Criticality/Shielding

RSI 1-1

Provide parameters that explicitly define the requested new contents to be stored in the NUHOMS EOS system.

The applicant provides some general parameters, such as general fuel array sizes (e.g., 17x17, 15x15 PWR fuel), that are to be stored in the requested new baskets and basket configurations in the revised safety analysis report (SAR) and proposed revision of the certificate of compliance. However, these parameters are not sufficient to characterize the fuel for the safety analyses. For example, criticality and shielding analyses need the fuel assembly geometry, rod and cladding length and diameters, rod pitch, and depletion parameters to determine the neutron multiplication factor and the neutron and gamma sources per the regulatory requirements of 10 CFR 72.236(a), 10 CFR 72.124, and 10 CFR 72.236(d). Although the applicant indicates in Section 2.2 of the SAR that the fuel characteristics are provided in Table 2-4 of the SAR, the staff was unable to find this table. The applicant needs to provide parameters, such as fuel assembly geometry, rod and cladding length and diameters, and rod pitch that can unambiguously define the fuel designs that are allowed to be stored in the EOS system as well as the parameters used to perform its safety analyses of the cask system design within Chapters 6 and 7 of the SAR so that the staff may determine if the safety analyses are bounding for the proposed allowable contents.

This is consistent with the acceptance criteria and review guidance provided in NUREG-1536, “Standard Review Plan for Dry Cask Storage Systems.” Specifically, Section 6.5.2 of NUREG-1536 states, “The review confirms that the applicant examined all fuel designs and burnup conditions for which the cask system is to be certified, to ensure that the bounding fuel type and values are used.” Section 7.5.2 of NUREG-1536 references NUREG-1745 which states in Section 2.0 “Approved Contents” that the “list is intended for intact fuel. As a result, the list may need to be modified if damaged fuel or fuel debris is stored in the cask.”

The staff needs this information to proceed with its review to determine if the NUHOMS EOS system with the requested new contents meets the regulatory requirements of 10 CFR 72.124 and 10 CFR 72.236(d).

RESPONSE TO RSI 1-1:

The scope of Certificate of Compliance (CoC) No. 1042 Amendment 1 is described in Enclosure 2, “Description, Justification, and Evaluation of Amendment 1 Changes” ML18053A229) of the original Amendment 1 submittal of February 15, 2018. The changes include two new basket types for the EOS-37PTH DSC, a new storage design (HSM-MX, for the EOS-37PTH DSC and EOS-89BTH DSC), two-year cooled fuels and loading options for damaged and failed fuels for the EOS-37PTH DSC.

The original Amendment 1 submittal (ML18053A222) was provided on a page replacement basis for the updated final safety analysis report (UFSAR) pages, so the requested information did not change from that provided in Amendment 0 and in the updated Revision 1 of the NUHOMS® EOS System UFSAR (ML18043A202) provided on January 31, 2018. Tables 2-2, 2-3, and 2-4 of the UFSAR show the allowable pressurized water reactor (PWR) and boiling water reactor (BWR) fuel assembly types and design characteristics for storage in the EOS/MATRIX system. The PWR fuel assembly types and design characteristics apply to intact, damaged and failed fuels per UFSAR Section 2.2.1. The BWR fuel assembly types and design characteristics shown in Table 2-3 and Table 2-4 apply to intact fuels, as described in UFSAR Section 2.2.2.

There were no changes to Tables 2-2, 2-3, or 2-4 in Amendment 1, so these were not included in the changed pages in Enclosures 5 and 6 (ML18053A234 and ML18053A235) of the original Amendment 1 submittal.

Application Impact:

No changes as a result of this RSI.

RSI 1-2

Provide drawings with dimensions and potential manufacturing tolerances for the new basket design.

The amendment incorporates a new Basket Type (Type 4) to allow for damaged and failed fuel compartments as well as a low-conductivity, low-emissivity poison plate basket option (Type 5). The applicant provides drawings for the new basket type. However, these drawing do not include dimensions and potential manufacturing tolerances. In particular, the drawings do not include information on the basket cells that are designated to hold failed fuels. Because the dimensions and associated tolerances are critical parameters in criticality and shielding safety analysis models, the applicant needs to revise the drawings to include these data. This is consistent with the acceptance criteria and review guidance provided NUREG-1536. Specifically, Section 6.5.3.1 of NUREG-1536 states: "The reviewer should verify that the model dimensions and materials are consistent with those specified in the cask drawings presented in Chapter 1, "General Information Evaluation" of the SAR. Voids, streaming paths, and irregular geometries should be accounted for or otherwise treated in a conservative manner." Section 7.5.3.1 of NUREG-1536 states, "Tolerances for poison material dimensions and/or concentrations should be defined, and the most reactive conditions should be used in the criticality analysis."

The staff needs this information to proceed with its review to determine if the NUHOMS EOS system with the requested new contents meets the regulatory requirements of 10 CFR 72.124 and 10 CFR 72.236(d).

RESPONSE TO RSI 1-2:

The EOS-37PTH DSC design is shown in drawings in Section 1.3.1 of Updated Final Safety Analysis Report (UFSAR) Chapter 1. Typically, UFSAR drawings include nominal dimensions or minimum dimensions when they are relevant to the safety analysis; UFSAR drawings do not include manufacturing tolerances.

The key basket dimensions and materials are shown in UFSAR Drawing EOS01-1010-SAR for the NUHOMS® EOS-37PTH Type 4 basket. The staggering of the basket assembly plates in the axial direction is accomplished by using steel and poison plates that are one inch shorter than the aluminum basket plates at the bottom of the basket assembly. The nominal poison material thickness and the damaged/failed fuel basket plates are respectively shown in Drawing EOS01-1010-SAR, Sheets 8 of 13 (Detail 2) and from Sheets 9 of 13 through 13 of 13. The minimum B-10 contents for the metal matrix composite (MMC) poison plates are shown in Drawing EOS01-1010-SAR, Sheets 1 of 13 and Table 5 of the Certificate of Compliance (CoC) No. 1042 Technical Specifications (TS). The Intact/Damaged and Intact/Failed configurations were added to EOS01-1010-SAR Sheet 12 with additional limitations, as provided in Figures 1F and 1H of CoC 1042 TS for, respectively, Heat Load Zone Configurations 6 and 8.

The following are the key elements for the criticality analysis to ensure the adequacy of the criticality model for the damaged and failed analysis:

- The criticality analysis in Chapter 7 takes 90% credit for the B-10 content of the MMC poison plates (75% credit for the B-10 content of the Boral material).

- The sensitivity criticality analysis performed on the poison plate thickness in UFSAR Section 7.4.2 A 3 demonstrates the effect on the variation in the thickness of the poison plate is statistically insignificant.

- One-inch uncovered fuel, no poison material, modeled at the bottom end of the basket, Section 7.4.2 A 10 of Chapter 7.

- While the EOS-37PTH DSC is authorized to store up to eight damaged fuel assemblies or four failed fuel assemblies in HLZC 6 or HLZC 8, the criticality analysis assumes 12 failed fuel assemblies, as shown in Figure 7-24 of Chapter 7.

Dimensions and manufacturing tolerances for the NUHOMS® EOS-37PTH Type 4 basket do not need to be added to the drawings because the criticality analysis bounds anticipated manufacturing tolerances.

Note that the shielding analyses in Chapter 6 and Chapter A.6 are not sensitive to tolerances on the poison plates and do not take credit for the B-10 content in the poison plates.

Application Impact:

EOS01-1010-SAR was revised as described in the response.

RSI 6-1

Provide inspectable parameters for fuel and Non-Fuel Hardware (NFHW) that correlate the radiation source terms with the decay heat limits or parameters that characterize the radiation source terms as a function of enrichment, burnup and cooling time for all of the new requested contents and loading patterns.

In Chapter 6 of the revised SAR, the applicant provides neutron and gamma sources for some combinations of enrichments, burnup and cooling times. However, it is not clear how the source terms are related to the decay heat limit. It is not clear whether these data bound all potential combinations of enrichments, burnup and cooling times for all requested new fuels, including failed fuels, and other non-fuel hardware contents. Because these parameters are critical for shielding design, fuel selection and qualification for the licensees, and the NRC inspectors to verify whether the selected fuels and NFHW qualify for storage in the NUHOS EOS system based ISFSI, the applicant needs to provide these data in the SAR. This is consistent with the acceptance criteria and review guidance provided in NUREG-1536. Specifically, Section 6.5.2 "Radiation Source Definition" of NUREG-1536 states: "The reviewer should examine the description of the design-basis fuel in Chapter 2, "Principal Design Criteria" of the SAR to verify that the applicant calculated the bounding source term. The review confirms that the applicant examined all fuel designs and burnup conditions for which the cask system is to be certified, to ensure that the bounding fuel type and values are used." Section 6.5.2.1, "Initial Enrichment" of NUREG-1536 states: "However, the staff should not attempt to use specific source terms as bases for establishing operating controls and limits for cask use because these are not readily inspectable parameters. The fuel assembly initial enrichment, burnup, and cooling time are more appropriate for use as loading controls and limits."

The staff needs this information to proceed with its review to determine if the NUHOMS EOS system with the requested new contents meets the regulatory requirements of 10 CFR 72.236(d).

RESPONSE TO RSI 6-1:

Amendment 1 changes for pressurized water reactor (PWR) fuel assemblies include the addition of damaged and failed fuel as authorized contents and addition of several heat load zone configurations (HLZCs). Further, the minimum cooling time for PWR fuel has been reduced to two years. The PWR fuel assembly designs for the intact, damaged, and failed fuel contents remain unchanged in Amendment 1. For boiling water reactor (BWR) fuel, there are no changes to the fuel assembly designs or authorized contents based on Amendment 1.

The parameters for the new spent fuel contents include the maximum decay heat of the fuel assembly and authorized loading patterns (HLZCs), the maximum allowable burnup of 62 GWd/MTU, and the minimum cooling time of two years. These parameters are limited by Technical Specifications (TS) Section 2.0, *Functional and Operating Limits.*

Non-Fuel Hardware (NFHW) source terms are characterized by a maximum allowable Co-60 content and are limited by TS Table 3. These Co-60 limits are unchanged from approved Amendment 0.

Table 6-7 of the UFSAR provides the burnup and minimum enrichment combinations utilized in the analysis, while the analyzed combinations are shown in Tables 6-8 and 6-9 of the UFSAR for PWR and BWR fuel assemblies, respectively. Tables 6-8 and 6-9 show the correlation between decay heat and the source terms employed in the analysis.

For Amendment 1, Table 6-8 is modified to include additional combinations in support of the changes due to damaged and failed contents, new HLZCs, and two-year cooled PWR fuel. Design basis source terms are developed to maximize transfer cask and HSM dose rates based on Table 6-8. The equivalent table for BWR fuel (Table 6-9) has not been modified in Amendment 1. Dose rates due to damaged and failed fuel are discussed in more depth as part of the Response to RSI 6-2.

The qualification methodology employed for Amendment 1 changes remains unchanged from the methodology employed for approved Amendment 0. The NRC has accepted this approach to fuel qualification in the Final Safety Evaluation Report (ML17116A278) for Amendment 0.

The titles in the source term tables for new contents (Tables 6-14 through 6-19) are updated to clearly indicate the heat load associated with each source.

Application Impact:

UFSAR Tables 6-14 through 6-19 have been revised as described in the response.

RSI 6-2

Demonstrate how the failed fuel retains its geometric shape that is consistent with the assumption used in the shielding analyses or provide shielding analyses consistent with the potential fuel geometry changes during operations.

The new basket type (Type 4) allows for storage of failed fuel in the canister. However it is not clear how the geometric shape of the failed fuel is retained, in particular with consideration of the fact that the basket is loaded in vertical position and then turned into horizontal position when it is moved and eventually stored in the concrete module. The applicant needs to provide information on how the geometric shape is retained by the cask design and provide appropriate shielding analyses consistent with the potential changes of fuel geometry during normal, off normal, and accident conditions with the specific design feature, including the operations, of the system. The staff needs this information to perform its evaluation of the shielding design of the NUHOMS EOS system per the acceptance criteria of NUREG-1536, "Standard Review Plan for Spent Fuel Dry Storage Systems at a General License Facility," which states: "If the applicant has requested storage of damaged fuel assemblies, ensure that the applicant has adequately described the proposed damage assemblies. If the fuel assemblies are damaged to the extent that reconfiguration of the fuel into a geometry different from intact fuel assemblies can occur, ensure that the applicant provides appropriate close assessments for normal, off-normal and accident conditions." NUREG-1536 further states: "On the basis of experience, comparison to similar systems, or scoping calculations, the reviewer should make an initial assessment of whether the dose rates appear reasonable and whether their variation with location is consistent with the geometry and shielding characteristics of the cask system." The staff needs this information to perform its evaluation of the shielding design of the NUHOMS EOS system per the acceptance criteria of NUREG-1536.

The staff needs this information to proceed with its review to determine if the NUHOMS EOS system with the requested new contents meets the regulatory requirements of 10 CFR 72.236(d).

RESPONSE TO RSI 6-2:

Explicit Monte Carlo N-Particle (MCNP) calculations for various damaged and failed fuel configurations for normal, off-normal, and accident conditions have been performed and added to the Updated Final Safety Analysis Report (UFSAR).

EOS-37PTH dry shielded canister (DSC) heat load zone configurations (HLZC) 6 and 8 are used for storage of failed or damaged fuel. HLZC 6 is used only with the EOS-HSM, and HLZC 8 is used only with the HSM-MX. DSCs that employ these HLZCs may be transferred only in the EOS-TC125/135. MCNP models are developed for 1.0 kW/FA in Zone 1, 1.5 kW/FA in Zone 2, 1.5 kW/FA for intact fuel in Zone 3, and 0.85 kW/FA for failed fuel in Zone 3 (bounds 0.8 kW/FA). This configuration bounds both HLZC 6 and 8.

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UFSAR Section 6.2.2, *PWR and BWR Source Terms*, has been revised to add appropriate source terms for HLZC 6/8. The new tables are Table 6-16a, 6-16b, and 6-16c.

UFSAR Section 6.3.2, *MCNP Model Geometry for the EOS-TC*, has been revised to add a description of the damaged/failed fuel configurations modeled.

UFSAR Section 6.4.3, *EOS-TC Dose Rates*, has been revised to add a discussion of the damaged/failed fuel dose rate results. Normal/Off-Normal dose rate results for damaged/failed fuel are included in new Table 6-53a. The accident dose rate at 100 m is provided in the UFSAR text.

UFSAR Section 6.4.4, *EOS-HSM Dose Rates*, has been revised to clarify that the presence of damaged/failed fuel will cause a reduction in the vent dose rates.

Application Impact:

UFSAR Sections 6.2.2, 6.3.2, 6.4.3 and 6.4.4 have been revised as described in the response.

UFSAR Tables 6-16a, 6-16b, 6-16c, and 6-53a have been added as described in the response.

Materials

RSI 8-1

Explain how the use of basket end caps and a modified basket is an acceptable alternative to the use of a failed fuel can for the storage of failed fuel described in UFSAR, Section 1.2.3.1 (ML18053A234). Explain how loading of failed fuel will be accomplished without dispersing fuel fragments into other basket cells that are not intended for the storage of damaged or failed fuel. In addition, describe how a general licensee will determine whether the fuel should be classified as damaged fuel or failed fuel. The descriptions in the Technical Specifications (TS) Section 1.1 are not consistent with NUREG-1536 Revision 1 Section 8.4.17.2 Fuel Classification. It is not clear in the TS or the UFSAR how a general licensee will determine if fuel assemblies with greater than hairline cracks or greater than pinhole leaks could be handled by normal means and whether such assemblies should be classified as damaged fuel or failed fuel.

The NRC staff note that NUREG-1536, Revision 1, Section 8.6, “Supplemental Information for Methods for Classifying Fuel” contains the following information:

> *C. Canning Damaged Fuel*
>
> *Spent fuel that has been classified as damaged for storage must be placed in a can designed for damaged fuel, or in an acceptable alternative. The purpose of a can designed for damaged fuel is to (1) confine gross fuel particles, debris, or damaged assemblies to a known volume within the cask; (2) to demonstrate that compliance with the criticality, shielding, thermal, and structural requirements are met; and (3) permit normal handling and retrieval from the cask. The can designed for damaged fuel may need to contain neutron-absorbing materials, if results of the criticality safety analysis depend on the neutron absorber to meet the requirements of 10 CFR 72.124(a).*

The basket and end caps described in the Amendment application appear to be sufficient to (1) confine gross fuel particles, debris, or damaged assemblies to a known volume within the cask and (2) to demonstrate that compliance with the criticality, shielding, thermal, and structural requirements are met but it is unclear how the basket and end caps are an acceptable alternative that would (3) permit normal handling and retrieval from the cask because as stated in the amendment Technical Specifications (TS), failed fuel cannot be handled by normal means. It is noted that the Amendment application defines retrievability as removing a dry shielded canister (DSC) loaded with spent fuel assemblies from the storage location consistent with Option C in ISG-2 Revision 2 (ML16117A080).

This information is necessary to assure compliance with 10 CFR 72.236(a), (h) and (m).

RESPONSE TO RSI 8-1:

General licensees use site-specific procedures to classify their fuel assemblies and prepare loading plans for their dry storage loading campaigns. The sites use a combination of historical records, records from sipping campaigns and fuel inspections as inputs to their classification program. The procedures include license compliance evaluations against both the reactor 10 CFR Part 50 license and the applicable 10 CFR Part 72 storage CoC, TS and UFSAR requirements. Fuel that is to be classified as intact must not have fuel rods with known or suspected cladding defects greater than hairline cracks or pinhole leaks. Typically, incore measurements and sipping data are used to make this determination. If leaking rods are found from the incore measurements or sipping data, the assemblies are not classified as intact unless further inspections, such as ultrasonic testing, are completed. With respect to cladding and grid damage, the evaluations used to qualify both intact and damaged fuel consistent with the thermal, shielding and criticality analysis for normal and off-normal conditions are included in Chapter 2, Section 2.2.1 of the UFSAR. Licensees may use the methodologies and evaluations included in the UFSAR to evaluate damaged or slipped grid straps and end fitting damage when classifying a fuel assembly for purposes of storage. Failed fuel includes everything that cannot be classified as either intact or damaged.

With regard to the discussion on “normal means,” 10 CFR Part 72 does not specifically define “normal means” for handing fuel; however, NUREG-1536 Revision 1 defines “normal means” as:

> “Normal Means” is defined as the ability to move a fuel assembly and its contents by the use of a crane and grapple used to move undamaged assemblies at the point of cask loading. The addition of special tooling or modifications to the assembly to make the assembly suitable for lifting by crane and grapple does not preclude the assembly as being considered moveable by normal means.

All fuel transferred to the 37PTH DSC is handled by “normal means,” and as such, the definition of DAMAGED FUEL and FAILED FUEL has been revised to provide further clarification. These definitions have been revised in the TS Definitions and in UFSAR Sections 2.2.1 and TS Section 1.1.

Application Impact:

TS Section 1.1 has been revised as described in the response.

UFSAR Section 2.2.1 has been revised as described in the response.

RSI 8-2

Provide a description of EOS-37PTH DSC payloads that contain the control components (CCs), identified in UFSAR, Section 2.2.1 (ML18053A234) and indicate whether these contents are consistent with the component materials previously reviewed and determined acceptable as described in NUREG-1536, Revision 1, Section 8.4.8.2, “Canister Contents.” Provide a detailed description of any component material that is not determined acceptable per NUREG-1536, Revision 1, Section 8.4.8.2.

This information is necessary to assure compliance with 10 CFR 72.236(a), (b) and (h).

RESPONSE TO RSI 8-2:

Certificate of Compliance (CoC) No. 1042 Updated Final Safety Analysis Report (UFSAR) Section 2.2.1 details the control components (CCs) that can be stored with either damaged or intact fuel assemblies. Between Amendment 0 and Amendment 1, the control components listed in Section 2.1.1 were reorganized to group CCs that have similar functional characteristics, but the various contents themselves are largely unchanged. The various categories of CC were divided into the following categories in Amendment 1: thimble plug assemblies (TPAs), burnable poison rod assemblies (BPRAs), control element assemblies (CEAs), and neutron sources. All control components presented in Amendment 0 were accounted for in Amendment 1, with the addition of the following CCs: 1) burnable absorber assemblies (BAAs) and 2) flux suppression inserts (FSIs). Section 2.2.1 of the UFSAR has been revised to group the CCs having similar functional characteristics. In addition, a description of these broad groupings has been added to UFSAR Section 2.2.1, and a new reference has been added to UFSAR Section 2.5.

There were BAAs added in the group category labeled as BPRAs. BAAs are burnable absorber rods consisting of Pyrex borosilicate glass tubes contained within Type 304 stainless steel tubular cladding, which is plugged and seal welded at the ends to encapsulate the glass [Reference 1]. BAA is the Westinghouse trade name for burnable poison rod assemblies; these perform the same function as the BPRAs. The definition of CCs in TS Section 1.1 has been revised to add these BAAs.

There were FSIs added to the category labeled as control element assemblies. FSIs absorb neutrons at peripheral core locations. The FSI assembly contains rods fastened to a baseplate hold down assembly. Each neutron absorber rod consists of thick-walled zircaloy cladding welded to a bottom end plug and top connector, which encapsulates a stack of solid hafnium bars. These bars are supported by a zircaloy support spacer held against the spacer by a spring clip [Reference 2]. These FSI assemblies perform similar functions as control rod assemblies and are classified with them as authorized components.

Materials used in construction of the aforementioned control components are made of materials to ensure no significant galvanic/corrosive reactions, consistent with the guidance of NUREG-1536, Rev. 1 Section 8.4.8.2. The hafnium bars used in the FSIs are not explicitly listed in the aforementioned section; however, hafnium is commonly used as a neutron absorber in control rods. Chemically, hafnium is almost identical to zirconium, and mining of zirconium is almost certain to produce hafnium as a coproduct. Therefore, since zirconium and zirconium alloys are acceptable for compatibility in the DSC, hafnium is also considered to be an acceptable material [Reference 3].

References

1. NUREG/CR-6761, Parametric Study of the Effect of Burnable Poison Rods for PWR Burnup Credit, Oak Ridge National Laboratory, Section 2.1, March 2002.

2. Surry Power Station UFSAR, Rev. 39, September 27, 2007, Section 3.3, Virginia Electric and Power Company (Dominion), Docket Nos. 50-280/281.

3. Holmes, D.R., ATI Wah Chang, “Corrosion of Hafnium and Hafnium Alloys,” Allegheny Technologies, ASM Handbook Volume 13C, ASM International, 2005.

Application Impact:

TS Section 1.1 has been revised as described in the response.

UFSAR Sections 2.2.1 and 2.5 have been revised as described in the response.

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RSI 8-4

Provide the procedure and specifically describe the loading and unloading steps for the damaged fuel and failed fuel. Address, as necessary, the testing of fission gases, radiation dose rates and ALARA practices, removal of top and bottom end caps and the recovery of failed fuel that cannot be handled by normal means. Based on a review of previous TN Americas CoCs, the procedures for removing damaged or failed fuel require additional steps that are not included in EOS UFSAR, Revision 1.

UFSAR 9.2.2 Removal of Fuel from the DSC (ML18053A234) states the following:

> *Note that the EOS-37PTH DSC will provide the retrievability function for damaged and failed FAs per ISG-2, Revision 2. However, if it is necessary to remove fuel from the DSC, intact and damaged fuel can be removed in a dry transfer facility or the initial fuel loading sequence can be reversed and the plant's spent fuel pool utilized.*
>
> *Procedures for wet unloading of the DSC are presented here. Dry unloading procedures are essentially identical up to the removal of the DSC vent plug and drain port cover.*

However, no procedures are provided for the removal of damaged or failed fuel.

This information is necessary to assure compliance with 10 CFR 72.236(h).

RESPONSE TO RSI 8-4:

UFSAR Section 9.2.2, Step 34 has been updated to provide additional steps for removing damaged and failed fuel from the dry shielded canister (DSC). If the DSC contains damaged fuel, then (1) the top end caps are removed, and (2) the fuel is removed using standard fuel handling procedures. If the DSC contains failed fuel, then (1) the top end caps are removed, (2) large pieces of the fuel assembly, and any rod storage baskets and/or debris containers/baskets are removed using lifting devices similar to those used during loading operations consistent with their design, (3) a long lifting rod is threaded into the bottom end cap and the end cap is slowly raised toward the top of the basket to allow the removal of larger pieces of loose debris that has fallen into the end cap, and (4) the bottom end cap and any remaining small debris is removed from the DSC.

Note that the existing procedure (Steps 15 and 16) includes provisions for checking for the presence of fission gas indicative of degraded fuel conditions and additional measures to be taken for radiation protection and to keep occupational radiation exposures As Low As Reasonably Achievable (ALARA).

Application Impact:

UFSAR Section 9.2.2 has been revised as described in the response.

RSI 8-5

Clarify UFSAR, Table 8-10, “Material Properties, High Strength Low Alloy Steel” to identify the reference for Note 5 (ML18053A234).

Note 5 is included in the footnotes for Table 8-10 and specifies room temperature yield strength and ultimate strength requirements for ASTM A829 Grade 4130 steel. The yield strength and ultimate strength requirements listed in Note 5 are not consistent with the entries in Table 8-10. There is no reference or call out to Note 5 identified in the actual table.

This information is necessary to assure compliance with 10 CFR 72.236(b).

RESPONSE TO RSI 8-5:

The values in UFSAR Table 8-10 are those used for analysis. The values in Note 5 of this table are used for procurement of the ASTM A829 Gr 4130 steel. The values in Note 5 were determined so that room temperature tensile tests ensure the elevated temperature design values used in the analysis. They were calculated in Reference [8-24], a proprietary test report that was submitted to NRC as Enclosure 6 of TN Americas LLC submittal number E-40553 [Reference 1].

These room temperature requirements of 103.6 ksi yield strength and 123.1 ksi ultimate strength are duplicated in UFSAR Section 10.1.7. Therefore, Note 5 is not needed and has been deleted from Table 8-10.

Reference:

1. E-40553, “Application for Approval of the Spent Fuel Cask Design for the NUHOMS® EOS System,” Docket 72-1042, December 19, 2014, ML15005A475.

Application Impact:

UFSAR Table 8-10 has been revised as described in the response.

RSI 8-6

Clarify the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel (B&PV) code year and section for the basket structural components and identify the grades of the SA-517 materials used in the construction of the basket. UFSAR, Section 10.1.7, "High-Strength Low-Alloy Steel for Basket Structure" (ML18053A234) states:

> *The basket structural material shall be a High-Strength Low-Alloy (HSLA) steel meeting one of the following requirements A, B, or C:*
>
> *A. ASTM A829 Gr 4130 or AMS 6345 SAE 4130, quenched and tempered at not less than 1050 °F. This material is qualified as described in [10-31].*
>
> *B. ASME SA-517 Gr A, B, E, F, J, or P. This material is qualified by the material properties at elevated temperature in ASME Section II, Part D, which exceed the values of yield and ultimate strength in UFSAR Table 8-10.*
>
> *C. Other HSLA steel, with the specified heat treatment, meeting these qualification criteria:*

UFSAR requirement B identifies ASME SA-517 grades A, B, E, F, J and P. Technical Specification 4.4.2 (ML18053A233) identifies the ASME B&PV code 2010 with the 2011 addenda as the code for the DSC but there is no code identified for the basket. In the ASME B&PV code 2010 with the 2011 addenda, the specifications for ASME SA-517 do not identify a grade J. ASME SA-517 grades A, B, E, F, and P have lower allowable yield strengths (100 ksi) and ultimate strengths (115 ksi) compared to the 103.6 ksi yield strength and the 123.1 ksi ultimate strength identified in the next paragraph in UFSAR, Section 10.1.7 (ML18053A234) and also included in Note 5 of UFSAR Table 8-10. Except for grades A and B, the grades listed for SA-517 have different thicknesses and the yield and ultimate strength of these materials generally decrease as the thickness increases. Grade P (2.5 to 4 in) has a lower allowable yield and ultimate compared to grades A, B, E, and F. The ASME B&PV code 2010 with the 2011 addenda Section IID allowable yield strength for SA-517 grade P (2.5 to 4 in) as 90 ksi which is below the yield strength requirements in UFSAR Table 8-10 for temperatures from -20 to 200°F. This information is necessary to assure compliance with 10 CFR 72.236(b) and (g).

RESPONSE TO RSI 8-6:

Updated Final Safety Analysis Report (UFSAR) Section 10.1.7 B has been revised to delete Grade J and to reference ASME Code edition 2010 with 2011 addenda.

The high-strength low-alloy (HSLA) steel plates for the EOS baskets are less than 0.32 inch thick. Therefore, the mechanical properties that apply are those for the thinnest materials identified in ASME 2010E/2011A, Section II, Part D, as listed in the following two tables. The ASME Section II Part D yield and ultimate strengths for all listed SA-517 grades exceed the design requirements of UFSAR Table 8-10, which are also included in the tables, at all temperatures.

S_y (ksi) for SA-517 grades from ASME 2010E/11A Section II Part D, Table Y-1, compared to design requirements in UFSAR Table 8-10								
Grade	**70 °F**	**200 °F**	**300 °F**	**400 °F**	**500 °F**	**600 °F**	**700 °F**	**800 °F**
Tbl 8-10	96.4	91.6	87.7	83.9	80.0	76.1	71.3	66.0
A≤1.25	100.0	95.5	92.4	89.9	87.6	85.5	83.0	79.5
B≤1.25	100.0	95.5	92.4	89.9	87.6	85.5	83.0	79.5
E≤2.5	100.0	95.5	92.5	90.0	88.0	86.3	84.8	83.0
F≤2.5	100.0	95.5	92.4	89.9	87.6	85.5	83.0	79.5
P≤2.5	100.0	95.5	92.4	89.9	87.6	85.5	83.0	79.5

S_u (ksi) for SA-517 grades from ASME 2010E/11A Section II Part D, Table U, compared to design requirements in UFSAR Table 8-10								
Grade	**70 °F**	**200 °F**	**300 °F**	**400 °F**	**500 °F**	**600 °F**	**700 °F**	**800 °F**
Tbl 8-10	101.2	96.2	92.1	88.1	84.0	79.9	74.9	69.3
A≤1.25	115.0	115.0	115.0	115.0	115.0	115.0	112.6	106.0
B≤1.25	115.0	115.0	115.0	115.0	115.0	115.0	112.6	106.0
E≤2.5	115.0	115.0	115.0	115.0	115.0	115.0	114.6	110.0
F≤2.5	115.0	115.0	115.0	115.0	115.0	115.0	112.6	106.0
P≤2.5	115.0	115.0	115.0	115.0	115.0	115.0	112.6	106.0

Further revisions have been made to UFSAR Section 10.1.7:

- The 103.6 ksi yield and 123.1 ksi ultimate strength requirements in Section 10.1.7 have been moved so that they only apply to the A829 Gr 4130 material. These tensile criteria are not necessary for SA-517, because the mechanical properties from ASME Section II Part D exceed the design requirements of Table 8-10 at all temperatures (as shown above). The rationale for applying these acceptance criteria to A829 Gr 4130 is explained in the response to RSI 8-5. Other HSLA steels must develop material-specific tensile criteria by a similar method, as required by UFSAR Section 10.1.7(C)(iii).

- The ASME NG-2330 Charpy impact testing acceptance criteria of UFSAR Section 10.1.7 have been revised. NG-2330 does not provide Charpy testing acceptance criteria for material below 5/8 inch thick. From 5/8 inch to 2 inches, NG-2330 provides only lateral expansion criteria, which may not be applicable to the subsize specimens required due to the basket plate thickness. Therefore, the acceptance criteria of UFSAR Section 10.1.7 to the absorbed energy values of ASME Table NF-2331(a)-4 for 5/8 to 1 inch thick, 75 to 105 ksi yield strength material has been revised. The intention is to provide an alternate means of demonstrating sufficiently ductile behavior at the minimum service temperature. An alternate is sought due to the limited availability of dynamic tear testing.

- The reference in UFSAR Section 10.1.7 to ASME NG-2000 has been removed from the specimen location, orientation, and sampling rate statement. ASTM A6 or A20 provides sufficient rules.

Technical Specifications (TS) 4.3.2 has also been revised consistent with the changes in UFSAR Section 10.1.7 discussed above, except that the ASME Code edition is not included in the TS. Procurement to later code editions may be acceptable, and should be open to change under the 10 CFR 72.48 process. The specimen location, orientation, and sampling rate statement in UFSAR Section 10.1.7 was not part of TS 4.3.2, and therefore the change to that part of Section 10.1.7 does not apply to TS 4.3.2.

Application Impact:

UFSAR Section 10.1.7 has been revised as described in the response.

TS 4.3.2 has been revised as described in the response.

<u>Materials Observations</u>

Observation 8-1

UFSAR, Section 2.2, 2nd paragraph (ML18053A234) states:

> *Damaged and failed fuel that meet the characteristics detailed in Table 2-2 and Table 2-4 are also acceptable for storage in the EOS-37PTH DSC in the appropriate compartments as shown in Figures 1F and 1H of the Technical Specifications [2-18].*

The staff notes that Table 2-4 has both PWR and BWR fuel assembly design characteristics and the amendment application does not seek the approval for the storage of damaged BWR fuel. The statement in UFSAR, Section 2.2, and the tables should be revised to be specific to PWR fuel.

This information is necessary to assure compliance with 10 CFR 72.236(a) and (b).

RESPONSE TO OBSERVATION 8-1:

The second paragraph of Updated Final Safety Analysis(UFSAR) Section 2.2 has been revised to clarify that the information for damaged and failed fuel pertains only to pressurized water reactor (PWR) fuels in UFSAR Table 2-4. Similar clarification has also been provided in the note to UFSAR Table 7-3.

Application Impact:

UFSAR Section 2.2 and Table 7-3 have been revised/added/deleted as described in the response.

Observation 8-2

UFSAR Section 2.2, 9th paragraph (ML18053A234) states:

> *The NUHOMS® EOS-37PTH DSCs can also accommodate up to a maximum of four compartments with failed fuel, placed in cells located on the outer edge of the DSC as shown in Figures 1F and 1H of the Technical Specifications [2-18]. Failed fuel is defined in Section 2.1 of the Technical Specifications [2-18].*

The staff note that the definition of failed fuel is in Section 1.1 of the TS (page 1-2) (ML18053A233). Section 2.1 of the TS indicates how many failed fuel assemblies may be stored in the EOS-37PTH (page 2-1). The statement should be clarified to indicate what information in the TS is being referenced.

This information is necessary to assure compliance with 10 CFR 72.236(a) and (b).

RESPONSE TO OBSERVATION 8-2:

The failed fuel definition is located in Technical Specifications (TS) Section 1.1, as noted. UFSAR Sections 1.1 and 2.2 have been revised to clarify the appropriate TS section for the definitions of both damaged and failed fuel. In addition, clarity has been added to UFSAR Section 2.2 to indicate that the specifications for the fuel to be stored are provided in TS Sections 2.1 and 2.2.

Application Impact:

UFSAR Sections 1.1 and 2.2 have been revised as described in the response.

Thermal Observations:

Observation 4-1

Provide justification for not performing daily visual inspection of HSM-MX wind deflectors, or modify Technical Specifications (TS) 5.1.3.2.a and 5.5 to describe daily visual inspection of wind deflectors.

Section A.1.2.1 of the UFSAR states, “Wind deflectors are integrated to the outlet vent covers and installed on the top of the HSM-MX to mitigate the effect of sustained winds for high heat load DSCs.” Technical Specification 5.1.3.1.a.ii describes daily visual inspection of wind deflectors which is required, per TS 5.5 for the EOS-HSM, for certain heat load, HLZC, and DSC conditions. Yet the HSM-MX is not addressed in TS 5.5 and there is no analogous TS to 5.1.3.1.a.ii in TS 5.1.3.2.a for daily visual inspection of wind deflectors on the HSM-MX. Alternatively, justification for not performing daily visual inspection of HSM-MX wind deflectors should be provided.

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

RESPONSE TO OBSERVATION 4-1:

For the EOS-HSM System, in order to mitigate the effect of sustained winds for high heat load dry shielded canisters (DSCs), wind deflectors are included as auxiliary hardware installed on the top of the EOS-HSM next to the outlet. For these high heat load DCSs (as specified in Technical Specifications (TS) 5.5), wind deflectors shall be installed. Any loss or damage to the wind deflectors could affect the outlet vents. Therefore, TS 5.1.3.1.a.ii describes daily visual inspection of wind deflectors, if installed as specified by TS 5.5, for the EOS-HSM with certain heat load, HLZC, and DSC conditions.

However, for the HSM-MX System shown in UFSAR Figure A.1-7, outlet vent covers installed on the top of the HSM-MX are designed to mitigate the effect of sustained winds. The use of wind deflectors is not required for the HSM-MX System, and is therefore not included in TS 5.5. Since there are no wind deflectors installed on the HSM-MX, daily visual inspection of the wind deflectors is not applicable. Only daily visual inspection of the HSM-MX outlets is needed, as described in TS 5.1.3.2.a.

Since there are no wind deflectors installed in the HSM-MX, the HSM-MX does not need the analogous heat load requirements as those specified in TS 5.5 for the EOS-HSM. To provide clarification, the description of the HSM-MX in Section A.1.2.1 has been revised to delete mention of the wind deflectors since the outlet vent covers installed on the top of the HSM-MX are designed to mitigate the effect of sustained winds.

Application Impact:

UFSAR Section A.1.2.1 has been revised as described in the response.

Observation 4-2

Provide additional description that addresses how the user will develop a daily temperature measurement program to verify the thermal performance of each HSM-MX System through the direct measure of the HSM-MX concrete temperature in TS 5.1.3.2.b.ii.

TS 5.1.3.2.b.ii. describes that the user shall establish in the program concrete measurement locations in the HSM-MX that are representative of the HSM-MX thermal performance and directly correlated to the predicted fuel cladding temperatures, air mass flow rates, and NUHOMS MATRIX System temperature distributions that would occur with the off-normal and accident blockage conditions, as analyzed in the UFSAR. It is not clear how the concrete measurement locations in the HSM-MX are chosen, and then how the concrete measurement locations are directly correlated to the predicted fuel cladding temperatures, air mass flow rates, and NUHOMS MATRIX System temperature distributions.

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

RESPONSE TO OBSERVATION 4-2:

[ ]

Application Impact:

No changes as a result of this OBS.

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Observation 4-3

Provide a detailed list of the applicable thermal calculation package(s) for the thermal evaluation in Appendix A.4 of the UFSAR.

Appendix A.4 of the application provides a summary of the applicant's thermal evaluation for storage. Due to the new HSM-MX design and decay heat load, a detailed list of the thermal calculation package(s) for the thermal evaluation in Appendix A.4 of the application should be provided so that the staff will have a clear understanding what is in the calculation package(s). In addition, the staff may request any or all of the documents during the review to assist in understanding the details of and provide justification for the applicant's thermal evaluation. The details and justification for the thermal evaluation should appear in the calculation package(s) and that information may assist the staff to more efficiently perform the review.

This information is needed to determine compliance with 72.236(f) and (l).

RESPONSE TO OBSERVATION 4-3:

[ ]

Application Impact:

No changes as a result of this OBS.

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<u>Confinement Observation:</u>

Observation 5-1

Provide information to clarify how the end cap with multiple through holes will contain any potential fuel debris if fuel were to rubblize due to unexpected events during on-site transfer or insertion of the DSC into EOS-HSM.

FSAR Section 5.1 <u>Confinement Boundary</u> states, “For damaged and failed assemblies, top and bottom caps are provided to contain any potential fuel debris, such as broken rods, loose pellets, and/or pieces of cladding in the fuel compartment. The end caps fit snugly into the top and bottom of the fuel compartment. They are held in place by the fuel compartments and the inner bottom cover plate and the top shield plug during transfer and storage. The end caps have multiple through holes to permit unrestricted flooding and draining of the fuel compartments.”

It’s not clear to staff that for damaged and failed assemblies loaded in dry shielded canister (DSC), the end caps with multiple through holes are able to contain the potential fuel debris, loose pellets and/or pieces of cladding if rubblized into tiny pieces (e.g., fines) due to unexpected events during on-site transfer or insertion of the DSC into EOS-HSM (horizontal storage modulus). Irradiated fuel debris escaping from the end caps of the fuel compartment could potentially cause a safety issue.

The applicant should provide information (e.g., configuration of end cap, size of holes, etc.) for clarification.

This information is needed to determine compliance of 10 CFR 72.236(e).

RESPONSE TO OBSERVATION 5-1:

UFSAR Drawing EOS01-1010-SAR has been revised to identify the 0.12 inch typical hole size in the top and bottom end caps.

This size is consistent with end cap and failed fuel can hole sizes employed in the other NUHOMS® designs, such as CoC 1004 for the NUHOMS® 61BTH DSC (UFSAR Drawing NUH61BTH-1000-SAR, Revision 4, Sheet 5), and NUHOMS® 24PTH DSC (UFSAR Drawing NUH24PTH-72-1008, Revision 0, Sheets 1 and 2). The use of end cap is discussed in the NRC Safety Evaluation Report for CoC 1004 Amendment 10.

Application Impact:

UFSAR Drawing EOS01-1010-SAR has been revised as described in the response.