applicant. In addition, the staff observed that the analysis provided by the applicant shows that while embrittlement of the ferritic phase could occur, the austenitic phase is unaffected by the elevated temperature exposure. The staff determined that the applicant's conclusion that embrittlement is not a concern for the DSC shell at temperatures at 717°F (381°C) is valid because elevated temperature testing of the duplex stainless steal shows that the elevated temperature under the accident condition is not sufficient to have embrittlement that could compromise the safety functions of the duplex stainless steel DSC shell.

Change No. 3: Additional HLZCs for the EOS-37PTH DSC with Basket Type 4H

The applicant stated that this change for the EOS-37PTH DSC, adds basket type 4H, previously introduced in CoC No. 1042 Amendment 1, for HLZCs 1, 4, 5, 6, 8, and 9.

The staff reviewed the UFSAR changes associated with the addition of the type 4H basket to the EOS-37PTH DSC for HLZCs 1, 4, 5, 6, 8, and 9. The staff have previously reviewed the type 4H basket for the EOS-37PTH DSC (ADAMS Accession No. ML20136A052). The staff noted that the addition of the new HLZCs for the type 4H basket did not result in any changes to the allowable component temperatures. Because there are no new materials and no changes to the allowable component temperatures, the UFSAR and CoC Technical Specification revisions associated with this change do not affect the materials review.

Change No. 4: New HLZCs and 2-year cooling times for the EOS-37PTH DSC with EOS-TC108 TC

The applicant provided information in the application for the EOS-TC108 TC System with the EOS-37PTH DSC to add HLZCs 4 through 9 for the 4H basket and reduce the minimum cooling times to 2 years (HLZC 2 through 9). The applicant provided an analysis in Chapter 4, Section 4.9.6, to compare the component temperatures for an EOS-37PTH DSC with a maximum heat load of 50 kW. The summary of the applicant's analysis in UFSAR Table 4.9.6-13 shows the temperature difference between EOS-37PTH DSC with HLZC 4 for LC 1 in EOS-TC108 and EOS-TC125 from Table 4.9.6-5. The fuel cladding temperature is well below the allowable limit of 752°F [400°C]. In addition, the temperatures for the lead gamma shield and the neutron shields are well below their allowable temperature limits.

The staff reviewed the UFSAR changes associated with the addition of the new HLZCs and 2-year cooling times for the EOS-37PTH DSC with EOS-TC108 TC. The staff noted that the addition of the new HLZCs and 2-year cooling times for the EOS-37PTH DSC with EOS-TC108 TC did not result in any changes to the allowable component temperatures. Because there are no new materials and no changes to the allowable component temperatures, the UFSAR and CoC TS revisions associated with this change do not affect the materials review.

Change No. 5: Increased Control Component Source Terms for the EOS-37PTH DSC

For the EOS-37PTH DSC, the UFSAR was revised to increase the control component source terms to address control component sources from shutdown plants.

The staff reviewed the UFSAR and TS changes. Because there are no new materials and no changes to the allowable component temperatures, the UFSAR and CoC TS revisions associated with this change do not affect the materials review.

Change No. 6: CoC and TS Revisions

The applicant proposed changes to the CoC and TS which included additions consistent with the changes described in the amendment request, an additional change for the concrete testing TS, and revisions to certain TS and CoC items for consistency and clarity. The applicant provided a description of these changes with the application. The staff's review of the TS changes is documented in the following subsections.

<u>CoC and TS changes for the 61BTH Type 2 DSC and the OS197 TC</u>

The applicant included changes to the CoC for the inclusion of the 61BTH Type 2 DSC and use of the OS197 TC for transfer operations for the 61BTH Type 2 DSC into the HSM-MX. The applicant included changes to the CoC that are consistent with the changes to the UFSAR to identify and describe the 61BTH Type 2 DSC and the OS197 TC, and also included the UFSAR additions to support the proposed amendment.

The applicant provided changes to the TS to support the addition of the 61BTH Type 2 DSC and use of the OS197 TC for transfer operations. The TS changes included functional and operating limits for the fuel to be stored in the 61BTH Type 2 DSC, time limits for completion of

61BTH Type 2 DSC transfer operations, codes and standards for the 61BTH Type 2 DSC and the OS197 TC including the ASME B&PV Code alternatives for the 61BTH Type 2 DSC confinement boundary and the basket. The applicant included tables for the minimum boron-10 (B-10) areal density for the neutron absorber materials used in the 61BTH basket types. The applicant also included a system configuration description that identified the OS197 transfer cask type (OS197/OS197H/OS197FC-B/OS197HFC-B) that is permitted for the 61BTH type 2 DSC HLZC.

The staff compared the information provided to support the addition of the 61BTH Type 2 DSC to the NUHOMS® EOS system to the TS for the CoC No. 1004 Amendment 15 (ADAMS Accession No. ML18347B336). The staff determined that the CoC changes for the inclusion of the 61BTH Type 2 and the OS197 TC are acceptable because the CoC changes accurately identify the proposed changes and reference the applicable UFSAR sections that describe these components. The staff determined that the TS changes for the CoC No. 1042 Amendment 2 for the inclusion of the 61BTH Type 2 DSC along with the transfer operations using the OS197 TC and DSC storage in the HSM-MX are acceptable because the TS changes are consistent with or conservative with respect to the approved TS for the 61BTH Type 2 DSC and the OS197 TC in the TS for CoC No. 1004 Amendment 15.

Other CoC and TS changes

The applicant proposed several changes to the CoC and TS for consistency and clarity. These changes included revisions to definitions and terms and minor editorial changes. The staff reviewed the additional changes and determined that the changes to the definitions of terms was acceptable because the revisions were consistent with the definitions that are universally used in NRC approved TS by the CoC holder. Because there are no new materials and no changes to the allowable component temperatures, the CoC and TS revisions associated with this change do not affect the materials review.

Additional Change No. 3 not associated with the RAI: Integrated Shield Plug and Inner Top Cover Plate for EOS-37PTH DSC

The applicant proposed an additional change to UFSAR Section 1.2.1.1 for the EOS-37PTH DSC and Section 1.2.1.2 for the EOS-89BTH DSC to include an option of using a shield plug integrated with the inner top cover plate. The applicant provided revised drawings for the EOS-37PTH and EOS-89BTH DSCs showing the alternate integrated top shield plug and inner top cover plate for both DSCs that identifies the closure weld location and post welding NDE. The revised drawings provided by the applicant included material specifications, quality category, and code criteria for the alternate components. The applicant also provided an additional table in Chapter 8 of the UFSAR for the material specification and properties of the alternate components.

The staff reviewed the descriptions of the alternate integrated top shield plug and inner top cover plate in UFSAR Section 1.2.1.1 for the EOS-37PTH DSC and Section 1.2.1.2 for the EOS-89BTH DSC. The staff also reviewed the revised drawings of the alternate components, the material specifications, code criteria, and NDE specifications. The staff determined that the overall design of the alternate integrated top shield plug and inner top cover plate is acceptable because the thickness for the integrated component is equivalent to the combined thickness of the original separate components. The staff determined that the applicant's quality category specification for the integrated component was acceptable because it is consistent with the guidance in NUREG/CR-6407. In addition, the staff determined that the ASME code specification for the alternate component is acceptable because the integrated component is classified as an ASME Section III, Subsection NB, component. This is appropriate for a confinement boundary component and consistent with the inner top cover plate approved in the original designs of the DSCs. The staff reviewed the information provided in the revised drawings and determined that the NDE of the closure weld in the alternate integrated top shield plug and inner top cover plate is acceptable because the closure weld NDE requirement is identical to the originally approved DSC designs and is consistent with the guidance in NUREG-1536, Section 8.4.7.

The staff reviewed the material specifications for the alternate integrated top shield plug and inner top cover plate and determined that the materials specifications were appropriate because they are forged austenitic stainless steels that are compatible with the canister shell. The staff reviewed the materials properties of the alternate integrated top shield plug and inner top cover plate and determined that the properties were acceptable because (1) materials properties including yield strength, tensile strength, thermal expansion coefficient, density, thermal conductivity and specific heat capacity reference the appropriate tables in ASME Section II Part D that were verified by the staff and (2) the allowable stress intensity values are consistent with the specified values in ASME Section II, Part D, Table 2A that is applicable to the component material specifications.

Additional Change No. 5 not associated with the RAI: Concrete Testing Change to Technical Specifications

The applicant proposed changes to the TS Paragraph 4.4.4 that references the ACI 349-06, “Code Requirements for Nuclear Safety-Related Concrete Structures and Commentary,” requirements for the EOS HSM and HSM-MX concrete. The applicant also added the stipulations of ACI Code 349-06, Appendix E, Paragraph E.4.3 to the technical specifications. Paragraph E.4.3 states that higher temperatures than those given in E.4.1 for normal operation and E.4.2 for accidents or any other short-term period, are allowed for concrete if (1) tests are provided to evaluate the reduction in strength and this reduction is applied to design allowables, and (2) the evidence provided shows that the increased temperatures do not cause deterioration of the concrete either with or without the postulated loads.

In the alternatives, justification and compensatory measures section of the code alternatives for the HSM concrete specifications, the applicant stated that the concrete temperature limit criteria in NUREG-1536, Section 8.4.14.2 is used for normal and off-normal conditions. In addition, the applicant stated that alternatively, per ACI 349-13, Section RE.4, the specified compressive strength, which may be tested up to 56 days, is increased to 7,000 psi for HSM fabrication so that any losses in properties (e.g., compressive strength) resulting from long-term thermal exposure will not affect the safety margins based on the specified 5,000 psi compressive strength used in the design calculations. In a previously proposed additional alternative to the ACI Code for concrete testing, in a letter for Docket No. 72-1042, CoC No.1042 Amendment 1 (ADAMS Accession No. ML20241A115), the applicant stated that the alternative higher strength concrete mixture may contain mineral cementitious materials such as slag and fly ash. The applicant stated that these additions to the concrete mixture have numerous advantages including higher compressive and flexural strengths, lower permeability, and improved resistance to aggressive chemicals. The applicant also stated that one disadvantage of the higher strength mixtures is that the strength gain is slow. The applicant stated that it is an industry standard practice to designate 56 days, or even 90 days, as the test age for the specified concrete compressive strength when similar mix designs are used.

The staff reviewed the applicant's proposed changes and the specifications in ACI-349. The staff confirmed that the applicant did not change the concrete temperature limit criteria identified in NUREG-1536, Section 8.4.14.2 for normal and off-normal conditions. In addition, the applicant did not change the EOS HSM and HSM-MX specified concrete compressive strength, which remained at 5,000 psi or 7,000 psi for the alternative higher strength mixture. The staff confirmed that the changes proposed by the applicant were limited to the change in the concrete compressive strength testing from a specified time of 28 days after placement to up to 56 days and this change was limited to concrete mixtures with a specified 7,000 psi compressive strength. In its review of the proposed changes by the applicant, the staff noted that ACI-349 paragraph 5.1.3 states that if other than 28 days, the test age for the concrete compressive strength shall be as indicated in design drawings or specifications. Therefore, the staff determined that the proposed changes by the applicant were acceptable because the changes to the technical specifications are consistent with ACI-349.

Evaluation Findings

The staff concludes that the material design features for the NUHOMS® EOS system are in compliance with 10 CFR Part 72, and that the applicable design and acceptance criteria have been satisfied. The evaluation of the material design provides reasonable assurance that the NUHOMS® EOS system will allow safe storage of spent fuel. This finding is reached on the basis of a review that considered the regulation itself, appropriate regulatory guides, applicable codes and standards, and accepted engineering practices. Some of the key findings from the staff's review of Amendment 2 include:

F8.1 The applicant has met the requirements in 10 CFR 72.236(b). The applicant described the materials design criteria for SSCs important to safety in sufficient detail to support a safety finding.

F8.2 The applicant has met the requirements in 10 CFR 72.236(g). The properties of the materials in the storage system design have been demonstrated to support the safe storage of SNF.

F8.3 The applicant has met the requirements in 10 CFR 72.236(h). The materials of the SNF storage container are compatible with their operating environment such that there are no adverse degradation or significant chemical or other reactions.

F8.4 The applicant has met the requirements in 10 CFR 72.236(a) and 10 CFR 72.236(m). SNF specifications have been provided and adequate consideration has been given to compatibility with retrieval of stored fuel for ultimate disposal.

8.8 References

NRC, “Standard Review Plan for Spent Fuel Dry Storage Systems at a General License Facility,” NUREG-1536, Revision 1, Washington, DC, 2010a, ADAMS Accession No. ML101040620.

NUREG/CR-5502, U.S. Nuclear Regulatory Commission, “Engineering Drawings for 10 CFR Part 71 Package Approval,” UCRL-ID-130438, Lawrence Livermore National Laboratory, May 1998.

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9.0 OPERATING PROCEDURES EVALUATION

The applicant made no substantial changes to the UFSAR Chapter 9 for the NUHOMS® EOS system or Chapter A.9 for the EOS-MATRIX HSM included in Amendment 1. The applicant added Appendix B including Chapter B.9 to address operating procedures with the 61BTH Type 2 DSC. The operating procedures in Chapter B.9 included procedures for loading the DSC and transfer to the HSM-MX and procedures for unloading the DSC.

The staff reviewed the procedures for loading the 61BTH Type 2 DSC and transfer to the HSM-MX included in Chapter B.9.1 and determined that the procedures are acceptable because they address DSC loading operations, including preparation of the transfer cask and DSC, DSC fuel loading, DSC drying and backfilling, and DSC sealing operations. The staff verified that the 61BTH Type 2 DSC loading operations are consistent with the approved operating procedures included in the CoC No. 1004 UFSAR Revision 18. The staff reviewed the operating procedures for DSC transfer including TC downending, transfer to the ISFSI and transfer of the DSC to the HSM-MX. The staff determined that the procedures are acceptable because they include the necessary steps for the described operations and are consistent with the transfer operations for the 37PTH DSC and the 89BTH DSC to the HSM-MX. The procedures also cover the necessary addition of the required spacer blocks at the front and rear DSC supports inside HSM-MX compartment and the TC adapter necessary to transfer the 61BTH Type 2 DSC from the OS197 TC to the HSM-MX. The staff reviewed the post transfer monitoring operations and noted that the applicant referred to the monitoring operations previously approved in the NUHOMS® EOS Amendment 1 and included in Appendix A.9.1.7 of the UFSAR. The staff determined that the monitoring procedures included in UFSAR Appendix A.9.1.7 were acceptable because they include either (1) daily visual surveillance of the HSM-MX air inlets and outlets to verify that no debris are obstructing the HSM-MX vents in accordance with

Section 5.1.3.2(a) of the Technical Specification requirements, or (2) a temperature measurement for each EOS-HSM in accordance with Section 5.1.3.2(b) of the Technical Specification requirements.

The staff reviewed the procedures for unloading the 61BTH DSC included in UFSAR Section B.9.2. The staff determined that the procedures for the 61BTH Type 2 DSC retrieval from the HSM-MX were acceptable because these procedures are consistent with the retrieval operations for the 37PTH DSC and the 89BTH DSC from the HSM-MX with the addition of the required TC adapter to retrieve the 61BTH type 2 DSC from the HSM-MX using an OS197 TC. The staff noted that the procedures for the removal of fuel from the DSC references the previously approved procedures included in the Appendix T of the CoC No. 1004 UFSAR Revision 18.

9.6 Findings

The staff concludes that the operating procedures for the NUHOMS® EOS system are in compliance with 10 CFR Part 72, and that the applicable design and acceptance criteria have been satisfied. The evaluation of the operating procedures provides reasonable assurance that the NUHOMS® EOS system will allow safe storage of spent fuel. This finding is reached on the basis of a review that considered the regulation itself, appropriate regulatory guides, applicable codes and standards, and accepted engineering practices. Some of the key findings from the staff's review of Amendment 2 include:

F9.1 The 61 BTH Type 2 DSC is compatible with wet/dry loading and unloading. General procedure descriptions for these operations are summarized in the Standardized NUHOMS® system UFSAR Revision 18. Detailed procedures will need to be developed and evaluated on a site-specific basis.

F9.2 The 61BTH Type 2 DSC is designed to facilitate decontamination. Only routine decontamination will be necessary after the cask is removed from the spent fuel pool.

F9.3 The content of the general operating procedures described in the SAR are adequate to protect health and minimize damage to life and property. Detailed procedures will need to be developed and approved on a site-specific basis.

10.0 ACCEPTANCE TESTS AND MAINTANANCE PROGRAM EVALUATION

The applicant made no substantial changes to the UFSAR Chapter 10 for the NUHOMS® EOS system or Chapter A.10 for the EOS-MATRIX HSM included in Amendment 1. The applicant added Appendix B including Chapter B.10 to address the acceptance testing and maintenance program for important-to-safety components of the 61BTH Type 2 DSC transferred in the OS197 and stored in the NUHOMS® HSM-MX. The applicant included a description of the acceptance tests for the 61BTH Type 2 DSC, the HSM-MX, and the OS197 TC in UFSAR Section B.10.1. The applicant included a description of the maintenance program in B.10.2. The applicant included a description of the repair, replacement, and maintenance program in UFSAR Section B.10.3.

The applicant's description of the structural and pressure tests for the 61BTH Type 2 DSC and the OS197 TC incorporates by reference the information included in the Standardized NUHOMS® system UFSAR Revision 18 used to support CoC No. 1004 Amendment 15. The applicant's description of the HSM-MX acceptance tests referenced the applicable portions of UFSAR Appendix A which was previously reviewed by the NRC for NUHOMS® EOS Amendment 1. For the HSM-MX, the applicant provided the testing specifications for the spacer blocks necessary to accommodate the smaller diameter 61BTH Type 2 DSC. The applicant's description of the specifications provided for the spacer blocks to accommodate the smaller 61BTH Type 2 DSC included in the Amendment 2 application are included in the component drawings included in UFSAR Section B.1. The applicant's description of the leak tests and thermal acceptance tests for the 61BTH Type 2 DSC and the OS197 TC also incorporates by reference the information included in the Standardized NUHOMS® system UFSAR Revision 18. The applicant stated that DSC, HSM, and TC are marked with a model number, serial number, and empty weight per the requirement of 10 CFR 72.236(k).

The applicant stated that the acceptance tests also include visual examinations and other NDE, as well as shielding tests. The applicant stated that visual inspections are performed at the fabricator's facility to ensure that the 61BTH Type 2 DSC, the OS197 TC and the HSM-MX conform to the drawings and specifications. The visual inspections include weld, dimensional, surface finish, and cleanliness inspections. Visual inspections specified by codes applicable to a component are performed in accordance with the requirements and acceptance criteria of those codes. In addition, the applicant stated that all weld inspections are performed using qualified processes and qualified personnel according to the applicable code requirements. For the confinement welds on the DSC, the applicant stated that these welds are inspected in accordance with ASME B&PV Code Section III, Subsection NB, and the non-confinement welds are inspected to the NDE acceptance criteria of ASME B&PV Code Section III, Subsection NG or NF, based on the applicable code for the components. The applicant stated that alternatives to the ASME Code are specified in Section 4.4.4 of the TS for the NUHOMS-61BTH DSC confinement boundary and basket.

The applicant's description of the 61BTH Type 2 DSC acceptance tests included neutron absorber tests for the borated aluminum alloys, boron containing aluminum metal matrix composite (MMC) materials, and Boral®. The applicant described the manufacturing processes, visual inspection criteria and thermal conductivity testing for the neutron absorber materials. The applicant also described acceptance testing of neutron absorbers by neutron transmission and B-10 volume density measurement. The applicant's qualification testing of MMCs included mechanical integrity testing and testing for B-10 distribution uniformity. The applicant described the process controls for MMCs including the definition and control of key process changes.

The staff determined that the applicant's description, testing and inspections of the 61BTH Type 2 DSC and the OS197 TC were acceptable because the application referenced and incorporated the acceptance tests included in CoC No. 1004 UFSAR Revision 18 (Amendment 15) which was previously reviewed and approved by the NRC. The staff determined that the applicant's description of the HSM-MX acceptance tests were acceptable because the acceptance tests either (1) referenced NUHOMS® EOS Amendment 1 which was previously reviewed and approved by the NRC or (2) were included by reference in the specifications provided for the spacer blocks to accommodate the smaller 61BTH Type 2 DSC included in the Amendment 2 application drawings provided in UFSAR Section B.1. The staff determined that the acceptance testing, qualification and process controls for the neutron absorber materials for the 61BTH Type 2 DSC were acceptable because the testing qualification and process controls described by the applicant followed the guidance in NUREG-1536, Section 8.4.13.

The applicant's description of the maintenance program for the OS197 TC referenced Sections 4.5.1 and 4.5.2 of the CoC No. 1004 UFSAR Revision 18 (Amendment 15), which was previously reviewed and approved by the NRC. The applicant's description of the HSM inspections referenced the UFSAR Section 10.2, which was previously reviewed and approved by the NRC.

The applicant's description of the repair, replacement and maintenance program for the OS197 TC referenced Section 4.5 of the Standardized NUHOMS® system UFSAR Revision 18 which was previously reviewed and approved by the NRC. The applicant's description of the HSM inspections referenced the Standardized NUHOMS® system UFSAR Section 10.3 which was previously reviewed and approved by the NRC.

Evaluation Findings

The staff concludes that the acceptance tests and maintenance program for the NUHOMS® EOS system are in compliance with 10 CFR Part 72, and that the applicable design and acceptance criteria have been satisfied. The evaluation of the acceptance tests and maintenance program provides reasonable assurance that the NUHOMS® EOS system will allow safe storage of spent fuel. This finding is reached on the basis of a review that considered the regulation itself, appropriate regulatory guides, applicable codes and standards, and accepted engineering practices. Some of the key findings from the staff's review of Amendment 2 include:

F10.1 Chapter 10 of the SAR describes the applicant's proposed acceptance testing and maintenance program.

F10.2 Structures, systems, and components (SSCs) important to safety will be designed, fabricated, erected, tested, and maintained to quality standards commensurate with the importance to safety of the function they are intended to perform. Chapters 10, A.10, and B.10 of the SAR identifies the applicable standards for their design, fabrication, and testing the safety importance of SSCs.

11.0 RADIATION PROTECTION EVALUATION

The objectives of the radiation protection evaluation are to determine whether the design features and proposed operations meet the following criteria:

1. the radiation protection features with the proposed changes to the DSC design meet the NRC design criteria for protecting the general public and occupational workers from direct radiation,

2. the applicant has proposed engineering features and operating procedures for the DSC that will ensure occupational exposures will remain as low as reasonably achievable (ALARA), and

3. the radiation doses to the general public will meet regulatory standards during both normal conditions, anticipated operational occurrences and accidents.

The applicant provided an updated dose rate versus distance curve for the new contents of the 61BTH DSC loaded with intact fuel, reconstituted fuel, damaged fuel, and failed BWR fuel with the burnup, enrichment, and cooling times as well the loading patterns. The applicant also provided an update of the estimated dose that is expected to be received by the operators when completing the operations of loading the ISFSI.

The applicant revised the radiation protection analyses to account for the dose rate changes around the transfer cask and the HSM modules of the ISFSI resulting from the new contents, i.e., same intact fuel with shorter cooling time. The total annual exposure estimates are based on 100% occupancy for 365 days. At large distances, the annual exposure from the 2x10 back-to-back array is similar to the two 1x10 front-to-front array (two rows of 1x10 array) configurations. Per 10 CFR 72.104, the annual whole-body dose to an individual at the site boundary is limited to 25 mrem. Based on the data shown in Table 11-6, the offsite dose rate drops below 25 mrem at a distance of approximately 370 m from the ISFSI. Therefore, 370 m is the minimum distance with design basis fuel to the site boundary for a 20-cask array with the NUHOMS® EOS System.

The staff reviewed the operating procedures, the estimated time for completing each step of the operation, and the estimated dose for loading and unloading a 61BTH Type 2 DSC loaded with authorized contents and provided the results in Table B.11-2, "Occupational Exposure, OS197 with 61BTH DSC." These tables show that dose rates for transfer of the 61BTH DSC within the OS197 TC are similar to dose rates for transfer of the EOS-89BTH DSC within the EOS-TC125, which is approved in Amendments 0 and 1 for the NUHOMS® EOS system as documented in Chapter 6 of the UFSAR. Also, the estimated times for loading and unloading the 61BTH Type 2 DSC using the OS197 are almost identical to that of the EOS-89BTH DSC. Therefore, the exposure estimate for transfer of the 61BTH Type 2 DSC, loaded with the authorized contents as specified in the TS, to the HSM-MX documented in Chapter B.11 is similar to the exposure estimate for transfer of the EOS-89BTH DSC to the HSM-MX documented in Chapter A.11.

The staff reviewed the updated radiation protection plan for the EOS dry cask spent fuel storage system with these requested changes. The staff finds that the applicant has provided an adequate estimate of the doses in Table B.11-2 of the UFSAR for the system operations and found the estimated dose to be appropriate. The radiation protection plan outlined in the UFSAR includes cautions and reminders of the use of optional supplemental shielding when practical to further reduce the operator's exposure to radiation. On these bases, the staff determined, with a reasonable assurance, that the amended EOS dry cask spent fuel storage system design continues to meet the regulatory requirements within 10 FR 72.104 as referenced by 10 CFR 72.236(d) and radiation protection planning is sufficient to allow the GLs to meet 10 CFR Part 20 requirements.

The applicant also revised the estimated doses for loading and unloading the new heat load zones for the EOS-37PTH DSC (change No. 2) with a minimum cooling time from the previous values (vary depending on the HLZCs) to two years for HLZCs 2 through 9 (change No. 5) and the impact on the dose on loading and operating the system.

The staff reviewed the revised the dose estimates for completing these operations and determined that the applicant has correctly calculated the expected dose for completing the necessary operating procedures. The other proposed changes (No. 3 and 6, nor additional changes (Nos. 2, 3, 4 and 5) not associated with the RAI) do not impact radiation protection.

12.0 ACCIDENT ANALYSIS EVALUATION

The applicant provided a revised accident analysis for the NUHOMS® EOS system in UFSAR Chapter 12. The applicant also provided revisions to the accident analysis for the HSM-MX storage system in UFSAR Section A.12. The applicant added Appendix B to the FSAR for the 61BTH Type 2 DSC stored in the HSM-MX. The added Appendix B includes Section B.12, which addresses off-normal events and postulated accidents. The staff's review of these changes is included in the following sections.

EOS-TC Accident Analysis

The applicant revised the accident dose rate calculations in Chapter 6 and Chapter A.6 of Appendix A of the UFSAR for the EOS-TC neutron shield that the applicant stated may be damaged in an accidental drop. The applicant stated that the maximum accident dose rate is 5.8 mrem/hr and the bounding EOS-TC dose rates provided in Chapter 6 are applicable to transfer of the different canisters to the HSM-MX. The applicant calculated the dose to an individual at the site boundary to be 46 mrem assuming an 8-hour recovery time. The applicant's calculated dose is significantly below the 10 CFR 72.106 dose limit of 5 rem.

The applicant revised the corrective actions in UFSAR Section 12.3.1 for the EOS-TC drop where the neutron shield and air circulation are lost. The applicant stated that the actions immediately after an accident would include the following:

1. Reinstating the neutron shielding to protect workers on the site and/or restart air circulation to control the fuel cladding and the DSC temperatures, if necessary, based on the heat load of the DSC.
2. Evaluation of the TC and DSC condition to determine if they are safe to move including a transient thermal evaluation to determine that the DSC to a safe condition for transfer considering the accident specifics such as the decay heat load and the ambient temperature.
3. Returning the TC/DSC to the fuel building or other acceptable location for evaluation of continued service after evaluations have determined that the TC is safe to move.
4. The DSC can then be opened, if necessary, to permit fuel inspection.
5. The EOS-TC is inspected, repaired and tested as appropriate prior to reuse.

The applicant revised the corrective actions following tornado wind and tornado missile effects on the EOS-TC in UFSAR Section 12.3.4. The revised corrective actions include evaluations of the neutron shield function, air circulation to maintain component temperatures and time limits for transfer. The applicant stated that if the time limit for transfer is exceeded the general licensee is directed to follow the corrective actions detailed in UFSAR Section 12.3.1 for the accident drop and the transfer cask and DSC would be moved only after evaluations determined it was safe to do so. The applicant stated that special lifting devices may need to be procured after such an accident. If necessary, the applicant stated that temporary shielding may be required to protect workers until the TC and DSC can be moved.

The applicant also revised the corrective actions following a fire or explosion in UFSAR Section 12.3.8. The applicant stated that the DSC should be inspected for damage if the EOS-TC neutron shield were damaged or the air circulation on the EOS-TC was lost and time limits for transfer exceeded. For these accident conditions, the UFSAR revisions direct the general licensee to follow the corrective actions detailed in Section 12.3.1 for the accident drop of the TC.

The staff reviewed the revised corrective actions for the EOS-TC drop, tornado wind and tornado wind missiles effect, and fire and explosions. The staff determined that the changes are acceptable because the corrective actions include (1) consideration of accident specifics and DSC heat loads, (2) shielding evaluations and actions to protect workers, (3) evaluations to assess the post accident movement, (4) evaluations of the DSC, the TC and the fuel if necessary. As such, the applicant's description of the consequences of off-normal events is consistent with NUREG-1536, Section 12.4.2 "Dose Limit for Design-Basis Accidents" and the design and administrative controls that assure compliance with the regulatory requirements of 10 CFR 72.106 site boundary dose rates.

EOS-HSM and HSM-MX Analyses

The applicant considered the effects of the lighter weight of the 61BTH Type 2 DSC in the earthquake analysis in Chapters B.3.9.4 and B.3.9.7 of Appendix B of the UFSAR. The applicant stated that the results of these analyses show that seismic stresses are well below the applicable stress limits. The applicant stated that the dose rate increase is bounded by Section A.12.3.3, tornado wind and tornado missiles effect on the HSM-MX, where the applicant assumed a recovery time of five days (120 hours), where the total exposure to an individual at a distance of 200 m is 132 mrem, which is significantly below the 10 CFR 72.106 limit of 5 rem.

The applicant revised the accident dose rate calculation for the analysis of tornado wind and tornado missiles effect on HSM-MX in UFSAR Section A.12.3.3. The applicant's revised analysis considered that the HSM array would be in the expansion configuration with the removable end shield wall absent and the two inner walls could be damaged as a result of a missile impact.

The applicant performed a shielding analysis for the EOS-HSM with the assumption that the roof covers would be lost in a tornado wind accident. The average EOS-HSM roof dose rates and surface fluxes in an accident are presented in Tables 6-56 through 6-58 for the EOS-89BTH DSC and Tables 6-58a through 6-58c for the EOS-37PTH DSC. The results show that in accident conditions, the roof dose rate for the EOS-89BTH DSC is larger than the roof dose rate for the EOS-37PTH DSC. Because the accident dose rates are slightly larger for the EOS-89BTH DSC, only the EOS-89BTH DSC accident dose rates are reported as bounding conditions for accident analysis.

The applicant also performed shielding analyses for the HSM-MX module with the same assumption that all vent covers and dose reduction hardware are absent. A model is also developed for a missile impact when the HSM-MX is in the construction joint expansion configuration with the removable end shield wall absent. In this configuration, the applicant conservatively assumed that two interior walls are penetrated in its calculation. The results of the calculations show that the HSM-MX accident for the EOS-37PTH DSC increases the average dose rate on the front, roof, and end of the module and are slightly higher than the accident dose rates for the HSM-MX loaded with the EOS-89BTH DSC.

The applicant assumed that the recovery time for this accident is five days (120 hours) and calculated that the total exposure to an individual at a distance of 200 m is 66 mrem. The applicant stated that the calculated dose is significantly less than the 10 CFR 72.106 limit of 5 rem. In addition, the applicant noted that the dose is bounded by the EOS-HSM accident dose documented in UFSAR Section 12.3.3.

The staff reviewed the revised analyses provided by the applicant. The staff determined that the applicant's analyses were acceptable because the applicant considered a reasonable time for corrective actions to be implemented and showed that the accident dose rate for an individual at the site boundary was well below the regulatory limit.

Off-Normal Events for the 61BTH Type 2 DSC, OS197 TC and HSM-MX

The off-normal events related to the 61BTH Type 2 DSC and the OS197 TC is documented in UFSAR Appendix B.12.2. The off-normal events include off-normal transfer loads and extreme temperatures. For each off-normal event, the applicant provided a description including the probable cause of the event, detection of the event, analysis of effects and consequences, and corrective actions.

The applicant stated that off-normal loads could occur during transfer operations if the 61BTH DSC was not properly aligned during transfer operations. The applicant stated that the interfacing dimensions of the top end of the OS197 transfer cask and the HSM-MX access opening sleeve are specified so that docking the OS197 transfer cask with the HSM-MX is not possible should gross misalignments between the OS197 transfer cask and HSM-MX exist. The applicant stated that if motion is prevented, the pressure increases, thereby increasing the force on the 61BTH Type 2 DSC until the ram system pressure limit is reached. The applicant stated that the system pressure limit is controlled so that adequate force is available but is sufficiently low to ensure that component damage does not occur. As a result, for either loading or unloading of the DSC under off-normal conditions, the applicant stated that stresses on the shell assembly components are demonstrated to be within the ASME allowable stress limits and permanent deformation of the DSC shell components does not occur. The applicant stated that because the components are not damaged as a result of the off-normal event and there are no changes to the corrective actions as described in UFSAR Section 12.2.1.

The applicant stated that components affected by postulated extreme ambient temperatures are the OS197-TC and 61BTH Type 2 DSC during their transfer from the plant's fuel/reactor building to the ISFSI site, and the HSM-MX during storage of a 61BTH Type 2 DSC. The applicant included an analysis for these components and operations in UFSAR Section B.3.9.4 and B.3.9.7. The applicant's analysis for the 61BTH Type 2 DSC shell is included in UFSAR Section B.3.9.1. The applicant stated that the maximum shell temperature of the 61BTH Type 2 DSC is less than the EOS 37PTH-DSC shell temperature when stored in the HSM-MX. In UFSAR Section B.3.9.2, the applicant stated that analysis for the 61BTH Type 2 basket is bounded by the analysis in Standardized NUHOMS® system UFSAR Revision 18. The applicant stated that the analysis for the HSM-MX with the 61BTH Type 2 DSC is bounded by the larger EOS-37PTH DSC that has a higher heat load. The applicant stated that there is no change to the evaluation of the OS197 TC body structural analysis documented in Standardized NUHOMS® system UFSAR Revision 18 Sections T.3.6.1.9 for normal and off-normal operations under the CoC No. 1004 when used for the HSM-MX system.

The staff reviewed the applicant's descriptions and analyses for the off-normal events. The staff determined that the applicant's analysis of off-normal transfer loads was acceptable because (1) the system is designed to prevent transfer misalignment that could result in off-normal transfer loads, (2) the transfer system is designed with administrative controls on transfer loads. and (3) the maximum load under a misaligned condition would not result in damage to the DSC or result in a loss of confinement. As such, the applicant's description of the consequences of off-normal events is consistent with NUREG-1536, Section 12.4.1 "Dose Limits for Off-Normal Events" and the design and administrative controls that assure compliance with the regulatory requirements of 10 CFR 72.104. The staff determined that the applicant's analysis for the off-normal temperature effects on the storage and transfer system components were acceptable because they are either bounded by the analyses in Standardized NUHOMS® system UFSAR Revision 18 used to support CoC No.1004 Amendment 15 or by the existing analysis for the HSM-MX system in the UFSAR.

Postulated Accidents for the 61BTH Type 2 DSC, OS197 TC and HSM-MX

The accident analysis related to the NUH61BTH Type 2 DSC with the OS197 TC and the HSM-MX is documented in UFSAR Appendix B.12.3. The postulated accidents include the OS197 TC drop, earthquake, tornado wind and tornado missiles effect on HSM-MX, tornado wind and tornado missiles effect on the OS197 TC, flood, blockage of HSM-MX air inlet openings, lightning, and fire and explosions. For each accident analysis the applicant provided a description including the cause of the accident, an accident analysis, accident dose calculations and corrective actions.

The applicant provided an OS197 TC drop analysis with the 61BTH DSC Type 2 DSC. The applicant stated that there was no change to the accident analysis as described in Standardized NUHOMS® system UFSAR Revision 18 Section T.11.2.5.2. The applicant stated that the accident dose of 46 mrem at 100 m from the EOS-TC documented in Section 12.3.1 for an EOS-TC drop bounds the accident dose for the 61BTH DSC within the OS197-TC. This dose is significantly below the 10 CFR 72.106 limit of 5 rem. The applicant stated that there was no change to the corrective actions as described in Standardized NUHOMS® system UFSAR Revision 18 Sections T.11.2.5.4.

The applicant stated in UFSAR Section B.12.3.2 that the seismic analyses of the components important to safety are analyzed in UFSAR Section B.3.9. The applicant stated that the dose rate increase is bounded by UFSAR Section A.12.3.3 tornado wind and tornado missiles effect on HSM-MX. In that analysis, the applicant showed that for a recovery time of five days (120 hours), the total exposure to an individual at a distance of 200 m is 66 mrem, which is significantly less than the 10 CFR 72.106 limit of 5 rem. The applicant stated that there was no change to the corrective actions as described in Section 12.3.2 for the earthquake analysis for the NUHOMS® EOS system.

The applicant stated in UFSAR Section B.12.3.3 that the tornado wind and tornado missiles impact on HSM-MX is bounded by UFSAR Section A.12.3.3 tornado wind and tornado missiles effect on HSM-MX where the calculated dose is significantly less than the 10 CFR 72.106 limit of 5 rem. The applicant stated that there was no change to the corrective actions as described in Section A.12.3.3 for the analysis of tornado wind and tornado missiles effect on HSM-MX.

The applicant stated in UFSAR Section B.12.3.4 that the analysis for tornado wind and tornado missiles effect on OS197 TC is bounded by the event described in Standardized NUHOMS® system UFSAR Revision 18 Section 8.2.2. This dose is significantly below the 10 CFR 72.106 limit of 5 rem. Thus, the 10 CFR Part 72 requirements for this postulated event are met for the general public.

The applicant stated in UFSAR B.12.3.5 for the flood analysis with the 61BTH Type 2 DSC that the cause of accident, the accident analysis, the accident dose calculations are bounded by the flood analysis for the EOS HSM provided in UFSAR Section 12.3.5. In addition, the applicant stated that the corrective actions for the hypothetical flood accident are the same as described in UFSAR Section 12.3.5, where the applicant determined that the radiation dose due to flooding of the HSM is negligible because flooding does not breach the DSC confinement boundary. The applicant’s description of the bounding flood analysis for the EOS HSM provided in UFSAR Section 12.3.5 was previously reviewed and approved by the NRC.

The applicant stated in UFSAR B.12.3.6 that for the blockage of HSM-MX air inlet openings the thermal evaluation of this event is presented in Chapter B.4, Section B.4.4 for the 61BTH Type 2 DSC stored inside an HSM-MX. The applicant stated that the analysis performed for the EOS-37PTH DSC bounds the values for the 61BTH Type 2 DSC and therefore, the temperatures determined for Load Case #3-S in UFSAR Section A.4.5.4 with an EOS-37PTH DSC are bounding for the evaluation of this event. The applicant stated that the HSM-MX structural analysis, presented in UFSAR Appendix B.3.9.4, demonstrates that the HSM-MX component stresses remain below allowable values. The applicant’s description of the bounding HSM-MX air inlet blockage provided in UFSAR Section A.4.5.4 was previously reviewed and approved by the NRC.

The applicant stated in UFSAR Section B.12.3.7 that for a lightning analysis the cause of the accident, the accident analysis, and the corrective actions, are as described in UFSAR Section 12.3.7. The applicant’s analysis in UFSAR Section 12.3.7 states that the likelihood of lightning striking the HSM and causing an off-normal condition is not considered to be a credible event. The applicant stated that lightning protection system requirements are site-specific and depend on the frequency of occurrences of lightning storms in the proposed ISFSI location, and the degree of protection offered by other grounded structures in the proximity of the HSM. The applicant stated that should lightning strike in the vicinity of the HSM, the normal storage operations of the HSM are not affected. The current discharged by the lightning follows the low impedance path offered by the surrounding structures. Therefore, the HSM is not damaged by the heat or mechanical forces generated by current passing through the higher impedance concrete. The applicant's description of the bounding lightning analysis provided in UFSAR Section 12.3.7 was previously reviewed and approved by the NRC.

The applicant stated in UFSAR Section B.12.3.8 Fire/Explosion that the evaluation of the hypothetical fire event is bounded by the loss of neutron shield and loss of air circulation accident described in Appendix T.4, Table T.4-10, Table T.4-21, and Table T.4- 23 of Standardized NUHOMS® system UFSAR Revision 18 used to support CoC No. 1004 Amendment 15. This analysis shows that the maximum component temperatures are below the allowable limits. The maximum temperatures for the bounding loss of neutron shield and loss of air circulation steady-state accident condition demonstrates that the maximum component temperatures are below the allowable limits. The DSC confinement boundary is not breached as a result of the postulated fire/explosion scenario and therefore no release of radioactivity is postulated. The applicant stated that because no radioactivity is released, no resultant dose increase is associated with this event. The applicant stated that an evaluation of EOS-TC neutron shield damage as a result of a fire is to be performed to assess the need for temporary shielding (if fire occurs during transfer operations) and repairs to restore the EOS-TC to pre-fire design conditions for ALARA considerations. The applicant's description of the bounding the loss of neutron shield and loss of air circulation accident provided in Appendix T.4, of Standardized NUHOMS® system UFSAR Revision 18 was previously reviewed and approved by the NRC.

Evaluation Findings

The staff reviewed the applicant analysis for postulated accident conditions for the 61BTH Type 2 DSC with the OS197 TC and the HSM-MX storage module. The staff determined that the applicant's analyses of postulated accidents are acceptable because the applicant considered a reasonable time for corrective actions and showed that the consequences of off-normal events including man-made events or natural phenomena are below the regulatory limits of 10 CFR 72.104. In addition, the applicant has provided analysis to show that the consequences of accident conditions are below the regulatory dose limits of 10 CFR 72.106. Some of the key findings from the staff's review of Amendment 2 include:

F12.1 Structures, systems, and components of the NUHOMS® EOS system are adequate to prevent accidents and to mitigate the consequences of accidents and natural phenomena events that do occur.

F12.2 Technical Specifications for the 61BTH Type 2 DSC, OS197 TC and the HSM-MX are provided in CoC No. 1042 Amendment 2 Technical Specifications.

F12.3 The applicant has evaluated the 61 BTH DSC Type 2 DSC to demonstrate that it will reasonably maintain confinement of radioactive material under credible accident conditions.

F12.4 The SNF will be maintained in a subcritical condition under accident conditions.

F12.5 Neither off-normal nor accident conditions will result in a dose to an individual outside the controlled area that exceeds the limits of 10 CFR 72.236(d).

F12.6 No instruments or control systems are required to remain operational under accident conditions.

13.0 CERTIFICATE OF COMPLIANCE AND TECHNICAL SPECIFICATIONS

The staff reviewed the proposed amendment to determine that applicable changes made to the conditions in the CoC and to the TS for CoC No. 1042, Amendment No. 2, would be in accordance with the requirements of 10 CFR Part 72. The staff reviewed the proposed changes to confirm that the changes were properly evaluated and supported in the applicant's revised UFSAR. These modifications were found acceptable based on the staff's findings for the Structural, Thermal, Confinement, Shielding, Criticality, Materials, Operating Procedures, Acceptance Test and Maintenance Program, and Radiation Protection sections of this SER.

The staff finds that the proposed changes to the TS for the NUHOMS® EOS system conform to the changes requested in the amendment application and do not affect the ability of the cask system to meet the requirements of 10 CFR Part 72. The proposed changes provide reasonable assurance that the NUHOMS® EOS system will continue to allow safe storage of spent nuclear fuel.

14.0 QUALITY ASSURANCE EVALUATION

There were no changes to the applicant's quality assurance program requested in the amendment application.

15.0 CONCLUSIONS

The staff has performed a comprehensive review of the amendment application, during which the following requested changes to the NUHOMS® EOS system were considered:

Change No. 1:
Add the 61BTH Type 2 dry shielded canister (DSC) transferred in the OS197 Transfer Cask (TC) for storage in the NUHOMS® MATRIX (HSM-MX) design approved in Amendment 1 to CoC No. 1042. The 61BTH Type 2 DSC design included in this amendment is approved in CoC No. 1004 Amendment 15. The associated design change to the HSM-MX included in this amendment is the addition of spacer blocks at the front and rear DSC supports to maintain the centerline of the DSC in line with the HSM door centerline.

Change No. 2:
For the EOS-37PTH DSC, add two new heat load zone configurations (HLZCs) for the EOS-37PTH for higher heat load assemblies, up to 3.5 kW/assembly, that also allow for damaged and failed fuel storage.

Change No. 3:
For the EOS-37PTH DSC, add basket type 4H, previously introduced in CoC No. 1042 Amendment 1, for HLZCs 1, 4, 5, 6, 8, and 9.

Change No. 4:
For the EOS-TC108 TC System with the EOS-37PTH DSC, add HLZCs 4 through 9 for the 4H basket and reduce the minimum cooling times to 2 years (HLZC 2 through 9).

Change No. 5:
For the EOS-37PTH DSC, increase the control component source terms to better address potential control component sources from various shutdown plants.

Change No. 6:
Certain CoC and Technical Specification (TS) items are revised for consistency and clarity. The CoC and TS have been revised accordingly.

<u>Additional Changes not associated with the RAI</u>

Additional Change No. 1:
Move TS Table 3 relating to control component (CC) Co-60 from the TS to the Updated Final Safety Analysis Report (UFSAR) as Table 6-37a as part of continued application of the graded approach. *Note: On October 29, 2020, the applicant withdrew this change. Therefore, there was no evaluation of this change needed in the SER.*

Additional Change No. 2:
Add description of methodology on Co-60 equivalence to UFSAR Section 6.2.4, Control Components, to clarify methodology for CCs.

Additional Change No. 3:
Add description to UFSAR Section 1.2.1.1 for EOS-37PTH and Section 1.2.1.2 for EOS-89BTH to clarify the option of using a shield plug integrated with the inner top cover plate.

Additional Change No. 4:
Update UFSAR Section 2.4.3 to clarify the methodology to reduce the maximum allowable heat load based on the fuel assembly type.

Additional Change No. 5:
Replace the phrase “28 days” with “which may be tested up to 56 days” in Paragraph 4.4.4 of the TS to clarify whether concrete testing is required based on HSM component temperatures.

Based on the statements and representations provided by the applicant in its amendment application, as supplemented, the staff concludes that the changes described above to the NUHOMS® EOS system do not affect the ability of the cask system to meet the requirements of 10 CFR Part 72. Amendment No. 2 for the NUHOMS® EOS system should be approved.

Issued with Certificate of Compliance No. 1042, Amendment No. 2, on September 15, 2021.