SAFETY EVALUATION REPORT

TRANSNUCLEAR, INC.

NUHOMS® HD HORIZONTAL MODULAR STORAGE

SYSTEM FOR IRRADIATED NUCLEAR FUEL

DOCKET NO. 72-1030

AMENDMENT NO. 1

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Docket No. 72-1030
NUHOMS® HD Horizontal Modular Storage System for Irradiated Nuclear Fuel
Certificate of Compliance No. 1030
Amendment No. 1

SUMMARY

By application dated November 1, 2007, and as supplemented on December 15, 2008; February 19, 2009; April 30, 2009; May 26, 2009; June 10, 2009; September 17, 2009; June 17, 2010 (proprietary information, not publicly available); July 9, 2010; July 26, 2010; and August 24, 2010; Transnuclear, Inc. (TN) requested approval of an amendment, under the provisions of 10 CFR Part 72, Subpart K and L, to Certificate of Compliance (CoC) No. 1030 for the NUHOMS® HD Horizontal Modular Storage System for Irradiated Nuclear Fuel.

Staff initially completed its technical review of the proposed amendment in October 2009. On May 6, 2010, and May 7, 2010, the direct final rule and proposed rule, respectively, were published in the *Federal Register* (75 FR 24786 and 75 FR 25120). On July 16, 2010, both the direct final rule and proposed rule were withdrawn because TN identified that a certain Technical Specification (TS) related to Boral characterization (TS 4.3.1, ‘‘Neutron Absorber Tests’’) was not written precisely and in a manner that could be readily and demonstrably implemented. TN submitted additional information on Boral in letters dated June 17, 2010 (proprietary information, not publicly available) and July 9, 2010, and submitted revised language for TS 4.3.1 on July 26, 2010, and August 24, 2010.

TN requested a change to the CoC, including its attachments, and revision of the Final Safety Analysis Report (FSAR). The requested changes are as follows:

- Add Combustion Engineering (CE) 16x16 class fuel assemblies as authorized contents of the NUHOMS® HD System described in the Updated Final Safety Analysis Report (UFSAR). The NUHOMS® HD System is currently authorized to store CE 14x14, Westinghouse (WE) 15x15 and WE 17x17 classes only.

- Reduce the off-normal ambient temperature from -20°F to -21°F.

- Expand the authorized contents of the NUHOMS® HD System to include Pressurized Water Reactor (PWR) fuel assemblies with Control Components (CCs), (also referred to as Non-Fuel Assembly Hardware (NFAH) in CoC No. 1030 Amendment 0), such as Burnable Poison Rod Assemblies (BPRAs), Thimble Plug Assemblies (TPAs), Control Rod Assemblies (CRAs), Control Element Assemblies (CEAs), Rod Cluster Control Assemblies (RCCAs), Vibration Suppressor Inserts (VSIs), Axial Power Shaping Rod Assemblies (APSRAs), Orifice Rod Assemblies (ORAs), Neutron Source Assemblies (NSAs), and Neutron Sources. All PWR fuel assemblies currently authorized for storage may be stored with CCs.

The NUHOMS® HD System is currently authorized to store three types of CCs: BPRAs, TPAs and VSIs, for the WE 15x15 and WE 17x17 classes only.

- Reduce the minimum initial enrichment of fuel assemblies from 1.5 wt% U-235 to 0.2 wt% U-235.

- Clarify the requirements of reconstituted fuel assemblies.

- Add requirements to qualify metal matrix composite (MMC) neutron absorbers with integral aluminum cladding.

- Clarify the requirements for neutron absorber testing.

- Delete use of nitrogen for draining the water from the dry shielded canister (DSC), and allow only helium as a cover gas during DSC cavity water removal operations.

The 32PTH DSC is designed to store up to 32 intact PWR fuel assemblies. Non-Fuel Assembly Hardware are allowed for these fuel assemblies. The 32PTH DSC is also designed for storage of up to 16 damaged fuel assemblies, and remaining intact assemblies, utilizing top and bottom end caps. The maximum heat load per 32PTH DSC, including any integral insert components, is 34.8 kW for WE 15x15, WE 17x17, and CE 16x16; and 33.8 kW for CE 14x14 assemblies.

The applicant previously added a new canister design identified as the 32PTH Type 1, and added a new transfer cask design identified as the OS-187H Type 1. The staff did not review or evaluate any content changes associated with the OS-187H Type 1 or the 32PTH Type 1 additions as part of this amendment request. Therefore, use of the revised contents in these design additions is not formally authorized as part of this certification action for the NUHOMS® HD. Use by a general licensee of the 32PTH Type 1 or the OS-187H Type 1 cask design must satisfy the criteria of 10 CFR 72.48, and is subject to NRC inspection. If the general licensee cannot satisfy the criteria of 10 CFR 72.48, it must seek approval from the NRC prior to using the 32PTH Type 1 or the OS-187H Type 1 cask design.

NRC staff has reviewed the application using the guidance provided in NUREG-1536, “Standard Review Plan for Dry Cask Storage Systems,” January 1997, and applicable Interim Staff Guidance Documents (ISGs). Based on the statements and representations in the application, as supplemented, the staff concludes that the TN NUHOMS® HD System, as amended, meets the requirements of 10 CFR Part 72.

1 GENERAL DESCRIPTION

By application dated November 1, 2007 (Ref. 1), and as supplemented on December 15, 2008; February 19, 2009; April 30, 2009; May 26, 2009; June 10, 2009; September 17, 2009; June 17, 2010 (proprietary information, not publicly available); July 9, 2010; July 26, 2010; and August 24, 2010 (Refs. 2 – 11); Transnuclear, Inc. (TN) requested approval of an amendment, under the provisions of 10 CFR Part 72, Subpart K and L (Ref. 12), to Certificate of Compliance (CoC) No. 1030 for the NUHOMS® HD Horizontal Modular Storage System for Irradiated Nuclear Fuel (Ref. 13).

The objective of the review of the general description of Amendment 1 to the NUHOMS® HD System is to ensure that TN has provided a non-proprietary description that is adequate to familiarize reviewers and other interested parties with the pertinent features of changes to the system.

1.1 General Description and Operations Features

The NUHOMS® HD System is based on the Standardized NUHOMS® System described in Certificate of Compliance (CoC) No. 1004 (Ref. 14). The 32PTH dry shielded canister (DSC) included in this system is similar to the 24PTH DSC approved for use under Amendment 8 to the Standardized NUHOMS® System.

The scope of Amendment 1 to CoC No. 1030 includes eight separate changes. These changes are:

- Add Combustion Engineering (CE) 16x16 class fuel assemblies as authorized contents of the NUHOMS® HD System described in the Updated Final Safety Analysis Report (UFSAR) (Ref. 15). The NUHOMS® HD System is currently authorized to store CE 14x14, Westinghouse (WE) 15x15 and WE 17x17 classes, only. (Note that the Framatome ANP Advanced MK BW 17x17 fuel assembly design is part of the WE 17x17 class.)

- Reduce the off-normal ambient temperature from -20°F to -21°F in Technical Specification 4.6.3.

- Expand the authorized contents of the NUHOMS® HD System to include Pressurized Water Reactor (PWR) fuel assemblies with Control Components (CCs), also referred to as Non-Fuel Assembly Hardware (NFAH), in CoC No. 1030, such as Burnable Poison Rod Assemblies (BPRAs), Thimble Plug Assemblies (TPAs), Control Rod Assemblies (CRAs), Control Element Assemblies (CEAs), Rod Cluster Control Assemblies (RCCAs), Vibration Suppressor Inserts (VSIs), Axial Power Shaping Rod Assemblies (APSRAs), Orifice Rod Assemblies (ORAs), Neutron Source Assemblies (NSAs), and Neutron Sources. All PWR fuel assemblies currently authorized for storage may be stored with CCs.

  The NUHOMS® HD System is currently authorized to store three types of CCs: BPRAs, TPAs and VSIs, for the WE 15x15 and WE 17x17 classes only.

- Reduce the minimum initial enrichment of fuel assemblies from 1.5 wt% U-235 to 0.2 wt% U-235.

- Clarify the requirements of reconstituted fuel assemblies.

- Add requirements to qualify metal matrix composite (MMC) neutron absorbers with integral aluminum cladding.

- Clarify the requirements for neutron absorber testing.

- Delete use of nitrogen for draining the water from the DSC, and allow only helium as a cover gas during DSC cavity water removal operations.

1.1.1 Changes to the NUHOMS® HD Technical Specifications

A brief description for each of the changes to the Technical Specifications (TS) is provided in the following bullets.

- Revised the definition for Damaged Fuel Assembly.
- Added a definition for Fuel Class.
- Added a definition for Reconstituted Fuel Assembly.
- Revised the definition for Transfer Operations for clarity.
- Revised TS 2.1, “Fuel to be Stored in the 32PTH DSC,” to revise the description of Fuel Class, add the description of Reconstituted Fuel Assemblies, revise the list of Control Components authorized for storage in the 32PTH DSC, specify the Location of Damaged Assemblies, add the Maximum Assembly plus CC weight (from original Table 2), add the Burnup, Enrichment, and Minimum Cooling Time for the 32PTH DSC; add the Maximum Assembly Average Initial Fuel Enrichment; and revise the Decay Heat per DSC limits.
- Revised the time limit from 30 days to 60 days (in accordance with the regulations in 10 CFR 72.75(g)) for the Functional and Operating Limits Violations report in paragraph 2.2.3.
- Revised paragraph 3.1, Fuel Integrity, (Limiting Condition for Operation (LCOs) 3.1.1, 3.1.2, and 3.1.3) to allow only helium as a cover gas during DSC cavity water removal operations, to clarify that the applicability is during Loading Operations, but before Transfer Operations, and to adjust time constraints.
- Revised paragraph 3.2, Criticality Control, (LCO 3.2.1) to clarify the applicability, and add an additional required action if the condition is not met.
- Revised paragraph 4.3.1 to indicate revised referenced FSAR sections that clarify requirements for neutron absorber testing.
- Revised paragraph 4.6.3(5) to reflect reduction of the minimum off-normal ambient temperature, without solar insolation, from -20°F to -21°F.
- Revised paragraph 5.2.5 to add a new paragraph 5.2.5(c) that adds an alternate surveillance activity with associated corrective actions (thermal performance), to add “Daily Visual Inspection” of the HSM-H inlets and outlets, and to add corrective actions for blocked air vents and damaged bird screens.
- Revised paragraph 5.3.2, Cask Drop, to clarify that it applies to transfer cask side drops.
- Added paragraph 5.6, Hydrogen Gas Monitoring, to ensure that the combustible mixture concentration remains below the flammability limit.

- Deleted Table 1, Fuel Specifications, which was replaced with TS 2.1, “Fuel to be Stored in the 32PTH DSC”.
- Revised Table 2, (originally Fuel Dimension and Weights), now “Fuel Assembly Design Characteristics for the NUHOMS® HD-32PTH DSC,” to reflect the changes in allowed fuel assemblies, and delete the information now incorporated in TS 2.1.
- Revised Table 3, Maximum Control Component Source Terms, to add allowed control component specifications, and to delete information pertaining to the Framatome ANP Advanced MK BW 17x17 fuel assemblies, since they are part of the WE 17x17 class.
- Revised Table 4, Fuel Qualification Table(s), to reflect the changes in allowed fuel assemblies, show maximum allowable assembly burnup as a function of assembly average enrichment, and to show minimum cooling time as a function of assembly average enrichment.
- Deleted Table 5, NFAH Thermal Qualification, which was replaced with TS 2.1, “Fuel to be Stored in the 32PTH DSC”.
- Revised Table 7, Maximum Assembly Average Initial Enrichment for Intact and Damaged Fuel Loading, to reflect the changes in allowed fuel assemblies.

1.2 Addition of 32PTH Type 1

The applicant previously added a new canister design identified as the 32PTH Type 1, and added a new transfer cask design identified as the OS-187H Type 1. The staff did not review or evaluate any content changes associated with the OS-187H Type 1 or the 32PTH Type 1 additions as part of this amendment request. Therefore, use of the revised contents in these design additions is not formally authorized as part of this certification action for the NUHOMS® HD. Use by a general licensee of the 32PTH Type 1 or the OS-187H Type 1 cask design must satisfy the criteria of 10 CFR 72.48, and is subject to NRC inspection. If the general licensee cannot satisfy the criteria of 10 CFR 72.48, it must seek approval from the NRC prior to using the 32PTH Type 1 or the OS-187H Type 1 cask design.

1.3 System Description

1.3.1 Dry Shielded Canister (32PTH DSC)

The 32PTH consists of a stainless steel cylindrical shell with welded inner top cover/shield plug (including siphon/vent cover welds) and inner bottom cover plate which form the confinement boundary. Shield plugs are installed inside of the confinement boundary, at the top and bottom, to provide radiological shielding. Inside the 32PTH DSC is a basket assembly that consists of stainless steel square tubes and support strips for structural support and geometry control, and aluminum/borated aluminum for heat transfer and criticality control. The 32PTH DSC is similar to the Standardized NUHOMS® System 24PTH DSC.

1.3.2 Horizontal Storage Module (HSM-H)

The HSM-H is constructed of reinforced concrete and structural steel. The key design parameters of the HSM-H are provided in Table 1-1 of the UFSAR. The HSM-H design is virtually identical to the HSM-H for the NUHOMS® 24PTH DSC included in Amendment 8 to CoC No. 1004. The HSM-H provides spent fuel decay heat removal, and physical and radiological protection for the 32PTH DSC. Ambient air enters the HSM-H through ventilation inlet openings located on both sides of the lower front of the HSM-H and circulates around the 32PTH DSC and the heat shields. Air exits through air outlet openings located on each side of the top of the HSM-H.

1.3.3 Transfer System

The OS-187H Transfer Cask (TC) used with the NUHOMS® HD System, provides shielding and protection from potential hazards during 32PTH loading and closure operations, and transfer to the HSM-H. The OS-187H TC is similar to the OS-197 and OS-197H TCs described in the SAR for the Standardized NUHOMS® System. The TC is constructed from two concentric stainless steel shells with a bolted and gasketed top cover plate and a welded bottom end assembly. The TC also includes an outer steel jacket which is filled with water to provide neutron shielding. The top and bottom end assemblies also incorporate a solid neutron shield material. Two top lifting trunnions are provided for handling the TC using a lifting yoke and overhead crane. Lower trunnions are provided for rotating the cask from/to the vertical and horizontal positions on the support skid/transport trailer. A gasketed cover plate is provided to seal the bottom hydraulic ram access penetration of the cask during loading. The TC lid is also provided with gaskets so that a helium environment can be maintained during DSC transfer operations.

The transfer trailer is not important to safety because the NUHOMS® HD System Technical Specifications (TS) limit the lifting height of the 32PTH DSC to eighty inches, which is within the design basis drop for the DSC.

1.4 Drawings

Section 1 of the SAR contains the non-proprietary drawings for the NUHOMS® HD System, including drawings of the structures, systems, and components (SSC) important to safety.

1.5 32PTH DSC Contents

The 32PTH DSC is designed to store up to 32 intact PWR Westinghouse 15x15 (WE 15x15), Westinghouse 17x17 (WE 17x17), Combustion Engineering 14x14 (CE 14x14), and/or Combustion Engineering 16x16 (CE 16x16) fuel assemblies. Non-Fuel Assembly Hardware (NFAH) such as Burnable Poison Rod Assemblies (BPRAs), Thimble Plug Assemblies (TPAs), Control Rod Assemblies (CRAs), Control Element Assemblies (CEAs), Rod Cluster Control Assemblies (RCCAs), Vibration Suppressor Inserts (VSIs), Axial Power Shaping Rod Assemblies (APSRAs), Orifice Rod Assemblies (ORAs), Neutron Source Assemblies (NSAs), and Neutron Sources are allowed for these fuel assemblies. The 32PTH DSC is also designed for storage of up to 16 damaged fuel assemblies, and remaining intact assemblies, utilizing top and bottom end caps. The maximum heat load per 32PTH DSC, including any integral insert components, is 34.8kW for WE 15x15, WE 17x17, and CE 16x16 assemblies; and 33.8kW for CE 14x14 assemblies.

Additional fuel characteristics are discussed in Sections 2 and 6 of the SAR.

1.6 Technical Qualifications of the Applicant

Section 1.3 of the SAR contains identification of agents and contractors. This information has not changed with the amendment.

1.7 Notes on Review Areas

1.7.1 Radiation Protection Evaluation

Changes to the Radiation Protection aspects of this cask system are evaluated in Chapters 5 and 6 of this SER.

1.7.2 Materials Evaluation

Changes to the materials aspects of this cask system are discussed in Chapter 3 of this SER.

1.7.3 Confinement Evaluation

No changes were made with the requested Amendment 1 that affected the Confinement Evaluation discussed in the original SER.

1.7.4 Operating Procedures Evaluation

Changes to operating procedures, specifically in the areas of fuel specifications, and draining, drying, filling and pressurization; are described throughout this SER.

1.7.5 Accident Analysis

Amendment changes affecting the original accident analysis are discussed in Chapters 3 and 6 of this SER.

1.7.6 Acceptance Test and Maintenance Programs

The only amendment changes that affected the acceptance test and maintenance programs, are in the materials area, and are discussed in Chapter 3.

1.7.7 Quality Assurance and Decommissioning Review Areas

The TN QA program has been previously reviewed and accepted (Ref. 17), has not changed, and is therefore not addressed in this Safety Evaluation Report (SER). Similarly, no changes were made with the requested Amendment 1 that affected the Decommissioning Evaluation discussed in the original SER.

1.8 Evaluation Findings

F1.1 A general description of the NUHOMS® HD System is presented in Section 1 of the SAR, with special attention to design and operating characteristics, unusual or novel design features, and principal safety considerations.

F1.2 Drawings for SSC important to safety are presented in Section 1 of the SAR. Specific SSC are evaluated in Sections 3 through 6 of this SER.

F1.3 Specifications for the spent fuel to be stored in the NUHOMS® HD System are stated in SAR Sections 1, 2 and 6.

F1.4 The technical qualifications of the applicant to engage in the proposed activities are identified in Section 1.3 of the SAR.

F1.5 The quality assurance program and implementing procedures are described in Section 13 of the SAR.

F1.6 The staff concludes that the information presented in Section 1 of the SAR satisfies the requirements for the general description under 10 CFR Part 72. This finding is reached on the basis of a review that considered the regulation itself, Regulatory Guide 3.61 (Ref. 16), and accepted practices.

F1.7 The applicant previously added a new canister design identified as the 32PTH Type 1, and added a new transfer cask design identified as the OS-187H Type 1. The staff did not review or evaluate any content changes associated with the OS-187H Type 1 or the 32PTH Type 1 additions as part of this amendment request. Therefore, use of the revised contents in these design additions is not formally authorized as part of this certification action for the NUHOMS® HD. Use by a general licensee of the 32PTH Type 1 or the OS-187H Type 1 cask design must satisfy the criteria of 10 CFR 72.48, and is subject to NRC inspection. If the general licensee cannot satisfy the criteria of 10 CFR 72.48, it must seek approval from the NRC prior to using the 32PTH Type 1 or the OS-187H Type 1 cask design.

1.9 References

1. Transnuclear, Inc., "Application for Amendment 1 of the NUHOMS® HD Certificate of Compliance No. 1030 for Spent Fuel Storage Casks, Revision 0," November 1, 2007. (ML073110525)

2. Transnuclear, Inc., "Revision 1 to Transnuclear, Inc. (TN) Application for Amendment 1 to the NUHOMS® HD System, Response to Request for Additional Information (Docket No. 72-1030; TAC NO. L24153)," December 15, 2008. (ML083570513)

3. Transnuclear, Inc., "Revision 2 to Transnuclear, Inc. (TN) Application for Amendment 1 to the NUHOMS® HD System (Docket No. 72-1030; TAC NO. L24153)," February 19, 2009. (ML090540418)

4. Transnuclear, Inc., "Revision 3 to Transnuclear, Inc. (TN) Application for Amendment 1 to the NUHOMS® HD System, Response to Second Request for Additional Information (Docket No. 72-1030; TAC NO. L24153)," April 30, 2009. (ML091240234)

5. Transnuclear, Inc., "Revision 4 to Transnuclear, Inc. (TN) Application for Amendment 1 to the NUHOMS® HD System (Docket No. 72-1030; TAC NO. L24153)," May 26, 2009. (ML091490165)

6. Transnuclear, Inc., “Revision 5 to Transnuclear, Inc. (TN) Application for Amendment 1 to the NUHOMS® HD System (Docket No. 72-1030; TAC NO. L24153),” June 10, 2009. (ML091660144)

7. Transnuclear, Inc., “Revision 6 to Transnuclear, Inc. (TN) Application for Amendment 1 to the NUHOMS® HD System (Docket No. 72-1030, TAC NO. L24153),” September 17, 2009. (ML092640683)

8. Transnuclear, Inc., “Boral™-Related Information Pertaining To Discussions Regarding Certificate of Compliance No. 1030, Amendment 0 Technical Specifications, for the NUHOMS® HD System (Docket No. 72-1030),” June 17, 2010. (ML102580291, proprietary information, not publicly available)

9. Transnuclear, Inc., “BORAL® Boron Carbide Particle Size (Docket No. 72-1030; TAC NO. L24153),” July 9, 2010. (ML101930536)

10. Transnuclear, Inc., “Revision 7 to Transnuclear, Inc. (TN) Application for Amendment 1 to the NUHOMS® HD System (Docket No. 72-1030; TAC NO. L24153),” July 26, 2010. (ML102100192)

11. Transnuclear, Inc., “Revision 8 to Transnuclear, Inc. (TN) Application for Amendment 1 to the NUHOMS® HD System (Docket No. 72-1030; TAC NO. L24153),” August 24, 2010. (ML102380404)

12. U.S. Code of Federal Regulations, “Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor - Related Greater Than Class C Waste,” Title 10, Part 72.

13. Certificate of Compliance (CoC) No. 1030 for the NUHOMS® HD Horizontal Modular Storage System for Irradiated Nuclear Fuel, January 10, 2007.

14. Certificate of Compliance (CoC) No. 1004 for the Standardized NUHOMS® Horizontal Modular Storage System for Irradiated Nuclear Fuel, January 23, 1995.

15. Updated Final Safety Analysis Report for the NUHOMS® HD System, Revision 1, Docket No. 72-1030, October 3, 2007 (ML072840178)

16. U.S. Nuclear Regulatory Commission, Regulatory Guide 3.61, “Standard Format and Content for a Topical Safety Analysis Report for a Spent Fuel Dry Storage Cask,” February 1989.

17. U.S. Nuclear Regulatory Commission, Revision 5 to Transnuclear’s 10 CFR Part 72 Quality Assurance Manual, December 30, 1999.

2 PRINCIPAL DESIGN CRITERIA

The objective of reviewing the principal design criteria related to the structures, systems, and components (SSC) important to safety, is to ensure that they comply with the relevant general criteria established in 10 CFR Part 72 (Ref. 1).

2.1 Structures, Systems, and Components Important to Safety

The SSCs important to safety are discussed in Section 2.5 of the Updated Final Safety Analysis Report (SAR) (Ref. 2) and are summarized in Table 2.5 of the SAR. In this table, each component is assigned a safety classification. The SSCs important to safety include the 32PTH DSC, the HSM-H, and the OS-187H TC. The staff agrees with the determinations stated in Section 2.5 of the SAR. This information has not changed in the requested amendment.

2.2 Design Basis for Structures, Systems, and Components Important to Safety

2.2.1 Spent Fuel Specifications

The NUHOMS® HD System can store 32 intact, or up to 16 damaged (with remaining intact), WE 15x15, WE 17x17, CE 14x14, and/or CE 16x16 PWR fuel assemblies. The 32 PWR fuel assemblies can be stored with, or without, Non-Fuel Assembly Hardware, which includes BPRAs, VSIs, or TPAs. As stated in TS 2.1, equivalent reload fuel assemblies that are enveloped by the fuel assembly design characteristics listed in TS Table 2 for a given assembly class, are also acceptable for storage.

The applicant clarified the definition of damaged fuel assemblies to be a fuel assembly with known or suspected cladding defects greater than pinhole leaks or hairline cracks and which can be handled by normal means. This definition is consistent with the staff guidance outlined in Interim Staff Guidance-1 (ISG-1) (Ref. 3).

The fuel to be stored in the 32PTH DSC is limited to fuel with a maximum initial enrichment of 5 wt% U-235. The maximum allowable burnup is given as a function of initial fuel enrichment but does not exceed 60 GWd/MTU. The minimum cooling time for fuel assemblies is five years.

2.2.2 External Conditions

The NUHOMS® HD System SAR Section 2.2 includes a summary of environmental conditions, natural phenomena, and manmade situations that the system has been designed to withstand. These include:

- tornado and wind loadings
- flooding
- seismic events
- snow and ice loadings
- lightning
- fire
- cask drop

The staff has determined that these descriptions contain sufficient detail to provide an overview of which conditions, phenomena, and situations required further evaluation. Further evaluation of these and other normal, off-normal, and accident conditions are discussed in Sections 3 through 6 of this SER.

2.3 Design Criteria for Safety Protection Systems

The safety protection systems, a summary of design criteria for the NUHOMS® HD System are described in Section 2.3 of the SAR.

2.3.1 General

The NUHOMS® HD System was designed to provide long term storage of spent fuel. The 32PTH DSC cylindrical shell, the inner top cover/shield plug (including the vent and siphon covers and welds), and the bottom, form the pressure retaining confinement boundary for the spent fuel. The outer top closure plate is welded to the shell to provide a redundant confinement boundary. The 32PTH DSC shell and bottom end assembly confinement boundary weld is made during fabrication of the 32PTH DSC. The top closure confinement and structural welds are made after fuel loading.

2.3.2 Structural

The structural analysis for the 32PTH DSC, HSM-H, and OS-187H TC is presented in Section 3 of the SAR. Section 3 of the SAR also describes the ability of these components to perform their design functions during normal and off-normal operating conditions, as well as under postulated accident conditions and extreme natural phenomena. The load combinations considered for combining normal operating, off-normal, and accident loads for the 32PTH DSC, HSM-H, and OS-187H TC are discussed in Section 2.2.7 of the SAR.

2.3.3 Thermal

The thermal analysis is presented in Section 4 of the SAR. The NUHOMS® HD System is designed to passively remove decay heat. Fuel cladding integrity is assured by the DSC design which limits fuel cladding temperature and maintains a non-oxidizing environment inside the canister.

2.3.4 Shielding/Confinement/Radiation Protection

The shielding analysis, confinement analysis and radiation protection capabilities of the NUHOMS® HD System are discussed in Sections 5, 7 and 10, of the SAR, respectively. The DSC’s confinement is obtained with redundant welded closures, and verified through non-destructive examinations at the completion of welding. Radiation exposure is minimized through the shielding capabilities of the OS-187H transfer cask and the HSM-H.

2.3.5 Criticality

The criticality analysis is presented in Section 6 of the SAR. The design criteria for criticality safety is that the effective neutron multiplication factor upper sub-critical limit of 0.95 minus statistical uncertainties and bias, is limiting for all postulated arrangements of fuel within the canister. The control method used to prevent criticality is incorporation of poison material in the DSC and credit for soluble boron in the spent fuel pool.

2.3.6 Materials

The materials used to manufacture the 32PTH DSC, the HSM-H, and the OS-187H TC are described throughout the SAR, and discussed in Section 3.2 of this SER. Significant changes regarding the neutron absorbing materials were made in Amendment 1 to the NUHOMS® HD application. Staff's review of these changes is discussed in detail in Section 3.2.6 of this SER.

2.3.7 Operating Procedures

Generic operating procedures are described in Section 8 of the SAR. This section outlines the loading, unloading, and recovery operations, and provides the basis and general guidance for more detailed, site-specific procedures. This amendment deleted use of nitrogen for draining the water from the DSC, and allows only helium as a cover gas during DSC cavity water removal operations.

2.3.8 Acceptance Tests and Maintenance

The acceptance test and maintenance program for the NUHOMS® HD System are described in Section 9 of the SAR, including the commitments, industry standards, and regulatory requirements used to establish the acceptance, maintenance, and periodic surveillance tests.

2.3.9 Decommissioning

Decommissioning considerations for the NUHOMS® HD System are described in Section 14 of the SAR. No changes were made with the requested Amendment 1 that affected the Decommissioning Evaluation discussed in the original SER.

2.4 Evaluation Findings

F2.1 The staff concludes that the principal design criteria for the NUHOMS® HD System are acceptable with regard to meeting the regulatory requirements of 10 CFR Part 72. 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. A more detailed evaluation of design criteria and an assessment of compliance with those criteria are presented in Sections 3 through 6 of this SER.

2.5 References

1. U.S. Code of Federal Regulations, Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor - Related Greater Than Class C Waste, Title 10, Part 72.

2. Updated Final Safety Analysis Report for the NUHOMS® HD System, Revision 1, Docket No. 72-1030, October 3, 2007. (ML072840178)

3. U.S. Nuclear Regulatory Commission, Division of Spent Fuel Storage and Transportation; Interim Staff Guidance Document -1 (ISG-1), "Classifying the Condition of Spent Nuclear Fuel for Interim Storage and Transportation Based on Function," Revision 2, May 2007.

3 STRUCTURAL AND MATERIALS EVALUATION

By letter dated November 1, 2007, Transnuclear, Inc. submitted an application for Amendment 1 of the NUHOMS® HD design (Ref. 1). The staff reviewed the application and found it generally acceptable in terms of content and completeness. The applicant further supplemented their application with responses to the staff's requests for additional information (RAI) dated November 14, 2008, and April 3, 2009 (Refs. 2, 3). In May 2010, the applicant identified an issue with imprecise language regarding Boral characterization in Technical Specification (TS) 4.3.1, ''Neutron Absorber Tests.'' The applicant submitted additional information on Boral and revised language for TS 4.3.1 in letters dated June 17, 2010 (proprietary information, not publicly available), July 9, 2010, July 26, 2010, and August 24, 2010 (Refs. 4, 5, 6, and 7). The detailed structural and materials reviews of the application are described in this section.

The applicant requested several changes to the NUHOMS® HD design including allowing additional fuel assembly types and additional control components as authorized contents. Significant changes regarding the neutron absorbing materials were made in Amendment 1 to the NUHOMS® HD application, and the definition of damaged fuel was revised.

3.1 Structural Evaluation of Amendment 1 Changes

This section reviews two of the requested TS revisions that are related to clarifying structural design bases for the approved NUHOMS® HD system.

Technical Specification 2.1 consolidates the previously approved TS Table 1, "Fuel Specifications"; and Table 2, "Fuel Dimension and Weights." It identifies the maximum assembly plus control component (CC) weight as 1,585 lbs, which is higher than the previously listed weights ranging from 1,450 lbs to 1,575 lbs. In the December 15, 2008, response to the request for additional information (RAI) (Ref. 8), TN cites the applicable Final Safety Analysis Report (FSAR) sections and pages to ascertain that structural evaluations of the system components are all based on the bounding fuel assembly weight of 1,585 lbs. Hence, the staff agrees with the applicant that revision of the fuel assembly design basis weight in TS 2.1 is made to be consistent with the analysis documented in the FSAR.

FSAR, Section 3.1.1.4, notes that all lifting of the loaded transfer cask (TC) must be made within the existing plant heavy loads requirements and procedures, and the TC is transported to the independent spent fuel storage installation (ISFSI) in a horizontal configuration. This is recognized in the Safety Evaluation Report (SER) for Certificate of Compliance (CoC) No. 1030, Section 3.4.1.1(b), dated January 10, 2007 (Ref. 9), and is found acceptable as a basis for not considering the end- and corner-drops as credible handling accidents during the storage and transfer operations. However, although an 80-inch TC side drop is considered the only credible accident for evaluating fuel cladding integrity, the applicable TC drop accident scenario is not clearly captured in the approved TS. In revising the TS 5.3.2, Cask Drop, Background, TN deletes reference to a broadly defined drop accident scenario for the TC en route from the Fuel Handling Building to the ISFSI. The resulting Background reads, "TC/32PTH DSC handling and loading activities are controlled under the 10 CFR Part 50 license until a loaded TC/32PTH DSC is placed on the transporter, at which time fuel handling activities are controlled under the 10 CFR Part 72 license." This revision effectively clarifies the TS structural design basis for requiring only a TC side-drop fuel clad integrity evaluation, which has been provided in the FSAR, for meeting the 10 CFR Part 72 requirements. It is also consistent with the previous SER finding, which notes the necessity for demonstrating fuel clad integrity or demonstrating that the drop accidents are not credible under the 10 CFR Part 50 (Ref. 10) license.

3.1.1 Conclusions

On the basis of the review above, the staff concludes that the proposed TS clarifications continue to meet the 10 CFR 72.236(b) and (c) requirements, with regard to technical specifications pertaining to the structural design features and administrative controls.

3.2 Materials

3.2.1 Changes to Package Contents

The amendment request expanded the authorized contents of the NUHOMS® HD System to include PWR fuel assemblies with Control Components (CCs) and neutron sources. These components include Burnable Poison Rod Assemblies (BPRAs), Thimble Plug Assemblies (TPAs), Control Rod Assemblies (CRAs), Control Element Assemblies (CEAs), Rod Cluster Control Assemblies (RCCAs), Vibration Suppressor Inserts (VSIs), Axial Power Shaping Rod Assemblies (APSRAs), Orifice Rod Assemblies (ORAs), Neutron Source Assemblies (NSAs) and Neutron Sources. The cladding for the control components (CCs) and neutron sources vary, and may be made of stainless steel, Inconel, or zirconium-based alloys such as Zircaloy, M5, or Zirlo. The materials contained inside the various CCs, which are all non-fuel material, vary among Inconel, boron carbide (B_4C), silver-indium-cadmium (Ag-In-Cd), and aluminum oxide (Al_2O_3), depending on the specific component.

The stainless steel, Inconel, and zirconium-based alloys are materials that are widely used as components of fuel assemblies and are normally contained within the dry shielded canister (DSC). Thus, no adverse chemical or galvanic reactions occur by the introduction of such materials. Boron carbide is a stable and generally inert chemical compound. The chemical characteristics of B_4C show that it is a non-metallic, electrically neutral material. As such, it will not create any galvanic or chemical interaction in either the short-term water environment of cask loading or the long-term helium storage environment inside the DSC. The Ag-In-Cd alloy contained in some control components may oxidize slightly if exposed to water (assuming a perforated cladding) during the wet loading of fuel into the cask. However, the amount of oxidation or galvanic corrosion that would occur would be limited by the short immersion time of the loading process. The chemical byproducts of any such corrosion would be in the form of inert metal oxides and a small amount of hydrogen. The metal oxides would not further react in the cask wet or dry environments. The hydrogen would be removed during the dewatering and drying steps of the overall cask loading procedure. The hydrogen monitoring or mitigation plan, which is part of the loading procedures, would alleviate any issues that could arise from the small amount of hydrogen that might be generated. Aluminum oxide is a stable inert metal oxide that will not result in any adverse chemical or galvanic reaction in the wet or dry cask environments. Therefore, the staff finds that no significant corrosion or galvanic effects would occur among these materials.

Based upon these considerations, the staff finds these changes to the proposed contents of the package acceptable.

3.2.2 Definition of Damaged Fuel

The applicant clarified the definition of damaged fuel assemblies to be a fuel assembly with known or suspected cladding defects greater than pinhole leaks or hairline cracks and which can be handled by normal means. This definition is consistent with the staff guidance outlined in Interim Staff Guidance Document, No. 1 (ISG-1) (Ref.11).

3.2.3 Drying Operations

Amendment 1 (TS 3.1, and SAR Section 8.1.1.3) specifies that only helium will be allowed for use as a cover gas during DSC cavity water removal operations. As approved in Amendment 0, both nitrogen and helium were specified as acceptable cover gasses. Limiting cover gas to helium eliminates the need to use three vacuum drying procedures.

Use of a cover gas ensures that the cladding will not be exposed to an oxidizing environment during loading, drying, or unloading procedures, following the guidance in Interim Staff Guidance Document 22, "Potential Rod Splitting Due to Exposure to an Oxidizing Atmosphere During Short-Term Cask Loading Operations In LWR [Light Water Reactor] or Other Uranium Oxide Based Fuel" (Ref. 12). Helium is an acceptable cover gas according to ISG-22; therefore, this change is acceptable to staff.

During drying and backfilling operations, the fuel cladding reaches a maximum temperature of 734°F (390^{o}C). This temperature limit is below the staff accepted 400°C limit for high burn-up fuel. This, and the lack of thermal cycling during drying operations are consistent with the guidance in Interim Staff Guidance Document, No. 11, Rev. 3, "Cladding Considerations for the Transportation and Storage of Spent Fuel" (Ref. 13).

The staff finds these changes acceptable.

3.2.4 Hydrogen Gas Monitoring

TS paragraph 5.6, and the FSAR (Sections 8.1.1.3 and 8.2.2) specify that hydrogen gas monitoring or mitigation measures will be followed during all lid welding and cutting operations. Chapter 8 of the FSAR specifies that welding operations will be stopped and the DSC cavity will be purged with helium if the hydrogen concentration exceeds 2.4%. This is a conservative limit which precludes an ignition event during welding of the cask lid. The Technical Specifications require that the hydrogen not exceed the ignition concentration of 4.0%, which is the actual ignition concentration of hydrogen.

The staff finds these changes acceptable.

3.2.5 Alternate Welding Configurations (Drawings)

Alternate weld configurations were mentioned in Note 4 of licensing drawing 10494-72-5, and in Note 1 on licensing drawing 10494-72-17. These configurations were not described on the licensing drawings or in the application; therefore, the staff could not evaluate these configurations. The staff requested clarification or removal of Notes 1 and 4 on the applicable drawings. In response, the applicant has removed the two engineering notes. The removal of the alternate weld configuration notes is acceptable to the staff.

3.2.6 Neutron Absorbing Materials

Significant changes regarding the neutron absorbing materials were made in Amendment 1 to the NUHOMS® HD application. These changes can be found in Section 9.1.7 and 9.5 of the FSAR, and in paragraph 4.3.1 of the TS.

The amendment permits the applicant to use boron carbide/aluminum metal matrix composites (MMCs) with up to 40% B_4C, or aluminum clad MMCs with up to 50% B_4C. The maximum permissible total porosity for aluminum clad MMCs was increased from 2% to 3% volume percent, with a maximum open porosity of 0.5%. The limitations on porosity ensure the consistent physical properties and corrosion resistance of the clad and unclad MMCs. The average boron carbide particle size is limited to a diameter of 40 microns or smaller.

All panels of neutron absorbing material will be visually inspected. Panels which fail to meet the criteria listed in Section 9.1.7.4 of the application will be reworked, repaired, or scrapped. A reference to the Aluminum Standards and Data for the criteria of the visual acceptance tests was removed from the Technical Specifications, but retained in the application. A one hundred percent visual inspection of the plates will satisfy the criteria in Section 9.1.7.4 and is sufficient to ensure that the neutron absorbing panels will have the mechanical durability necessary for the application.

The thermal neutron beam diameter used for qualification and acceptance testing of the neutron absorbing materials has been increased to 1.1-inches, which is consistent with Draft Interim Staff Guidance Document, No. 23 (ISG-23) (Ref. 14).

Both homogenous and heterogeneous calibration standards can be used for neutron attenuation testing. The applicant clarified that such standards must be traceable to nationally recognized standards, or by attenuation of a monoenergic neutron beam to the known cross section of boron-10, of that energy. This clarification ensures that these calibration standards will be able to provide accurate results with neutron beam attenuation measurements.

The description of the neutron absorber statistical analysis was removed from the Technical Specifications, but retained in the SAR as an example methodology for determining the areal density of each lot of material with a 95% probability and 95% confidence level. The staff finds that it is an unnecessary regulatory burden for the applicant to include the statistical methodology for determining the 95/95 criteria in the Technical Specifications, so the deletion of this discussion in the Technical Specifications is acceptable.

Required mechanical testing of the neutron absorbers has been included in the Technical Specifications. The applicant has agreed not to use scanning electron microscopy (SEM) to demonstrate the ductility of the neutron absorbing material, as the bulk ductility of composite materials cannot be accurately determined using SEM of fracture surfaces. Qualitative mechanical testing, in accordance with the methods of ASTM E390 (Ref. 15), may be used to determine if the neutron absorbing materials have sufficient ductility for the application. Aluminum clad metal matrix composites (MMCs) must undergo mechanical testing after submersion in water and followed by heating in a pre-heated oven for 24 hours at 825°F. This condition was added to ensure that the aluminum clad MMCs will not be damaged by cask drying operations.

Density testing of the metal matrix composites (clad and un-clad) is required by the Technical Specifications. This is to ensure that the open porosity, which could influence the corrosion of the composites, is limited to 0.5% or less. These changes, along with visual acceptance testing of each neutron absorbing panel ensure that the neutron absorbing material will be adequately resistant to mechanical damage and corrosion that could result from cask loading or unloading operations.

Radiography was originally proposed in the amendment request (discussed in the SAR) as a methodology for determining the uniformity of the boron-10 in the neutron absorbers. To date, no applicant has used radiography for determining the quantitative boron-10 content of a neutron absorber material for spent nuclear fuel, and no detailed procedure was provided to the staff for doing so. Therefore, during the review, the staff and the applicant determined that the option of using radiography is unnecessary and redundant, and the applicant removed the discussion from the application (SAR).

The definition and general description of key process changes was added to the Technical Specifications, while specific examples of key process changes were removed from the Technical Specifications (but retained in the SAR). This change retains the applicant's intent that significant changes to fabrication of the neutron absorber will require a partial or full requalification of the material, but without the need to list every potential example of a key process change.

The staff does not agree with the applicant's assumption that aluminum clad MMCs have isotropic thermal conductivity. However, the staff finds that the expected change in MMC thermal characteristics (whether the MMCs have isotropic thermal conductivity or not) due to the presence of the aluminum cladding would not affect the safety of the package.

The staff finds the use of metal matrix composites with up to 40% B_4C content, or the use of aluminum clad MMCs with up to 50% B_4C content does not compromise the safety of the design, and is acceptable. Furthermore, the staff finds the changes to the acceptance and qualification testing of the neutron absorbing material outlined in the body of the application and specified in the Technical Specifications adequate to ensure the expected performance of the design.

3.3 Evaluation Findings

F3.1 The proposed TS clarifications continue to meet the 10 CFR 72.236(b) and (c) requirements, with regard to TS pertaining to structural design features and administrative controls.

F3.2 The changes to the proposed contents of the package are acceptable. The staff finds no significant corrosion or galvanic effects would occur among these materials.

F3.3 The definition of damaged fuel assemblies is consistent with the staff guidance outlined in Interim Staff Guidance Document, No. 1 (ISG-1).

F3.4 The staff finds the proposed changes for Drying Operations acceptable.

F3.5 The staff finds the proposed changes for Hydrogen Gas Monitoring acceptable.

F3.6 The staff finds the use of metal matrix composites with up to 40% B_4C content, or the use of aluminum clad MMCs with up to 50% B_4C content does not compromise the safety of the design, and is acceptable. Furthermore, the staff finds the changes to the acceptance and qualification testing of the neutron absorbing material outlined in the body of the application and specified in the TS adequate to ensure the expected performance of the design.

3.4 References

1. Transnuclear, Inc., “Application for Amendment 1 of the NUHOMS® HD Certificate of Compliance No. 1030 for Spent Fuel Storage Casks, Revision 0,” November 1, 2007. (ML073110525)

2. J. Davis, USNRC, “Request for Additional Information for Review of Amendment 1 to the NUHOMS® HD System (TAC No. L24153), Including Updated Review Schedule,” November 14, 2008 (ML083010097)

3. J. Davis, USNRC, “Second Request for Additional Information for Review of Amendment 1 to the NUHOMS® HD System (TAC No. L24153), April 3, 2009. (ML090910589)

4. Transnuclear, Inc., “Boral™-Related Information Pertaining To Discussions Regarding Certificate of Compliance No. 1030, Amendment 0 Technical Specifications, for the NUHOMS® HD System (Docket No. 72-1030),” June 17, 2010. (ML102580291, proprietary information, not publicly available)

5. Transnuclear, Inc., “BORAL® Boron Carbide Particle Size (Docket No. 72-1030; TAC NO. L24153),” July 9, 2010. (ML101930536)

6. Transnuclear, Inc., “Revision 7 to Transnuclear, Inc. (TN) Application for Amendment 1 to the NUHOMS® HD System (Docket No. 72-1030; TAC NO. L24153),” July 26, 2010. (ML102100192)

7. Transnuclear, Inc., “Revision 8 to Transnuclear, Inc. (TN) Application for Amendment 1 to the NUHOMS® HD System (Docket No. 72-1030; TAC NO. L24153),” August 24, 2010. (ML102380404)

8. Transnuclear, Inc., “Revision 1 to Transnuclear, Inc. (TN) Application for Amendment 1 to the NUHOMS® HD System, Response to Request for Additional Information (Docket No. 72-1030; TAC NO. L24153),” December 15, 2008. (ML083570513)

9. U.S. Nuclear Regulatory Commission, "Safety Evaluation Report for the Transnuclear Inc., NUHOMS® HD Horizontal Modular Storage System for Irradiated Nuclear Fuel, Docket No. 72-1030," January 10, 2007. (ML070160089)

10. U.S. Code of Federal Regulations, "Domestic Licensing Of Production And Utilization Facilities," Title 10, Part 50.

11. U.S. Nuclear Regulatory Commission, Division of Spent Fuel Storage and Transportation; Interim Staff Guidance Document -1 (ISG-1), "Classifying the Condition of Spent Nuclear Fuel for Interim Storage and Transportation Based on Function," Revision 2, May 2007.

12. U.S. Nuclear Regulatory Commission, Division of Spent Fuel Storage and Transportation; Interim Staff Guidance Document – 22 (ISG-22), "Potential Rod Splitting Due to Exposure to an Oxidizing Atmosphere During Short-Term Cask Loading Operations In LWR or Other Uranium Oxide Based Fuel," May 2006.

13. U.S. Nuclear Regulatory Commission, Division of Spent Fuel Storage and Transportation; Interim Staff Guidance Document - 11, (ISG-11), "Cladding Considerations for the Transportation and Storage of Spent Fuel" Revision 3, November 2003.

14. U.S. Nuclear Regulatory Commission, Division of Spent Fuel Storage and Transportation; Draft Interim Staff Guidance Document – 23 (ISG-23), "Application of ASTM Standard Practice C1671-07 When Performing Technical Reviews of Spent Fuel Storage and Transportation Packaging Licensing Actions," July 2009.

15. American Society for Testing and Materials (ASTM), "ASTM E390, Standard Reference Radiographs for Steel Fusion Welds," 2006.

4 THERMAL EVALUATION

4.1 Introduction

By letter dated November 1, 2007, Transnuclear, Inc. submitted an application for Amendment 1 of the NUHOMS® HD design (Ref. 1). The staff reviewed the application and found it generally acceptable in terms of content and completeness. The applicant further supplemented their application with responses to the staff's requests for additional information (RAI) dated November 14, 2008, and April 3, 2009 (Refs. 2, 3). The detailed thermal review of the application is described in this section.

The applicant requested several changes to the NUHOMS® HD design including allowing additional fuel assembly types and additional control components as authorized contents. The applicant also requested a revision to Technical Specification 3.1.1 to eliminate vacuum drying times for various procedure options, and specify only the need for helium backfill during draining operations. The applicant also requested a revision to Technical Specification 5.2.5 to add a daily thermal monitoring program, as an alternative option to the daily visual surveillance requirements of the HSM-H vents for blockage. The applicant did not request changes to the overall decay heat load of the system or any other changes to the heat removal system.

4.2 Review of Proposed Changes

The changes proposed for new contents have minimal impacts on the thermal performance of the NUHOMS® HD system; however, the staff required additional information regarding the effective thermal conductivity (K_{eff}) calculations for the new fuel assembly type (Ref. 3). The staff specifically inquired about the effects of UO_2 material properties on the K_{eff} for the fuel assemblies. The UO_2 material properties used by the applicant were for unirradiated UO_2 as opposed to irradiated UO_2, which have been demonstrated to have reduced thermal conductivity values when compared to unirradiated UO_2.

4.2.1 Effective Conductivity of Additional Fuel Assembly Type

The staff used the applicant's analysis model of the CE 16x16 fuel assembly to conduct a sensitivity study of the K_{eff}, and the clad temperature, based on the use of irradiated material properties for UO_2, finding that the changes in either the K_{eff}, or clad temperature, were minimal (Refs. 4, 5). The applicant's response to the staff's first RAI (Ref. 6) provided similar conclusions. Therefore, the use of unirradiated thermal properties is acceptable for this particular design configuration and requested contents.

4.2.2 Vacuum Drying Technical Specification

The applicant proposed a revision to Technical Specification 3.1.1 to specify the use of helium cover gas during drainage of bulk water and to remove vacuum drying time limits previously required for various procedures. The applicant indicated, as part of the technical specification bases, that the helium cover gas would provide sufficient heat transfer during vacuum drying operations, and would not result in spent fuel cladding exceeding its temperature limits at any time. The applicant revised the thermal analyses in Chapter 4 of the SAR to account for the helium cover gas, and determined the maximum temperature would not exceed 400°C for normal conditions. The staff reviewed the proposed change, and agrees there is reasonable assurance that cladding limits will not be exceeded during the vacuum drying operations as proposed by the applicant. Therefore, the staff had revised the Technical Specification to remove vacuum drying time limits, require helium to be used as a cover gas during water removal, and to sustain a vacuum drying pressure below 3 Torr for at least 30 minutes.

4.2.3 Daily Temperature Monitoring Technical Specification

The applicant proposed a revision to Technical Specification 5.2.5 to add a daily thermal monitoring program as an alternative option to the daily visual surveillance of the HSM-H vents for blockage. The applicant proposed that the user establish a method to measure DSC, HSM-H and/or vent temperatures to monitor the performance of the system, and to detect any vent blockage conditions. The applicant indicated that a temperature monitoring program provides an equivalent level of assurance as visual surveillance, in detecting vent blockage conditions. The staff reviewed the proposed request, and agrees that there is reasonable assurance that it would provide an adequate level of assurance in identifying and mitigating the effects of potential vent blockage. Therefore, the staff added Technical Specification 5.2.5(c) that gives the user the option to develop a daily temperature monitoring program. The TS provides specific requirements for the user to establish appropriate administrative temperature limits, monitoring locations, and corrective actions for potential temperature excursions.

4.2.4 Minimum Ambient Temperature Technical Specification

The applicant proposed changing the minimum ambient temperature technical specification (TS 4.6.3, Item 5) from -20°F to -21°F. This change will have no impact on the thermal performance of the system and is therefore acceptable.

4.3 Conclusions

The staff finds the content changes requested to the NUHOMS® HD design have minimal impact on the thermal performance of the system and are, therefore, acceptable. The staff finds that the request to modify the Technical Specifications provides adequate safety during operations.

4.4 Evaluation Findings

F4.1 There were no changes to the thermal SSCs important to safety in this amendment request, therefore, all cask SSCs important to safety continue to remain within their operating temperature limits.

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

F4.3 The staff has reasonable assurance that the spent fuel cladding will be protected against degradation that could lead to gross ruptures by maintaining the clad temperature below maximum allowable limits and by providing an inert environment in the cask cavity.

F4.4 The staff finds that the thermal design of the system is in compliance with 10 CFR Part 72 (Ref. 7), and that the applicable design and acceptance criteria have been satisfied. The evaluation of the thermal design provides reasonable assurance that the system will allow safe storage of spent fuel for a certified life of 20 years. 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.

4.5 References

1. Transnuclear, Inc., "Application for Amendment 1 of the NUHOMS® HD Certificate of Compliance No. 1030 for Spent Fuel Storage Casks, Revision 0," November 1, 2007. (ML073110525)

2. J. Davis, USNRC, "Request for Additional Information for Review of Amendment 1 to the NUHOMS® HD System (TAC No. L24153), Including Updated Review Schedule," November 14, 2008 (ML083010097)

3. J. Davis, USNRC, "Second Request for Additional Information for Review of Amendment 1 to the NUHOMS® HD System (TAC No. L24153), April 3, 2009. (ML090910589)

4. K. Minato, et. al., "Thermal conductivities of irradiated UO2 and (U,Gd)O2," Journal of Nuclear Materials 300 (2002) 57–64.

5. C. Ronchi, et. al., "Effect of burn-up on the thermal conductivity of uranium dioxide up to 100.000 MWdt," Journal of Nuclear Materials 327 (2004) 58-76.

6. Transnuclear, Inc., "Revision 1 to Transnuclear, Inc. (TN) Application for Amendment 1 to the NUHOMS HD System, Response to Request for Additional Information," December 15, 2008.

7. U.S. Code of Federal Regulations, "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor - Related Greater Than Class C Waste," Title 10, Part 72.

5 SHIELDING EVALUATION

5.1 Summary

By application dated November 1, 2007, (Ref. 1), and as supplemented on December 15, 2008 (Ref. 2), Transnuclear, Inc. (TN) submitted a request for amendment to the Certificate of Compliance (CoC) No. 1030 for the NUHOMS® HD Horizontal Modular Storage System for Irradiated Nuclear Fuel under the provisions of 10 CFR Part 72 (Ref. 3).

The NUHOMS® HD-32PTH dry shielded canister (DSC) provides confinement and criticality control for the storage and transfer of irradiated fuel. TN requested changes to the Technical Specifications (TS) attached to CoC No. 1030, with supporting revisions to the NUHOMS® HD Updated Final Safety Analysis Report (UFSAR), in order to reflect the addition of the Combustion Engineering 16x16 fuel (CE 16x16) as an allowable assembly class. The amendment also includes provisions to have control components (CC) allowed as authorized contents. In addition, TN proposed a more generalized fuel qualification table (FQT) which specifies allowable cask contents.

The amendment application included the proposed page changes and engineering analyses to be incorporated into the UFSAR. The technical bases supporting the requested changes to the CoC No. 1030 are similar to those included as a part of an exemption request submitted by PPL Susquehanna, LLC on January 31, 2006 (Ref. 4).

5.2 Shielding Evaluation

In its November 1, 2007, letter, TN discusses the shielding evaluation and radiation protection evaluation for the CE 16x16 fuel assembly. TN concludes that the results for each of those evaluations are bounded by those for existing evaluations for the NUHOMS® HD-32PTH DSC contained in Sections 5 and 10, respectively, of the original UFSAR for the NUHOMS® HD System (Ref. 5).

Regarding the shielding and radiation protection evaluations, the CE 16x16 class of assembly will be within the bounds of the original design basis assembly (Westinghouse Advanced MK BW 17x17) due to a lower heavy metal loading (uranium); therefore, for the same burnup and cooling time, the source term from the CE 16x16 fuel assembly will be lower than for the MK BW 17x17. Design-basis heavy metal loading is 0.476 MTU per assembly. TN has presented many alternative cases at various burnup, enrichment and cooling times to indicate conditions that lie outside the bounding analysis. Additional burnup and cooling requirements are conservatively placed in the FQT to account for this. Additionally, the applicant stated that the CC hardware source term is bounded by the WE 17x17 class of fuel; all analyses have been made with the limiting class of CC regardless of the actual fuel assembly investigated.

TN's analysis of the design basis assembly does not use the most conservative initial assembly enrichment. The Standard Review Plan for Dry Cask Storage (Ref. 6) states that the lowest permissible enrichment for a given burnup should be used in the source term analysis. However, further analysis is presented to show that the lowest enrichment at each burnup level in the FQT is still bounded by the design basis assembly when the thermal limits are applied. A table presenting the external dose rate and decay heat power for the design basis assembly at varying enrichment, burnup and cooling time is included in the shielding analysis of the SAR. While fuel may meet the minimum cooling and maximum burnup constraints, the specific nature of the fuel may still fail the thermal limitations. The thermal limitations for this system limit the storage of spent fuel with initial enrichment of 0.2 wt% U-235; therefore, the reduction in minimum initial enrichment of spent fuel assemblies from 1.5 wt% U-235 to 0.2 wt% U-235 is acceptable to staff. A formula is provided to determine whether a particular assembly is acceptable for loading. A longer cooling time may be required in some cases.

Additional limitations are placed on fuel assemblies with an average enrichment less than 1.5 wt% U-235. Maximum burnup and minimum cooling times are presented in a table in the SAR. For extremely low weight-percent of U-235, burnup limit is set at 25 and 20 GWd/MTU for assemblies with a minimum average enrichment of 0.3 and 0.2 wt% U-235 respectively. Fuel assemblies with a minimum enrichment of 0.7 wt% U-235 are limited to 32 GWd/MTU. The minimum acceptable cooling time for all extremely low-enriched assemblies of 5 years allows placement in Zones 2 and 3. If the cooling time is extended to 7 years, there is no limit on the location of these fuel assemblies.

5.2.1 Computer Codes and Cross Section Libraries

The applicant estimated the source term with the SAS2H/ORIGEN-S sequence in SCALE 4.4. The 44-group ENDF/B-V cross-section libraries were used. As discussed above, this is appropriate for use of most uranium fuel.

The applicant used the results of the SAS2H/ORIGEN analysis to specify the source in a separate MCNP shielding analysis. MCNP is a three-dimensional Monte Carlo code with continuous energy cross-sections. Developed by Los Alamos National Laboratory (LANL), this code has been used extensively in a variety of shielding evaluations.

5.2.2 Confirmatory Analysis

TN’s analysis was conducted with SCALE 4.4; NRC staff uses SCALE 5.1. Staff analysis of the design-basis assembly with both SCALE 4.4 and SCALE 5.1 confirms TN’s assessment of spent fuel activity. In addition, the results are in acceptable agreement among the versions of the code.

Since this was an amendment to an existing approved design, staff analyses focused on the changes made in the amendment. The analysis of external dose rates in normal and off-normal conditions will remain unchanged in the updated FSAR provided that the design-basis assembly source-term is still bounding of all other fuel classes, enrichment and burnup.

The staff ran confirmatory calculations with SAS2H to verify the source term of the design-basis assembly and several of the lowest initial enrichments and highest burnups allowed by the FQT. Staff confirmed that the limits on maximum burnup and cooling time due to thermal constraints adequately ensure that assemblies with initial enrichment higher than 1.5 wt% U-235 are bound by the design basis assembly. Using both the shielding analysis and the limits as written in the FQT, the staff was able to verify the requirements of 10 CFR Part 72 were met for fuel assemblies having an initial average enrichment greater than 1.5 wt% U-235.

Staff calculations were made with the 25.0 MW/assembly power described in the shielding analysis. In all cases, the design basis assembly is bounding given the thermal limits of the FQT. In particular, staff checked the lowest enrichments for the highest burnup and shortest cooling time allowed following the FQT. Of particular interest are assemblies having an initial average enrichment below 0.7 wt%. At higher gamma energies, from 1.6 to 4 MeV, the emission rate of these assemblies is not bounded by the design basis assembly. However, the source term in the unbounded range is orders of magnitude smaller than the range where the design basis fuel is still bounding. The staff concludes that this difference will have a negligible effect on external dose rates.

5.3 Evaluation Findings

F5.1 Based on the review of the statements and representations in the application amendment and confirmatory analyses, the staff has reasonable assurance that the radiation shielding and safety design has been adequately described and evaluated and that the package meets the requirements of 10 CFR Part 72.

5.4 References

1. Transnuclear, Inc., "Application for Amendment 1 of the NUHOMS® HD Certificate of Compliance No. 1030 for Spent Fuel Storage Casks, Revision 0," November 1, 2007. (ML073110525)

2. Transnuclear, Inc., "Revision 1 to Transnuclear, Inc. (TN) Application for Amendment 1 to the NUHOMS® HD System, Response to Request for Additional Information (Docket No. 72-1030; TAC NO. L24153)," December 15, 2008. (ML083570513)

3. U.S. Code of Federal Regulations, "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor - Related Greater Than Class C Waste," Title 10, Part 72.

4. B. T. McKinney, PPL Susquehanna, LLC., "Susquehanna Steam Electric Station request For Exemption From NUHOMS® Certificate Of Compliance No. 1004, Amendment No. 8, January 31, 2006. (ML060390150)

5. Updated Final Safety Analysis Report for the NUHOMS® HD System, Revision 1, Docket No. 72-1030, October 3, 2007. (ML072840178)

6. U.S. Nuclear Regulatory Commission, "Standard Review Plan for Dry Cask Storage Systems (NUREG-1536)," January 1997.

6 CRITICALITY EVALUATION

6.1 Introduction

The objective of the criticality review is to ensure that the spent fuel will remain subcritical under all credible normal, off-normal, and accident conditions encountered during handling, packaging, transfer, and storage. The objective of this section includes a review of the changes to the criticality design criteria, configuration and material properties, features and fuel specifications, and verification for the NUHOMS® HD System. It also includes a review of the criticality analyses that includes computer programs, benchmark comparisons, and multiplication factors proposed in this amendment request. The applicant requested several changes to the NUHOMS® HD System design and Certificate of Compliance (CoC). Only those changes that may affect the criticality safety of the system are discussed in this section.

The staff reviewed proposed Amendment 1 to the NUHOMS® HD System criticality safety analysis to ensure that all credible normal, off-normal, and accident conditions have been identified and their potential consequences on criticality considered such that the NUHOMS® HD System, as revised, meets the following regulatory requirements: 10 CFR 72.124(a), 72.124(b), 72.236(c), and 72.236(g) (Ref. 1). The staff's review also involved a determination on whether the cask system satisfies the acceptance criteria listed in Section 6 of NUREG-1536 (Ref. 2).

The following proposed changes were considered for their impact on criticality safety:

a) add Combustion Engineering (CE) 16x16 class fuel assembly as authorized contents of the NUHOMS® HD System described in the UFSAR.

b) expand the authorized contents of the NUHOMS® HD System to include CE14x14 and CE16x16 class fuel assemblies for the storage with Control Components (CCs), also referred to as Non Fuel Assembly Hardware (NFAH) in CoC 1030 Amendment 0. CCs are components such as Burnable Poison Rod Assemblies (BPRAs), Thimble Plug Assemblies (TPAs), Control Rod Assemblies (CRAs), Control Element Assemblies (CEAs), Rod Cluster Control Assemblies (RCCAs), Vibration Suppressor Inserts (VSIs), Axial Power Shaping Rod Assemblies (APSRAs), Orifice Rod Assemblies (ORAs), Neutron Source Assemblies (NSAs) and Neutron Sources. All PWR fuel assemblies currently authorized for storage may be stored with CCs.

The staff's conclusions, summarized below, are based on information provided in proposed Amendment 1, as supplemented, to the NUHOMS® HD System FSAR.

6.2 Criticality Design Criteria and Features

The design criterion for criticality safety of the cask system is that the calculated value of the effective neutron multiplication factor, k_{eff}, including biases and uncertainties, shall not exceed 0.95 under normal, off-normal, and accident conditions.

For this Amendment 1, the design criteria and features of the NUHOMS® HD System are the same as previously approved with the exceptions of the addition of CE16x16 class fuel assembly and changes to allow for the storage of CCs within the CE14x14 and CE16x16 class fuel assemblies.

Criticality safety of the NUHOMS® HD system depends on the geometry of the fuel baskets, the use of fixed neutron absorber panels, and the presence of soluble boron in the spent fuel pool water for absorbing neutrons. The NUHOMS® HD design includes the 32PTH Dry Shielded Canister (DSC), designed to store the CE14x14, CE16x16, WE15x15, and WE17x17 class fuel assemblies listed in Table 6-3 of the SAR. The fuel assemblies are placed in square, stainless steel fuel tubes held in place by aluminum panels and stainless steel straps in an egg-crate type basket design.

In the previous SAR, the basket design modeled in the calculation was based on the 32PTH basket detailed in Chapter 1 of the SAR, with a section length of 15.03" (13.28" basket section + 1.75" steel plate). However, in this amendment a slightly different, yet more conservative 32PTH basket model is used in the evaluation of the CE16 x16 fuel assemblies. Only a 15.03" (for the CE 16x16 models, this section is 13.48") section of the basket with fuel assemblies is explicitly modeled with periodic axial boundary conditions, therefore the model is effectively infinitely long.

The staff reviewed Sections 1, 2, and 6 of Amendment 1, and verified that the design criteria and features important to criticality safety are clearly identified and adequately described. The staff also verified that the SAR contains engineering drawings, figures, and tables that are sufficiently detailed to support an in-depth staff evaluation. Additionally, the staff verified that the design-basis off-normal and postulated accident events would not have an adverse effect on the design features important to criticality safety. Section 3 of the SAR shows that the basket will remain intact during all normal, off-normal, and accident conditions. Based on the information provided in the SAR, the staff concludes that the NUHOMS® HD System design with the 32PTH DSC meets the double contingency requirements of 10 CFR 72.124(a).

6.3 Fuel Specification

The NUHOMS® HD System 32PTH DSC is capable of transferring and storing a maximum of 32 intact PWR fuel assemblies. Additionally, a maximum of 16 locations (out of 32 locations) per DSC can be loaded with damaged PWR fuel assemblies with the remaining locations loaded with intact PWR fuel assemblies. In the previous SAR, the assembly types allowed are limited to the CE14x14, WE15x15, and WE17x17 PWR fuel assemblies described in Table 6-3 of the SAR. All assemblies, except the CE14x14, may contain CCs. In this Amendment 1, CE16x16 fuel assemblies are requested as authorized contents as well. The fuel specifications for the various types of assemblies are listed in Section 2.1 of the TS. Fuel dimensions and weights are listed in Table 2 of the TS described in detail in Table 6-4 of the SAR. The fuel specifications that are most important to criticality safety are:

- maximum initial enrichment
- number of fuel rods
- clad outer diameter
- minimum clad thickness
- fuel rod pitch
- number of guide tubes

The parameters listed above represent the limiting or bounding parameters for the fuel assemblies. In terms of criticality safety, the most important fuel specification is the fuel initial enrichment. The 32PTH DSC may contain 32 PWR assemblies with maximum initial enrichments up to 5.0 wt% U-235, depending on the DSC basket type, minimum soluble boron concentration in the canister water during loading, and the presence of damaged fuel in the DSC. The maximum initial enrichment for intact and damaged fuel loadings are given in Table 7 of the TS for all assembly types, for different basket types, and for minimum soluble boron concentrations. Specifications on the condition of the fuel are also included in the SAR and TS. The 32PTH DSC is designed to accommodate intact fuel assemblies, or up to 16 damaged fuel assemblies, as defined in the TS. The damaged fuel must be placed in the inner 16 fuel assembly positions in the DSC, as shown in Figure 1 of the TS. Fuel assembly compartments containing damaged fuel must contain top and bottom end caps, in order to maintain the fuel in a known, subcritical geometry. Reconstituted fuel assemblies, where the fuel pins are replaced by lower enriched fuel pins, or non-fuel pins (prior to initial irradiation or following initial irradiation) that displace the same amount of borated water, are considered intact fuel assemblies.

In Section 3.5 of the SAR, the applicant has shown that the fuel cladding will not fail during the cask drop accidents which bound all storage conditions. Thus the criticality analysis need only consider intact fuel pins for the undamaged fuel.

The staff verified that all fuel assembly parameters important to criticality safety have been included in the TS. The staff reviewed the fuel specifications considered in the criticality analysis and verified that they are consistent with the specifications given in Sections 1, 2, and 12 of the SAR and TS.

6.4 Model Specification

6.4.1 Configuration

The NUHOMS® HD System evaluated in this analysis consists of the 32PTH DSC, the OS-187H transfer cask (TC), and the horizontal storage module (HSM-H). The applicant used 3–D calculation models in its criticality analyses. The bounding model for each basket type, soluble boron loading, assembly type, and enrichment is based on a 32PTH DSC in the TC, with optimum moderator density. Figures containing the details of the criticality models are provided in Figures 6-1 through 6-19 of the SAR. The models were based on the engineering drawings in Section 1 of the SAR and consider the worst-case dimensional tolerance values. The design-basis off-normal events do not affect the criticality safety design features of the cask system. The neutron shield of the TC was not included in the criticality model; however, unborated water was placed between the casks in an infinite array, as well as in the DSC to TC wall gap. Failure of the damaged fuel assemblies within the fuel compartments and top and bottom end caps was also considered.

The normal condition model combined the most reactive basket dimensions. The applicant performed a series of criticality analyses to determine the most reactive fuel spacing and basket dimension conditions. These analyses were performed with the WE 17x17 standard assembly, modeled in the 32PTH DSC over a 15.03-inch axial section, including the 13.28-inch neutron absorber plate section and one of the two 1.75-inch sections of perpendicular steel straps. This model included periodic boundary conditions, effectively representing an infinite axial canister. The calculation models also conservatively assumed the following:

1. fresh fuel isotopics (i.e., no burnup credit),
2. no burnable poisons present in the fuel,
3. pellet density of 97.5 % theoretical density with no dishing or chamfer,
4. maximum fuel enrichment modeled uniformly throughout the assembly (i.e., no axial or radial enrichment zones or natural uranium blankets),
5. omission of spacer grids, spacers, and hardware in the fuel assembly,
6. 75% credit for the ^{10}B content in the Boral® panels,
7. 90% credit for the ^{10}B content in the borated aluminum and aluminum-B_4C metal matrix composite,
8. flooding of the fuel rod gap regions with full density water,
9. infinite radial array of casks with interstitial water, and
10. CCs like BPRA, TPA, and VSI are conservatively assumed to exhibit neutronic properties similar to B_4C.

The applicant determined that the most reactive configuration for the CE16x16 and CE14x14 was the optimum pitch configuration of the rods. For the WE15x15 and the WE17x17 fuel the most reactive configuration was the double-ended rod shear with a shear ratio of one-half. The resulting most reactive configuration determined from these parametric studies was used as the baseline for all other criticality calculations.

The staff reviewed the applicant's criticality models for the NUHOMS® HD System and agrees that they are consistent with the description of the cask and contents given in Sections 1 and 2 of the SAR, including the engineering drawings. Based on the information presented, the staff has reasonable assurance that the most reactive combination of cask parameters and dimensional tolerances were incorporated into the calculation models, or are bounded by the assumptions used in these models.

For its confirmatory analyses, the staff independently modeled the cask system using the engineering drawings and bills of materials presented in Section 1.5 of the SAR. Models of the cask system and its contents created by the staff were similar to those presented by the applicant.

The staff reviewed the applicant's model descriptions and assumptions and agrees that they are consistent with the description of the contents given in FSAR Chapters 1 and 2. The staff reviewed the proposed CoC changes to ensure that the fuel specifications important to criticality safety are included.

6.4.2 Material Properties

From the previous review, the compositions and densities for the materials used in the criticality safety analysis computer models are provided in Table 6-9 of the NUHOMS® HD SAR. The applicant's models considered 75% of the specified ^{10}B areal density of the Boral® panels, in order to bound the effects of neutron channeling between B_4C particles in the neutron absorber plates. The applicant also considered 90% of the specified ^{10}B areal density of the borated aluminum and aluminum- B_4C metal matrix composite panels. Section 9.1.7 of the SAR gives the acceptance tests for the neutron absorber plates.

The staff reviewed the composition and number densities presented in the SAR and found them to be reasonable. The staff notes that these materials are not unique and are commonly used in other spent fuel storage and transportation applications.

6.5 Criticality Analysis

6.5.1 Computer Programs

The applicant included in this amendment the criticality analyses for the CE16 x16 and CE14x14 with CCs using the CSAS25 module of the SCALE 4.4 code package 3 (Ref. 3), with KENO V.a and the 44-group ENDF/B-V cross-section library. KENO V.a is a three-dimensional Monte Carlo multigroup neutron transport code used by the SCALE system to calculate k_{eff}. This code is a standard in the nuclear industry for performing criticality analyses.

The staff agrees that the code and cross-section set used by the applicant are appropriate for this particular application and fuel system. The staff performed its independent criticality analyses using the CSAS25 sequence of SCALE 5, along with the SCALE system's 44-group cross-section library.

6.5.2 Multiplication Factor

The applicant's criticality analyses indicate that the highest calculated k_{eff} was for the CE16x16 class fuel assemblies with an initial enrichment of 4.80 wt% U-235, 2000ppm soluble boron and a poison loading of 28.8mg $^{10}B/cm^2$ (Type D Basket) without BPRAs. Table 6-1 shows a summary of limiting criticality evaluation for all assemblies. All resulting values for $k_{eff} + 2\sigma$ are shown to be less than the SCALE 4.4 minimum calculated upper subcritical limit (USL) of 0.9419. Results for the CE16x16 class fuel assembly based on positioning studies are shown in Table 6-10. Table 6-19 shows limiting parameters for damaged fuel calculations including the CE16x16 class fuel assemblies. Table 6-20 includes the results of optimum pitch studies for the CE16x16 and CE14x14 class fuel assemblies. The single ended rod shear studies are presented in Table 6-21. The results of the double ended rod shear studies are shown in Table 6-22. For the CE16x16 fuel assemblies, Table 6-23 shows the evaluation of the shifting of fuel rods beyond the position. Table 6-33 and Table 6-34 show the final results for the CE14x14 class intact assemblies, with and without BPRAs. Table 6-35 and Table 6-36 show the final results for the CE16x16 class intact assemblies, with and without BPRAs. Table 6-37 and Table 6-38 show the final results for the CE14x14 class damaged assemblies, with and without BPRAs. Table 6-39 and Table 6-40 show the final results for the CE16x16 class damaged assemblies, with and without BPRAs.

The staff reviewed the applicant's calculated k_{eff} values and agrees that they have been appropriately adjusted to include all biases and uncertainties at a 95% confidence level or better.

Results of the staff's calculations based on Scale 5.1 were in close agreement with the applicant's k_{eff} results for the selected assembly types. Based on the applicant's criticality evaluation, as confirmed by the staff's calculations, the staff concludes that the NUHOMS® HD System will remain subcritical, with an adequate safety margin, under all credible normal, off-normal, and accident conditions.

6.5.3 Benchmark Comparisons

The applicant performed benchmark calculations on critical experiments selected, as much as possible, to bound the range of variables in the NUHOMS® HD System design. A summary of all of the pertinent parameters for each experiment along with the results of each case is included in Table 6-30. According to the applicant, the best correlation (linear regression correlation for each parameter vs. k_{eff}) is observed for fuel assembly separation distance, with a correlation of 0.656. The applicant stated that the benchmark calculations were performed with the same cross section library, fuel materials, and similar material and geometry modeling options as were used in the criticality calculations for the original NUHOMS® HD System.

The USL resulting from the applicant's benchmark analysis is 0.9419. This USL incorporates the biases and uncertainties of the model and computer code into a value that has a 95% confidence level such that any k_{eff} less than the USL is less than 0.95, which is the design criterion.

The staff reviewed the benchmark comparisons in the SAR and agrees that the computer code used for the analysis was adequately benchmarked using representative critical experiments. The staff also reviewed the applicant's method for determining the USL and found it to be acceptable and conservative. Additionally, the staff verified that only biases that increase k_{eff} have been applied.

6.6 Supplemental Information

All supportive information has been provided in the SAR, primarily in Sections 1, 2, 6, and 12.

6.7 Evaluation Findings

Based on the information provided in the SAR and verified by the staff's own confirmatory analyses, the staff concludes that the NUHOMS® HD system meets the acceptance criteria specified in NUREG-1536. In addition, the staff finds the following:

F6.1 Structures, systems, and components (SSCs) important to criticality safety are described in sufficient detail in Sections 1, 2, and 6 of the SAR to enable an evaluation of their effectiveness.

F6.2 The NUHOMS® HD system is designed to be subcritical under all credible conditions.

F6.3 The criticality design is based on favorable geometry and fixed neutron poisons. An appraisal of the fixed neutron poisons has shown that they will remain effective for the 20-year storage period. In addition, there is no credible way to lose the fixed neutron poisons; therefore, there is no need to provide a positive means to verify their continued efficacy during the storage period.

F6.4 The analysis and evaluation of the criticality design and performance have demonstrated that the cask will enable the storage of spent fuel for 20 years with an adequate margin of safety.

F6.5 The staff concludes that the changes made in this amendment do not affect the criticality design features for the NUHOMS® HD system and 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® HD system will allow safe storage of spent fuel. In reaching this conclusion, the staff has considered the regulation itself, appropriate regulatory guides, applicable codes and standards, and accepted engineering practices.

6.8 References

1. U.S. Code of Federal Regulations, “Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor - Related Greater than Class C Waste,” Title 10, Part 72.

2. U.S. Nuclear Regulatory Commission, “Standard Review Plan for Dry Cask Storage Systems,” NUREG-1536, January 1997.

3. SCALE, “A Modular Code System for Performing Standardized Computer Analyses for Licensing Evaluation,” Oak Ridge National Laboratory, March 1997.

7 CONDITIONS FOR CASK USE – TECHNICAL SPECIFICATIONS

7.1 Changes to the NUHOMS® HD Technical Specifications

A brief description for each of the changes to the Technical Specifications (TS) is provided below.

- In TS 1.1, "Definitions," the definition of Damaged Fuel Assembly was revised for clarity. For a discussion of this change and its impacts, see Section 3.2.2 of this SER.

- In TS 1.1, "Definitions," a new definition for Fuel Class was added in response to the first RAI. The term "fuel type" refers to the individual fuel assembly designs whereas the term "fuel class" includes various fuel assembly types. The term "fuel class" was originally included in Revision 0 of NUHOMS® HD Technical Specifications and in the original FSAR, to allow for equivalent reload fuel assemblies that are enveloped by the fuel assembly design characteristics given in the Technical Specifications for a given assembly class to be accepted for loading.

- In TS 1.1, "Definitions," a new definition for Reconstituted Fuel Assembly was added in response to the first RAI. For more information, see Section 6.3.

- In TS 1.1, "Definitions," the definition of Transfer Operations was revised for clarity.

- TS 2.1, "Fuel to be Stored in the 32PTH DSC," was revised to update the description of Fuel Class, add the description of Reconstituted Fuel Assemblies, revise the list of Control Components authorized for storage in the 32PTH DSC, specify the Location of Damaged Assemblies, add the Maximum Assembly plus CC weight (from original Table 2), add the Burnup, Enrichment, and Minimum Cooling Time for the 32PTH DSC; add the Maximum Assembly Average Initial Fuel Enrichment; and revise the Decay Heat per DSC limits. TS 2.1 replaces Table 1, Fuel Specifications, and Table 5, NFAH Thermal Qualification, from the initial CoC. For discussion of these changes and their impacts, see Chapters 3 through 6 of this SER.

- In TS 2.2.3, the time limit was revised from 30 days to 60 days (in accordance with the regulations in 10 CFR 72.75(g)) for the Functional and Operating Limits Violations report. The requirements in 10 CFR 72.75(g) specify a "written follow-up report to the Commission within 60 days of the initial notification"; therefore, this change, which allows the licensee more time for consideration of safety significance prior to reporting, meets the regulation and is acceptable to staff.

- Paragraph 3.1, “Fuel Integrity,” (Limiting Condition for Operation (LCOs) 3.1.1, 3.1.2, and 3.1.3) was revised to allow only helium as a cover gas during DSC cavity water removal operations. For discussion of this change and its impacts, see Sections 3.2.3 and 4.2.2 of this SER.

- Paragraph 3.2, “Criticality Control,” (LCO 3.2.1) was revised to clarify the applicability, and add an additional required action if the condition is not met. Staff reviewed the proposed changes as part of the Criticality Evaluation in Chapter 6, and determined that the changes are acceptable.

- Paragraph 4.3.1 was revised to indicate the associated revised FSAR sections. Paragraph 4.3.1 incorporates FSAR sections into the TS by reference. The added sections describe specifications for Neutron Absorbing Materials. Significant changes regarding the neutron absorbing materials were made in Amendment 1 to the NUHOMS® HD application. For discussion of these changes and their impacts, see Section 3.2.6 of this SER.

- Paragraph 4.6.3(5) was revised to reflect reduction of the minimum off-normal ambient temperature, without solar insolation, from -20°F to -21°F. For discussion of this change, see Section 4.2.4 of this SER.

- Paragraph 5.2.5 was revised to add a new paragraph 5.2.5(c) that adds an alternate surveillance activity with associated corrective actions (thermal performance), to add “Daily Visual Inspection” of the HSM-H inlets and outlets, and to add corrective actions for blocked air vents and damaged bird screens. The TS provides specific requirements for the user to establish appropriate administrative temperature limits, monitoring locations, and corrective actions for potential temperature excursions.

- Paragraph 5.3.2, “Cask Drop,” was revised to clarify that it applies to transfer cask side drops. For discussion of this change, and its impacts, see Section 3.1 of this SER.

- A new paragraph 5.6, “Hydrogen Gas Monitoring,” was added to ensure that the combustible mixture concentration remains below the flammability limit. For discussion, see Section 3.2.4 of this SER.

- Table 2, (originally Fuel Dimension and Weights), now “Fuel Assembly Design Characteristics for the NUHOMS® HD-32PTH DSC,” was revised to reflect the changes in allowed fuel assemblies and delete the information now incorporated in TS 2.1.

- Table 3, Maximum Control Component Source Terms, was revised to add allowed control component specifications, and to delete information pertaining to the Framatome ANP Advanced MK BW 17x17 fuel assemblies, since they are part of the WE 17x17 class.

- Table 4 was altered to remove the “Examples for Zone...” tables. Table 4 provides a calculation for decay heat, and originally included example tables for the user to verify proper use of the equation. Since the example tables did not constitute requirements for using the NUHOMS® HD system, they have been removed from the TS, and the SAR location (Table 2-2D) has been referenced.

- Table 7, Maximum Assembly Average Initial Enrichment for Intact and Damaged Fuel Loading, was revised to reflect the changes in allowed fuel assemblies.

7.2 Evaluation Findings

F7.1 The staff concludes that the conditions for use for the NUHOMS® HD Horizontal Modular Storage System for Irradiated Nuclear Fuel identify necessary technical specifications to satisfy 10 CFR Part 72 and that the applicable acceptance criteria have been satisfied.

The proposed technical specifications, if properly implemented, provide reasonable assurance that the dry storage system will allow safe storage of spent nuclear fuel. This finding is based on the regulation itself, appropriate regulatory guides, applicable codes and standards, and accepted practices.

8 CONCLUSIONS

The NRC staff has performed a comprehensive review of the CoC amendment request and found that the proposed changes do not reduce the safety margin for the NUHOMS® HD Horizontal Modular Storage System for Irradiated Nuclear Fuel.

The areas of review addressed in NUREG-1536, "Standard Review Plan for Dry Cask Storage Systems," January 1997, are consistent with the applicant's proposed changes. The Certificate of Compliance has been revised to include the TN requested changes. Based on the statements and representations contained in TN's application, as supplemented, the staff concludes that the proposed changes to the approved contents of the NUHOMS® HD System meet the requirements of 10 CFR Part 72.

Issued with Certificate of Compliance No. 1030, Amendment No. 1 on March _29_, 2011.

APPENDIX A –
LIST OF ABBREVIATIONS AND ACRONYMS

APSRA	Axial Power Shaping Rod Assemblies
BPRA	Burnable Poison Rod Assemblies
CC	Control Components
CE	Combustion Engineering
CEA	Control Element Assemblies
CoC	Certificate of Compliance
CRA	Control Rod Assemblies
DSC	Dry Shielded Canister
FQT	Fuel Qualification Table
FSAR	Final Safety Analysis Report
GWd	Giga-Watt Days
HSM-H	Horizontal Storage Module, Model H
ISFSI	Independent Spent Fuel Storage Installation
ISG	Interim Staff Guidance
K_{eff}	Effective Thermal Conductivity
k_{eff}	Effective Neutron Multiplication Factor
LANL	Los Alamos National Laboratory
LCO	Limiting Condition for Operation
LWR	Light Water Reactor
MeV	Mega Electron Volts
mg	Milligrams
MMC	Metal Matrix Composite
MTU	Metric Tons of Uranium
MW	Mega Watts
NFAH	Non-Fuel Assembly Hardware
NRC	U.S. Nuclear Regulatory Commission
NSA	Neutron Source Assemblies
ORA	Orifice Rod Assemblies
ppm	Parts Per Million
PWR	Pressurized Water Reactor
QA	Quality Assurance

RAI	Request for Additional Information
RCCA	Rod Cluster Control Assemblies
SAR	Safety Analysis Report (applicant)
SEM	Scanning Electron Microscopy
SER	Safety Evaluation Report (NRC staff)
SSC	Structures, Systems, and Components
TC	Transfer Cask
TN	Transnuclear, Inc.
TPA	Thimble Plug Assemblies
TS	Technical Specifications
UFSAR	Updated Final Safety Analysis Report
USL	Upper Subcritical Limit
VSI	Vibration Suppressor Inserts
WE	Westinghouse
wt%	Weight Percent