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. 3

SUMMARY

This safety evaluation report (SER) documents the U.S. Nuclear Regulatory Commission (NRC) staff's review and evaluation of the request to amend Certificate of Compliance (CoC) No. 1042 for the NUHOMS® EOS system. By letter dated March 31, 2021 (Agencywide Documents Access and Management System (ADAMS) Accession Number ML21102A281), as supplemented in letters dated June 23, 2021 (ML21174A231), August 4, 2021 (ML21209A098), September 3, 2021 (ML21246A136), October 22, 2021 (ML21295A260), November 30, 2021 (ML21334A206), February 25, 2022 (ML22056A458), June 7, 2022 (ML22158A293), June 29, 2022 (ML22180A266), September 30, 2022 (ML22273A031), October 31, 2022 (ML22304A217), November 14, 2022 (ML22318A205), and December 21, 2022 (ML22355A219), 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 three new heat load zone configurations (HLZCs) for the EOS-89BTH Dry Shielded Canister (DSC), with increased heat load up to 1.7 kW per fuel assembly, which reduces the minimum cooling time to 1 year.

Change No. 2:
Add a variable-lead thickness EOS-TC125 for transfer with the EOS-89BTH DSC.

Change No. 3:
Add ATRIUM 11 fuel as an allowable content in the EOS-89BTH DSC. Reran the limiting GNF2 and ABB-10-C cases to reduce the statistical uncertainties and increase the enrichment limits.

Change No. 4:
Update the criticality evaluation to allow short-loading the EOS-89BTH DSC with less than 89 fuel assemblies to increase the enrichment limits.

Change No. 5:
For the technical specifications (TS); a revision to allow for phased array automated ultrasonic testing (PA-AUT) and to utilize a single pass high amperage gas tungsten arc weld (HA-GTAW) or multipass GTAW on the outer top cover plate (OTCP).

Enclosure

Change No. 6:
For the TS; a revision to reduce EOS-37PTH HLZC 1 and 2 time limit for transfer to 8 hours.

Change No. 7:
Incorporate a method to determine new loading patterns based on the maximum allowable heat load per DSC and per location specified in the TS. All HLZCs and time limits for transfer for the EOS-89BTH DSC transferred in the EOS-TC125 are moved from the TS to the updated final safety analysis report (UFSAR) chapter 2.

Change No. 8:
For the single bottom forging EOS-DSCs, waive the fabrication pressure test requirement.

Change No. 9:
TS and UFSAR changes for consistency among DSC types and terminology clarifications.

In addition to the nine changes requested by applicant in their letter dated March 21, 2021, the applicant requested three additional scope changes in letters dated October 22, 2021, June 29, 2022, and September 30, 2022. The additional scope changes include:

Additional Scope Change No. 1:
UFSAR revisions associated with transfer cask lifting heights and consideration of severe weather.

Additional Scope Change No. 2:
UFSAR revisions associated with maintaining water in the annulus.

Additional Scope Change No. 3:
Design changes to the Matrix Loading Crane (MX-LC).

The amended CoC, when codified through rulemaking, will be denoted as Amendment No. 3 to CoC No. 1042. This SER documents the staff's review and evaluation of the proposed amendment. The staff followed the guidance of NUREG-2215, "Standard Review Plan for Spent Fuel Dry Storage Systems and Facilities," 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 TS requested in the amendment as supported by the submitted revised UFSAR (see ML21102A287, ML21174A231, ML21209A098, ML21295A260, ML21334A206, ML22273A031, ML22304A217, ML22318A205, and ML22355A219) 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 staff finds that the description of the proposed changes requested by the applicant are adequate to allow staff's detailed evaluation as documented in other 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 and determined that the following changes are applicable to the principal design criteria evaluation:

Change No. 1:
Add three new HLZCs for the EOS-89BTH Dry Shielded Canister (DSC), with increased heat load up to 1.7 kW per fuel assembly, which reduces the minimum cooling time to 1 year.

Change No. 2:
Add a variable-lead thickness EOS–TC125 for transfer with the EOS-89BTH DSC.

Change No. 3:
Add ATRIUM 11 fuel as an allowable content in the EOS-89BTH DSC. Reran the limiting GNF2 and ABB-10-C cases to reduce the statistical uncertainties and increase the enrichment limits.

Change No. 4:
Update the criticality evaluation to allow short-loading the EOS-89BTH DSC with less than 89 fuel assemblies to increase the enrichment limits.

Change No. 5:
For the TS; a revision to allow for PA-AUT and to utilize a single pass HA-GTAW or multipass GTAW on the OTCP.

Change No. 6:
For the TS; a revision to reduce EOS-37PTH HLZC 1 and 2 time limit for transfer to 8 hours.

Change No. 7:
Incorporate a method to determine new loading patterns based on the maximum allowable heat load per DSC and per location specified in the TS. All HLZCs and time limits for transfer for the EOS89BTH DSC transferred in the EOS–TC125 are moved from the TS to UFSAR chapter 2.

Change No. 8:
For the single bottom forging EOS-DSCs, waive the fabrication pressure test requirement.

Additional Scope Change No. 3:
Design changes to the Matrix Loading Crane (MX-LC).

2.1 Classification of SSC

The applicant did not make any changes to the classification of SSCs for the NUHOMS® EOS system and did not add additional SSCs to the NUHOMS® EOS system. Therefore, the staff determined that no additional review of the classification of SSCs or additional SSCs to the NUHOMS® EOS system is required for review of this amendment.

2.2 Spent Nuclear Fuel Specifications - Change No. 1 and Change No. 3

In Change No. 1, the applicant added three new heat zone loading configurations (HLZCs) for the EOS-89BTH dry shielded canister (DSC) with a maximum heat load of 48.2 kW (in the EOS horizontal storage module (HSM) and in the lower compartment of the EOS horizontal storage module-matrix (HSM–MX)) and reduced the minimum cooling time for boiling water reactor (BWR) fuel stored in the EOS-89 DSC from two years to one year. The applicant provided corresponding revisions to UFSAR chapter A.2 for the EOS Matrix HSM. In addition, the applicant included thermal evaluations for the new HLZCs in UFSAR appendix 4.9.8 and provided revisions to the shielding analysis in chapters 6 and A.6. The applicant also included the new HLZCs in the revisions to the radiation protection analysis in UFSAR chapters 11 and A.11 and the accident analysis in UFSAR chapters 12 and A.12. The staff's review of the applicant's thermal, shielding, radiation protection and accident analysis associated with the new HLZCs for the EOS-89BTH DSC are provided in the corresponding sections of this SER.

In Change No. 3, the applicant added ATRIUM 11 fuel as an allowable content in the EOS-89BTH DSC. The applicant provided the design characteristics for the ATRIUM 11 fuel in UFSAR table 2-3. The information provided by the applicant was consistent with fuel designs that were previously approved for storage in the EOS-89BTH DSC. The applicant provided an update to the structural analysis for the storage of the ATRIUM 11 fuel in UFSAR chapter 3. The applicant updated the effective thermal properties for the BWR spent fuel assemblies in the EOS-89BTH DSC to account for the storage of ATRIUM 11 fuel in UFSAR chapter 4. The applicant updated the BWR source specifications to account for the ATRIUM 11 fuel in the shielding analysis in UFSAR chapters 6 and A.6. The applicant also included the storage of the ATRIUM 11 fuel in the revisions to the radiation protection analysis in UFSAR chapters 11 and A.11 and the accident analysis in UFSAR chapter 12.

The staff reviewed the information provided by the applicant on the new HLZCs and the additional fuel to be stored in the EOS-89BTH DSC. The staff determined that the applicant provided a complete description of the new HLZCs and the characteristics of the ATRIUM 11 BWR fuel assemblies for the EOS-89 BTH. The staff's review of the applicant's thermal, shielding, radiation protection and accident analysis associated with the storage of ATRIUM 11 fuel are provided in the corresponding sections of this SER.

2.3 Design Criteria for Safety Protection Systems – Additional Scope Change No. 3

In Additional Scope Change No. 3, the applicant provided design changes to the Matrix Loading Crane (MX-LC). The staff reviewed the information provided by the applicant and determined that the applicant provided a complete description of the changes proposed to the MX-LC.

The staff's review of the applicant's proposed changes to the MX-LC is included in the structural evaluation associated with Additional Scope Change No. 3 in sections 2.4.2, 3 and 9 of this SER.

2.4 Safety Protection Systems

Changes made by the applicant that impact design criteria safety protection systems, and the staff's review of those changes, are described in the following subsections.

2.4.1 General – Change No. 5 and Change No. 8

The applicant included revisions to the chapter of the UFSAR for general information to describe the revisions associated with Change No. 5, which sought a revision to the TS to allow for phased array automated ultrasonic testing (PA-AUT) for the examination of the outer top cover plate (OTCP) to DSC shell weld. and to utilize a single pass high amperage gas tungsten arc weld (HAGTAW) for the OTCP to DSC shell weld as an alternative to the multipass gas tungsten arc welding (GTAW) process. The applicant revised the description of the EOS37PTH DSC and the EOS89BTH DSC to state that the top and bottom end confinement boundary welds are multiple-layer welds. As noted in Change No. 5, the applicant stated that the OTCP weld could be either be a multipass weld inspected by penetrant testing (PT) or a single pass high amperage gas tungsten arc weld (HAGTAW) that is examined by phased array ultrasonic testing (PA-AUT). The applicant revised the drawings for the EOS37PTH DSC and the EOS89BTH DSC to include the option of UT of the OTCP-toDSC shell weld.

The staff reviewed the applicant's description of the changes to the DSC and determined that the applicant's description is consistent with the change described in the application. The staff reviewed the drawings for EOS-37PTH DSC and the EOS-89BTH DSC and determined that the drawing revisions identified the option for single and multipass welding and use of UT as the nondestructive examination (NDE) for the OTCP-to-DSC shell weld. The staff's review of the structural evaluation of the HA-GTAW weld for the OTCP is included in SER section 3. The staff's review of the UT acceptance criteria is included in SER section 10.

The applicant included revisions to the UFSAR section 2.4 to describe Change No. 8, which waives the fabrication pressure test required in American Society of Mechanical Engineers Boiler and Pressure Vessel (ASME B&PV) Code, Section III, NB-6000 for the EOS-37PTH and the EOS-89BTH DSCs with a single piece bottom forging. The applicant stated that the confinement boundary weld between the DSC shell and the single piece bottom forging, the weld between the DSC shell and the inner top cover (including drain port cover and vent port plug welds), and structural attachment weld between the DSC shell and OTCP are in accordance with ASME B&PV Code Section III, subsection NB, with alternatives to the ASME code described in section 4.4.4 of the TS.

The applicant included drawings showing the single piece bottom forging for the EOS-37PTH DSC and the EOS-89BTH DSC in UFSAR chapter 1. The drawings indicate that the additions of the single piece bottom forging for the EOS-37PTH DSC and the EOS-89BTH DSC were implemented by a 10 CFR 72.48 change. The application included revised drawings descriptions for the EOS-37PTH DSC and the EOS-89BTH DSC stating that the fabrication pressure test in ASME B&PV Code, Section III, NB-6000 is not required for these DSCs with the single piece bottom forging. The applicant also provided a description of the change in UFSAR section 1.2.1 for the EOS-37PTH DSC and the EOS-89BTH DSC. In addition, the applicant provided UFSAR revisions in the structural, confinement, and the acceptance tests and maintenance chapters associated with Change No. 8.

The staff reviewed the changes to the chapter of the UFSAR for design criteria, the revised drawings, TS changes, and the general description to support Change No. 8. The applicant provided a technical justification for the change that included a description of nondestructive examination (NDE) methods required by the ASME B&PV Code and leak testing performed in accordance with ANSI N14.5 for DSCs with the one-piece bottom forging. The applicant's justification for waiving the pressure test in the TS states that the ASME B&PV Code required pressure for the fabrication pressure test is too low to stress a single piece bottom and bottom-to-shell weld and cause preexisting defects to propagate into leaks. The TS also state that the helium leak test that is performed in accordance with ANSI N14.5 is a more sensitive method for detecting leaks. The fabrication process of the DSCs with a one-piece bottom forging uses a full penetration weld to the DSC shell. The weld is examined using ASME Section III, subsection NB requirements for radiographic testing (RT) and PT NDE methods, which are sufficient to demonstrate the integrity of the weld.

The staff determined that these NDE methods are acceptable because they are consistent with the NDE methods specified in ASME B&PV Code, Section III, subsection NB for the construction of austenitic stainless steel pressure vessels. The staff determined that the stresses on the bottom-to-shell during the NB-6000 pressure test are well below the yield strength of the material. The staff determined that the applicant's change to eliminate the NB-6000 pressure test for DSCs with a forged bottom lid was acceptable because any defects in the weld would be below the detection limit of RT and the testing pressure required by NB-6000 would be insufficient to stress such a non-detectable flaw such that it would propagate and create a leak path. Furthermore, a helium leak test will suffice as it provides a greater sensitivity for detection of leaks. Therefore, for purposes of design criteria evaluation, the staff determined, based on these reasons, that the proposed change in Change No. 8 was acceptable. Additional discussion of Change No. 8 is provided in sections 3, 5, and 10 of this SER.

2.4.2 Structural – Change No. 1 and Additional Scope Change No. 3

The applicant updated the structural EOS-DSC Design Criteria to address Change No. 1 which included a revision to the maximum heat load of the EOS-89BTH DSC to 48.2 kW per DSC. Included with Change No. 1, the applicant also updated the maximum heat load for any single assembly to 1.7 kW for the EOS-89BTH DSC. The applicant also introduced design changes to the MX-LC as Additional Scope Change No. 3.

The staff's review of the applicant's structural evaluation associated with Change No. 1 and additional scope Change No. 3 are included in section 3 of this SER.

2.4.3 Thermal – Change No. 1, Change No. 6, and Change No. 7

The applicant updated the thermal EOS-DSC Design Criteria in UFSAR section 2.4.3 to address Change No. 1 which included a revision to the maximum heat load of the EOS-89BTH DSC to 48.2 kW per DSC. The applicant updated the thermal EOS-DSC Design Criteria in UFSAR section A.2.4.3 to address Change No. 1 which included a revision to the maximum heat load of the EOS-89BTH DSC to 48.2 kW per DSC in the lower compartment of the EOS-HSM-MX and 41.8 kW per DSC in the upper compartment of the HSM-MX. The applicant clarified that UFSAR section 4.5.4 calculates the minimum time for transfer for EOS-37PTH HLZC's and concludes that 10 hours is sufficient for EOS-37PTH HLZCs 1 and 2 consistent with Change No. 6. The applicant stated that reducing the time limit to 8 hours increases the margin to the maximum allowable fuel cladding temperature limit and provides greater flexibility and consistency. The applicant also includes a description of the methodology for Evaluating Additional HLZCs in EOS-89BTH DSC in UFSAR section 2.4.3.1 consistent with Change No. 7.

The staff's review of the applicant's thermal evaluation associated with Changes No. 1, No. 6 and No. 7 is included in section 4 of this SER.

2.4.4 Shielding and Radiation Protection – Change No. 2

In Change No. 2 the applicant added a variable-lead thickness EOS–TC125 for transfer with the EOS-89BTH DSC. The applicant stated that the shielding evaluation for the EOS–TC125 with a minimum lead thickness for transfer with the EOS-89BTH DSC is included in UFSAR chapters 6 and A.6. The applicant also included revisions to the radiation protection analysis in UFSAR chapters 11 and A.11 and the accident analysis in UFSAR chapters 12 and A.12. The staff's review of the applicant's shielding, radiation protection and accident analysis associated with the new variable-lead thickness EOS–TC125 for transfer with the EOS-89BTH DSC are provided in the corresponding sections of this SER.

2.4.5 Criticality – Change No. 4

The applicant updated the criticality EOS-DSC Design Criteria to address Change No. 4 to allow short-loading the EOS-89BTH DSC with less than 89 fuel assemblies to increase the enrichment limits. The applicant referenced figure 10 in the TS which identifies the empty locations in short-loading configurations for the EOS-89BTH DSC.

The staff's review of the applicant's criticality evaluation associated with Change No. 4 is included in section 7 of this SER.

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. This finding is reached based on a review that considered the regulation itself, appropriate regulatory guides, applicable codes and standards, and accepted engineering practices. The evaluation of the principal design criteria provides reasonable assurance that the NUHOMS® EOS system will allow safe storage of spent fuel. Some of the key findings from the staff's review of Amendment No. 3 include:

F2.1 The UFSAR and docketed materials adequately identify and characterize the spent nuclear fuel (SNF) to be stored in the dry storage system (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 72.236(c).

F2.4 The UFSAR and docketed materials adequately define the bounding conditions under which the DSS is expected to operate in accordance with the requirements of 10 CFR 72.236.

F2.5 The UFSAR and docketed materials meet the regulatory requirements for design bases and criteria for thermal consideration as given in 10 CFR 72.236(f).

3.0 STRUCTURAL EVALUATION

The staff reviewed the information provided by the applicant and found six changes that required structural evaluation:

Change No. 3:
Add ATRIUM 11 fuel as an allowable content in the EOS-89BTH DSC.

Change No. 5:
Revise TS to utilize a single pass high amperage gas tungsten arc weld (HA-GTAW) on the OTCP, and to allow for PA-AUT on the outer top cover plate weld.

Change No. 7:
Incorporate a method to determine new loading patterns based on the maximum allowable heat load per DSC and per location specified in the TS. All HLZCs and time limits for transfer of the EOS-89BTH DSC in the EOS-TC125 are moved from the TS to UFSAR chapter 2.

Change No. 8:
Waive the fabrication pressure test requirement for the single bottom forging EOS-DSCs.

Change No. 9:
Revise TS for consistency among DSC types and terminology clarifications.

Additional Scope Change No. 3:
Design changes to the Matrix Loading Crane (MX-LC).

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

3.1 Change No. 3: Addition of ATRIUM 11 fuel as an allowable content in the EOS-89BTH DSC

In Change No. 3, the applicant proposed to add ATRIUM 11 fuel as an allowable content in the EOS-89BTH DSC. The applicant performed cladding structural analysis using the LS-DYNA finite element (FE) program to evaluate structural integrity of the ATRIUM 11 fuel type in the DSC. The results of the analysis are provided in sections 3.9.6.5 and 3.9.6.6 of appendix 3.9.6, "NUHOMS® EOS FUEL CLADDING EVALUATION," of the UFSAR.

Two drop cases (side and corner drops) were considered by the applicant. The methodology employed to evaluate the ATRIUM 11 fuel type was identical to the previously reviewed and accepted methodology for the 7x7, 8x8, 9x9, and 10x10 fuel types, as described in the UFSAR. By using the same analytical methodology, the applicant calculated the maximum cladding bending stress of the 11x11 fuel type (ATRIUM 11 fuel) and showed that the maximum bending stress was less than the yield stress. The applicant also provided the calculated maximum principal strain of the corner drop for the ATRIUM 11 fuel rod. The applicant's analysis showed that the calculated strain was well below the yield strain of the fuel assembly.

The staff reviewed the structural analysis and its results and found that the calculated maximum bending stress and strain are smaller than the allowable stress and strain. Therefore, addition of ATRIUM 11 fuel as an allowable content in the EOS-89BTH DSC is acceptable.

3.2 Change No. 5: Utilization of a single pass high amperage gas tungsten arc weld on the OTCP and allowance of UT on the OTCP weld

In Change No. 5, the applicant proposed to use a single pass high amperage gas tungsten arc weld (HA-GTAW) on the OTCP and allow for PA-AUT of the OTCP-to-DSC shell weld. The applicant provided a justification of the proposed change that the use of a single pass HA-GTAW results in a faster weld and less occupational exposure, and the use of ultrasonic examination (UT) allows to verify the welds for more stringent weld examination.

In subsection 3.9.1.2.2, "DSC Shell Stress Criteria," of the UFSAR, the applicant stated that the OTCP-to-DSC shell weld, which is a partial penetration weld, is to be evaluated using a joint efficiency factor of 0.8. Per NUREG-2215, the minimum inspection requirement for end closure welds is multipass dye PT using a stress (allowable) reduction factor of 0.8. The allowable weld stresses are summarized in table 3.9.1-4 of the UFSAR.

The staff reviewed the proposed change with respect to stress criteria for the design and analysis of the DSC structure and found that the proposed change is acceptable because the applicant did not change the stress criteria set forth in tables 3.9.1-4 and 3.9.1-4a of the UFSAR, which are applicable to a multipass GTAW OTCP-to-DSC shell weld with multiple PT examinations. The stress criteria in these tables were previously reviewed and accepted by the staff for design and analysis of the DSC.

For a OTCP-to-DSC shell weld conducted using either multipass GTAW or the single pass HA-GTAW method, the applicant stated in section 3.9.1.2.2 of the UFSAR that a stress reduction factor is not required when the weld is examined using PA-AUT. In UFSAR section 3.9.1.2.7.2, the applicant stated that the resulting minimum required weld size, for a stress ratio of 0.90, is 0.30 inch. In section 10.1.3.1 of the UFSAR, the applicant included acceptance criteria for the PA-AUT examination that is consistent with the stress analysis cited in section 3.9.1.2.7.2 of the UFSAR. Since there are no changes in mechanical design strength parameters (I.e., yield strength, ultimate strength, weld strength), the design and analysis of the DSC remain valid. Therefore, the staff determines that the proposed change does not affect the structural integrity of the DSC under the combined loads of normal, off-normal, and accident conditions and, therefore, the proposed change is acceptable. More evaluations are provided in sections 8 and 10 of this SER.

3.3 Change No. 7: Incorporation of a method to determine new loading patterns based on the maximum allowable heat load per DSC and per location specified in the TS. All HLZCs and time limits for transfer of the EOS-89BTH DSC in the EOS-TC125 are moved from the TS to UFSAR chapter 2

In Change No. 7, the applicant proposed an approach and incorporated a method to determine new loading patterns based on the maximum allowable heat load per DSC and per location specified in the TS. All HLZCs and time limits for transfer of the EOS-89BTH DSC in the EOS-TC125 are moved from the TS to UFSAR chapter 2. The applicant provided a justification of the proposed change that allows flexibility in developing heat loading plans, in particular when performing full-core offload of shutdown cores.

In section 3.6.2 of the UFSAR, the applicant proposed to increase the maximum heat load from 43.6 kW to 48.2 kW for the EOS-89BTH DSC based on the evaluations of the new HLZCs. Since there was no information provided related to potential impacts and changes on the design and functions of the EOS-89BTH DSC due to the heat load increase, the staff issued a request for additional information (RAI) for any impacts and changes by the heat load increase on: (i) design functions and criteria, (ii) mechanical and thermal properties, (iii) stress and strain criteria with associated limits, and (iv) methodologies and technical assumptions for the design and analysis of the EOS-89BTH DSC.

The applicant provided responses to the RAI that there have been no impacts and changes made to the design functions and criteria, mechanical and thermal properties, stress and strain criteria with associated limits, methodologies, and assumptions due to the heat load capacity increases or temperature changes based on the proposed new additional HLZCs, and, as a result, no additional safety evaluations for the structural design and analysis of the EOS-89BTH DSC were performed. The technical justification for no changes and evaluations is that the EOS-89BTH DSC was previously analyzed and designed with the maximum temperature of 500 °F based on the heat load of 50 kW, which is still bounding for the maximum temperature of 478 °F based on the heat load of 48.2 kW for the proposed new additional HLZCs as described in chapter 4, “THERMAL EVALUATION,” of the UFSAR. Therefore, the evaluations in section 3.9.6 of the UFSAR remain bounding.

The staff confirmed that the evaluations of the EOS-89BTH DSC under the maximum temperature of 500 °F based on the heat load of 50 kW were previously reviewed and accepted by the staff and therefore determined that the EOS-89BTH DSC will maintain its structural integrity and perform its intended functions under the maximum temperature of 478 °F based on the proposed new heat load of 48.2 kW due to the new additional HLZCs in the UFSAR.

In addition, new proposed HLZCs could be evaluated using the methodology in section 2.4.3.1, "Methodology for Evaluating Additional HLZCs in EOS-89BTH DSC," of the UFSAR. In that case, the applicant stated in the RAI responses that the potential impact of temperature changes on the structural system resulting from any new HLZCs will be addressed by verifying that the following are met:

(1) The temperature profile considered in the NRC-approved thermal stress analysis still bounds the updated temperature profile, and

(2) The temperature at which mechanical properties, including the allowable stresses, of the system were evaluated and approved by the NRC still bounds the updated maximum temperature.

The staff reviewed the applicant's response and found the methodology acceptable because the applicant will evaluate the temperature profile and temperature due to any new HLZCs and make sure that they are bounded by the temperature profile and temperature, which were previously reviewed and accepted by the staff.

3.4 Change No. 8: Waive the fabrication pressure test requirement for the single bottom forging EOS-DSCs

In Change No. 8, the applicant proposed to waive the fabrication pressure test requirement for the single bottom forging EOS-DSCs. The DSC is not a complete pressure vessel until the top closure is welded following placement of fuel assemblies within the DSC. Due to the inaccessibility of the shell and lower end closure welds following fuel loading and top closure welding, the pressure testing of the DSC is performed in two parts. The DSC shell including all longitudinal and circumferential welds is pneumatically tested and examined at the fabrication facility when using the three plate bottom assembly. The purpose of a pressure test is to check the welds and examine leakage for joints, connections, and regions of high stress of the DSC. The confinement boundary pressure test by either hydrostatic or pneumatic methods in accordance with the requirements of ASME B&PV Code Section II, Division 1, subsections NB-6300, is described in subsection 8.4.7.2, "Weld Testing and Design," of NUREG-2215.

The applicant's justification for waiving the pressure test in the TS states that the ASME B&PV Code required pressure for the fabrication pressure test is too low to stress a single piece bottom and bottom-to-shell weld and cause preexisting defects to propagate into leaks. The applicant's description of the fabrication process of the DSCs with a one-piece bottom forging uses a full penetration weld to the DSC shell. The weld is examined using RT and PT NDE methods. Additionally, a helium leakage test is performed on the confinement boundary in accordance with ANSI N14.5. This leakage test provides assurance that the confinement body is free of defects that could lead to a leakage rate greater than the allowable design basis leakage rate specified in the confinement analyses.

The staff reviewed the proposed change of removing the pressure test requirement per NB-6300 for the bottom assembly during fabrication only when a single bottom forging option is used, and found it acceptable because: (i) the low test pressure during the fabrication, which is smaller than design pressure used in the structural analysis, does not stress a single piece bottom and bottom-to-shell weld sufficiently to cause preexisting defects to propagate into leaks, and (ii) the helium leak test is far more sensitive than the pressure test for the purpose of finding leaks during the fabrication. Additional discussion of this change is provided in section 2 of this SER.

3.5 Change No. 9: Revisions of TS for consistency among DSC types and terminology clarifications

In Change No. 9, t the applicant provided a proposed change to the TS for consistency. The staff reviewed the proposed TS section 4.4.4, where the applicant proposed to waive the fabrication pressure test requirement for the single bottom forging EOS-DSCs. For the reasons provided in subsection 3.4 above and section 10 of the SER, the staff finds the structural TS change acceptable.

3.6 Additional Scope Change No. 3: Design changes to the Matrix Loading Crane (MX-LC).

In Additional Scope Change No. 3, the applicant proposed several changes in Appendix A of the UFSAR to the design of the Matrix Loading Crane (MX-LC), which is a type of handling equipment used to load DSCs into the HSM-MX. The applicant described the MX-LC in section A.2.1.4.2.1 of the UFSAR with further detail in the referenced report, “ASME NOG-1 Compliance Assessment.”

The applicant listed the previously established lifting requirements for the NUHOMS® EOS in section 5.2.1 of appendix A, “NUHOMS EOS System Generic Technical Specifications,” to the CoC. These technical specifications (TS) require that only single-failure-proof equipment is used when lifting the transfer cask (TC) or DSC above the maximum lift height, which is the height supported by the drop analyses. The applicant proposed the MX-LC as a single-failure-proof handling device allowed to load DSCs into the HSM-MX above the maximum lifting height. The staff finds these lifting requirements meet the guidance on the drop accident condition in NUREG-2215 and the handling guidance in NUREG-0612, “Control of Heavy Loads at Nuclear Power Plants.”

The applicant depicted the MX-LC in figure A.2-2 of the UFSAR with details in Drawings No. 41041-LC-1000, 41041-LC-1001, 41041-LC-1002, 41041-LC-1003, 41041-LC-1004, 41041-LC-1006, 41041-LC-1007, and 41041-LC-1008. The MX-LC is a telescopic gantry crane. The MX-LC lower boom assembly consists of four towers with gantry boxes at their base that ride on crane rails. Jacking screws lift the upper boom assembly vertically from the lower boom assembly. The drive motors and gearboxes for the screws are located in the lower boom gantry boxes. The upper boom assembly consists of four booms lifted by the jacking screws, cross bracing with seismic dampers between the booms, two header beams connecting the tops of the four booms, and two cross beams on top of and perpendicular to the header beams. Two trolley assemblies, atop of the cross beams, are moved by actuators to slide on pads toward the HSM-MX. Two lift links are attached to the trolley assemblies. The lift links connect to the TC skid which supports the TC containing the DSC.

The applicant designed the MX-LC to meet the design criteria of single-failure-proof handling systems described in NUREG-0612, specifically section 5.1.6. These criteria include providing redundant load paths or large safety factors and the use of NUREG-0554, "Single-Failure-Proof Cranes for Nuclear Power Plants," and ANSI N14.6, “Special Lifting Devices for Shipping for Shipping Containers Weighing 10000 Pounds (4500 kg) or More,” for design, fabrication, installation, and testing. The applicant also followed portions of ASME NOG-1, “Rules for Construction of Overhead and Gantry Cranes,” for a type I gantry crane to design the MX-LC. The staff notes that guidance in Regulatory Guide 1.244, “Control of Heavy Loads at Nuclear Facilities,” endorses ASME NOG-1 for the design of single-failure-proof cranes.

The applicant defined specific design criteria for the MX-LC according to section 4000 of ASME NOG-1. The applicant used stress allowables from section 4300 for the stress analyses of the MX-LC, required minimum safety factors for kinematic stability from section 4457, and used load combinations from section 4140. The applicant noted that the MX-LC was not designed as the type of overhead crane or typical gantry crane that ASME NOG-1 considers in its requirements. As a result of this, the applicant has taken a number of exceptions to the ASME NOG-1 design code. To address this, the applicant developed the “ASME NOG-1 Compliance Assessment,” table, reference A.2-21 in the UFSAR. In the compliance table, the applicant individually addressed each requirement of ASME NOG-1 and discussed how the MX-LC complied with the requirement or justified the exception to the requirement with consideration of NRC guidance for single-failure-proof handling systems. When not adhering to ASME NOG-1 for the structural design of MX-LC components, the applicant followed other industry codes such as ASME B30, “Safety Standard for Cableways, Cranes, Derricks, Hoists, Hooks, Jacks, and Slings,” ANSI N14.6, including the safety factors of six with respect to material yield strength and ten for ultimate strength required by ANSI N14.6 for special lifting devices. The staff reviewed the application of the ASME NOG-1 design code criteria and the exceptions taken by the applicant for the analyses and safety features provided for the MX-LC and finds that the design criteria of the MX-LC provide structural integrity and safety features that meet the guidance on single-failure-proof criteria in NUREG-0612 and NUREG-0554 and, therefore, are acceptable.

The applicant analyzed the MX-LC for normal, off-normal, and accident conditions in four configurations covering the combinations of the upper boom in the lowered and raised position and the trolley assemblies both in the fully extended and fully retracted positions. The applicant determined the design loads according to section 4130 of ASME NOG-1 including the dead load of the MX-LC, live loads, normal operating dynamic loads, wind loads, and seismic loads. The applicant used the load combinations in section 4140 of ASME NOG-1 for the structural demands. Tables A.2-3 through A.2-5 of the UFSAR list the design parameters, including the 162-ton (324,000-pound) rated load and maximum component speeds, and the applicant considered an operating temperature of 0 °F to 117 °F. With this design information, the applicant performed stress analyses of the structural elements and connections of the MX-LC and structural and kinematic stability analyses to demonstrate the MX-LC will not significantly slide, tip, or buckle.

The applicant designed the MX-LC to retain control of the load during the design basis earthquake accident condition. The applicant considered five, three-dimensional time history ground motions for the seismic analysis. The applicant used the response spectrum from Regulatory Guide 1.60, “Design Response Spectra for Seismic Design of Nuclear Power Plants,” scaled to a zero-period acceleration of 0.3 g in both horizontal and vertical directions with 5% of critical damping.

The applicant included several seismic design features in the MX-LC: the braces in the upper boom assembly include viscous dampers; retention at each gantry secure the wheels to the rails; and a pair of wheel chocks are installed at each gantry box to prevent the MX-LC from sliding along the rails. The applicant assumed these wheel chocks were installed in the seismic analyses of the MX-LC. As the seismic analysis is part of the single-failure-proof criteria per NUREG-0612 and ASME NOG-1, the staff concludes that the MX-LC is a single-failure-proof device only when operated with the wheel chocks installed. The applicant addressed this in the operating procedure in appendix A.9 of the UFSAR by requiring the wheel chocks be installed before allowing the MX-LC to lift the loaded TC above the maximum lift height in TS 5.2.1.

However, the applicant requested no changes as part of this amendment request to the MX-LC as described in Appendix B of the UFSAR. The similar operating procedures in appendix B.9 of the UFSAR, which control the transfer and retrieval of the NUHOMS® 61BTH Type 2 DSC to and from the HSM-MX using the MX-LC, do not include the installation of wheel chocks. The staff reiterates that the MX-LC is a single-failure-proof device only when operated with the wheel chocks and wheel chocks must be installed before allowing the MX-LC to lift the loaded TC above the maximum lift height in TS 5.2.1. Therefore, changes to the operating procedures in appendix B.9, similar to changes made to appendix A.9, would be required for use of the MX-LC to lift the loaded NUHOMS® 61BTH Type 2 DSC above the maximum lift height in TS 5.2.1.

For the stress analysis, the applicant created a structural model of the MX-LC in the structural analysis programs, SAP2000 and RISA-3D, and performed a nonlinear time history analysis. The applicant compared the SAP2000 stress results from the controlling load combinations to the allowable stresses from table 4311-1 of ASME NOG-1. The applicant listed the ratio of the maximum induced stresses to the allowable stress for the different structural components of the MX-LC in table A.2-6 of the UFSAR. All of the stress ratios are less than 1 indicating the induced stresses were less than the allowable stresses for the normal, off-normal, and accident conditions. Based on the results of the stress analysis, the staff finds that the MX-LC has sufficient structural integrity to maintain control of the loaded TC under the normal, off-normal, and accident conditions.

The applicant determined that lamellar tearing of the weld joints would not occur in the MX-LC. The staff notes that lamellar tearing primarily occurs in rolled steel materials that have low through-thickness ductility. The applicant designed the primary load bearing members of the

MX-LC using plate steel, not rolled steel. The applicant also required that all butt welds be radiographed and all other primary welds be examined with magnetic particle or dye penetrant following section 4251.4 of ASME NOG-1. Based on this consideration of lamellar tearing, the staff finds that the design of the MX-LC meets the guidance on the specifications and design criteria for lamellar tearing in NUREG-0554 and is acceptable.

The applicant determined that structural fatigue will not affect the use of the MX-LC. The applicant estimated that the MX-LC will be subjected to a total of 7,500 full-load cycles over the 50-year operating period. This estimate is significantly less than the 20,000 cycles required in section 4350 of ASME NOG-1 as the minimum full-load cycles for considering the effects of fatigue on the structure. The applicant required that all welds and welding procedures be performed and qualified in accordance with the requirements of AWS D1.1, "Structural Welding Code." Based on the consideration of fatigue and the applicant's welding requirements, the staff finds that the design of the MX-LC meets the guidance on the specifications and design criteria for structural fatigue and welding procedures in NUREG-0554 and NUREG-0612 and is acceptable.

The applicant designed the MX-LC with a number of safety features intended to provide a combination of fail-safe features, increased safety factors, and ASME NOG-1 design criteria for compliance with the single-failure-proof criteria. The applicant designed the screw spindle drives to be self-locking and capable of holding the load in a loss of power event or drive motor failure. The applicant designed the gantry boxes on the track rails with self-locking drive motors and the lift links on the trolley rails with self-locking actuators and end stops. The applicant also provided service brakes and emergency brakes for the gantry boxes. The applicant designed the MX-LC such that the self-locking features will maintain control of the load if the system is de-energized, and the applicant provided an emergency stop button to de-energize the system on the operator control panel. The applicant designed travel encoders and sensors with stop limits on the jacking screws. The applicant did not provide a load sensor for the MX-LC. However, the staff notes the following design features of the MX-LC affecting overloading and load hangup: (1) the lifted weight is known prior to handling; (2) the MX-LC structural frame surrounds the lifted components preventing interference; (3) the MX-LC has a slow lifting speed; (4) interlocks within the MX-LC controller prevent lateral movements while lifting; and (5) the lifting is monitored by a crane operator and dedicated spotter. Therefore, the staff finds the design and procedures for the MX-LC are sufficient to prevent an overload and hangup from occurring and a load sensing system is not required for the MX-LC to satisfy the single-failure-proof handling criteria. Based on the design of the safety features for the MX-LC, the staff finds that the MX-LC design meets the guidance on safety features and hoisting machinery in NUREG-0554 and NUREG-0612 and is acceptable.

The applicant described the maintenance and testing requirements for the MX-LC in sections A.2.1.4.2.1.10 through A.2.1.4.2.1.15 of the UFSAR. The applicant required the inspection and testing of the MX-LC be performed in accordance with section 7000 of ASME NOG-1. The staff finds that the applicant's maintenance and testing requirements for the MX-LC meets the guidance on testing and preventive maintenance in NUREG-0554 and NUREG-0612 and is acceptable.

Based on the review described above, the staff finds that the applicant has adequately designed the MX-LC to provide single-failure-proof handling capabilities and handle the NUHOMS® EOS system in a manner that meets the requirements of 10 CFR 72.236 under normal, off-normal, and accident conditions.

3.7 Evaluation Findings

The staff concludes that the structural performance of the EOS-89BTH DSC and EOS-TC125 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 4 "STRUCTURAL EVALUATION," of NUREG-2215, have been satisfied. The evaluation of structural performance provides reasonable assurance that the NUHOMS® EOS 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 No. 3 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 EOS-89BTH DSC 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 EOS-89BTH DSC and the EOS-37PTH DSC for 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 EOS-89BTH DSC and the EOS-37PTH DSC under various design loads are determined by the FE analysis. Total calculated stresses under the combined loads of normal, off-normal, and accident conditions are acceptable and are found to be within the limits given in the applicable codes.

F3.3 The SNF storage cask is designed to store the SNF safely for the term proposed in the application, and therefore meets the requirements in 10 CFR 72.236(g).

F3.4 The SNF storage cask and its systems important to safety have been evaluated by appropriate test or other acceptable means and have demonstrated that they will reasonably maintain confinement or radioactive material under normal, off-normal, and credible accident conditions, and therefore meet the requirements in 10 CFR 72.236(l).

4.0 THERMAL EVALUATION

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

Change No. 1:
Add three new HLZCs for the EOS-89BTH DSC, with increased heat load up to 1.7 kW per fuel assembly, which reduces the minimum cooling time to 1 year.

Change No. 2:
Add a variable-lead thickness EOS-TC125 for transfer with the EOS-89BTH DSC.

Change No. 3:
Add ATRIUM-11 fuel as an allowable content in the EOS-89BTH DSC.

Change No. 6:
For the NUHOMS® EOS System TS, revise to reduce EOS-37PTH HLZC 1 and 2 time limit for transfer to 8 hours.

Change No. 7:
Incorporate a method to determine new loading patterns based on the maximum allowable heat load per EOS-89BTH DSC and per location specified in the TS.

Change No. 9:
TS and UFSAR changes for consistency among DSC types and terminology clarifications.

Additional Scope Item No. 2:
UFSAR revisions associated with maintaining water in the annulus.

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

4.1 Change No. 1: Add Three HLZCs for the EOS-89BTH DSC in a Type 1 Basket

The applicant increased the heat load capacity of the EOS-89BTH to 48.2 kW in the EOS-HSM, 48.2 kW in the lower compartment of the EOS-HSM-MX (NUHOMS® Matrix), and 41.8 kW in the upper compartment of the EOS-HSM-MX; the staff verified this was shown in the NUHOMS® EOS System TS figure 11. The applicant also increased the per assembly heat load to 1.7 kW; the staff also verified this was shown in the NUHOMS® EOS System TS figure 11. In chapter 2 of the UFSAR, the applicant added three new HLZCs (HLZCs 4, 5, and 6 shown in figures 2-2d through 2-2f of the UFSAR), and in appendices 4.9.8 and A.4 of the UFSAR, the applicant analyzed the thermal design function in a Type 1 basket that is based on the decay heat limitations in NUHOMS® EOS System TS figure 11. The applicant provided storage and transfer evaluations of HLZCs 4, 5, and 6 in the EOS-HSM and EOS-TC125 TC in appendix 4.9.8 of the UFSAR. The applicant also provided evaluations of HLZCs 4, 5, and 6 in the EOS-89BTH in the EOS-HSM-MX in appendix A.4 of the UFSAR. The staff evaluates the addition of the three HLZCs for the EOS-89BTH DSC in a Type 1 basket that is in the EOS-HSM or EOS-HSM-MX in sections 4.1.1 and 4.1.2 of this SER, respectively.

4.1.1 Description, storage, and transfer of HLZCs 4, 5, and 6 in the EOS-HSM

The applicant provided the descriptions of HLZCs 4, 5, and 6 in figures 2-2d through 2-2f of the UFSAR. An applicant-proprietary sensitivity study performed by the Pacific Northwest National Laboratory concluded that loading higher decay heat fuel assemblies in the outer zones resulted in a lower peak cladding temperature (PCT), as compared to when the decay heat is concentrated in the inner zones that resulted in a higher PCT. The applicant maximized the decay heat in the outer zones to evaluate the basket temperatures. The staff reviewed the description of the HLZCs 4, 5, and 6 in section 4.9.8.1 of the UFSAR and as shown in figures 2-2d, 2-2e, and 2-2f of the UFSAR and notes that, although the total decay heat of the three HLZCs is the same, there are some decay heat variations in individual fuel assembly locations. The staff evaluation of HLZCs 4, 5, and 6, to which the individual fuel assembly location decay heat variations contribute, is found in sections 4.1.1 (this section) and 4.1.2 of this SER. The applicant also included a maximum total decay heat in the evaluation of HLZC 5 that was conservatively higher than the total decay heat that is allowed by figure 2-2e; the staff finds this conservatism to be acceptable.

The applicant evaluated the EOS-HSM-FPS (fuel plate support) with the bounding HLZC 4 for normal, off-normal, and accident conditions during storage, and the applicant also evaluated the impact due to wind and discussed the grid convergence index (GCI). The staff reviewed table A.4-45 of the UFSAR and finds the applicant's conclusion that the HLZC 4 provides maximum fuel cladding and concrete temperatures in the EOS-89BTH DSC with the EOS-HSM-MX, as compared to the relative lower temperatures shown in table A.4-45 of the UFSAR for HLZCs 5 and 6, to be acceptable based on the staff's review of table A.4-45 of the UFSAR. Based on the HLZC 4 being bounding for normal, off-normal, and accident storage conditions for the EOS-89BTH DSC in the EOS-HSM-MX, the staff also finds the applicant's conclusion that the HLZC 4 is bounding for the HLZCs 5 and 6 in the EOS-HSM-FPS to be acceptable.

In section 4.9.8.2 of the UFSAR, the applicant described the normal, off-normal, and accident load cases, and the thermal computational fluid dynamics (CFD) model. The staff verified that the ambient temperatures used for the load cases were consistent with ambient temperature values that had been previously approved. The applicant described that the thermal CFD model for the EOS-89BTH DSC in the EOS-HSM is similar to the thermal model for the EOS-37PTH DSC in the EOS-HSM in section 4.9.5 of the UFSAR; the only exceptions to the models being identical are the EOS-89BTH DSC model and certain EOS-HSM components have been updated to accommodate the longer EOS-89BTH DSC. Based on the staff's review of the applicant's description of these limited changes to the thermal model, the staff finds the thermal model changes to be acceptable. The staff reviewed the applicant provided temperature results in tables 4.9.8-3 and 4.9.8-4 of the UFSAR and concluded that the calculated maximum temperatures for the load cases were below the allowable temperature limits that were provided in section 4.2 of the UFSAR. Finally, based on the staff's review of section 4.9.8.2 of the UFSAR, the staff finds that the internal pressure based on the average helium temperature in table 4.9.8-7 remains bounded by the maximum internal pressure in table 4-46 of the UFSAR.

In section 4.9.8.3 of the UFSAR, the applicant described the thermal performance of the EOS-89BTH DSC in the EOS-TC125 transfer cask during transfer operations for normal, off-normal, and accident conditions, based on HLZCs 4, 5 and 6. The applicant also described the transfer load cases in table 4.9.8-8 of the UFSAR and the thermal model of the EOS-TC125 with the EOS-89BTH DSC with no changes except for the heat loads used for evaluation of load cases with HLZC 4. The applicant described that HLZC 4 is the bounding storage load case because the maximum temperatures of the fuel cladding and concrete for the EOS-89BTH DSC in the HSM-MX with HLZC 4 bounded those with HLZCs 5 and 6, and therefore the applicant concluded that the EOS-89BTH DSC in the EOS-TC125 with HLZC 4 would also be bounding for HLZCs 5 and 6. The staff finds there is reasonable assurance that the choice of analyzing HLZC 4 in the EOS-TC125 would provide higher temperatures in some components because of the higher decay heat near the DSC center, based on the staff's review of the temperature results in table A.4-45. The applicant also described that the thermal model of the EOS-TC125 with the EOS-89BTH DSC in vertical operations has not changed from the model described in section 4.5.7 of the UFSAR, that the thermal model of the EOS-TC125 with the EOS-89BTH DSC was built using the same methodology in section 4.5.2.1 of the UFSAR, and that the thermal evaluation of the EOS-TC125 with the EOS-89BTH DSC uses the same methodology provided in section 4.5.2.2 of the UFSAR. The applicant's thermal analysis was based on a 223 °F TC/DSC annulus boundary condition. Although the staff finds this temperature can be considered as a boundary condition in the thermal model (i.e., theoretical), there was no demonstration in the application that boiling within the annulus is acceptable, such that boiling during actual operations is an unanalyzed condition. Additional discussion is provided in section 4.7 of this SER that considers boiling in the TC/DSC annulus and provides additional guidance to mitigate it. Based on the staff's review of the applicant's description of the thermal models as described above, the staff finds the thermal models of the EOS-89BTH DSC in the EOS-TC125 transfer cask for HLZCs 4 - 6 to be acceptable.

The applicant described the transfer conditions for normal and off-normal conditions with and without air circulation in section 4.9.8.3.3 of the UFSAR and time limits for normal and off-normal transfer operations in section 4.9.8.3.4 of the UFSAR. The staff reviewed the maximum temperature results in tables 4.9.8-9 and 4.9.8-10 of the UFSAR. The staff compared the temperature results to the maximum allowable temperature limits that were provided in section 4.2 of the UFSAR and within tables 4.9.8-9 and 4.9.8-10, and found the results to be below allowable limits. The staff verified that the air circulation minimum time duration discussed in section 4.9.8.3.3 and the time limits discussed in section 4.9.8.3.4 of the UFSAR were consistent with the NUHOMS® EOS System TS LCO 3.1.3. The staff also reviewed the temperature results in table 4.9.8-11 of the UFSAR for hypothetical accident transfer conditions and compared them to the maximum allowable temperature limits that were provided in section 4.2 of the UFSAR and within table 4.9.8-11, and based on the staff's comparison found the results to be acceptable.

4.1.2 Description and storage of HLZCs 4, 5, and 6 in the updated EOS-HSM-MX

As described and evaluated in section 4.1.1 of this SER, the applicant provided the descriptions of HLZCs 4, 5, and 6 in figures 2-2d through 2-2f of the UFSAR. In addition, an applicant-proprietary sensitivity study concluded that loading higher decay heat fuel assemblies in the outer zones resulted in a lower PCT, as compared to when the decay heat is concentrated in the inner zones that resulted in a higher PCT. Therefore, to evaluate the basket temperatures, the applicant maximized the decay heat in the outer zones.

The applicant described in section A.4.5.6 of the UFSAR the load cases for storage, the thermal CFD model and mesh for the EOS-89BTH DSC in the updated EOS-HSM-MX, as well as convergence, temperature, airflow, and GCI calculations. The applicant described in section A.4.5.6.2 of the UFSAR that the thermal model for the EOS-89BTH DSC in the updated EOS-HSM-MX follows the same methodologies described in sections A.4.4.2, A.4.5.3, and A.4.5.7.3 of the UFSAR for the EOS-37PTH DSC in the EOS-HSM-MX and updated EOS-HSM-MX.

Based on the staff's review of the applicant's description of limited changes to the thermal model, the staff finds the thermal model changes to be acceptable. The applicant described in section A.4.5.6.3 of the UFSAR that the HLZC 4 bounds the HLZC 3 because the HLZC 4 has a higher total heat load and a higher maximum heat load per assembly and therefore, HLZC 3 does not need to be further evaluated by the applicant; the staff finds that to be acceptable based on the staff's review of the description in section A.4.5.6.3 of the UFSAR. The staff reviewed the temperature results in table A.4-45 of the UFSAR and verified that HLZC 4 bounds HLZCs 3, 5, and 6 and the applicant-calculated temperatures for the fuel cladding and concrete were below the allowable limits that were provided in the table. The applicant similarly showed in table A.4-46 that HLZC 4 bounds HLZCs 3, 5, and 6 for the maximum temperatures of the basket plate, transition rails, DSC shell, and heat shield for both the upper and lower compartments, and based on the above review, the staff finds the applicant calculated temperature results to be acceptable.

4.2 Change No. 2: Add a Variable-Lead Thickness EOS-TC125 for Transfer with the EOS-89BTH DSC

The applicant added a variable-lead thickness EOS-TC125 transfer cask with minimum and maximum values for thickness for use with the EOS-89BTH DSC to decrease the lead thickness from the previously analyzed design. This was shown on Licensing Drawing No. EOS10-2010-SAR, Sheet 1 of 5, note 9, with a fixed nominal gap between the lead and the outer shell shown on Sheet 2 of 5. The applicant performed an analysis described in section 4.9.8.3.2 of the UFSAR using the nominal value of lead thickness that was close to the lower value of lead thickness. The applicant further analyzed the EOS-TC125 transfer cask with the EOS-89BTH DSC, as described in section 4.9.8.3.6 of the UFSAR, using the lower value of lead thickness that was 0.07 inches less than the nominal value. The applicant provided the maximum temperature results of the EOS-89BTH DSC, shown in table 4.9.8-17, which demonstrated that the fuel cladding temperature remained the same, the EOS-89BTH DSC temperatures decreased slightly, and the neutron shield outer skin temperature slightly increased, but it remains bounded by the maximum neutron shield outer skin temperature for LC10 with the EOS-37PTH DSC at 36.35 kW. Based on the staff's review of the temperature results using the lower value of lead thickness for the EOS-TC125 for transfer with the EOS-89BTH, the staff finds the variable-lead thickness for the EOS-TC125 for transfer with the EOS-89BTH to be acceptable because the fuel cladding temperature remained the same and neutron shield outer skin remained bounded by LC10.

4.3 Change No. 3: Add ATRIUM-11 Fuel as an Allowable Content in the EOS-89BTH DSC

The applicant added ATRIUM-11 fuel as an allowable content in the EOS-89BTH DSC. The applicant described in section 4.9.1.2 of the UFSAR that tables 4.9.1-8 and 4.9.1-9 of the UFSAR compare the applicant-calculated thermal properties for ATRIUM-11 fuel with the bounding fuel thermal properties and concluded that the ATRIUM-11 fuel remains bounded by other fuel assemblies. The staff reviewed tables 4.9.1-8 and 4.9.1-9 of the UFSAR and compared the thermal conductivity, effective density, and specific heat of the ATRIUM-11 fuel. From the comparison, the staff concluded that the effective density and specific heat for the ATRIUM-11 fuel was the same or greater than the bounding BWR fuel assembly, and was therefore, bounded. In the staff review of table 4.9.1-8, all values of transverse and axial effective thermal conductivities for ATRIUM-11 were higher than the values for the bounding BWR fuel assembly, except for the transverse effective thermal conductivity values at temperatures greater than or equal to 907 °F, which had values that were the same or lower and are therefore not bounded by the bounding fuel assembly. Because the maximum temperature during accident conditions is 935 °F, the staff could not conclude based on the information provided that the ATRIUM-11 fuel was bounded by the presumed bounding BWR fuel assembly transverse effective thermal conductivity for the EOS-89BTH DSC over the temperature range of 907 °F to 935 °F, and therefore the accident conditions maximum temperatures could be higher than 935 °F. However, given the 117 °F margin to the 1052 °F maximum allowable fuel cladding temperature limit during hypothetical accident conditions and the small impact on maximum temperature that the fuel assembly transverse effective thermal conductivity change would have given that it is relatively close to the bounding fuel assembly transverse effective thermal conductivity value at 935 °F, the staff concludes that the maximum temperature during accident conditions will continue to remain below the maximum allowable fuel cladding temperature limit.

4.4 Change No. 6: Revise EOS-37PTH HLZC 1 and 2 Time Limit for Transfer to 8 hours in TS

The applicant revised the EOS-37PTH HLZCs 1 and 2 time limit for transfer to 8 hours in LCO 3.1.3 of the NUHOMS® EOS System TS in order to make the time limit consistent among EOS-37PTH DSCs with transfer time limits. The staff verified the time limit for the EOS-37PTH HLZC 1 and 2 was revised to 8 hours (from 10 hours that was approved in LCO 3.1.3 of the initial issuance of the NUHOMS® EOS System TS, (ML16242A022)) in LCO 3.1.3 of the NUHOMS® EOS System TS. This lower time limit of 8 hours for the EOS-37PTH HLZC 1 and 2 is consistent with the time limit for the EOS-37PTH HLZCs 4 – 11 in the LCO 3.1.3 of the NUHOMS® EOS System TS. Because there were no changes to the EOS-37PTH, this lower time limit is still bounded based on the applicant’s prior analysis that showed components would begin to approach allowable temperature limits for a time period of ten hours, which is shown in section 4.5.4, 4.9.6.1.4.4, and 4.9.7.2.2.4 of the UFSAR; therefore, the staff finds the revised time limit of 8 hours for the EOS-37PTH HLZC 1 and 2 to be acceptable.

4.5 Change No. 7: Incorporate a Method to Determine New Loading Patterns Based on the Maximum Allowable Heat Load per EOS-89BTH DSC and per Location Specified in the NUHOMS® EOS System TS

4.5.1 Overview of Figure 11 in the TS, and HLZCs in the UFSAR

The applicant added figure 11 to the NUHOMS® EOS System TS. The NUHOMS® EOS System TS figure 11 is a maximum heat load configuration (MHLC) for the EOS-89BTH DSC and allows the applicant to develop additional HLZCs to be qualified for storage in the EOS-HSM, EOS-HSM-MX and when transferred in the EOS-TC125 transfer cask in a Type 1 basket, as described in chapter 2 of the UFSAR. Specifically, in section 2.4.3.1 of the UFSAR, the applicant provided the methodology to evaluate and pre-qualify HLZCs based on the MHLC in the NUHOMS® EOS System TS figure 11.

The applicant moved HLZCs 1 through 3 from the NUHOMS® EOS System TS to figures 2-2a through 2-2c in chapter 2 of the UFSAR, and these are evaluated by the applicant in sections 4.4 and 4.5 of the UFSAR. The staff verified that HLZCs 1 through 3, shown in figures 2-2a through 2-2c of the UFSAR, have not thermally changed as compared to the HLZCs 1 through 3 in the initial issuance of the NUHOMS® EOS System TS. The staff verified that the NUHOMS® EOS System TS figure 11 describes that the maximum heat load of the EOS-89BTH DSC is limited to 48.2 kW in the EOS-HSM, 48.2 kW in the lower compartment of the EOS-HSM-MX, and 41.8 kW in the upper compartment of the EOS-HSM-MX.

The applicant described that because the NUHOMS® EOS System TS figure 11 is used to develop HLZCs, and not directly intended for loading, there is no need to provide specific instructions with figure 11 to adjust the payload to maintain the total canister heat load limit, as is done in figures 2-2d through 2-2f of the UFSAR. Those instructions will be provided by the applicant for each applicant-developed HLZC that is used for loading and those applicant-developed HLZCs will be included in chapter 2, section 2.4.3.2 of the UFSAR as specified in the section on thermal parameters in the NUHOMS® EOS System TS 2.2. The staff finds the applicant's explanation to be acceptable. The staff also verified that the NUHOMS® EOS System TS figure 11 describes the per assembly, and per zone decay heat limitation. Based on the staff's review, the staff finds the description of the decay heat in the NUHOMS® EOS System TS figure 11 to meet 10 CFR 72.236(a).

4.5.2 Overview of the methodology in Section 2.4.3.1 of the UFSAR

The application provided the evaluation of HLZCs 4 - 6 in the EOS-HSM and EOS-TC125 in appendix 4.9.8 of the UFSAR. The applicant also provided the methodology for qualifying HLZCs 4 - 6 in the EOS-89BTH DSC in the updated EOS-HSM-MX in appendix A.4 of the UFSAR. The staff evaluated HLZCs 4 – 6 in section 4.1 of this SER. The staff reviewed the methodology that is described in section 2.4.3.1 of the UFSAR used to qualify the applicant-developed HLZCs for the EOS-89BTH DSC, and is based on the MHLC in the NUHOMS® EOS System TS figure 11. The applicant's methodology in section 2.4.3.1 is described and evaluated by the staff below.

NUHOMS® EOS System TS 2.2 specifies that section 2.4.3.2 of the UFSAR provides the specific HLZCs. Section 2.4.3.2 of the UFSAR includes references to figures for HLZCs 1 – 6 and any additional valid HLZCs that can be qualified using the methodology in section 2.4.3.1 of the UFSAR. The staff's evaluation of the methodology in section 2.4.3.1 of the UFSAR is in section 4.5.2.1 of this SER. Any change to the methodology in section 2.4.3.1 of the UFSAR to qualify additional HLZCs (whether by the CoC holder or by the licensee using the storage system) has to be evaluated, as required by 10 CFR 72.48 against the criterion 10 CFR 72.48(c)(2)(viii). In addition, at the time that this SER was written, no other generic methodology has been approved by the NRC; therefore, the applicant cannot substitute the methodology in section 2.4.3.1 of the UFSAR with another method. The applicant's only available methodology to use with TS 2.2 is in section 2.4.3.1 of the UFSAR. The staff notes that the methodology described in section 2.4.3.1 of the UFSAR has, as its basis, the already approved EOS-89BTH DSC storage (EOS-HSM and EOS-HSM-MX) and transfer designs (EOS-TC125) with the Type 1 basket, which includes the coated steel plate for high emissivity and high conductivity poison plate; therefore, the methodology in section 2.4.3.1 of the UFSAR is not a generic methodology and cannot be used with other systems.

The following provides a general overview of the methodology the applicant described in section 2.4.3.1 of the UFSAR.

- Items 1 and 2, below, address how the applicant-developed HLZCs are evaluated by the applicant using the existing methodology in the UFSAR for storage conditions and transfer operations.
- Item 3 and its sub-bullets address that the applicant-developed HLZCs shall meet the requirements in the NUHOMS® EOS System TS figure 11.
- Item 4 addresses that the applicant's thermal evaluation results will meet the existing thermal design criteria in the UFSAR.
- Item 5 addresses that the applicant's calculated duration for the blocked vent accident condition is greater than or equal to the durations specified in sections 5.1.3.1 and 5.1.3.2 of the TS for the EOS-HSM and HSM-MX, respectively, to demonstrate that those TS are met.
- Item 6 addresses that the applicant's thermal evaluation for each applicant-developed HLZC shall be greater than or equal the total time for transfer, as defined in section 4.9.8.3.4 of the UFSAR.
- Item 7 addresses that the methodology in section 4.9.1.2 of the UFSAR shall be used to calculate the thermal properties for the homogenized regions of the fuel assemblies, if valid fuel assemblies are updated.
- Item 8 addresses how design changes that require an amendment request and 10 CFR 72.48 changes could be incorporated into the thermal models that also includes the applicant-developed HLZCs.
- Item 9 addresses how changes in temperature results based on the applicant's thermal model shall consider the structural impact in accordance with the methodology in chapter 3 of the UFSAR.

These items of the methodology in section 2.4.3.1 of the UFSAR are described in more detail in section 4.5.2.1 of this SER.

4.5.2.1 Specifics of the Methodology in section 2.4.3.1 of the UFSAR

1. The applicant-developed HLZCs that the applicant evaluates for use in the EOS-89BTH DSC with the Type 1 basket, which includes the coated steel plate for high emissivity and high conductivity poison plate, shall follow the same storage evaluation methodology in section 4.9.8.2 of the UFSAR for the EOS-HSM (i.e., load cases; thermal and CFD models of EOS-HSM (FPS) with EOS-89BTH DSC; materials properties; boundary conditions; and convergence, temperature, airflow, GCI, and pressure calculations). Similarly, the applicant-developed HLZCs that the applicant evaluates for use in the EOS-89BTH DSC with the Type 1 basket, shall follow the same storage evaluation methodology in section A.4.5.6 of the UFSAR for the EOS-HSM-MX (i.e., load cases, thermal and CFD models of the EOS-HSM-MX with the EOS-89BTH DSC; materials properties; boundary conditions; and convergence, temperature, airflow, GCI, and internal pressure calculations). Section 4.9.8.2 of the UFSAR provides the description of the baseline thermal model for the EOS-89BTH DSC stored in the EOS-HSM and section A.4.5.6 of the UFSAR provides the description of the baseline thermal model for the EOS-89BTH DSC stored in the EOS-HSM-MX. The staff

reviewed the storage evaluation methodologies in sections 4.9.8.2 and A.4.5.6 of the UFSAR that will be used for the applicant-developed HLZCs with the EOS-89BTH DSC, the staff finds these to be acceptable.

2. The applicant-developed HLZCs that the applicant evaluates for transfer operations shall follow the same transfer operations methodology in section 4.9.8.3 of the UFSAR (i.e., load cases, thermal model for transfer in the EOS-TC125, normal and off-normal conditions with and without air circulation, time limits, and hypothetical accident conditions). Section 4.9.8.3 of the UFSAR provides the description of the baseline thermal model for the EOS-89BTH DSC in the EOS-TC125. The staff reviewed the transfer operations methodology in section 4.9.8.3 of the UFSAR that will be used for the applicant-developed HLZCs with the EOS-89BTH DSC and, because it follows the same transfer operations methodology in section 4.9.8.3 of the UFSAR which was previously approved, the staff finds it to be acceptable.

3. The applicant-developed HLZCs shall satisfy the maximum decay heat per EOS-89BTH DSC, maximum decay heat per zone, and maximum decay heat per spent fuel assembly in the NUHOMS® EOS System TS figure 11. The applicant-developed HLZCs in chapter 2 of the UFSAR that are used for loading may include additional instructions, based on the need to have the total decay heat adjusted as described in the following bullet.
    - The applicant-developed HLZCs may need to have the total decay heat adjusted to meet the decay heat requirements in the NUHOMS® EOS System TS figure 11 (i.e., like HLZCs 5 and 6 in chapter 2 of the UFSAR). For the applicant-developed HLZCs, the approach in sections 4.9.8.1 and A.4.5.6.1 of the UFSAR for HLZCs 5 and 6 shall be used to determine bounding temperatures and maximum internal pressure for the applicant-developed HLZCs.
    - As specified, for any applicant-developed HLZCs the decay heat for each spent fuel assembly shall be individually modeled to explicitly capture the PCT and maximum component temperatures. The applicant developed HLZCs may be symmetric or asymmetric, but the applicant developed HLZCs shall be based on the limitations presented in item 1.b, section 2.4.3.1 of the UFSAR. The applicant shall also verify the impact of the temperature profile on the structural design function.

    In section 4.5.1 of this SER, the staff reviewed NUHOMS® EOS System TS figure 11, the section on thermal parameters in the NUHOMS® EOS System TS 2.2, and chapter 2 that specifies that section 2.4.3.2 of the UFSAR provides the specific HLZCs. The staff considered the specifications in conjunction with the possible asymmetric loading about the horizontal plane and determined that, as long as the other design criteria within section 2.4.3.1 of the UFSAR, including the structural analyses, are met, then the staff finds it to be acceptable. Therefore, the staff finds the NUHOMS® EOS System TS figure 11 and the NUHOMS® EOS System TS 2.2 to specify the HLZCs in section 2.4.3.2 of the UFSAR to be acceptable.

4. The applicant's thermal evaluations of the applicant-developed HLZCs shall satisfy the thermal design criteria in section 4.2 of the UFSAR which is: containment function based on the maximum temperatures of the containment structural components; normal, off-normal, and accident fuel cladding temperature limits; lead in the TC temperature limit, bottom

neutron shield temperature limit that does not need to be applied to accident conditions because no credit is taken for the bottom neutron shield during accident conditions; temperature of the water in the neutron shield based on neutron shield pressure relief valve rating; ambient boundary conditions for normal and off-normal storage conditions, and off-normal transfer conditions; DSC internal pressure limits for normal, off-normal, and accident conditions; and normal, off-normal, and accident concrete temperature limits. The staff reviewed the thermal design criteria in section 4.2 of the UFSAR that will be used for the applicant-developed HLZCs with the EOS-89BTH DSC, the staff finds the use of the thermal design criteria to be acceptable because the information in section 4.2 of the UFSAR has not changed from the prior EOS Amd. 2 review.

5. The applicant's calculated that the duration for the blocked vent accident condition of the applicant-developed HLZCs shall be greater than or equal to the allowable durations specified in sections 5.1.3.1 and 5.1.3.2 of the NUHOMS® EOS System TS for the EOS-HSM and HSM-MX, respectively, to demonstrate that those TS are met. The staff reviewed the NUHOMS® EOS System TS sections 5.1.3.1 and 5.1.3.2, which have not changed in this amendment request, and based on the staff's review, finds it to be acceptable. The TS shall be satisfied with the applicant-developed HLZCs within the EOS-89BTH DSC when the applicant-calculated duration for the blocked vent accident condition is greater than or equal to the durations specified in sections 5.1.3.1 and 5.1.3.2 of the TS for the EOS-HSM and HSM-MX, respectively.

6. The applicant's thermal evaluation of transfer time limit for each applicant-developed HLZC that is qualified based on figure 11 of the TS shall not be less than the total time for transfer as defined in section 4.9.8.3.4 of the UFSAR (i.e., the sum of the transfer time limit (8 hours) and the duration for recovery actions (5 hours)). The total time for transfer is also required per LCO 3.1.3 of the NUHOMS® EOS System TS at the maximum heat load per HLZC, as well as at less than the maximum heat load per HLZC. The staff reviewed the changes to the NUHOMS® EOS System LCO 3.1.3 by comparing those to the NUHOMS® EOS System Amendment No. 2 TS, and found that the transfer time limit for the EOS-37PTH with HLZCs 1 and 2 was lowered to 8 hours as evaluated in section 4.4 of this SER, and the transfer time limit (also 8 hours) was added for the HLZCs qualified per figure 11 of the TS. The TS 3.1.3 was also revised to specify the maximum allowable heat load, 48.2 kW, for the EOS-89BTH DSC in the EOS-TC125. Therefore, based on the staff's review of the changes to the NUHOMS® EOS System LCO 3.1.3 and TS 3.1.3, the staff finds it to be acceptable that these TS shall be satisfied with the applicant-developed HLZCs within the EOS-89BTH DSC.

   According to note 1 of LCO 3.1.3 of the TS, if the decay heat is less than the 48.2 kW for the EOS-89BTH DSC, a new transfer time limit can be calculated, using the same methodology in the UFSAR, to provide additional time for transfer operations; however, the calculated transfer time cannot be less than the transfer time limit specified in LCO 3.1.3. Therefore, provided the decay heat is less than the maximum decay heat (given there are no other design changes to the DSC or TC, or content changes), a transfer time limit for the HLZC that is greater than the transfer time limits in LCO 3.1.3 satisfies LCO 3.1.3; however, a transfer time limit that is less than the transfer time limits in LCO 3.1.3 does not satisfy LCO 3.1.3. The staff finds that this is consistent with the concept described in section 2.4.3.1, item 2c of the UFSAR. The staff notes that consideration should be given to section B.4.5.6.4 of the UFSAR, in which the choice of transfer time limit considered additional margin to the temperature limit when determining the appropriate LCO 3.1.3 transfer time limit; this is especially relevant when a new HLZC shows allowable temperatures would be reached near the current LCO 3.1.3 8-hour transfer time limit using figure 11 of the TS.

7. Section 2.2 of the TS provides the fuel assembly classes. The bounding effective properties (i.e., transverse, and axial effective thermal conductivities, specific heat, and density) for the thermally modeled homogenized regions of the fuel assemblies are provided in appendix 4.9.1 of the UFSAR. The methodology in section 4.9.1.2 of the UFSAR shall be used to calculate the thermal properties for the homogenized regions of valid fuel assemblies, if the fuel assemblies are updated, and the applicant described in the response to RAI 4-4 (ML21334A206), that any changes to the contents will be evaluated through a 10 CFR 72.48 process using the same methodology documented in section 4.9.1.2 of the UFSAR. These thermal properties, if determined to be bounding, can then be used in the bounding analysis identified in section 2.4.3.1 of the UFSAR to evaluate the impact on the HLZCs. The applicant also clarified in the response to RAI 4-4 that some modifications to the contents (e.g., accommodating damaged / failed assemblies, or new fuel assembly classes) cannot be evaluated in a 10 CFR 72.48 process and the applicant would need to provide justification as appropriate within the thermal chapters in future amendment requests. Section 4.9.1.2, tables 2-3 and 2-4 of the UFSAR discuss the fuel assemblies considered in the EOS-89BTH DSC. The staff reviewed section 2.2 of the TS and section 4.9.1.2 of the UFSAR in conjunction with section 2.4.3.1 of the UFSAR; the staff finds the framework in section 2.4.3.1 of the UFSAR that describes how changes to content and how the bounding effective thermal conductivities, specific heat, and density for the thermally modeled homogenized regions of the fuel assemblies are addressed by the applicant to be acceptable based on the staff's review of the description in sections 2.4.3.1 and 4.9.1.2 of the UFSAR.

8. The applicant specified in section 2.4.3.1 of the UFSAR that any design changes that result in the applicant updating the thermal models for storage or transfer shall be evaluated separately, and then as necessary collectively by the applicant based on the 10 CFR 72.48 process, or through a CoC No. 1042 amendment submitted to the NRC for review and approval. The applicant also described the criteria used to evaluate the design changes and then incorporate the design changes in a thermal model. The applicant specified in section 2.4.3.1 of the UFSAR that the design changes (i.e., individually, and collectively) to the thermal models cannot result in an alteration of the thermal physics correlations, nor can the thermal-fluid submodels be outside their applicable ranges from the baseline analyses in appendix 4.9.8 of the UFSAR, and section A.4.5.6 of the UFSAR. Note that a specific example of a change to the thermal physics would be going from not allowing boiling to occur in the annulus, to allowing boiling to occur. Additional discussion is provided in section 4.7 of this SER that considers boiling in the TC/DSC annulus and provides additional guidance to mitigate it. An example regarding a submodel range of applicability is applying the appropriately valid friction factor for flow through the fuel assembly. The applicant specified aspects of the thermal model in section 2.4.3.1 of the UFSAR that shall not be modified in evaluating the applicant-developed HLZCs. The applicant also specified in the response to RAI 4-6 (No. ML21334A206) that the mesh uncertainty and GCI will be

recomputed, if design changes significantly alter the thermal mesh model, to ensure the maximum fuel cladding and component temperatures including the GCI remain below the design limits. The applicant also specified in the response to RAI 4-6 that if applicant-developed HLZCs and any associated design changes that are evaluated based on figure 11 of the TS and section 2.4.3.1 of the UFSAR result in an increase to the bounding temperatures, or internal pressure, the UFSAR will be updated to include those results, in addition to updating the thermal model description.

The staff reviewed the applicant's response to observation 4-5 (ML21246A136) regarding the thermal models that the applicant will use to evaluate and qualify additional HLZCs. The applicant clarified in the response to observation 4-5 that the same thermal models, which the staff has evaluated as part of this amendment request, will be used by the applicant to evaluate and qualify additional HLZCs. The applicant also clarified that the heat generation rates in the individual cell locations may be modified in the thermal models. In addition, the 10 CFR 72.48 process can be used to incorporate approved design changes that are associated with 10 CFR 72.48 licensing reviews into the thermal models. Corrective actions associated with the software and changes to the software version can also be incorporated into the thermal models, as long as compliance with 10 CFR 72.48(c)(2)(viii), which addresses the need to obtain a CoC amendment prior to implementing a proposed change if the change would result in a departure from a method of evaluation described in the UFSAR used in establishing the design bases or in the safety analyses, is demonstrated.

Based on the staff's review of item 8 above and the associated applicant-provided information to observation 4-5, RAI 4-4, and RAI 4-6 as described above, the staff finds the methodology of incorporation of the design changes, whether 10 CFR 72.48 design changes, or design changes that necessitate prior NRC review and approval through a CoC No. 1042 amendment request, that result in the applicant updating the thermal models for storage or transfer to be acceptable provided that there is an associated necessary change to the applicant-developed HLZC that the applicant evaluates for use in the EOS-89BTH DSC with the Type 1 basket as described in item 1, above. The intent of the language in UFSAR section 2.4.3.1 and in the observation and RAI responses is for the applicant to analyze updated HLZCs and that the applicant-developed HLZC is not a means to include broad changes in the thermal models that would be different from its thermal model predecessors.

9. Based on the applicant's thermal evaluation of the applicant-developed HLZC (steps 4 – 8 above) and any applicable 10 CFR 72.48 design changes (steps 7 and 8 above), the applicant shall consider the impact of temperature changes on structural design functions based on the methodology in chapter 3 of the UFSAR. The applicant specified in the response to RAI 3-1 (ML21334A206) that the temperatures resulting from any applicant-developed HLZCs that are evaluated based on section 2.4.3.1 of the UFSAR shall be confirmed by the applicant and that the following criteria are met: 1) the temperature profile used in the stress analysis continues to bound the temperature profile that is based on the applicant-developed HLZC, and 2) the temperature at which the system mechanical properties are evaluated continues to bound the updated maximum temperature. The staff's evaluation of this portion of the methodology is provided in section 3.3 of this SER because it involves the impact of temperature changes on the structural design functions.

Based on the staff's review of the methodology in section 2.4.3.1 of the UFSAR, as described above, that is used by the applicant in conjunction with the MHLC in the NUHOMS® EOS System TS figure 11, and the section on thermal parameters in the NUHOMS® EOS System TS 2.2, which specifies that section 2.4.3.2 of the UFSAR provides the specific applicant-developed HLZCs, the staff finds the methodology to be acceptable for the applicant to use to add and evaluate the new applicant-developed HLZCs in the EOS-89BTH that is within the EOS-HSM, EOS-HSM-MX, or TC-125. The staff also notes that the methodology described in section 2.4.3.1 of the UFSAR has, as its basis, the already approved EOS-89BTH DSC storage (EOS-HSM and EOS-HSM-MX) and transfer designs (EOS-TC125) with the Type 1 basket. Therefore, there was no discussion in the methodology associated with vacuum drying time limits, failed fuel, damaged fuel, and other aspects associated with other basket types.

4.5.2.2 Thermal Model Audit

As part of the staff's thermal model audit of the applicant's CFD models that are associated with items 1 and 2 of section 4.5.2.1 of this SER, the staff reviewed the applicant's thermal models used in the analyses and confirmed that the proper material properties and boundary conditions were used. The staff verified that the applicant's selected code models and assumptions were adequate for the flow and heat transfer characteristics prevailing in the EOS-89BTH within the EOS-TC125, EOS-HSM, and EOS-HSM-MX geometry and analyzed conditions.

4.5.3 Graded Approach Evaluation

The applicant proposed Change No. 7 as a change under the graded approach. However, the graded approach as defined in RIRP-I-16-01 and endorsed by the NRC, is a process regarding content and format of information in the certificate of compliance and its appendices based on specific criteria defined through RIRP-I-16-01 for that purpose; it is not intended for use for technical changes. Because the proposed changes requested by TN in this area are technical changes (i.e., design and operational requirement changes), the staff did not consider this amendment as an application of the graded approach. Nonetheless, the proposed changes are consistent in aim as other recent and ongoing initiatives, such as topical reports and the graded approach, for ensuring that necessary storage system information and requirements are provided in the appropriate licensing basis documents (the certificate of compliance, its appendices, or the UFSAR). The staff has determined that proposed Change No. 7 is acceptable based on the technical basis provided for it, as discussed in this SER.

4.6 Change No. 9: TS Changes

The staff reviewed the thermal NUHOMS® EOS System TS changes as described in sections 4.4 and 4.5 of this SER:

- the revision of the EOS-37PTH HLZCs 1 and 2 time limit for transfer to 8 hours in LCO 3.1.3,
- the addition of TS figure 11,
- the section on thermal parameters in TS 2.2,

- the movement of HLZCs 1 through 3 from the TS to figures 2-2a through 2-2c in chapter 2 of the UFSAR,
- the TS sections 5.1.3.1 and 5.1.3.2, which have not changed in this amendment request.

The staff finds based on its review of the thermal TS changes as discussed in the aforementioned sections of this SER that the thermal TS changes are acceptable.

4.7 Additional Scope Item No. 2: UFSAR Revisions Associated with Maintaining Water in the Annulus.

The staff reviewed the supplemental information provided in section 4.5.11 of the UFSAR related to preventing and mitigating boiling occurring in the water in the TC/DSC annulus. For the conditions modeled, the applicant's calculations indicated a change in temperature between the hot DSC wall and the saturated water that is less than the change in temperature that is required for heterogenous nucleate boiling to occur in the water in the TC/DSC annulus. Based on this and the step-wise helium backfill described in steps 18 and 25 in UFSAR section 9.1.3 (discussed below,) boiling mentioned in UFSAR chapter 9 (e.g., sections 9.1.3 and 9.1.4) should be prevented or mitigated. In addition, staff notes that the applicant's calculated temperature difference (approximately 2.4 °C (4.3 °F)) between the heated surface and the saturated water, also known as delta T_{sat}, is well below the critical heat flux that is at a delta T_{sat} of approximately 30 °C and a heat flux of 10^6 Watts/m^2 for a typical pool boiling curve for water at 1 atmosphere (atm).

The applicant provided thermal analysis files for the EOS Amendment No. 3 with helium (modeled as a solid) in the DSC with a thermal conductivity at atmospheric conditions, and the TC/DSC annulus modeled as a solid with a very low conductivity material that is open to the atmosphere and has a boundary condition of 106 °C (222.8 °F). Although the applicant's analysis assumed a low conductivity material in the TC/DSC annulus, the UFSAR operating procedures state that water (which has better heat transfer capability) will be maintained within the TC/DSC annulus at a level of 12 inches below the top edge of the DSC shell through demineralized water replenishment during vacuum drying and subsequent helium backfill operations.

To better capture the heat transfer associated with the helium in the DSC cavity as a result of being backfilled into the DSC after vacuum drying, the staff first revised the applicant's thermal analysis to: 1) include thermal radiation within the DSC cavity, 2) reduce the helium gas pressure to 3 Torr, and 3) reduce the associated thermal conductivity of helium for a more realistic thermal analysis. The thermal conductivity of helium at 3 Torr is not that different from the thermal conductivity of helium at 0.75 Torr, which is the lower pressure limit in section 9.1.3 of the UFSAR operating procedures, steps 17 and 24; therefore, this assumption for the helium thermal conductivity is appropriate in the staff's revision of the applicant's thermal analysis. The staff ran the thermal analysis with the three above-mentioned steady-state vacuum drying conditions followed by a transient analysis that assumed a helium pressure of 1 atm within the DSC. The staff determined based on the review of the thermal analysis results that the fuel, DSC shell, and DSC lid temperatures, although higher than the prior steady-state vacuum drying condition temperatures, remained below the maximum allowable temperature limits during vacuum drying and subsequent backfilling of the DSC.

The continuous addition of demineralized water in the TC/DSC annulus, or the use of a feed and bleed system for the demineralized water in the TC/DSC annulus, is described in chapter 9 of the UFSAR. The applicant also specified in section 9.1.3 of the UFSAR operating procedures, steps 18 and 25, that the helium would be introduced in the DSC in a step-wise function over time, which aides in preventing rapid boiling from occurring in the TC/DSC annulus. Chapter 9 of the UFSAR includes the additional operation of replenishing demineralized water at the applicant-provided recommended flow rate, which can be adjusted as required to ensure the water remains approximately twelve inches below the top edge of the DSC. Based on the staff's review of the applicant's submittal, the staff finds the demineralized water replenishment operations at a recommended flow rate that can be adjusted to ensure the water remains approximately twelve inches below the top edge of the DSC shell, as described in section 9.1.3 of the UFSAR, to be acceptable.

4.8 Evaluation Findings

The staff concludes that the thermal design of the EOS-HSM and EOS-HSM-MX 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 EOS-HSM and EOS-HSM-MX will allow safe storage of spent fuel for a 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 No. 3 include:

F4.1 SSCs important to safety are described in sufficient detail in chapter 4 and appendix A.4 of the UFSAR to enable an evaluation of their thermal effectiveness. The EOS-HSM and EOS-HSM-MX SSCs important to safety remain within their operating temperature ranges.

F4.2 The EOS-HSM and EOS-HSM-MX are designed with a heat removal capability having verifiability and reliability consistent with its importance to safety. The EOS-HSM and EOS-HSM-MX are 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.

F4.4 The methodology in section 2.4.3.1 of the UFSAR that is used by the applicant in conjunction with the MHLC in the NUHOMS® EOS System TS figure 11, and the section on thermal parameters in the NUHOMS® EOS System TS 2.2, which specifies that section 2.4.3.2 of the UFSAR provides the specific applicant-developed HLZCs, provides reasonable assurance of adequate protection for the applicant to add and evaluate the new applicant-developed HLZCs in the EOS-89BTH with the Type 1 basket that is within the EOS-HSM, EOS-HSM-MX, or TC-125.

5.0 CONFINEMENT EVALUATION

The staff reviewed the information provided by the applicant and determined the following three amendment changes are applicable for discussion in the confinement evaluation:

Change No. 3:
Add ATRIUM 11 fuel as an allowable content in the EOS-89BTH DSC.

Change No. 8:
Option to waive the fabrication pressure test requirement associated with the EOS-DSC's alternate large-thickness single bottom forging.

Change No. 9:
TS changes related to fabrication pressure test requirement for EOS-DSCs with an alternate large-thickness single bottom forging, the use of single pass high amperage gas tungsten arc weld on the OTCP, and the use of UT on the OTCP weld.

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

Change No. 3: Add ATRIUM 11 fuel as content in the EOS-89BTH DSC

Although ATRIUM 11 fuel (described in UFSAR chapter 1, page 1-2) was added as new content to the EOS-89BTH DSC, which therefore, potentially could result in new release terms, there were no changes in the UFSAR's Confinement chapter. According to UFSAR chapter 5 and TS 4.4.4, a DSC helium leak test is performed in accordance with ANSI N14.5 and considers SNT-TC-1A and ASME Code Section V, Article 10. As noted in ANSI N14.5 and SNT-TC-1A, leak rate testing personnel and leak test procedures are qualified. According to UFSAR chapter 5, the helium leak tests have a "leaktight" acceptance criteria (as defined by ANSI N14.5) such that release calculations are not necessary. Staff finds that the addition of ATRIUM 11 fuel does not impact the potential release confinement evaluation in the previous NUHOMS® EOS amendment..

Change No. 8: Option to waive the fabrication pressure test requirement for the single bottom forging EOS-DSCs

UFSAR Confinement section 5.1.1 stated that the fabrication pressure test associated with the large-thickness, single piece forged bottom of the alternate confinement boundary (described in drawing EOS01-1001-SAR, Sheet 2, Detail 1 – Alternate 1 and drawing EOS01-1006-SAR, sheet 2, Detail 1- Alternate 1) can be waived; similar statements were also made in UFSAR section 10.1.1.1 and TS section 4.4.4. In particular, UFSAR section 10.1.1.1 indicated that the normal pressures for the EOS-37PTH and EOS-89BTH DSCs are 10.5 psig and 10.8 psig, respectively, and that both DSCs have a 15 psig design pressure. It was also noted that, per ASME Article NB-6300, a pneumatic test pressure would be 16.5 psig (i.e.,1.1 times the design pressure). The applicant's discussion in UFSAR section 10.1.1.1 regarding not having a structural-related fabrication pressure acceptance test for the alternate large-thickness single piece forged bottom referred to UFSAR section 10.1.2 and ANSI N14.5, which described the ‘leaktight’ helium leak test as having a pressure differential across the confinement boundary that is comparable to the pneumatic pressure test. The staff finds that the option to waive the fabrication pressure test requirement for the single bottom forging EOS-DSCs does not impact the potential release confinement evaluation in the previous NUHOMS® EOS amendment. Additional discussion and staff evaluation of this change is found in the section 2 and section 3 of the SER.

Change No. 9: TS changes
As noted above, TS section 4.4.4 stated the fabrication pressure test associated with the large-thickness, single piece forged bottom of the alternate confinement boundary (described in drawing EOS01-1001-SAR, Sheet 2, Detail 1 – Alternate 1 and drawing EOS01-1006-SAR, sheet 2, Detail 1- Alternate 1) can be waived. Additional staff discussion and evaluation of this change is found in the paragraph above and in section 3 and section 10 of the SER.

TS section 4.4.4 also described the use of a single pass high amperage gas tungsten arc weld (HA-GTAW) on the OTCP and the allowance for UT on the outer top cover plate weld. Staff notes that the OTCP and its corresponding weld are not part of the confinement boundary. The staff evaluation of this change is found in the section 3 and section 10 of the SER.

Evaluation Findings

The staff concludes that the Amendment No. 3 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. The key confinement finding from the staff’s review of Amendment No. 3 includes:

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.

6.0 SHIELDING EVALUATION

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

Change No. 1:
The first change adds three new HLZCs for the EOS-89TH for higher heat load 1.7 kW/assembly and reduces the cooling time to one year and increases the heat load capacity of the EOS-89BTH to 48.2 kW.

Change No. 2:
Add a variable-lead thickness EOS-TC125 for transfer with the EOS-89BTH DSC.

Change No. 3:
The fourth change to the EOS-89BTH adds ATRIUM 11 fuel as an allowable content.

Change No. 9:
TS changes for consistency among DSC types and terminology clarifications.

This section of the SER documents the staff's review and conclusions with respect to the shielding design of the NUHOMS® EOS system with the proposed amendments.

The objective of the shielding review is to determine whether the NUHOMS® EOS system with the proposed amendments continues to meet the regulatory requirements of 10 CFR 72.234(a) and 10 CFR 72.236(d).

Change No. 1: The first change adds three new HLZCs for the EOS-89TH for higher heat load 1.7 kW/assembly and reduces the cooling time to one year and increases the heat load capacity of the EOS-89BTH to 48.2 kW.

In the proposed Change No. 1, the applicant requested to add three new HLZCs to the EOS-89BTH DSC. These three new HLZCs No. 4, No. 5 and No. 6 are shown in figures 2-2d, 2-2e and 2-2f of the TS. Figure 11 of the TS is used to establish the limits on the total decay heat load of the DSC and the maximum heat load in each fuel compartment to qualify the various HLZCs. There is no change in the structural design of the EOS-HSM or the HSM-MX that have been approved under Amendment Nos. 0 and 1 for the NUHOMS® EOS system.

These new HLZCs allow for heat load up to 1.7 kW per assembly. With the three new HLZCs, the EOS-89BTH DSC will have six HLZCs available for loading. The new HLZCs are defined in figure 2e through figure 2-2f of the revised UFSAR for the EOS-HSM system design. The EOS-89BTH DSC is designed for a maximum heat load of 48.2 kW when transferred by the EOS-TC125 transfer cask.

As approved in Amendment No. 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. The three new HLZCs (i.e., 4, 5 and 6) proposed for the EOS-89BTH DSC are designed for the EOS-HSM. The applicant developed the source terms for the fuel to be loaded in each loading zone of the three new HLZCs based on the HLZC per figure 11 of the TS. The ORIGEN-ARP module of the Oak Ridge National Laboratory (ORNL) SCALE6.0 code package was used by the applicant to develop bounding gamma and neutron source terms. The B&W 15x15 and GE 7x7 fuel assemblies (FAs) were selected as the design basis pressurized water reactor (PWR) and BWR FAs, respectively. The applicant states that these FAs were selected to be design basis assemblies based primarily on their high specific uranium loadings. The staff found these FAs as design basis acceptable because it is well known that when a fuel assembly contains high uranium loadings, the gamma and neutron source terms result in high source terms which could increase the dose rates making this assemblies the bounding sources.

The applicant presents the source terms for both normal and accident conditions in table 6-10 through table 6-29a of the UFSAR. EOS-TC accident source terms maximize the neutron source because the only EOS-TC accident that results in a loss of shielding effectiveness is a loss of neutron shield accident.

To justify which HLZC is bounding, the applicant developed an EOS-89BTH DSC “shielding HLZC” to bound HLZC 1 through 6 when transferred in the EOS-TC125 and stored in the EOS-HSM. According to the applicant, each basket location in the “shielding HLZC” configuration bounds the corresponding heat load at that location allowed in HLZC 1 through 6. The “shielding HLZC” is provided in figure 6-18 of the UFSAR and is identical to the MHLC as shown in figure 11 of the TS. The staff found that the “shielding HLZC” is conservative for dose rate analysis, since the “shielding HLZC” provides the maximum dose rates within the entire DSC. The peripheral FAs are defined in figure 8 of the TS. The minimum cooling time used in the shielding calculations for the “shielding HLZC” is 1.0 year. The staff found the applicant’s bounding source to be conservative to calculate the dose rates for the three new HLZC (4,5, and 6) because they are bounded by the MHLC, which is the worst case scenario. . Therefore, the staff found the source term calculations to be acceptable.

In section 6.2.2.3, the applicant described development of the fuel qualification tables (FQTs), which are the combinations of burnup, enrichment and cooling times (BECTs). The applicant stated that the candidate source terms over a range of BECT combinations were generated to match the decay heat of each zone of the EOS-89BTH DSC shielding HLZC provided in figure 6-18 of the UFSAR. A comprehensive set of 142 burnup and enrichment combinations were considered for the EOS-89BTH DSC shielding HLZC. The burnup and enrichment combinations considered correspond to the FQT provided in TS table 21 of the UFSAR. The FQTs included in TS table 21 are used to control the source terms for shielding calculations. The applicant used MCNP compute code to generate the response functions for the side of the EOSTC125 and outlet vent opening of the EOS-HSM. The response functions when multiplied by a source term generate a dose rate. These dose rates were used to rank the source terms and select bounding BECT combinations in the active fuel region. As an added conservatism, the bounding BECT of the hardware regions that consists of the bottom nozzle, plenum, and top nozzle, which are due almost entirely to Co-60, is selected to optimize Co-60 activation and may differ from the bounding BECT of the active fuel region.

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 states that candidate source terms over a range of BECT combinations are generated to match the decay heat of each zone of the EOS-89BTH DSC shielding HLZC provided in figure 6-18 of the UFSAR. The source terms for the EOS-89BTH DSC when transferred in the EOS-TC125 and stored in the EOS-HSM are selected over a comprehensive set of 142 BECT combinations rather than a limited number of BECT combinations. The applicant used the same method as used in the previously approved Amendment No. 1 for the NUHOMS® EOS system.

The applicant performed shielding calculations for the EOS-HSM system containing the EOS-89BTH canister with the new HLZCs. The applicant provided a summary of the maximum EOS-HSM dose rates in table 6-53 of the UFSAR. The applicant also calculated the dose rate for the EOS-TC containing the fuel with the three new HLZCs under accident conditions. For accident analyses, the applicant used the same assumptions as it used in the previously approved Amendment Nos. 0 and 1 for the NUHOMS® EOS system. The MCNP model geometry was described in section 6.3.3 of the UFSAR. The EOS-HSM models were developed for the EOS-EOS-89BTH with the EOS-HSM-Medium. Single-, double-, and triple-reflection models were developed for normal conditions, and a triple-reflection model is developed for accident conditions. Reflective boundary conditions are used to simulate adjacent EOS-HSMs in several array configurations in order to determine the maximum dose rates. The applicant demonstrated that the system will be able to meet the dose limit prescribed in 10 CFR 72.236(d) 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 No. 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.

Source Terms Confirmatory Calculations

The staff performed confirmatory analysis. The staff calculated the source terms for the new spent fuel to be stored in the EOS-89BTH DSC using the ORIGEN-ARP module of the SCALE 6.0 code package (ORNL, 2009). The staff used the design basis assembly and the BECTs in the TS to ensure that the source terms are clearly defined by these spent fuel parameters.

The staff reviewed the applicant's source term calculation. The staff found that the BECTs specified in the TS provide data that are sufficient for calculating 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-2215 and this code has been used and accepted by the staff in the review of the previously approved Amendment Nos. 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.

The staff also reviewed the applicant's shielding calculation for the system under accident conditions and found that the assumptions and the methodology are similar as those used in the previously approved accident conditions for Amendment No. 0 for the NUHOMS® EOS system. For this reason, the staff finds that the applicant's shielding analyses for change No. 1 are acceptable and that there is reasonable assurance that the shielding design for the EOS-HSM system, as amended, will continue to meet the regulatory requirements of 10 CFR 72.236(d).

Change No. 2: Add a variable-lead thickness EOS-TC125 for transfer with the EOS-89BTH DSC.

In the proposed change No. 2, the applicant requested to introduce a variable-lead thickness design for the EOS-TC125/135. The EOS-TC125 dose rates analysis for the EOS-89BTH DSC is performed at a lead thickness of 3.07 inches. The response functions for EOS-HSM and EOS-TC125 analysis are provided in table 6-62 and table 6-63 of the UFSAR, respectively. The EOS-TC source terms provided in chapter 6 of the UFSAR was used to compute normal condition EOS-TC dose rates to the modified EOS-TC design.

For the EOS-89BTH DSC models, the lead thickness was modeled at 3.07 inches, which is the minimum value of the variable-lead EOSTC125/135 design. Based on the dose rates analysis performed for the new added HLZCs design described in Change No. 1 of this amendment, the staff found acceptable the use of the thickness of 3.07 inches and that there is reasonable assurance that the shielding design for the EOS-HSM system, as amended, will continue to meet the regulatory requirements of 10 CFR 72.106.

Change No. 3: Add ATRIUM 11 fuel as an allowable content in the EOS-89BTH DSC.

The applicant stated that no source term or shielding calculations are performed for ATRIUM 11 fuel because the design basis BWR GE 7x7 fuel assembly type is used as the design basis fuel assembly for all shielding calculations. Justification for this approach is provided in section 6.2 of the UFSAR. This approach is unchanged from previous amendments. In particular, the design basis BWR GE 7x7 fuel has a uranium loading of 0.198 MTU, and ATRIUM 11 fuel has a uranium loading of 0.183 MTU. Therefore, for the same burnup, enrichment, and cooling time, the design basis BWR GE 7x7 fuel will result in larger sources than ATRIUM 11 fuel because the design basis BWR GE 7x7 fuel has a larger uranium loading per fuel assembly. The ATRIUM 11 axial burnup profile is similar to the axial burnup profile provided in table 6-31 of the UFSAR. The staff found acceptable the addition of the ATRIUM Fuel because it is bounded by the design basis BWR GE 7x7 fuel, therefore, the addition of this fuel assembly will continue meeting the regulatory requirements 72.236(d).

Change No. 9: TS changes for consistency among DSC types and terminology clarifications.

The applicant revised the TS for the NUHOMS® EOS system to reflect revised contents supported by the shielding analyses described in the preceding sections of this SER. The primary changes to the TS due to changes in the shielding analysis are:

> Addition of three new HLZCs for the EOS-89TH for higher heat load 1.7 kW/assembly and reduces the cooling time to one year and increases the heat load capacity of the EOS-89BTH to 48.2 kW, additions of a variable-lead thickness EOS-TC125 for transfer with the EOS-89BTH DSC, and change to the EOS-89BTH adds ATRIUM 11 fuel as an allowable content.

The staff reviewed the proposed TS for the NUHOMS® EOS system, and finds that the proposed changes are consistent with the results of the applicant's shielding analysis. The proposed TS will ensure that the NUHOMS® EOS system dose rates as required by 10 CFR 72.124(a) and 72.236(c).

Evaluation Findings

The staff concludes that the Amendment No. 3 shielding safety design features for the EOS-

HSM system are in compliance with 10 CFR Part 72 and the applicable design and acceptance criteria have been satisfied. The evaluation provides reasonable assurance that the shielding design of the EOS-HSM 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. Key findings from the staff's review of Amendment No. 3 include:

F6.1 The SSCs important to shielding are described in sufficient detail in chapter 6 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 safety analysis for the shielding design has demonstrated that the cask will enable the storage of spent fuel for the term specified in the CoC.

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. 3:
Add ATRIUM 11 fuel as an allowable content in the EOS-89BTH DSC. Reran the limiting GNF2 and ABB-10-C cases to reduce the statistical uncertainties and increase the enrichment limits.

Change No. 4:
Update the criticality evaluation to allow short-loading the EOS-89BTH DSC with less than 89 FAs to increase the enrichment limits.

Change No. 9:
TS changes for consistency among DSC types and terminology clarifications.

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

Change No. 3: Add ATRIUM 11 fuel as an allowable content in the EOS-89BTH DSC. Reran the limiting GNF2 and ABB-10-C cases to reduce the statistical uncertainties and increase the enrichment limits.

The applicant requested a change to the CoC for the NUHOMS® EOS system to increase the maximum lattice average initial enrichment values for the GNF2 and ABB-10-C 10x10 BWR fuel assembly types in the EOS-89BTH canister, and to add the ATRIUM 11 11x11 BWR fuel assembly type as an allowable EOS-89BTH canister content. The applicant had previously evaluated all BWR assembly types up to a 10x10 lattice configuration and determined that the GNF2 10x10 BWR fuel assembly type was more reactive than all BWR fuel types except the ABB-10-C BWR fuel type. The applicant determined limiting lattice average initial enrichment values for three different basket neutron absorber loadings for the GNF2 fuel assembly type. The applicant also determined required maximum lattice average initial enrichment reductions for each basket neutron absorber loading for the ABB-10-C fuel assembly type. These maximum lattice average initial enrichment values are shown in table 8 of the Amendment No. 2 TS for the NUHOMS® EOS system.

For this amendment request, the applicant updated its criticality evaluations for the GNF2 and ABB-10-C BWR fuel assembly types to reduce uncertainties, resulting in small increases in allowable maximum lattice average initial enrichments for both assembly types. The results of these revised evaluations are shown in table 7-43 of the UFSAR and demonstrate that the NUHOMS® EOS system k_{eff} remains below the applicant's calculated Upper Subcritical Limit (USL) of 0.9418 with the requested small increases in allowable maximum lattice average initial enrichments.

For the ATRIUM 11 fuel assembly type, the applicant revised the criticality evaluation for the NUHOMS® EOS system to include an analysis of the EOS-89BTH canister with 11x11 fuel contents. Since the ATRIUM 11 fuel assembly contains both short and long partial-length rods and rods with non-uniform pitch, as shown in figures 7-27 and 7-31 of the UFSAR, the applicant performed sensitivity analyses to determine the most reactive configuration of the fuel assembly.

The ATRIUM 11 sensitivity analyses compared three fuel configurations, shown in figure 7-27 of the UFSAR. Dimensions for the fuel rods are as shown in table 2-3 of the UFSAR. The results of this sensitivity analysis, shown in table 7-82 of the UFSAR, indicate the most reactive fuel configuration. The applicant uses this fuel assembly configuration to determine maximum allowable lattice average initial enrichment values for the ATRIUM 11 fuel assembly type. The staff reviewed the sensitivity analyses to determine the most reactive ATRIUM 11 fuel configuration and finds reasonable assurance that the applicant has identified the most reactive configuration. The most reactive configuration is consistent with staff's experience modeling BWR fuel in fresh water moderated environments. The staff also confirmed the most reactive configuration in its independent analysis of the EOS-89BTH canister with ATRIUM 11 fuel contents. As a result, the staff finds that using the identified most reactive configuration to determine maximum allowable lattice average initial enrichment values is appropriate and conservative.

The applicant modeled the most reactive configuration of the ATRIUM 11 fuel assembly type in the most reactive configuration of the EOS-89BTH canister determined in previous amendments to determine the maximum allowable lattice average initial enrichment values. The results of the ATRIUM 11 fuel type evaluations are shown in table 7-43 of the UFSAR and demonstrate that the NUHOMS® EOS system k_{eff} is below the applicant's calculated USL of 0.9418 with the requested fuel assembly contents.

For both the revised 10x10 BWR fuel assembly analyses and the new ATRIUM 11 analysis, the applicant used the same computer code and cross section library as in the previously approved criticality analysis (SCALE 6.0 with KENO V.a and the 44-group ENDF/B-V cross section library). The applicant did not revise the benchmarking analysis or the resulting calculated USL of 0.9418 for the NUHOMS® EOS system. Since the 10x10 and ATRIUM 11 BWR fuel contents remain within the range of applicability of the previously approved computer code benchmarking analysis, the staff finds its use for the revised criticality analysis for 10x10 and ATRIUM 11 fuel assembly contents appropriate.

The staff performed confirmatory calculations for 10x10 and ATRIUM 11 fuel assembly configurations in the NUHOMS® EOS system using the CSAS6 sequence of the SCALE 6.2.3 code system, with the KENO VI three-dimensional Monte Carlo neutron transport program and the continuous-energy ENDF/B-VII.1 cross section library. Using assumptions similar to the applicant's, the staff calculated k_{eff} values for select configurations which were similar to or bounded by those calculated by the applicant, and the staff confirmed that the storage system is subcritical per the requirements of 10 CFR 72.124(a) and 72.236(c).

The applicant demonstrated that k_{eff} values for the storage configurations for 10x10 and ATRIUM 11 BWR fuel in the EOS-89BTH canister and NUHOMS® EOS system are all below the calculated USL, which accounts for all biases and uncertainties determined for the canister in the benchmarking analysis for the SCALE 6.0 code and 44-group ENDF/B-V cross section library used in the criticality analysis. Therefore, the staff finds reasonable assurance that the NUHOMS® EOS system with the EOS-89BTH canister with revised 10x10 fuel assembly maximum lattice average initial enrichments and the addition of the ATRIUM 11 fuel assembly type will remain subcritical under normal, off-normal, and accident conditions, demonstrating the design of the system is subcritical as required by 10 CFR 72.124(a) and 72.236(c).

Change No. 4: Update the criticality evaluation to allow short-loading the EOS-89BTH DSC with less than 89 FAs to increase the enrichment limits.

The applicant requested a change to the CoC for the NUHOMS® EOS system to allow "short loading" configurations of BWR fuel in the EOS-89BTH canister. Short-loading configurations consist of less than the maximum 89 FAs, with specified empty basket locations, and corresponding higher allowed maximum lattice average initial enrichment values. Using the most reactive canister and fuel configurations determined in previous analyses, the applicant evaluated configurations with 88, 87, and 84 FAs, instead of the maximum of 89 FAs. The applicant determined maximum lattice average initial enrichment for ATRIUM-11, ABB-10-C, and GNF2 fuel types. The maximum limit for the GNF2 fuel type applies to all BWR fuel except the ABB-10-C and ATRIUM 11 fuel types. Required empty basket locations are as shown in figures 7-28, 7-29, and 7-30 of the UFSAR. The results of the short-loading evaluations for the GNF2, ABB-10-C, and ATRIUM 11 fuel types are shown in table 7-43a of the UFSAR and demonstrate that the NUHOMS® EOS system k_{eff} is below the applicant's calculated USL of 0.9418 with the requested fuel assembly contents.

For the revised BWR fuel assembly analyses of short-loading configurations, the applicant used the same computer code and cross section library as in the previously approved criticality analysis (SCALE 6.0 with KENO V.a and the 44-group ENDF/B-V cross section library). Since the BWR fuel contents for the short-loading configurations remain within the range of applicability of the previously approved computer code benchmarking analysis, the applicant did not revise the benchmarking analysis or the resulting calculated USL of 0.9418 for the NUHOMS® EOS system. The staff agrees that the applicant's use of the previously approved USL for the revised criticality analysis for short-loading configurations is appropriate.

The staff performed confirmatory calculations for short-loading configurations of 10x10 and ATRIUM 11 fuel assembly types in the NUHOMS® EOS system using the CSAS6 sequence of the SCALE 6.2.3 code system, with the KENO VI three-dimensional Monte Carlo neutron transport program and the continuous-energy ENDF/B-VII.1 cross section library. Using assumptions similar to the applicant's, the staff calculated k_{eff} values for select configurations which were similar to or bounded by those calculated by the applicant, and confirmed that the storage system is subcritical per the requirements of 10 CFR 72.124(a) and 72.236(c).

The applicant demonstrated that k_{eff} values for short-loading storage configurations for 10x10 and ATRIUM 11 BWR fuel in the EOS-89BTH canister and NUHOMS® EOS system are all below the calculated USL, which accounts for all biases and uncertainties determined for the canister in the benchmarking analysis for the SCALE 6.0 code and 44-group ENDF/B-V cross section library used in the criticality analysis. Therefore, the staff finds reasonable assurance that the NUHOMS® EOS system with the EOS-89BTH canister with short-loading configurations of 10x10 and ATRIUM 11 BWR fuel types will remain subcritical under normal, off-normal, and accident conditions, demonstrating the design of the system is subcritical as required by 10 CFR 72.124(a) and 72.236(c).

Change No. 9: TS changes for consistency among DSC types and terminology clarifications.

The applicant revised the TS for the NUHOMS® EOS system to reflect revised contents supported by the criticality analyses described in the preceding sections of this SER. The primary changes to the TS due to changes in the criticality analysis were:

- Revision of table 8 to include increased maximum lattice average initial enrichment values for 89 10x10 FAs for each basket neutron absorber loading, and maximum lattice average initial enrichment values for configurations of 88, 87, and 84 10x10 FAs for each basket neutron absorber loading; and
- Addition of table 8A for maximum lattice average initial enrichments for the ATRIUM 11 11x11 fuel assembly type for 89, 88, 87, or 84 FAs, for each basket neutron absorber loading.

The staff reviewed the proposed TS for the NUHOMS® EOS system, and finds that the proposed limits in tables 8 and 8A are consistent with the results of the applicant's criticality analysis. The proposed TS will ensure that the NUHOMS® EOS system is subcritical as required by 10 CFR 72.124(a) and 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 No. 3 include:

F7.1 SSCs important to criticality safety are described in sufficient detail in chapter 2 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 the information provided by the applicant and the following changes are applicable to the materials evaluation:

Change No. 3:
Add ATRIUM 11 fuel as an allowable content in the EOS-89BTH DSC. Reran the limiting GNF2 and ABB-10-C cases to reduce the statistical uncertainties and increase the enrichment limits.

Change No. 5:
For the TS; a revision to allow for PA-AUT and to utilize a single pass HA-GTAW or multipass GTAW on the OTCP.

Additional Scope Change No. 2:
UFSAR revisions associated with maintaining water in the annulus between the TC and the DSC

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

For Change No. 3, the addition of ATRIUM 11 fuel, there was no change in the thermal design criteria for applicant's evaluation of fuel burnup, no changes to the cladding materials or cladding temperature limits and no changes to the drying and inerting procedures for the prevention of oxidation during fuel loading, therefore the applicant did not make any changes to the materials selection. The staff reviewed the ATRIUM 11 fuel specifications and determined that no changes to the chapter of the UFSAR for materials review were necessary.

For Change No. 5, the applicant added that the OTCP to DSC shell weld may be examined by UT with the acceptance criteria specified in section 10.1.3.1 of the UFSAR and section 10 of this SER. The OTCP-to-DSC shell weld may also be examined using multiple progressive PT when a multipass GTAW welding method is used. For both EOS-37PTH and EOS-89BTH DSCs, the applicant stated that UT is specified for the single pass weld using HA-GTAW to establish a structural weld that connects the OTCP to the shell. This change does not apply to the 61BTH DSC.

The staff reviewed the drawings for EOS-37PTH DSC and the EOS-89BTH DSC. The staff determined that the drawing revisions provided by the applicant accurately reflect the option of phased array UT as the NDE for the OTCP-to-DSC shell weld as discussed in section 10 of this SER. The staff's review of the structural evaluation of the HA-GTAW weld for the OTCP is included in SER section 3. The staff's review of the phased array UT acceptance criteria is included in SER section 10.

For Additional Scope Change No. 2, the applicant clarified in UFSAR section 1.2.3.1 "Spent Fuel Assembly Loading Operations," and UFSAR section 9.1.1, "TC and DSC Preparation," that demineralized water is used to fill TC/DSC Annulus. In addition, the applicant stated that the term 'demineralized' water includes any water that may be used for makeup to the reactor coolant system or spent fuel pool. The applicant clarified that demineralized makeup water is monitored as it pertains to the impact to the reactor coolant system and spent fuel pool, which includes being regularly analyzed for conductivity, silica, pre- and post-ultraviolet (UV) chlorides and sulfates, total organic carbon (TOC) and gamma activity. Further, the applicant stated in UFSAR section 9.1.3, "DSC Drying and Backfilling," that demineralized water is used to replenish water lost by boiling or evaporation from the TC and DSC annulus to maintain a water lever that is approximately 12 inches below the top of the DSC during the fuel loading and DSC drying operations. The applicant also provided operational experience regarding water replenishment in the TC/DSC annulus which indicates that the amount of water necessary to replenish that lost from evaporation is a small fraction of the total water volume in the TC/DSC annulus.

The staff reviewed the information provided by the applicant and the revisions to the UFSAR and determined that the effect of water loss in the TC/DSC annulus as a result of boiling and evaporation would not be significant for either the DSC or the TC because (1) the chemical composition of the makeup water is controlled, (2) the amount of water needed to replenish losses from evaporation is small with respect to the total water volume in the TC/DSC annulus, and (3) the make-up water needed to maintain the required level in the TC/DSC is readily available on-site. This ensures that the water chemistry in the TC/DSC annulus remains compatible with the dry storage system component materials. Therefore, the staff determined that the replenishment of water lost as a result of boiling and evaporation would not affect the operation or performance of the DSC or the TC.

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. This finding is reached based on a review that considered the regulation itself, appropriate regulatory guides, applicable codes and standards, and accepted engineering practices. The evaluation of the material design provides reasonable assurance that the NUHOMS® EOS system will allow safe storage of spent fuel. Some of the key findings from the staff's review of Amendment No. 3 include:

F8.1 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.

F8.2 The applicant has met the requirements in 10 CFR 72.234(b). Quality assurance programs and control of special processes are demonstrated to be adequate to ensure that the design, testing, fabrication, and maintenance of materials support SSC intended functions.

9.0 OPERATING PROCEDURES EVALUATION

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

Change No. 1:
Add three new heat load zone configurations (HLZCs) for the EOS-89BTH Dry Shielded Canister (DSC), with increased heat load up to 1.7 kW per fuel assembly, which reduces the minimum cooling time to 1 year.

Change No. 5:
For the TS; a revision to allow for phased array automated ultrasonic testing (PA-AUT) and to utilize a single pass high amperage gas tungsten arc weld (HA-GTAW) or multipass GTAW on the outer top cover plate (OTCP).

Change No. 6:
For the TS; a revision to reduce EOS-37PTH HLZC 1 and 2 time limit for transfer to 8 hours.

Change No. 9:
TS and UFSAR changes for consistency among DSC types and terminology clarifications.

Additional Scope Item No. 1:
UFSAR revisions associated with transfer cask lifting heights and consideration of severe weather.

Additional Scope Change No. 2:
UFSAR revisions associated with maintaining water in the annulus.

Additional Scope Change No. 3:
Design changes to the Matrix Loading Crane (MX-LC).

For Change No. 1, the staff's review of the applicant's TS associated with Change No. 1 noted the addition of Time Limits for Completion of DSC Transfer specific to DSC Model EOS-89BTH.

This is consistent with the changes, as well as the staff's review, of the applicant's thermal evaluation associated with Change No. 1 in section 4 of this SER, and is, therefore, acceptable.

For Change No. 5, the applicant's proposed changes to the operating procedures for both EOS-37PTH and EOS-89BTH, Amendment No. 3 permits ultrasonic testing a form of NDE and the use of a single pass HA-GTAW weld (option 2) on the structural weld that connects the outer top cover plate to the DSC Shell. As an alternative to the NDE requirements of NB-5230 for Category C welds, all closure welds are multi-layer welds and receive a root and final PT examination, except for the shell to the OTCP weld. The OTCP-to-shell, option 2 weld, may instead be examined by UT with the acceptance criteria specified in UFSAR section 10.1.3.1. This is consistent with the changes, as well as the staff's review, of the applicant's structural evaluation associated with Change No. 5 in section 3 of this SER, and is, therefore, acceptable.

For Change No. 6, the staff's review of the applicant's TS associated with Change No. 6 noted the time limit for transfer consistent among EOS-37PTH DSCs with transfer time limits. In addition, the staff evaluated the addition of Time Limits for Completion of DSC Transfer specific to DSC Model EOS-89BTH. This is consistent with the changes, as well as the staff's review, of the applicant's thermal evaluation associated with Change No. 5 in section 4 of this SER, and is, therefore, acceptable.

For Change No. 9, the applicant introduces improvements to the quality and consistency of the TS. The applicant proposed several changes to the CoC and TS for consistency and clarity among DSC types. These changes included the addition of functional operating limits, thermal, radiological, and physical parameters applicable to EOS-89BTH and 61BTH DSCs. In addition, the staff noted TS changes to EOS-37PTH and EOS-89BTH DSC ASME Code Alternatives. Specifically, the addition of ultrasonic examination of the shell to the outer top cover plate weld and the elimination of the redundant pressure test during the fabrication process of the single piece bottom forging circumferential weld. The TS changes are consistent with the structural, thermal, criticality, and materials evaluations associated with Change No. 9 as described and addressed in sections 3, 4, and 7 of this SER, and are, therefore, acceptable.

Additional Scope Change No. 1, introduces a revised definition of SAFE CONDITION AND FORECAST within the UFSAR (sections A.2.3.1, A.2.4.2.4, and A.12.3.1) to incorporate other forecasted weather conditions where the wind gust is expected to exceed the off-normal design condition operating wind limit of 44mph as defined in ASME NOG-1 with respect to the independent spent fuel storage installation (ISFSI) equipment MATRIX Loading Crane (MX-LC). In addition, staff notes the change avoids the potential for a tornado accident to occur during discrete periods when ISFSI handling operations are conducted without an analysis or evaluation.

Overall, the change satisfactorily incorporates administrative controls to verify a safe condition and forecast prior to lifting the loaded transfer cask/dry shielded canister (TC/DSC) above the lift height restriction of the TS and prior to exiting the tornado protected structure where prior loading operations occurred. This verification by trained and certified personnel is necessary to ensure the MX-LC is not exposed to winds above 44mph and tornado generated missiles during short duration transfer operations.

In the United States, the National Weather Service (NWS) is an agency under the National Oceanic and Atmospheric Administration (NOAA), within the Department of Commerce. NWS weather forecasting is recognized as being accurate and reliable in the windows of time associated with short duration transfer operations. Due to the higher reliability of shorter-term weather forecasting, administrative controls can be relied upon to ensure safety of MX-LC when a transfer activity occurs.

The staff notes, both the weather forecast, and wind speed are monitored for the duration of outdoor transfer operations until the DSC is inserted into the NUHOMS® MATRIX (HSM-MX) and the door installed. Such meteorological monitoring is coordinated with site operations procedures for tornado conditions, severe thunderstorms, and high winds. Additionally, a walkdown of the haul path and ISFSI apron will be performed to identify any potential hazards as a procedural prerequisite to the initiation of transfer operations.

The staff notes the change incorporates an acceptable time frame basis for completing the tasks necessary to lift the loaded TC with the MX-LC, dock the TC to the HSM-MX, and insert the DSC into the HSM-MX, where the total duration is conservatively estimated at eight hours. The staff notes that the UFSAR incorporates an acceptable description of an approach for compensatory actions in the event the weather deteriorates from a safe condition and forecast to impending tornado conditions during the eight-hour duration when the MX-LC is in use such that operations would be reversed to lower the MX-LC to below the TS lift height restriction, placing the TC/DSC on transfer skid in a safe parked position with the load secured. The staff notes that this is consistent with Crane Manufacturer's Association of America operating protocol.

The UFSAR also makes adequate references to alert general licensees to make modifications to administrative controls as necessary to adjust for any change and site-specific configuration where operations exceed 8 hours, or change in design winds limit is needed due to change of equipment. Staff notes that the change to UFSAR, sections A.9.1 and A.9.2 incorporate reference to UFSAR section A.2.4.2.4 for the definition of a safe condition and forecast and that transfer procedures require an initial check of the weather forecast prior to exiting the tornado protected structure where prior LOADING OPERATIONS occurred. UFSAR sections A.2.3.1, A.2.4.2.4, and A.12.3.1 have been revised to incorporate the revised definition of safe condition and forecast.

Accordingly, the staff determined, for this amendment, that formally documented administrative controls that (1) restrict initiation of transfer operations during projected periods of adverse weather and, (2) cease transfer operation and lower the MX-LC into an analyzed condition at the outset of adverse weather conditions, form an appropriate basis for demonstrating compliance with 10 CFR 72.236(l) in lieu of engineered controls solely for normal wind, off normal wind, and tornado accidents. Specifically, these administrative controls ensure that the MX-LC is designed to withstand the effects of normal wind, off normal wind, and tornados without impairing their capability to perform their intended design functions during transfer operations.

Overall, the staff concludes that the requirements of 10 CFR 72.236(l) are satisfied, in that the spent fuel storage cask and its systems important to safety have been demonstrated to reasonably maintain confinement of radioactive material under normal wind, off-normal, wind and tornado accident conditions.

Additional Scope Change No. 2, introduces UFSAR revisions associated with maintaining water in the TC/DSC annulus. Specifically, during loading operations, part of the heat generated within the DSC is dissipated to the water within the TC/DSC annulus which may result in loss of water (e.g., evaporation). To compensate for the water lost, the water in the TC/DSC annulus shall be monitored and replenished with demineralized water to maintain the water level approximately 12 inches below the top edge of the DSC shell.

The staff reviewed the supplemental information provided in section described in chapter 9 of the UFSAR related to preventing and mitigating boiling occurring in the water in the TC/DSC annulus by continuous addition of demineralized water in the TC/DSC annulus, or the use of a feed and bleed system for the demineralized water in the TC/DSC annulus (section 1.2.3.1 of the UFSAR noted demineralized water is makeup water for the reactor coolant system or spent fuel pool). The applicant also specified in section 9.1.3 of the UFSAR operating procedures, steps 18 and 25, that the helium would be introduced in the DSC in a step-wise function over time, which aides in preventing rapid boiling from occurring in the TC/DSC annulus. Chapter 9 of the UFSAR includes the additional operation of replenishing demineralized water at the applicant-provided recommended flow rate, which can be adjusted as required to ensure the water remains approximately twelve inches below the top edge of the DSC. Based on the staff's review of the applicant's submittal, the staff finds the demineralized water replenishment operations at a recommended flow rate that can be adjusted to ensure the water remains approximately twelve inches below the top edge of the DSC shell, as described in section 9.1.3 of the UFSAR, to be acceptable. This is consistent with the change, as well as the staff's review, of the applicant's thermal evaluation associated with Additional Scope Change No. 2 in section 4 of this SER, and is therefore, acceptable.

Additional Scope Change No. 3, introduces several changes to the design of the Matrix Loading Crane (MX-LC), which is a type of handling equipment used to load DSCs into the HSM-MX. The applicant described the MX-LC in section A.2.1.4.2.1 of the UFSAR with further detail in the referenced report, "ASME NOG-1 Compliance Assessment." As a seismic design safety feature, the applicant's proposed changes to the operating procedures in appendix A.9 of the UFSAR to install wheel chocks at each gantry box before allowing the MX-LC to lift the TC above the maximum lift height in TS 5.2.1 and while the DSC is being inserted into or retracted from the HSM-MX in order to prevent movement of the MX-LC wheels during a seismic event, is acceptable. This is consistent with the changes, as well as the staff's review, of the applicant's structural evaluation associated with Change No. 3 in section 3 of this SER, and is, therefore, acceptable.

The applicant did not include the installation of wheel chocks in the similar operating procedures in appendix B.9 of the UFSAR, which control the transfer and retrieval of the NUHOMS® 61BTH Type 2 DSC to and from the HSM-MX using the MX-LC. The staff reiterates that the MX-LC is a non-single-failure-proof device when operated without the wheel chocks and wheel chocks must be installed before allowing the MX-LC to lift the loaded TC above the maximum lift height in TS 5.2.1. Therefore, the transfer and retrieval of the NUHOMS® 61BTH Type 2 DSC to and from the HSM-MX using the MX-LC has not been analyzed or approved for use under Amendment no. 3. Instead, changes to the operating procedures in appendix B.9, similar to changes made to appendix A.9, would be required for use of the MX-LC to lift the loaded NUHOMS® 61BTH Type 2 DSC above the maximum lift height in TS 5.2.1.

Evaluation 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 description of operations provides reasonable assurance that the NUHOMS® EOS system will allow safe storage of spent fuel. This finding is reached based on 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 3 include:

F9.1 The *NUHOMS® EOS system* is compatible with dry loading and unloading in compliance with 10 CFR 72.236(h). General procedure descriptions for these operations are summarized in chapter 8 of the applicant's UFSAR. Detailed procedures will need to be developed and evaluated on a site-specific basis.

10.0 ACCEPTANCE TESTS AND MAINTANANCE PROGRAM EVALUATION

The applicant described the changes to the acceptance tests and maintenance program for the NUHOMS® EOS System in chapter 10 of the UFSAR. The staff reviewed the information provided by the applicant and found the two following changes in the application are applicable to the acceptance tests and maintenance program evaluation:

Change No. 5:
For the TS; a revision to allow for PA-AUT and to utilize a single pass HA-GTAW or multipass GTAW on the OTCP.

Change No. 8:
For the single bottom forging EOS-DSCs, waive the fabrication pressure test requirement.

For Change No. 5, the applicant stated that the NDE requirements for welds are specified on the drawings provided in chapter 1 and the confinement welds on the DSC are inspected in accordance with ASME Boiler and Pressure Vessel Code, Section III, subsection NB, including alternatives to ASME Code cited in section 4.4.4 of the TS. The applicant stated in UFSAR section 10.1.3.1 that the OTCP of the DSC is a structural weld, but not a confinement weld, and may be examined by PA-AUT. The applicant listed the acceptance criteria of the UT examination as follows:

1. Rounded flaws are evaluated by the acceptance criteria of NB-5331(a).
2. Planar flaws are allowable up to the limit where $(W - \Sigma hi) \geq 0.30$ inch at any location, where Σhi is the sum of the depth of aligned planar defects, and W is the measured thickness of the weld.
3. Laminar flaws are allowable.
4. Planar flaws that penetrate the surface of the weld are not allowable.

The 0.30 inch limit is based on the minimum weld size with a weld quality factor = 1.0, as shown in UFSAR section 3.9.1.6.

In response to a Request for Supplemental Information (RSI) (ML21174A231), the applicant stated that the PA-AUT procedure will be developed and that it will conform to ASME Section V, Articles 4 and 23, SE-2700, and that it will be endorsed by personnel certified to American Society for Nondestructive Testing (ASNT) Level III. The PA-AUT procedure will include steps to measure the depth of penetration of the OTCP weld to ensure the specified throat thickness is met. The applicant stated that the PA-AUT setup will be tested on a calibration block with various machined discontinuities at the minimum size at a variety of locations and orientations. The applicant also stated that NDE personnel requirements of NB-5500 apply, with the alternative to use versions of SNT-TC-1 A later than those specified in ASME B&PV Code table NCA-7100-1. In addition, the applicant stated that the examination procedure will be capable of detecting the flaws outlined in ASME section III, subsection NB-5330 and qualified as required by ASME section III, subsection NB-5112, and ASME section V, T-421.2.

The staff reviewed the application and the applicant's RSI responses (ML21174A231) and RAI responses (ML21334A206, and ML22056A458) regarding the nondestructive examination (NDE) of the OTCP-to-DSC shell weld using PA--A-UT. The staff also compared the PA-AUT acceptance criteria to the criteria in ASME B&PV Code, Section III, NB-5330. The staff determined that the acceptance criteria for rounded flaws was acceptable because the applicant used the acceptance criteria in ASME B&PV Code, Section III, NB-5331(a). The staff determined that the acceptance criteria for non-surface breaking planar flaws was acceptable because the sum of these planar flaws is subtracted from the thickness of the weld and the applicant provided an analysis to show that the acceptance criteria is sufficient to meet the structural requirements under normal, off-normal and accident conditions. The staff determined that the acceptance criteria for the laminar flaws was acceptable because laminar flaws are defined as flaws that are oriented within 10 degrees of a plane parallel to the surface of the component and do not affect the DSC stress analysis. The staff determined that the acceptance criteria for the surface breaking planar flaws was acceptable because these flaws are not permitted.

The staff reviewed the applicant's plan to develop and demonstrate an automated PA-AUT procedure from the top face of the cover plate. The staff determined that the applicant's plan was acceptable because the PA-AUT will be performed in accordance with the ASME B&PC Code, Section V, Article 4 as required by ASME B&PV Code, Section III, NB5111 and the procedure will be proved by performance demonstrations as required by ASME Section III, NB5112. The staff determined that while the plan for the PA-AUT procedure, calibration and demonstration follows the requirements in ASME B&PV Code, Section III, NB5111 and NB5112, the acceptance criteria in the plan only partially aligned with the acceptance criteria in NB5330. In order to ensure alignment in the PA-AUT procedure, , the applicant's acceptance criteria for planar flaws will require the ability to accurately size the flaws by accessing only the OTCP side of the OTCP-to-shell weld. At the time of the amendment review, the PA-AUT procedure was not developed nor reviewed by a person certified to ASNT Level III, which is necessary for qualification and approval of an acceptable written NDE practice/procedure. For these reasons, the staff added a condition to the CoC amendment requiring the applicant to provide the ASNT

Level III approved PA-AUT procedure and the supporting qualification report to the NRC no less than 60 days prior to use.

For Change No. 8, the applicant stated that the EOS-37PTH and the EOS-89BTH DSC confinement boundary is fabricated, inspected, and tested in accordance with ASME Code Section III, subsection NB with alternatives specified in section 4.4.4 of the TS. The applicant stated that the shell with the DSC bottom is pneumatically tested during fabrication in accordance with ASME Article NB-6300. In UFSAR section 10.1.1.1, the applicant stated that if the single piece bottom forging is used in the construction of the EOS-37PTH and the EOS-89BTH DSC, the fabrication leak test may be waived. The applicant stated that the pressure test at 18 to 23 psig does not sufficiently stress a single piece bottom and bottom-to-shell weld to cause pre-existing defects to propagate into leaks. Further, the applicant stated that for the purpose of finding leaks, the helium leak test described in UFSAR section 10.1.2 is far more sensitive than the pressure test. The applicant noted that the inner top cover plate and its weld to the DSC shell are pneumatically tested in the field in accordance with the ASME Code alternatives specified in section 4.4.4 of the TS.

The staff reviewed the proposed change to waive the ASME Section III, NB-6000 pressure test for the EOS-37PTH and the EOS-89BTH fabricated with the one-piece bottom forging. The staff review of Change No. 8 is included in section 2 of this SER.

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. This finding is reached based on a review that considered the regulation itself, appropriate regulatory guides, applicable codes and standards, and accepted engineering practices. The evaluation of the acceptance tests and maintenance program provides reasonable assurance that the NUHOMS® EOS system will allow safe storage of spent fuel. Some of the key findings from the staff's review of Amendment No. 3 include:

F10.1 SSCs important to safety will be designed, fabricated, erected, tested, and maintained to quality standards commensurate with the importance to safety of the function(s) they are intended to perform. Chapter 2 of the UFSAR identifies the safety importance of SSCs, and chapter 10 presents the applicable standards for their design, fabrication, and testing in accordance with 10 CFR 72.236(l).

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 a total annual exposure for each ISFSI layout versus distance curve for the new contents of the EOS-89BTH DSC loaded with intact fuel, reconstituted fuel, damaged fuel, and failed BWR fuel with the proposed burnup, enrichment, and cooling times as well the proposed 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 TC 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 450 m from the ISFSI. Therefore, 450 m is the minimum distance with design basis fuel to the site boundary for a 22-cask array with the NUHOMS® EOS System.

The applicant used MCNP inputs for a 2x10 ISFSI accident configuration using the same method as described for the normal condition models. At a distance of 200 m and 450 m from the ISFSI, the accident dose rate is approximately 2.6 mrem/hr and 0.1 mrem/hr, respectively. It is assumed that the recovery time for this accident is five days (120 hours). Therefore, the total exposure to an individual at a distance of 200 m and 450 m is 312 mrem and 12 mrem respectively. This is significantly less than the 10 CFR 72.106 limit of 5 rem.

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 EOS-89BTH DSC loaded with authorized contents and provided the results in table 11-5 of the UFSAR, “Occupational Exposure, EOS-TC125 with EOS-89BTH DSC.” This table also shows dose rates due to a crane hang-up event. A crane hang-up off-normal event adds 1556 person-mrem (dose rate location (DRL)1/decon * 4 workers * 1 hour). Contact doses for the EOS-HSM are designed to be ALARA. The key design parameters of the EOS-HSM are listed in table 1-1 of the UFSAR.

The applicant also revised the estimated doses for loading and unloading the new heat load zones for the EOS-89BTH DSC (Change No. 1) with a minimum cooling time of one year.

The staff reviewed the revised dose estimates for completing these operations and determined that the applicant has calculated the expected dose for completing the necessary operating procedures.

The staff reviewed the updated radiation protection evaluation 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 occupational doses rates in table 11-1 of the UFSAR for the system operations and found the estimated dose to be appropriate. The radiation protection evaluation 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. Based on its review, the staff has reasonable assurance that the design and operating procedures of the NUHOMS® EOS system provide acceptable means for controlling and limiting occupational radiation exposures within the limits given in 10 CFR Part 20 and for meeting the ALARA objective with respect to exposures, consistent with 10 CFR 20.1101(b). The EOS-HSM Dry Storage System is adequately designed to facilitate decontamination in accordance with 10 CFR 72.236(i) and includes, to the extent practical and appropriate, adequate features, operating pro
cedures, and controls that are designed to assist a general licensee to meet the radiological protection criteria in 10 CFR 72.126(a) and 10 CFR 72.126(d).

F10.1 The TC 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).

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 staff reviewed the information provided by the applicant and found the three following changes in the application are applicable to the accident analysis evaluation:

Change No. 1:
Add three new HLZCs for the EOS-89BTH Dry Shielded Canister (DSC), with increased heat load up to 1.7 kW per fuel assembly, which reduces the minimum cooling time to 1 year.

Change No. 2:
Add a variable-lead thickness EOS–TC125 for transfer with the EOS-89BTH DSC.

Change No. 3:
Add ATRIUM 11 fuel as an allowable content in the EOS-89BTH DSC. Reran the limiting GNF2 and ABB-10-C cases to reduce the statistical uncertainties and increase the enrichment limits.

The applicant conducted an accident analysis using conservative parameters that bound HLZC of Change No. 1, the DSC contents, including those in Change No. 3, and the allowable TC designs, including those described in Change No. 2. In UFSAR section 6.2.2.1 "Bounding HLZCs," the applicant described the selection of the HLZC in the EOS-89BTH DSC for the accident analysis evaluation. The applicant stated that the bounding HLZC used in the analysis, described as a "shielding HLZC," was conservative for dose rate analysis, as the shielding HLZC features 42.8 kW on the periphery and 82.8 kW within the entire DSC. The peripheral FAs are defined in TS figure 8. The applicant stated that the minimum cooling time associated with the shielding HLZC is 1.0 year. The applicant used the shielding HLZC for the accident analysis for the EOS-89BTH DSC stored in the EOS-HSM. Similarly, the applicant used the shielding HLZC for the accident analysis for the EOS-89BTH DSC stored in the HSM-MX as described in UFSAR section A.6.1. The applicant's transfer operations accident analysis conservatively used the EOS-TC125 with the minimum lead thickness and an EOS-89BTH DSC with the shielding HLZC. The staff reviewed the parameters used by the applicant in the accident analysis and determined that the parameters were acceptable because they conservatively bound the TC designs, allowable contents, decay heat loads, and HLZCs for the NUHOMS® EOS system.

EOS-TC Drop Accident Analysis

The applicant revised the accident dose calculations in chapter 12 and for an accidental EOS-TC drop with an EOS-37PTH or EOS-89BTH DSC. The applicant stated that the drop scenarios do not breach the EOS-37PTH or the EOS-89BTH DSC confinement boundaries. Further, the applicant stated that the function of EOS-TC lead shielding is not compromised by these drops. The applicant stated that the EOS-TC neutron shield may be damaged in an accidental drop. The applicant stated that the maximum dose rate at 100 m from an EOS-TC during a loss of neutron shield and lead slump as a result of an accidental drop accident is 3.74 mrem/hr. The applicant stated that, based on the discussion in UFSAR section 6.2.8, the maximum accident dose rate was doubled to 7.5 mrem/hr. The applicant calculated that the dose to an individual at the site boundary is 7.5×8 = 60 mrem assuming an 8-hour recovery time. The calculated dose is significantly below the 10 CFR 72.106 dose limit of 5 rem.

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.

EOS-HSM and HSM-MX Tornado Missile Accident Analysis

The applicant revised the accident dose calculations in chapter 12 and chapter A.12 of appendix A of the UFSAR for a tornado wind missile accident for the NUHOMS® EOS-HSM and HSM-MX respectively. The applicant used a 2 x 10 back-to-back array of EOS-HSMs and a distance to the site boundary of 450 m for evaluation of the impact on public exposure. The applicant stated that the accident dose rate is approximately 2.6 mrem/hour and 0.1 mrem/hr at 200 m and 450 m respectively from the ISFSI. The applicant calculated the total exposure to an individual at 200 m and 450 m is 312 mrem and 12 mrem, respectively, assuming a recovery time for the accident was five days (120 hours). The calculated dose is significantly below the 10 CFR 72.106 dose limit of 5 rem.

In UFSAR section A.12.3.3, the applicant stated that for the HSM-MX, the evaluation for the impact on public exposure was based on a 2 × 11 ISFSI configuration and a distance to the site boundary of 450 m. The applicant stated that the accident dose rate was approximately 1.34 mrem/hr, which was rounded up to 1.5 mrem/hour at 200 m from the ISFSI, which was noted by the applicant as significantly closer than the minimum estimated site boundary distance of 450 m. The applicant calculated the total exposure to an individual at 200 m was 180 mrem assuming a recovery time for the accident was five days (120 hours). The calculated dose is significantly below the 10 CFR 72.106 dose limit of 5 rem. The applicant stated that the dose is bounded by the EOS-HSM accident dose documented in UFSAR section 12.3.3.

The staff reviewed the revised EOS-HSM and HSM-MX tornado missile accident analysis 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.

Evaluation Findings

The staff reviewed the applicant revised accident analysis conditions for EOS-TC with an EOS-37PTH or EOS-89BTH DSC, the EOS-37PTH or EOS-89BTH DSC in the EOS-HSM or HSM-MX storage module and the 61BTH DSC within the OS197-TC. 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 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 No. 3 include:

F12.1 The analyses of off-normal and accident events and conditions and reasonable combinations of these and normal conditions show that the design of the DSS will acceptably meet the requirements in 10 CFR 72.236(d) regarding criteria for radiological protection.

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. 3, 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, Radiation Protection, and Accident Analysis Evaluation 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 three new HLZCs for the EOS-89BTH DSC, with increased heat load up to 1.7 kW per fuel assembly, which reduces the minimum cooling time to 1 year.

Change No. 2:
Add a variable-lead thickness EOS-TC125 for transfer with the EOS-89BTH DSC.

Change No. 3:
Add ATRIUM 11 fuel as an allowable content in the EOS-89BTH DSC. Reran the limiting GNF2 and ABB-10-C cases to reduce the statistical uncertainties and increase the enrichment limits.

Change No. 4:
Update the criticality evaluation to allow short-loading the EOS-89BTH DSC with less than 89 FAs to increase the enrichment limits.

Change No. 5:
For the TS; a revision to allow for PA-AUT and to utilize a single pass HA-GTAW or multipass GTAW on the OTCP.

Change No. 6:
For the TS; a revision to reduce EOS-37PTH HLZC 1 and 2 time limit for transfer to 8 hours.

Change No. 7:
Incorporate a method to determine new loading patterns based on the maximum allowable heat load per DSC and per location specified in the TS. All HLZCs and time limits for transfer for the EOS-89BTH DSC transferred in the EOS-TC125 are moved from the TS to UFSAR chapter 2.

Change No. 8:
For the single bottom forging EOS-DSCs, waive the fabrication pressure test requirement.

Change No. 9:
TS and UFSAR changes for consistency among DSC types and terminology clarifications.

Additional Scope Change No. 1:
UFSAR revisions associated with transfer cask lifting heights and consideration of severe weather.

Additional Scope Change No. 2:
UFSAR revisions associated with maintaining water in the annulus.

Additional Scope Change No. 3:
Design changes to the Matrix Loading Crane (MX-LC).

CoC Condition

The applicant shall provide the PAAUT procedure for conducting nondestructive examination of the outer top cover plate-to dry shielded canister shell weld and the supporting qualification report for the PAAUT procedure upon ASNT Level III approval to the NRC no less than 60 days prior to use.

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. 3 for the NUHOMS® EOS system should be approved.

Issued with Certificate of Compliance No. 1042, Amendment No. 3
on June 8, 2023.