TRANSNUCLEAR
AN AREVA COMPANY

February 20, 2009
E-27734

72-1004

U. S. Nuclear Regulatory Commission
Attn: Document Control Desk
One White Flint North
11555 Rockville Pike
Rockville, MD 20852

Subject: Transnuclear, Inc. Comments on the Proposed Certificate of Compliance and Preliminary Safety Evaluation Report for the Transnuclear, Inc. Standardized NUHOMS® Horizontal Modular Storage System, Amendment 10 (Docket No. 72-1004; TAC NO. L24052)

Reference: Letter from B. Jennifer Davis (NRC) to Don Shaw (TN), "Proposed Certificate of Compliance and Preliminary Safety Evaluation Report for the Transnuclear, Inc. Standardized NUHOMS® Horizontal Modular Storage System, Amendment 10 (TAC NO. L24052)," dated February 12, 2009

The referenced letter forwarded the Proposed Certificate of Compliance (CoC) and Preliminary Safety Evaluation Report (SER) for the Transnuclear, Inc. (TN) Standardized NUHOMS® Horizontal Modular Storage System, Amendment 10, for TN's review and identification of inaccuracies and omissions. The purpose of this submittal is to provide the results of TN's review. Enclosure 1 herein provides a listing of Proposed CoC and Preliminary SER pages for which TN has comments. Enclosure 2 provides those pages, with comments annotated by hand marking.

Should the NRC staff require additional information to support review of this application, please do not hesitate to contact Mr. Don Shaw at 410-910-6878 or me at 410-910-6881.

Sincerely,

Jayant Bondre
Vice President - Engineering

cc: B. Jennifer Davis (NRC SFST) (11 paper copies provided separately)

Enclosures:

1. Listing of Proposed CoC and Preliminary SER Pages for which TN has Comments
2. Proposed CoC and Preliminary SER Pages for which TN has Comments, with Comments Annotated by Hand Marking

7135 Minstrel Way, Suite 300, Columbia, MD 21045
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NMSS01

Listing of Proposed CoC and Preliminary SER Pages for which TN has Comments

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Enclosure 2 to TN E-27734

Proposed CoC and Preliminary SER Pages for which TN has Comments, with Comments Annotated by Hand Marking

CERTIFICATE OF COMPLIANCE FOR SPENT FUEL STORAGE CASKS

The U.S. Nuclear Regulatory Commission is issuing this Certificate of Compliance pursuant to Title 10 of the Code of Federal Regulations, Part 72, "Licensing Requirements for Independent Storage of Spent Nuclear Fuel and High-Level Radioactive Waste" (10 CFR Part 72). This certificate is issued in accordance with 10 CFR 72.238, certifying that the storage design and contents described below meet the applicable safety standards set forth in 10 CFR Part 72, Subpart L, and on the basis of the Final Safety Analysis Report (FSAR) of the cask design. This certificate is conditional upon fulfilling the requirements of 10 CFR Part 72, as applicable, and the conditions specified below.

Certificate No.	Effective Date	Expiration Date	Docket No.	Amendment No.	Amendment Effective Date	Package Identification No.
1004	1/23/95	1/23/2015	72-1004	10	Draft	USA/72-1004

Issued To: (Name/Address)

Transnuclear, Inc.
7135 Minstrel Way, Suite 300
Columbia, Maryland 21045

Safety Analysis Report Title

Transnuclear, Inc., "Final Safety Analysis Report for the Standardized NUHOMS® Horizontal Modular Storage System for Irradiated Nuclear Fuel"

CONDITIONS

1. Casks authorized by this certificate are hereby approved for use by holders of 10 CFR Part 50 licenses for nuclear power reactors at reactor sites under the general license issued pursuant to 10 CFR Part 72.210 subject to the conditions specified by 10 CFR 72.212 and the attached Technical Specifications.

2. The holder of this certificate who desires to change the certificate or Technical Specifications shall submit an application for amendment of the certificate or Technical Specifications.

3. CASK:

   a. Model Nos. Standardized NUHOMS®-24P, -52B, -61BT, -32PT, -24PHB, -24PTH, -32PTH1 and - 61BTH

   The two digits refer to the number of fuel assemblies stored in the dry shielded canister (DSC), the character P for pressurized water reactor (PWR) or B for boiling water reactor (BWR) is to designate the type of fuel stored, and T is to designate that the DSC is intended for transportation in a 10 CFR Part 71 approved package. The characters H or HB refer to designs qualified for fuel with burnup greater than 45 GWd/Mtu.

   b. Description

   The Standardized NUHOMS® System is certified as described in the final safety analysis report (FSAR) and in the NRC's Safety Evaluation Report (SER). The Standardized NUHOMS® System is a horizontal canister system composed of a steel dry shielded canister (DSC), a reinforced concrete horizontal storage module (HSM), and a transfer cask (TC). The welded DSC provides confinement and criticality control for the storage and transfer of irradiated fuel. The concrete module provides radiation shielding while allowing cooling of the DSC and fuel by natural convection during storage. The TC is used for transferring the DSC from/to the Spent Fuel Pool Building to/from the HSM.

1

The principal component subassemblies of the DSC are the shell with integral bottom cover plate, bottom shield plug or shield plug assemblies, ram/grapple ring, top shield plug or shield plug assemblies, top cover plate, and basket assembly. The shell length is fuel-specific. The internal basket assembly for the 24P, 24PHB, and 52B DSCs is composed of guide sleeves, support rods, and spacer disks. This assembly is designed to hold 24 PWR fuel assemblies or 52 BWR assemblies.

An alternate basket assembly configuration, consisting of assemblies of stainless steel fuel compartments held in place by basket rails and a holdown ring, is designed to hold 61 BWR assemblies. The 32PT, and 32PTH1 DSC basket assembly configurations are similar, consisting of welded stainless steel plates or tubes that make up a grid of fuel compartments supported by aluminum basket rails, and are designed to accommodate 32 PWR assemblies. The 24 PTH DSC basket assembly configuration consists of stainless steel tubes supported by basket rails and is designed to accommodate 24 PWR assemblies.

The basket assembly aids in the insertion of the fuel assemblies, enhances subcriticality during loading operations, and provides structural support during a hypothetical drop accident. The DSC is designed to slide from the transfer cask into the HSM and back without undue galling, scratching, gouging, or other damage to the sliding surfaces.

The HSM is a reinforced concrete unit with penetrations located at the top and bottom of the walls for air flow, and is designed to store DSCs with up to 24.0 kW decay heat. The penetrations are protected from debris intrusions by wire mesh screens during storage operation. The DSC Support Structure, a structural steel frame with rails, is installed within the HSM. An alternate version of the HSM-H design, has been provided to allow the use of the NUHOMS® system in locations where higher seismic levels exist.

The TC is designed and fabricated as a lifting device to meet NUREG-0612 and ANSI N14.6 requirements. It is used for transfer operations within the Spent Fuel Pool Building and for transfer operations to/from the HSM. The TC is a cylindrical vessel with a bottom end closure assembly and a bolted top cover plate. Two upper lifting trunnions are located near the top of the cask for downending/uprighting and lifting of the cask in the Spent Fuel Pool Building. The lower trunnions, located near the base of the cask, serve as the axis of rotation during downending/uprighting operations and as supports during transport to/from the Independent Spent Fuel Storage Installation (ISFSI). The 32PT DSC is transferred in a TC with a radial liquid neutron shield.

With the exception of the TC, fuel transfer and auxiliary equipment necessary for ISFSI operations are not included as part of the Standardized NUHOMS® System referenced in this Certificate of Compliance (CoC). Such site-specific equipment may include, but is not limited to, special lifting devices, the transfer trailer, and the skid positioning system

c. Drawings

The drawings for the Standardized NUHOMS® System are contained in Appendices E, K, M, N, and P, T and U of the FSAR.

d. Basic Components

The basic components of the Standardized NUHOMS® System that are important to safety are the DSC, HSM, and TC. These components are described in Section 4.2, Table K.2-8 (Appendix K), Table M.2-18 (Appendix M), and Table P.2-17 (Appendix P) of the FSAR.

, Section T.2.3 (Appendix T) and Section U.2.3 (Appendix U)

delete line

CERTIFICATE OF COMPLIANCE FOR SPENT FUEL STORAGE CASKS

Supplemental Sheet

4. Fabrication activities shall be conducted in accordance with a Commission approved quality assurance program which satisfies the applicable requirements of 10 CFR Part 72, Subpart G, and which is established, maintained, and executed with regard to the cask system.

5. Notification of fabrication schedules shall be made in accordance with the requirements of 10 CFR 72.232(d).

6. All Standardized NUHOMS® Systems must be fabricated and used in accordance with CoC No. 1004, Amendment No. 10. Standardized NUHOMS® Systems that were previously fabricated and put into operation by general licensees in accordance with the original CoC, or Amendment Nos. 1, 2, 3, 4, 5, 6, 7, 8, and 9, may continue to be used under the appropriate CoC or Amendment.

7. HSM-H concrete shall be tested for elevated temperatures to verify that there are no significant signs of spalling or cracking and that the concrete compressive strength is greater than that assumed in the structural analysis. Tests shall be performed at or above the calculated peak temperature and for a period no less than the 40 hour duration of HSM-H blocked vent transient for components exceeding 350 degrees F.

8. The use of HSM-H thermal performance methodology is allowed for evaluating HSM-H configuration changes except for changes to the HSM-H cavity height, cavity width, elevation and cross-sectional areas of the HSM-H air inlet/outlet vents, total outside height, length and width of HSM-H if these changes exceed 8% of their nominal design values shown on the approved CoC Amendment No. 8 drawings.

This is correct, as is.

FOR THE NUCLEAR REGULATORY COMMISSION

Eric J. Benner, Chief
Licensing Section
Spent Fuel Project Office
Office of Nuclear Material Safety
and Safeguards

Attachment: A. Technical Specifications

Dated: Draft

July 3, 2007, November 7, 2007, January 18, 2008, May 23, 2008, June 25, 2008, July 28, 2008, and October 8, 2008

SAFETY EVALUATION REPORT

Docket No. 72-1004
Standardized NUHOMS® Modular Storage System for Irradiated Nuclear Fuel
Certificate of Compliance No. 1004
Amendment No. 10

SUMMARY

By application dated January 12, 2007, as supplemented on February 21, 2007, and March 15, 2007, 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. 1004 for the Standardized NUHOMS® Horizontal Modular Storage System for Irradiated Nuclear Fuel.

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

- Addition of a dry shielded canister (DSC) designated the NUHOMS® 61BTH DSC and accompanying changes to accommodate this DSC.
- Addition of a DSC designated the NUHOMS® 32PTH1 DSC and accompanying changes to accommodate this DSC. TN also added an alternate high-seismic option of the horizontal storage module (HSM) for storing the 32PTH1 DSC.
- Allow storage of Westinghouse 15x15 Partial Length Shield Assemblies in the NUHOMS®-24PTH DSC.
- Allow storage of Control Components in the NUHOMS® 32PT DSC.

The NUHOMS® 61BTH system is designed to store up to 61 intact (or up to 16 damaged and the balance intact) boiling water reactor fuel assemblies with a maximum assembly average initial enrichment of 5.0 wt.%, a maximum assembly average burnup of 62 GWd/MTU, and a minimum cooling time of 3.0 years. The NUHOMS® 61 BTH system is designed to accommodate a maximum heat load of up to 31.2 kW per canister.

The NUHOMS® 32PTH1 system is designed to store up to 32 intact (or up to 16 damaged and the balance intact) pressurized water reactor fuel assemblies with a maximum assembly average initial enrichment of 5.0 wt.%, a maximum assembly average burnup of 62 GWd/MTU, and a minimum cooling time of 3.0 years. The NUHOMS® 32PTH1 system is designed to accommodate a maximum heat load of up to 40.8 kW per canister.

The Nuclear Regulatory Commission (NRC) staff has reviewed the application using the guidance provided in NUREG-1536, "Standard Review Plan for Dry Cask Storage Systems," January 1997. Based on the statements and representations in the application, as supplemented, the staff concludes that the TN Standardized NUHOMS® System, as amended, meets the requirements of 10 CFR Part 72. The Amendment No. 10 changes to the CoC are indicated by change bars in the margins.

- Revise the Title, "Applicability" and the "Bases" sections of Specification 1.2.4a to extend the applicability of this specification to the NUHOMS® 61BTH and NUHOMS® 32PTH1 DSC.

- Add a new Specification 1.2.7e, entitled "HSM-H Dose Rates with a Loaded Type 2 61BTH DSC Only", to specify the limiting doses rates due to the storage of a loaded Type 2 61BTH DSC inside the HSM-H.

- Add a new Specification 1.2.7f, entitled "HSM or HSM-H Dose Rates with a Loaded Type 1 61BTH DSC Only", to specify the limiting doses rates due to the storage of a loaded Type 1 61BTH inside the HSM or HSM-H.

- Add a new Specification 1.2.7g, entitled "HSM-H Dose Rates with a Loaded 32PTH1 DSC Only", to specify the limiting doses rates due to the storage of a loaded 32PTH1 DSC inside the HSM-H.

- Revise the Title of Specification 1.2.8 to include Type 1 61BTH DSC, since this DSC is qualified for storage in the Standardized HSM based on the shielding analysis provided Appendix T of the FSAR.

- Add a new specification 1.2.8b, entitled "HSM-H Maximum Air Exit Temperature with a Loaded 61BTH DSC", to specify the limiting air exit temperature due to the storage of a either a Type 1 or Type 2 NUHOMS® 61BTH DSC inside the HSM-H.

- Add a new specification 1.2.8c, entitled "HSM-H Maximum Air Exit Temperature with a Loaded 32PTH1 DSC", to specify the limiting air exit temperature due to the storage of a NUHOMS® 32PTH1 DSC inside the HSM-H.

- Add a new Specification 1.2.11d entitled "Transfer Cask Dose Rates with a Loaded 61BTH DSC", to specify the limiting doses rates due to the transfer of a loaded 61BTH DSC inside the Transfer Cask.

- Add a new Specification 1.2.11e entitled "Transfer Cask Dose Rates with a Loaded 32PTH1 DSC", to specify the limiting doses rates due to the transfer of a loaded 32PTH1 DSC inside the Transfer Cask.

- Revise the Title, Limit No. 1, and Bases of Specification 1.2.14, entitled "TC/DSC Transfer Operations at High Ambient Temperatures" to clarify that this Specification applies to all currently licensed systems (24P, 52B, 61BT, 32PT, 24PHB, and 24PTH DSCs) and the NUHOMS® 61BTH DSC. This clarification is needed since the new 32PTH1 system is designed for a maximum ambient temperature of 106°F as discussed in the next bullet item.

- Add a new Specification 1.2.14a, entitled "TC/DSC Transfer at High Ambient Temperatures (32PTH1 DSC Only)" to specify the maximum ambient temperature limit of 106°F for the NUHOMS® 32PTH1 system.

- Add a new Specification 1.2.15d, entitled "Boron Concentration in the DSC Cavity Water for the 32PTH1 Design Only", to specify the minimum boron concentration required during loading of the NUHOMS® 32PTH1 system.

- Revise the Limit No.2 of Specification 1.2.17b to correct a spelling error in the term "vacuum drying".

- Add a new Specification 1.2.18a, entitled "Time Limit for Completion of Type 2 61BTH DSC Transfer Operation" to specify the limits for the completion of transfer of a loaded NUHOMS® 61BTH DSC.

- Add a new Specification 1.2.18b, entitled "Time Limit for Completion of 32PTH1 DSC Transfer Operation" to specify the limits for the completion of transfer of a loaded NUHOMS® 32PTH1 DSC.

- Revise the bases section of Specification 1.3.1 to add FSAR Appendices T and U which provide the analysis for the storage of NUHOMS® 61BTH and NUHOMS® 32PTH1 DSCs inside a HSM-H. In addition, replace the term "40 hours limit" with "analyzed time limit" to describe the time limit in a generic manner.

- Update Table 1.3.1 to reflect the changes as described above.

1.2 Drawings

1.2.1 Equivalent Materials - 61BTH and 32PTH System Drawings

The TN canister designs which are the subject of this amendment are all of conventional construction methods and materials for a spent fuel storage canister. In order to provide manufacturing flexibility, the applicant has specified that "equivalent" or alternate materials may be used for fabrication of certain specified canister components. The allowable equivalent materials or material standards vary depending upon which specification governs the normally specified material(s).

For non-ASME Code materials, TN specifies ASTM as the governing standard for materials used to fabricate components which are not important to safety. For this class of materials, equivalent materials shall have yield and ultimate strength equal to or greater than the specified ASTM material, allowing for metric conversion round-off, and essentially the same chemistry as the specified ASTM material. Equivalent materials for ASTM materials may be produced to foreign standards in lieu of ASTM standards. TN approval is required for equivalent material selections.

For specified ASME Code materials, which are used for ITS components, only other ASME materials may used. Specific alternate ASME Code materials have been added to the drawings where needed.

The staff finds the applicants specification of alternate materials to be acceptable.

1.2.2 61BTH and 32PTH1 System Drawings

Appendix U, Chapter 1 of the UFSAR contains the drawings for the NUHOMS® 61BTH System, including drawings of the structures, systems and components (SSC) important to safety. The staff determined that the drawings contain sufficient detail on dimensions, materials, and specifications to allow for a thorough evaluation of the NUHOMS® 61BTH System. Specific SSC are evaluated in Sections 3 through 12 of this SER.

Appendix T Chapter 1 of the UFSAR contains the drawings for the NUHOMS® 32PTH1 System, including drawings of the structures, systems, and components (SSC) important to safety. The staff determined that the drawings contain sufficient detail on dimensions, materials, and specifications to allow for a thorough evaluation of the NUHOMS® 32PTH1 System. Specific SSC are evaluated in Sections 3 through 12 of this SER.

1.3 DSC Contents

The revisions and changes to the DSC contents are described below.

1.3.1 61BTH DSC Contents

The NUHOMS® 61BTH system is designed to store up to 61 intact (including reconstituted) or up to 16 damaged and balance intact, 7x7, 8x8, 9x9, or l0xl0 BWR fuel assemblies manufactured by General Electric, Exxon/ANF, or Framatome ANP, or equivalent reload fuel. The fuel to be stored is limited to a maximum initial lattice average initial enrichment of 5.0 wt.%, a maximum assembly average burnup of 62 GWd/MTU, and a minimum cooling time of 3.0 years.

1.3.2 32PTH1 DSC Contents

The NUHOMS® 32PTH1 system is designed to store up to 32 intact (including reconstituted) Babcock and Wilcox (B&W) 15x15, Westinghouse (WE) 17x17, Combustion Engineering (CE) 15x15, WE 15x15, CE 14x14, and WE 14x14 class PWR fuel assemblies. The fuel to be stored is limited to a maximum assembly average initial enrichment of 5.0 wt. % U-235, a maximum assembly average bumup of 62 GWd/MTU, and a minimum cooling time of 3.0 years. The 32PTH1 DSC is designed to store up to 32 Control Components (CCs) which include Burnable Poison Rod Assemblies (BPRAs), Thimble Plug Assemblies (TPAs), Control Rod Assemblies (CRAs), Rod Cluster Control Assemblies (RCCAs), Axial Power Shaping Rod Assemblies (APSRAs), Orifice Rod Assemblies (ORAs), Vibration Suppression Inserts (VSIs), and Neutron Source Assemblies (NSAs).

1.3.3 Change of Contents to the 24PTH and 32PT DSCs

The changes to the contents for the 24PTH and 32PT DSCs authorized by Amendment 10 to the Standardized NUHOMS® are described in Section 1.1.3 and 1.1.4 of this report.

2 PRINCIPAL DESIGN CRITERIA

The objective of evaluating the principal design criteria related to the system, structures, 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 for the NUHOMS® 61BTH System and the NUHOMS® 32PTH1 System are discussed in Safety Analysis Report (SAR) Sections U.2.3.1 and T.2.3.1 respectively (Ref. 2). These sections note that the quality category of components that are important to safety and those that are deemed not important to safety are shown in the drawings listed in SAR Section U.1.5 and T.1.5 for the NUHOMS® 61BTH System and the NUHOMS® 32PTH1 System, respectively. The staff agrees with the determinations stated in the drawings in SAR Section U.1.5 and T.1.5 for the NUHOMS® 61BTH dry shielded canister (DSC) and the NUHOMS® 32PTH1 DSC, respectively.

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

2.2.1 Spent Fuel Specifications

2.2.1.1 61BTH System

The allowable contents of the 61BTH DSC include 61 intact (including reconstituted) and/or damaged boiling water reactor (BWR) fuel assemblies meeting the parameters specified in Tables 1-1t and 1-1u of Technical Specification 1.2.1, "Fuel Specifications." There are two alternate design configurations for the NUHOMS® 61BTH DSC designated as the Type 1 and Type 2 configuration. The maximum decay heat per assembly for the Type 1 61BTH DSC is 0.54 kilowatts (kW) per assembly with a maximum canister heat load of 22kW. The maximum decay heat per assembly for the Type 2 61BTH DSC is 0.70 kW with a maximum heat load of 31.2 kW per canister. The fuel to be stored in the 61BTH DSC is limited to a maximum lattice average initial enrichment of 5.0 wt.% U235. The maximum allowable fuel assembly average burnup is 62 gigawatt days per metric ton (GWd/MTU) and the minimum cooling time is 3 years. A detailed description of the allowable fuel and storage configurations is provided in Tables T.2-1 through T.2-10 in the SAR.

2.2.1.2 32PTH1 System

The allowable contents of the 32PTH1 DSC include 32 intact (including reconstituted) and /or damaged pressurized water reactor (PWR) fuel assemblies meeting the parameters specified in Tables 1-1aa and 1-1bb of Technical Specification 1.2.1, "Fuel Specifications." There are three alternate design configurations for the 32PTH1 DSC depending on the canister length: a short DSC designated as the 32PTH1-S DSC, a medium length DSC designated as the 32PTH1-M DSC and a long DSC designated as the 32PTH1-L DSC. The 32PTH1 DSC basket is designed with two alternate options: a Type 1 basket with solid aluminum transition rails and a Type 2 basket with steel transition rails including aluminum inserts. The Type 1 basket is the preferred option for canisters with high decay heat loads, since the solid aluminum rails allow a more direct heat conduction path from the basket edge to the DSC shell.

The NUHOMS® 32PTH1 DSCs may store fuel assemblies in any of three alternate heat load zoning configurations. The maximum decay heat per fuel assembly and the maximum canister heat load allowed is specified in SAR Figures U.2-1 through U.2-3. The maximum DSC heat load of 40.8 kW is for heat load zoning configuration 1 shown in SAR Figure U.2-1 and is applicable to the Type 1 32PTH1 DSC only.

The fuel to be stored is limited to a maximum assembly average initial enrichment of 5.0 wt.% U-235. The maximum allowable assembly average burnup is limited to 62 GWd/MTU and the minimum cooling time is 3 years. The characteristics of the control components are described in SAR Table U.2-2. A detailed description of the allowable fuel and storage configurations is provided in Tables U.2-1 through U.2-12 in the SAR.

2.2.1.3 24PTH Changes

Amendment 10 to CoC 1004 adds Westinghouse 15x15 Partial Length Shield Assemblies (PLSAs) to the authorized content of the NUHOMS® 24PTH DSC described in SAR Section P.2.1. In addition, Amendment 10 added Vibration Suppression Inserts, and Neutron Sources to the list of controlled components that can be stored in the 24PTH DSC. The amendment also includes additional low enrichment burnups and cooling time options in the fuel qualification table for the 24PTH DSC. The applicant has made changes to SAR Tables P.2-1, P.2-2, P.2-3, and P.2-6 through P.2-13 that are consistent with these changes. In addition, corresponding changes were made to Technical Specification Tables 1.1l, 1.1m, and 1.1n to be consistent with the changes made in SAR Section P.2 regarding controlled components.

2.2.1.4 32PT Changes

Amendment 10 to CoC 1004 expands the authorized contents of the NUHOMS® 32PT DSC described in Appendix M of the UFSAR to include pressurized water reactor (PWR) fuel assemblies with Control Components such as Burnable Poison Rod Assemblies (BPRAs), Thimble Rod Assemblies (TPAs), Control Rod Assemblies (CRAs), 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 in a 32PT DSC may store Control Components except Combustion Engineering (CE) 15x15 fuel assemblies. The applicant has made changes to SAR Section M.2.1 and SAR Tables M.2-1 and M.2.2a describing the controlled components. In addition, corresponding changes were made to Technical Specification tables 1-1e, 1-1f, and 1-1ee to be consistent with the changes made in SAR Section M.2 regarding controlled components.

This is accurate.

2.2.2 External Conditions

Section T.2.2 of the SAR identifies the bounding site environmental conditions and natural phenomena for which the 61BTH DSC, HSM-H, and OS-197FC-B are analyzed. Section U.2.2 of the SAR identifies the bounding site environmental conditions and natural phenomena for which the 32PTH1 DSC, HSM-H, high seismic HSM-HS, and OS-200FC are analyzed. In cases where these did not change, no descriptions were given. External conditions are further evaluated in Sections 3 through 12 of this Safety Evaluation Report (SER).

2.3 Design Criteria for Safety Protection Systems

A summary of the design criteria for the safety protection systems of the 61BTH DSC is presented in Section T.2.3 of the SAR. Details of the design are provided in Sections T.3 though T.11 of the SAR. A summary of the design criteria for the safety protection systems of the 32PTH1 DSC, HSM-H, and high seismic HSM-HS are presented in Section T.2.3 of the SAR. Details of the design are provided in Sections T.3 though T.11 of the SAR.

The applicant has designed the 61BTH and 32PTH1 DSCs to provide storage of spent fuel for 40 years. The Standardized NUHOMS® System has been licensed by the NRC staff for 20 years of storage. The fuel cladding integrity is assured by the 61BTH and 32PTH1 DSCs and basket design which limits fuel cladding temperatures and maintains a non-oxidizing environment in the cask cavity. The 61BTH and 32PTH1 DSCs are designed to maintain a subcritical configuration during loading, handling, storage, and accident conditions. A combination of fixed neutron absorbers and favorable geometry are employed for the 61BTH DSC. A combination of soluble boron in the pool, fixed neutron absorbers, and favorable geometry are employed for the 32PTH1 DSC. The 61BTH and 32PTH1 DSC shells and basket structures are designed, fabricated and inspected in accordance with the ASME B&PV Code, Section III, Subsections NB and NG, respectively, with a few alternative provisions (Ref. 3). The complete list of alternative provisions to the ASME Code and the corresponding justification for the 61BTH DSC shell and the basket structure are provided in Table T.3.1-2 and Table T.3.1-3, respectively. The complete list of alternative provisions to the ASME Code and the corresponding justification for the 32PTH1 DSC shell and the basket structure is provided in Table U.3.1-1 and Table U.3.1-2, respectively. The staff has reviewed the alternative provisions and found that they are acceptable.

2.4 Evaluation Findings

Based on the review of the submitted material, the staff makes the following findings:

F2.1 The staff concludes that the principal design criteria for the NUHOMS® 61BTH System, NUHOMS® 32PTH1 System, the changes to the NUHOMS® 24PTH DCS, and the changes to the NUHOMS® 32PT DCS 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 is presented in Sections 3 through 14 of the 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.

The NUHOMS® 61BTH Type 1 and Type 2 baskets are welded assemblies of stainless steel boxes and designed to accommodate 61 BWR fuel assemblies. The basket structure consists of an assembly of stainless steel tubes (fuel compartments) separated by poison plates and surrounded by larger stainless steel boxes and support rails. The basket contains 61 compartments for proper spacing and support of the fuel assemblies.

The basket structure is open at each end and therefore, longitudinal fuel assembly loads are applied directly to the DSC/cask body and not on the fuel basket structure. The fuel assemblies are laterally supported in the stainless steel structural boxes. The basket is laterally supported by the rails and the DSC inner shell. The basket is keyed to the DSC at 180° and therefore its orientation with respect to the DSC always remains fixed. Under normal transfer conditions, the DSC rests on two 3" wide transfer support rails, attached to the inside of the transfer cask at 161.50° and 198.50°.

The NUHOMS® 32PTH1 system consists of the NUHOMS® 32PTH1 DSC, the HSM-H, and the OS200 Transfer Cask (TC). The 32PTH1 DSC and the OS200 TC are modified versions of the 32PTH DSC and OSI87H TC, respectively. The modifications implemented consist of increasing the cavity length in both the 32PTH1 and OS200 TC to allow storage of longer fuel assemblies. In addition, optional solid aluminum rails have been added to the 32PTH1 DSC to increase the heat load capacity.

The 32PTH1 DSC is a dual purpose canister that is designed to accommodate up to 32 intact PWR fuel assemblies (or up to 16 damaged assemblies, with the remaining intact) with total heat load of up to 40.8 kW. The HSM-H used with the 32PTH1 DSC is the same as that described in the UFSAR Appendix P for use with the 24PTH DSC, with minor modifications to allow storage of the bigger diameter and longer 32PTH1 DSC. These modifications include use of the door described in Appendix T, and a modified restraint structure at the back end of the steel support structure to allow insertion of the 32PTH1 further back into the HSM-H cavity. In addition, certain modifications were made to the HSM-H to increase its seismic capacity.

AND

The HSM-H with these modifications is referred to as the "high seismic" HSM-H (HSM-HS) design option. The OS200 TC is similar to the OS197/OS197H/OS197FC TCs described elsewhere in the UFSAR but with an increased diameter, (same diameter as the OS187H TC of the HD system. Reference to the OS200 is made when there is no option for air circulation in the annulus between DSC air transfer cask, and to the OS200FC when the air circulation option is used. Where the new components had an effect on the structural evaluations presented in the UFSAR, the changes were included. Sections that did not have an effect on the evaluations presented in the UFSAR include a statement that there was no change to the UFSAR. An evaluation of the 32PTH1 DSC shell assembly and basket components and the HSM-H was performed and summarized. The OS200 TC stress evaluations were also summarized.

The 32PTH1 DSC shell assembly is shown on drawings NUH32PTH1-1001-SAR and NUH32PTH1-1002-SAR provided in Chapter U.1, Section U.1.5. Chapter U.1, Figure U.1.1-1 U.1-1 shows a schematic view of the 32PTH1 DSC. There are three design type configurations for the 32PTH1 DSC with three different lengths as shown in the Table U.1-1 presented in the UFSAR: 32PTH1-S, 32PTH1-M, and 32PTH1-L.

The 32PTH1 DSC basket is designed with 2 alternate options: a Type 1 basket with solid aluminum transition rails, and a Type 2 basket with steel transition rails including aluminum inserts. The Type 1 basket is the preferred option for canisters with high decay heat loads, since the solid aluminum rails allow a more direct heat conduction path from the basket edge to the DSC shell.

The basket structure consists of a grid assembly of welded stainless steel plates or tubes that make up a grid of 32 fuel compartments. Each fuel compartment accommodates aluminum and/or neutron absorbing plates (which are made of either borated aluminum or metal matrix composites such as Boralyn®, Metamic®, or equivalent), that provide the necessary criticality control and heat conduction paths from the fuel assemblies to the canister shell. The space between the fuel compartment grid assembly and the perimeter of the DSC shell is bridged by transition rail structures. The transition rails are solid aluminum segments that support the fuel

3.1.2 HSM Module Changes

The HSM-H module design for the 32PTH1 system is nearly identical to the design of the HSM-H module provided for the storage of the currently licensed NUHOMS® 24PTH DSC with the following differences provided to accommodate the 32PTH1 DSC:

- The diameter of the access door is increased to accommodate the 32PTH1 DSC, similar to the 32PTH DSC,
- The thickness of the rail stop at the back end of the DSC support structure is reduced to increase the HSM-H cavity length, and
- Flat stainless steel side and roof heat shields are used.

The key design parameters and estimated weights of the HSM-H module are shown in Table U.1-1. Drawing NUH-03-7001-SAR included in Appendix T, Chapter T.1, Section T.1.5, shows the above listed modifications implemented to HSM-H.

3.1.2.1 HSM High Seismic (HSM-HS) Module

An upgraded version of the NUHOMS® HSM-H design, designated as NUHOMS® HSM-HS, was also provided to allow the use of the NUHOMS® system in locations where higher seismic levels exist. The HSM-HS module is designed to withstand maximum peak ground acceleration (PGA) in horizontal direction of 1.0g and a maximum PGA in vertical direction of 1.0g (compared to 0.3g and 0.25g respectively for HSM-H module).

The modifications implemented to the HSM-H design to meet the upgraded seismic criteria are based on a previously licensed HSM design, and are as listed below:

- The HSM-HS roof is tied to the base unit by steel rods or clamps in the vertical direction and by an interlocking concrete key located between the underside of the roof to restrain relative movement in the horizontal direction;

- Adjacent HSM-HS modules are tied to each other with ties located at the top (roof-to-roof connections) and at the base (base-to-base connections). A minimum of three modules are required in an HSM-HS array; and,

- The ISFSI pad is designed such that the HSM-HS array has 10 feet of space around to allow sliding and retrievability. Drawing NUH-03-7003-SAR included in Section U.1.5, shows the above features of the NUHOMS® HSM-HS module.

3.2 Materials

3.2.1 Materials of Construction and Fuel Payload

All of the canister designs which are the subject of Amendment 10 are of conventional spent fuel canister construction and materials. The structural and confinement components of the canister, along with the structural components of the fuel basket, are fabricated from austenitic stainless steel. The same neutron poison materials as previously employed by this applicant are employed. Thus, the materials of fabrication for Important to Safety (ITS) components are unchanged from those of ~~pervious~~ PREVIOUS amendment requests.

Some differences in material specifications or operating conditions for non-safety related components were noted in this amendment. Those differences are evaluated in other sections of this Safety Evaluation Report.

The fuel payload for the various canister designs did not involve any new types of fuel materials or fuel hardware materials. Thus, no additional consideration of potential adverse chemical or galvanic effects between the canister materials and the fuel payload is required.

3.2.2 Damaged Fuel

3.2.2.1 Damaged Fuel Definition

The applicant provided a definition of damaged fuel in the SAR, Chapter U.1, that is narrower in scope than an all-encompassing definition. Among the differences of this more restricted definition, all fuel meeting the applicant's definition as "damaged" must be capable of being handled by normal means. This precludes inclusion of fuel debris or assemblies with significant structural impairments. Any fuel assemblies which are damaged beyond the definition contained in the SAR are not permitted to be loaded into any of the canisters subject to this amendment.

The staff finds this more restricted definition of damaged fuel to be acceptable.

3.2.2.2 Top and Bottom End Cap for Confinement of Damaged Fuel

The applicant proposed to employ a separate top and bottom end cap for any cell of the fuel basket which contains a damaged fuel assembly. The definition of damaged fuel, in this case, is the restricted definition employed by the applicant. This definition of damaged fuel is narrower in scope than an all-inclusive definition and limits the amount of permissible fuel bundle damage. Normally, a damaged fuel assembly (or fuel debris) is first loaded into a

Section III, Subsection NB (Ref. 6), and the alternative provisions to the ASME Code as described in Table T.3.1-2. The principal design loadings for the NUHOMS® 61BTH DSC were provided in Table T.2-14. The applicable load combinations for the NUHOMS® 61BTH DSC were presented in Table T.2-11 and the corresponding stress criteria were presented in Table T.2-12 and Table T.2-13. The NUHOMS® 61BTH system is designed to withstand the effects of severe environmental conditions and natural phenomena such as earthquakes, tornadoes, lightning and floods. Chapter T.1 describes the NUHOMS® 61BTH DSC behavior under these accident conditions. The NUHOMS® 61BTH DSC design, fabrication and testing are covered by Trans-Nuclear Quality Assurance Program, which conforms to the criteria in Subpart G of 10 CFR Part 72 (Ref. 7).

The NUHOMS® 32PTH1 DSC (shell and closure) is designed and will be fabricated as a Class 1 component in accordance with the rules of the ASME Boiler and Pressure Vessel Code, Section III, Subsection NB [2.2] (Ref. 6), and the alternative provisions to the ASME Code as described in Table U.3.1-1. The NUHOMS® 32PTH1 DSC is designed to withstand the effects of severe environmental conditions and natural phenomena such as earthquakes, tornadoes, lightning and floods. Chapter U.11 describes the NUHOMS® 32PTH1 DSC behavior under these accident conditions. The NUHOMS® 32PTH1 DSC design, fabrication and testing are covered by Transnuclear's Quality Assurance Program, which conforms to the criteria in Subpart G of 10 CFR Part 72.

3.3.2.1 24PTH DSC Shield Assembly

A Partial Length Shield Assembly (PLSA) for WE 15 x 15 has been added to NUHOMS® 24PTH under this amendment, as described in appendix P of the FSAR.

3.3.2.2 Basket Assemblies

The NUHOMS® 61BTH basket is designed and will be fabricated in accordance with the rules of the ASME Boiler and Pressure Vessel Code, Section III, Subsection NG, Article NG-3200 (Ref. 6) and the alternative provisions to the ASME Code as described in Table T.3.1-2. The hypothetical impact accidents are evaluated as short duration, Level D conditions. The stress criteria are taken from Section III, Appendix F of the ASME Code. The basket hold-down ring and the alternate top grid are designed, and will be fabricated and inspected in accordance with the ASME Code Subsections NF, and NG, respectively, to the maximum practical extent.

The basket finite element model described in Section T.3.6.1.3.1 was used to perform the stress calculations for the seismic loads. Since the combined loading (2g axial + 2g transverse + 2g vertical) is non-symmetric, a 360-degree model was used. The canister shell is resting on two rails inside the HSM (3 in. wide x 0.1875 in. thick) at 300° on either side of the basket/canister centerline. The radial contact elements at the two rail locations were assumed closed. The canister nodes at one location of the rail were held in the circumferential directions to avoid rigid-body motion of the model.

The gap elements between the inside surface of the canister and the basket rails were assumed closed at the 180° orientation and remaining initial gaps are suitably modified (from 0 in. at 180° at the bottom to 0.25 in. at 0° at the top).

The NUHOMS® 32PTH1 basket is designed and will be fabricated in accordance with the rules of the ASME Boiler and Pressure Vessel Code, Section III, Subsection NG, Article NG-3200 and the alternative provisions to the ASME Code as described in Table U.3.1-2.

3.3.2.3 HSM Modules

For the NUHOMS® 61BTH there are no structural design changes to the HSM Model 80, 102, 152, or 202 designs. For the NUHOMS® 32PTH1 HSM-H and HSM-HS Off-Normal Loads, the following structural analyses were conducted:

- Off-Normal Thermal Loads Analysis: this load case is the same as the normal thermal load but with an ambient temperature range from 407°F to 17°F. The results of the thermal analysis for the off-normal condition are summarized in Table U.3.4-1. The temperature distributions for the extreme ambient conditions are used in the analysis for the concrete component evaluation.

- HSM-H Off-Normal Handling Loads Stress Analysis: the evaluation for off-normal handling loads described in Appendix P, Section P.3.6.2.3 (B) and summarized in Table P.3.6-10 remains applicable. The off-normal loads evaluations and analysis results for the HSM-H as described above are also applicable to the HSM-HS. In addition, the HSM-HS is evaluated for off-normal operational handling loads of 110 kips during insertion and 90kips during retrieval. For the HSM-H and HSM-HS loaded with a 32PTH1 DSC, Section U3.6 provided the thermal evaluation for the normal and off-normal conditions, and Section U3.7 for the accident conditions. A summary of the forces and moments in the concrete components due to different thermal load cases are summarized in Table U.3.4-1.

3.3.2.4 Transfer Casks

For the NUHOMS® 61BTH with the exception of increased seismic criteria from 0.25g to 0.30g (horizontal) and from 0.17g to 0.20g (vertical), the principal design criteria for the OS197, the OS197H, and the OS197FC-B are the same as that presented in Chapter 3 of the UFSAR. For the NUHOMS® 32PTH1, the top cover plate, top flange, inner liner, structural shell, and bottom assembly are the primary structural members of the OS200 TC. The OS200 transfer cask body structural analyses generally use static nonlinear analysis methods. T he stresses and deformations due to the applied loads are generally determined using the ANSYS (Ref. 8) computer program. The resulting stresses are compared with the allowable stresses set forth by ASME B&PV Code, Section III Subsection NC for normal and off-normal conditions. A 3-dimensional ANSYS (Ref. 8) finite element model, constructed primarily from SOLID45 elements, is used to analyze all the load cases. A 180° symmetric 3D model, or a half model, and a 360° 3D model, or a full model, are used. Selection of the model was dependent upon the type and orientation of the load. For example, the transfer load of 2g in all direction requires the full model. Element plots of the 3D finite element models (half model) are shown in Figure U.3.6-30, Figure U.3.6-31 and Figure U.3.6-32.

3.3.3 Analysis Results

For the NUHOMS® 61BTH the maximum calculated DSC shell stresses induced by normal operating load conditions are shown in Table T.3.6-4 for the Type 1 DSC and Table T.3.6-5 for the Type 2 DSC. The calculated stresses for each load case are combined in accordance with

C. Design basis flood. (U.3.7.3)

D. Accidental TC drop with loss of neutron shield. (U3.7.4) U.3.7.4

E. Lightning effects. (U3.7.5) U.3.7.5

F. Debris blockage of HSM-H air inlet and outlet opening. (U.3.7.6)

G. Postulated DSC leakage. (U.3.7.7)

H. Pressurization due to fuel cladding failure within the DSC. (U.3.7.8)

I. Reduced HSM air inlet and outlet shielding. (U.3.7.9)

J. Fire and explosion. (U.3.7.10)

3.4.1 Analysis Methods~~3.4.1 Analysis Methods3.4.1 Analysis Methods~~

Each accident condition was analyzed to demonstrate that the requirements of 10CFR72.122 are met and that adequate safety margins exist for the standardized ~~NUHOMS®~~ system design. The resulting accident condition stresses in the NUHOMS® system components were evaluated and compared with the applicable code limits set forth in Section 3.2, ~~and~~ Chapter T.2, AND CHAPTER U.2 as applicable. Where appropriate, these accident conditions stresses were combined with those normal operating loads in accordance with the load combinations defined.

3.4.1.1 Tornado Winds and Tornado Missile

For the NUHOMS® 61BTH HSM the applicable design basis tornado (DBT) and tornado missile load parameters were detailed in Section 3.2.1.2 for Models 80/102 and in their respective appendices for Models 152/202. To envelop the effects of wind on an HSM array, a conservative generic analysis was performed with tornado winds assumed to act on a single free-standing HSM (with two end shield walls and a rear shield wall). With the increased weight of NUHOMS® 61BTH DSC the HSM is more stable against the DBT tornado wind and missile effects. The sliding stability analysis was unchanged from the analyses presented in Section 8.2.2. For the HSM-H, results presented in section P.3.7.1 are still bounding.

For NUHOMS® 32PTH1 the applicable design parameters for the design basis tornado (DBT) were not changed from those specified in Chapter P.2, Section P.2.2.1. The determinations of the tornado wind and tornado missile loads acting on the HSM-H are also detailed in that section. The end modules of an array utilize shield walls to resist tornado wind and missile loads. The OS200 TC was designed for the tornado wind and tornado missile loads defined in UFSAR Section 3.2.1.

The stability and stress analyses performed and documented in Appendix P, Section P.3.7.1 to determine the response of the HSM-H to tornado wind pressure loads were applicable for the

TC Seismic Evaluation:

The seismic evaluation for the OS197/OS197H in Chapter 8, Section 8.2.3.2(D), was based on very conservatively derived seismic accelerations of 1.31 g horizontal and 0.84g vertical. These amplified accelerations were obtained by applying amplification factors of 3.5 and 3.3 for the horizontal and vertical directions, respectively, and, furthermore, applying a "multimode" factor of 1.5 to the base seismic criteria values of 0.25g and 0.17g for the horizontal and vertical directions, respectively.

The frequency analysis for a similar NUHOMS® TC documented the NUHOMS®-HD Final Safety Analysis Report (Ref. 9), showed that the TC can be considered a rigid component (the first mode frequency of the TC the NUHOMS®-HD FSAR (Ref. 9) the order of 69 Hz. This frequency content is well in the rigid range relative to the frequency content of the seismic input motion (33 Hz). Therefore, no significant response amplification is expected due to seismic load for the OS 197 type cask, and, thus, the maximum accelerations used in the seismic evaluation of the OS 197/OS 197H as discussed above are deemed to be more than adequate to meet the increased seismic criteria of 0.3g horizontal and 0.20g vertical. Consequently, the seismic stress evaluations and results as described in the UFSAR are applicable and no further evaluation is required.

The seismic stability evaluation described in Section 8.2.3.2(D) for the TC mounted horizontally in the transfer trailer and subjected to the 0.25g and 0.17g seismic accelerations shows a factor of safety of 2.0 against overturning. For the increased accelerations, the factor of safety is approximately 1.7. Sufficient margin exists to accommodate the increased seismic accelerations.

NUHOMS® 32PTH1:

The seismic criteria for the 32PTH1 DSC, HSM-H and OS200 TC consists of Regulatory Guide 1.60 "Design Response Spectra for Seismic Design of Nuclear Power Plants" with response spectral amplifications anchored to maximum accelerations of 0.3g horizontal and 0.25g vertical. For the NUHOMS® System components that were evaluated in accordance with the rules of the ASME B&PV Code (32PTH1 DSC and OS200 TC) the resulting seismic stresses were evaluated against the ASME Code Service Level C allowable.

The 32PTH1 DSC, HSM-H and OS200 TC were also evaluated to a higher seismic design criteria consisting of an "enhanced" Regulatory Guide 1.60 (Ref. 10) response spectra, anchored to a 1.0g maximum horizontal and vertical direction accelerations, as described in Chapter U.2, Section U.2.2.3. The HSM-H design, modified to accommodate the higher seismic accelerations, was referred to as the HSM-HS. No design modifications were required for the 32PTH1 DSC or the OS200 TC to accommodate the higher seismic loads as the design of these NUHOMS® components was controlled by the accident drop loads. The resulting seismic stresses of the 32PTH1 DSC and OS200 TC due to the higher seismic criteria were evaluated against ASME Code Service Level D allowable.

Based on NRC Regulatory Guide 1.61 "Damping Values for Seismic Design of Nuclear Power Plants" (Ref. 11), a damping value of three (3) percent was used for the 32PTH1 DSC seismic analysis. Similarly, a damping value of seven (7) percent was used for evaluation of the DSC support steel and concrete components of the HSM-H. Based on the evaluation of the frequency content of the loaded HSM-H, the amplified accelerations associated with the design basis seismic response spectra were determined and used for the structural evaluation of the NUHOMS® HSM-H/HSM-HS, OS200 TC and 32PTH1 DSC.

Using the results of the frequency analysis of the HSM-H, the maximum calculated design basis seismic accelerations for the DSC inside the HSM-H were 0.41g transverse and 0.36g axial in the horizontal directions and 0.25g in the vertical direction.

An equivalent static analysis using these seismic accelerations showed that the DSC will not lift off the support rails inside the HSM-H.

The stability of the DSC against lifting off from one of the support rails during a design basis seismic event was evaluated by performing a rigid body analysis, using the 0.41g horizontal and 0.25g vertical input accelerations. The horizontal equivalent static acceleration of 0.41g was applied laterally to the center of gravity of the DSC. The point of rigid body rotation of the DSC was assumed to be the center of the support rail, as shown in Figure U.3.7-1.

The applied moment acting on the DSC was calculated by summing the overturning moments. The stabilizing moment, acting to oppose the applied moment, was calculated by subtracting the effects of the upward vertical seismic acceleration of 0.25g from the total weight of the DSC and summing moments at the support rail. Since the stabilizing moment calculated was greater than that of the applied moment, the DSC will not lift off the DSC support structure inside the HSM-H. The factor of safety (SF) against DSC lift off from the DSC support rails inside the HSM-H obtained from this bounding analysis was: SF = 1.05.

The stability of the DSC inside the HSM-HS for the Level D seismic loads was evaluated by performing seismic non-linear (contact) time history analyses using an LS-DYNA (Ref. 12) model of the HSM-HS loaded with a 32PTH1 DSC, as described in Section U.3.7.2.4.1. Based on the results of the LS DYNA analyses, the DSC was shown to maintain its position and remain within the DSC support structure. In addition, based on the frequency analysis of the HSM-H (HSM-HS), the maximum calculated seismic accelerations for the DSC inside the HSM-HS when considering the higher seismic criteria were 2.0g transverse and 1.6g axial in the horizontal directions and 1.0g in the vertical direction.

The stresses in the DSC shell due to vertical and horizontal seismic loads for both sets of seismic criteria were determined and included in the appropriate load combinations.

Basket Assembly Seismic Loads Evaluation:

Seismic loads consistent with the 0.3g horizontal and 0.25g vertical maximum accelerations seismic criteria were evaluated for Level C conditions. Seismic loads consistent with the 1.0g

3. An oblique comer drop from a height of 80 inches at an angle of 30° to the horizontal, onto the top or bottom comer of the TC. This case was not specifically evaluated. The horizontal side drop and end drop cases envelop the comer drop.

TN provided clarifications and proper terminology used in their analyses in response to a staff RAI. TN performed new analyses and revised the relevant SAR Section T for the 61BTH, and Section U for the 32PTH1 as follows.

As described in revised SAR page U.3.5-6, the acceleration time history used for the fuel rod end drop analysis (Figure U.3.5-7) was obtained from LS-DYNA analysis of the TN TC documented in Appendix 3.9.10 (Transfer Cask LS-DYNA Dynamic Impact Analysis) of the FSAR for the NUHOMS® HD Horizontal Modular Storage System For Irradiated Nuclear Fuel (Ref. 8).

At no time during the transfer loading (or unloading) operations is there a need for any lifts of the TC with a loaded DSC. Therefore, the vertical end drops for the NUHOMS® System are non-mechanistic, not credible events and, therefore, no end drops are postulated. Sliding of the DSC out of the transfer cask or tilting of the transfer cask in such a way as to result in a corner drop are also non-mechanistic, highly unlikely events. Nevertheless, for conservatism a corner drop was postulated and evaluated for the NUHOMS® System. Since the end drop is not a credible event for the NUHOMS® System, the response acceleration time history from the corner drop was used for the fuel rod end drop analysis.

The response acceleration time history in the axial direction as shown in Figure 3.9.10-22 (corner drop) of Appendix 3.9.10 (Ref. 8) was not used in the fuel rod end drop analysis. The response acceleration time history shown in Figure 3.9.10-22 (corner drop) of Reference 8 corresponds to the nodal average axial accelerations (parallel to the cask axial direction) of the entire transfer cask lid. This time history may not represent the maximum input to the fuel rod that is closest to the point of impact. Therefore, in order to capture the maximum response of the fuel rod, a nodal acceleration response time history was obtained by differentiation of the nodal velocities in the immediate vicinity of the point of impact (corner of the cask). Figure U.3.5-7 is a new figure generated from the LS-DYNA corner drop result file (post processed from the existing corner drop analysis in Appendix 3.9.10 of Reference 8). Figure U.3.5-7 shows the response acceleration time history in the vertical direction $(axial^2 + transverse^2)^{1/2}$ developed as described in the preceding paragraph. This vertical response time history gives higher g values than response time history in Figure 3.9.10-22 (axial time history). This time history is considered to be bounding since it was developed at the point of corner impact.

Since the end drop is not a credible event for NUHOMS® System, the response time history is based on the corner drop analysis and not the end drop analysis. The response time history due to corner drop will be slightly different when compared with the end drop. During the corner drop, the cask corner will punch into the concrete pad at an angle; therefore the corner drop will have a longer duration and lower pulse amplitude than the end drop. Since a concrete surface is a yielding surface the response will be different than from an impact on an unyielding surface. The results of the response time histories will be different for the different drop conditions. TN performed a top end drop analysis (CE 16x16) based on the unfiltered curve as shown in Figure U.3.5-7. The resulting total strain increased by 0.02% (Table U.3.5-6, page U.3.5-15).

IN ADDITION, AS DESCRIBED IN REVISION 5 OF SAR PAGE U.3.5-7, THE RESPONSE TIME HISTORY AT THE CENTER REGION OF CASK LID WAS ALSO USED TO ANALYZE THE FUEL ROD CORNER DROP. FIGURE U.3.5-7 SHOWS THE TIME HISTORIES FOR BOTH LOCATIONS (AT CENTER OF LID AND AT CORNER IMPACT LOCATION). THE BOUNDING RESULTS ARE SHOWN IN TABLE U.3.5-6.

Based on this result, it is concluded that the response time history used in the fuel rod drop analysis is adequate. The staff concurs that the modal frequency results for the TN TC, using the cutoff frequency for filtering as shown in Figure T3.5.5-15 for 61BTH, and Figure U3.5-7 for 32PTH1, in Revision 4 of the application (Ref. 13), are reasonable. The maximum strain for all analysis remained below the yield value therefore there is a reasonable assurance that there will be no permanent deformation of the spent fuel rods.

These bounding scenarios for the 61BTH system, and the 32PTH1 system assured that the structural integrity of the DSC and spent fuel cladding was not compromised. Analyses of these scenarios demonstrated that the TC will maintain the structural integrity of the DSC confinement boundary avoiding any potential for a release of radioactive materials to the environment due to a cask drop. The structural integrity analyses of the standardized NUHOMS® System on-site TC, DSC and its internal basket assembly when subjected to the postulated TC drop conditions presented in relevant Sections T for the 61BTH, and Section U for the 32PTH1 were reviewed by the staff and the results were found acceptable. Note that for NUHOMS® 61BTH the DSC shell assembly and basket drop analyses were performed using ANSYS finite element models as appropriate. A confirmatory dynamic time history analysis using LS-DYNA was also performed for the basket that showed margin against buckling collapse relative to the 75g acceleration postulated for accidental side drop. A non-linear elastic-plastic analysis was performed considering both the material and geometric non-linearity. A 45° drop orientation was used for this confirmatory analysis. For this CoC amendment request the staff reviewed this analysis and determined the results acceptable for satisfying the requirements of 10 CFR Part 72.

For NUHOMS® 32PTH1 the DSC shell assembly and basket drop analyses were performed using ANSYS finite element models as appropriate. A confirmatory dynamic time history analysis using LS-DYNA was also performed for the basket. Since no data was available on the shape of irradiated fuel cladding, a bowing value as indicated in the FSAR was introduced to the bottom two spans (critical spans) for the bottom end drop and top two spans for the top end drop of the fuel cladding in the shape of the lowest buckling mode. The bowing also facilitates axial instability by providing initial out-of-straightness and it also accounts for manufacturing tolerances and distortion from radiation growth. Figure U.3.5-5 shows the bowing used in all models. A three-dimensional finite element model of the basket and DSC shell was constructed. LS-DYNA was used for the accidental drop cases because it has a relatively more robust contact algorithm which is able to model contact between the different components in the model. Three side drop orientations were evaluated corresponding to 0°, 30° and 45° side drop orientations at 75g and 95g. The structural integrity analyses presented in Sections U.3.7.4.2, U.3.7.4.3, U.3.7.4.4, and U.3.7.4.5 were also reviewed by the staff and the results were found acceptable. For this CoC amendment request the staff reviewed this analysis and determined the results acceptable for satisfying the requirements of 10 CFR Part 72.

In response to a staff RAI the applicant verified the structural integrity of damaged fuel cladding using a fracture mechanics approach. The fracture mechanics analysis was presented by the applicant using three postulated crack geometries. The staff disagreed with the applicant's original understanding of the reorientation of the hydrides (radial and circumferential) in the cladding material, and its effects on the design allowable for high burnup spent fuel. In response to the staff, the applicant submitted a revised analysis, which staff determined to be acceptable.

Only a limited amount of mechanical properties test data exists for high burnup fuel cladding with radial hydrides. Due to the lower stress and hydrogen content expected in low burnup rods, the mechanical properties of Zircaloy cladding with circumferential hydrides was determined to be acceptable for use when analyzing cladding behavior from low burnup rods. However, this is not acceptable for the analysis of high burnup rods where the stress is much higher and considerable hydride reorientation might occur.

CURRENTLY ALLOWABLE STRESS INTENSITY FACTOR (K_{IC})

The staff reviewed the revised analysis using the fracture mechanics approach to establish the adequacy of structural integrity of cladding of high burnup damaged spent fuel. In view of the fact that there is no consensus or accurate and adequate information available in the industry, at this point in time, with respect to mechanical properties of high burnup nuclear spent fuel, the staff does not agree that the ~~fracture mechanics approach~~ as presented in the current application to verify the adequacy of the high burn-fuel is appropriate. ~~As such the applicant should remove this analysis from the FSAR in its entirety.~~

OF RAI #2

Staff agrees that for the through-wall axial crack in the cladding, the key driving force on the crack is the tensile hoop stress due to internal pressure. Since there is no internal pressure acting on the damaged cladding, the applied K_I would be essentially negligible. As shown in Figure 3-2-~~1~~, the existing axial crack would not propagate further (sustain further damage) due to an applied bending moment. The finite element analysis described in the Amendment 10 SAR Revisions 1 through 3 is to quantify that the applied K_I for an axial crack in a tube under bending or axial load to demonstrate that it is minimal.

HIGH BURNUP FRACTURE MECHANICAL PROPERTIES ARE NOT CURRENTLY CONSIDERED

However, although the ~~fracture mechanics approach is not~~ acceptable to the staff as presented in the FSAR, in view of the fact that the fuel cladding allowable stress intensity factor for high burnup spent fuel (K_{IC}) as specified in the FSAR is an order of magnitude larger than the expected demand on the spent fuel cladding, the staff has determined that, there is a reasonable assurance, that for this application, the structural integrity of the high burnup damaged fuel will be maintained for storage and expected on-site transfer operations.

For NUHOMS® 61BTH Loss of Neutron Shield there was no change in this amendment for the analysis performed in the past.

For NUHOMS® 32PTH1 Loss of Neutron Shield, as this was a post-drop accident thermal condition, the peak stresses resulting from this condition has to be less than the allowable fatigue stress limit per the ASME Code. Fatigue is not a concern for TC. As demonstrated by similar analyses in the past for other NUHOMS® System the TC stresses need not be evaluated.

3.4.1.5 Blockages of HSM Air Inlet and Outlet Openings

The analysis, conservatively postulated the complete blockage of the HSM-H ventilation air inlet and outlet openings on the HSM-H side walls. As the NUHOMS® HSM-Hs are located outdoors, ventilation air inlet and outlet openings could become blocked by debris from floods, tornadoes, etc.. The structural consequences due to the weight of the debris blocking the air inlet and outlet openings were found negligible and bounded by the HSM-H loads induced for a

THIS VALUE OF K_{IC} SHOULD NOT BE USED FOR TRANSPORTATION OF HIGH BURNUP FUEL WITHOUT ADDITIONAL JUSTIFICATION postulated tornado or earthquake.

For the 32PTH1 this accident conservatively postulates the complete blockage of the HSM-H/HSM-HS ventilation air inlet and outlet openings on the HSM-H/HSM-HS side walls. The structural consequences due to the weight of the debris blocking the air inlet and outlet vent openings are negligible and were bounded by the HSM-H/HSM-HS loads induced for a postulated Tornado or Earthquake.

3.4.1.6 DSC Leakage and Accident Pressurization of DSC

The NUHOMS® 61BTH DSC was leak tested to meet the applicable leak-tight criteria of ANSI N14.5 (Ref. 14). The analysis demonstrated that the pressure boundary will not be breached for normal, off-normal and postulated accident conditions. The DSC was also evaluated and designed for internal pressure which bounds the maximum postulated accident pressure.

The 32PTH1 DSC was leak tested to meet the leak tight criteria (1x 10^{-7} std. cm 3/sec) of ANSI N14.5 -1997 (Ref. 14). The analyses of the 32PTH1 demonstrated that the pressure boundary was not breached since it met the applicable stress limits for normal, off-normal and postulated accident conditions. U.3.7-8 Accident Pressurization of DSC.

The NUHOMS® 32PTH1 DSC was evaluated and designed for DSC internal pressures which bound the maximum accident pressures calculated in U.4.6. The pressure boundary stresses due to this pressure load were bounded by the results presented in Table U.3.7-20. Therefore, the 32PTH1 DSC was acceptable for this postulated accident condition.

3.4.2 Load Combinations for DSC, TC, and HSM

The load categories associated with normal operating conditions, off-normal conditions, and postulated accident conditions were described and analyzed in various sections of the SAR. The load combination for the NUHOMS® components important to safety, the fatigue effects on the DSC and the TC were as follows:

The stress intensities in the DSC at various critical locations for the appropriate normal operating condition loads were combined with the stress intensities experienced by the DSC during postulated accident conditions. It was assumed that only one postulated accident event occurs at any one time. The DSC load combinations summarized in Table 3.2-6 were expanded in Table T.2-11. Since the postulated cask drop accidents are by far the most critical, the load combinations for these events envelop all other accident event combinations. Tables T.3.7-12 through T.3.7-18 tabulate the maximum stress intensity for each component of the DSC (shell and basket assemblies) calculated for the enveloping normal operating, off-normal, and accident load combinations. For comparison, the appropriate ASME Code allowable stress intensities were also presented in these tables.

Although the normal and off-normal internal pressures for the NUHOMS® 61BTH DSC are slightly higher relative to the NUHOMS® 52B DSC, the range of pressure fluctuations due to seasonal temperature changes are essentially the same as those evaluated for the NUHOMS® 52B DSC. Similarly the normal and off-normal temperature fluctuations for the NUHOMS® 61BTH DSC due to seasonal fluctuations was essentially the same as those calculated for the NUHOMS® 52B DSC. Therefore, the fatigue evaluation presented in Section 8.2.10.2 of the provisions in the structural design: design, fabrication, erection, and testing to acceptable quality standards, adequate structural protection against environmental conditions and natural phenomena, fires and explosions; appropriate inspection, maintenance, and testing; adequate accessibility in emergencies; a confinement barrier that acceptably protects the spent fuel cladding during storage; structures that are compatible with appropriate monitoring systems; and structural designs that are compatible with ready retrieval of spent fuel.

F3.8 The applicant has met the specific requirements of 10 CFR 72.236(e), (f), (g), (h), (i), (j), (k) and (m), as applicable to the structural design for spent fuel storage cask approval. The cask system structural design acceptably provides for the following required provisions: redundant sealing of confinement systems, adequate heat removal without active cooling systems, storage of the spent fuel for a minimum of 20 years, compatibility with wet or dry spent fuel loading and unloading facilities, acceptable ease of decontamination, inspections for defects that might reduce confinement effectiveness, conspicuous and durable marking, compatibility with removal of the stored fuel from the site, transportation, and ultimate disposition by the U.S. Department of Energy.

F3.9 The NUHOMS® systems were described in sufficient detail to enable an evaluation of its structural effectiveness and are designed to accommodate the combined loads of normal, off-normal, accident, and natural phenomena events. The systems are designed to allow handling and retrieval of spent nuclear fuel for further processing or disposal. The staff concludes that no accident or natural phenomena events analyzed will result in damage of the NUHOMS® 61BTH, and the NUHOMS® 32PTH1 DSC that would prevent retrieval of the DSC.

F3.10 A complete structural evaluation of the 61BTH and the 32PTH1 DSC shell assembly and basket components, the HSM-H, HSM-HS, and the ~~OS187H~~ OS200 transfer cask has been performed. The structural evaluation shows that the NUHOMS® system design is compatible with the requirements of 10 CFR 72.236 for maintaining the spent fuel in a subcritical condition, providing adequate radiation shielding and confinement, having adequate heat removal capability, providing a redundant sealing of the confinement system, and providing wet or dry transfer capability.

3.6 References

1. Transnuclear, Inc., "Application for Amendment 10 of the NUHOMS® Certificate of Compliance No. 1004 for Spent Fuel Storage Casks, Revision 0, January 12, 2007.

2. U.S. Nuclear Regulatory Commission, Interim Staff Guidance - 2 (ISG- 2), "Fuel Retrievability", Revision 0.

3. Aluminum Association, "Properties of Aluminum Alloys: Tensile, Creep and Fatigue Data and High and Low Temperatures", The Aluminum Association and ASM International, J. G. Kaufman, ed., 1999

4. U.S. Nuclear Regulatory Commission, Regulatory Guide 3.48, “Standard Format and Content for the Safety Analysis Report for an Independent Spent Fuel Storage Installation or Monitored Retrievable Storage Installation (Dry Storage)”, Revision 1; August, 1989

5. ANSI/ANS 57.9-1984, “Design Criteria for an Independent Spent Fuel Storage Installation (Dry Type), Reaffirmed 2000

6. ASME Boiler and Pressure Vessel Code, Section III, “Rules for Construction of Nuclear Power Plant Components”, American Society of Mechanical Engineers.

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.

9. ANSYS Engineering Analysis Systems User’s manual for ANSYS Rev. 8.1 and later, Swanson Analysis Systems, Inc. PA

10. NUHOMS® - HD Safety Analysis Report, NRC Docket No. 72-1030. NUHOMS® HD Horizontal Modular Storage System For Irradiated Nuclear Fuel

11. U.S. Nuclear Regulatory Commission, Regulatory Guide 1.60, “Design Response Spectra for Seismic Design of Nuclear Power Plants,” Revision 1; December, 1973

12. U.S. Nuclear Regulatory Commission, Regulatory Guide 1.61 “Damping Values for Seismic Design of Nuclear Power Plants,” Revision 1, December 2007.

13. LSDYNA, version 970, Key Word User’s manual, “Nonlinear Dynamic Analysis”.

14. Transnuclear, Inc., “Revision 4 to Transnuclear, Inc. (TN) Application for Amendment 10 to the Standardized NUHOMS® System (Docket No. 72-1004; TAC No. L24052);” July 28, 2008.

15. American National Standards Institute, ANSI N14.5-1997, “Leakage tests on Packages for Shipments,” January 1997.

normal, off-normal, and accident conditions of storage and transfer is provided in Sections U.4.4 and U.4.5 of the SAR, respectively.

Section U.4.6 of the SAR describes the 32PTH1 DSC analysis for storage and transfer conditions. The DSC cavity internal pressures are also calculated in Section U.4.6 of the SAR for all storage and transfer conditions. Section U.4.7 of the SAR describes the evaluation performed for loading/unloading conditions.

An evaluation of the effective thermal conductivity of the fuel assemblies to use in the 32PTH1 DSC thermal analysis is based on the methodology described in Appendix P, Section P.4.8 of the NUHOMS® base SAR. Section U.4.8 of the SAR presents the evaluation of the fuel assembly and DSC basket effective thermal properties for a helium environment.

The applicant's thermal evaluation concludes that the NUHOMS® 32PTH1 system listed above meets all the design criteria. The staff has conducted an evaluation of the applicant's submittal to determine if it meets the applicable regulations in 10 CFR Part 72. The staff's review is documented in this Safety Evaluation Report (SER).

4.2 Spent Fuel

4.2.1 Spent Fuel Storage in the 61BTH System

The NUHOMS® 61BTH System is designed to store up to 61 BWR fuel assemblies with 7x7, 8x8, 9x9, or 10x10 rod arrays, manufactured by General Electric, Exxon/ANF, or FANP, or reload fuel manufactured by other vendors that are enveloped by the fuel assembly design characteristics listed in Table T.2-2. Up to 16 of the assemblies may contain damaged fuel, but the remainder must be intact. Reconstituted fuel assemblies are included in the definition of 'intact', if they contain:

- No more than 10 replacement stainless steel rods, OR
- No more than 61 lower enrichment UO_2 rods (replacing Zircaloy-clad enriched UO_2 rods)

A maximum of four reconstituted fuel assemblies with stainless steel rods are permitted in the DSC. All 61 assemblies may be reconstituted assemblies, if the reconstituted rods contained in the assemblies consist only of lower enrichment UO_2 rods.

Damaged fuel is defined as BWR assemblies with missing or partial fuel rods, or fuel rods with known or suspected cladding defects greater than hairline cracks or pinhole leaks. Damaged fuel assemblies may be located only in the 2x2 array of fuel compartments at the four outer corners of the 61BTH basket.

The NUHOMS® 61BTH is designed for unirradiated fuel with an assembly average initial enrichment of less than or equal to 5.0 wt. % U-235, as shown in Table 1-1d of the Technical Specifications (TS). Specific initial enrichment limits defined for each fuel assembly class are shown in Table 1-1e for intact fuel (or reconstituted fuel) and in Table 1-1j for damaged fuel.

The basket for the 61BTH DSC is supported by four rails (R90 rails) on the long flat faces of the rectilinear basket grid and by eight rails (R45 rails) at the 'corners' of the basket grid. In the Type 1 basket design, the R90 and R45 rails consist of a supporting scaffold of stainless steel plates. Thin aluminum shims are inserted between the outer surface of the outer steel plate of and Type 2 basket. The two designs are identical in all aspects, except for the transition rails. Type 1 basket transition rails are solid aluminum billets that fill the space between the flat basket plates and the curved inner surface of the cylindrical DSC shell. The transition rails for the Type 2 basket consist of a supporting scaffold of stainless steel plates, some of which have thin aluminum plates bolted to the inner surface.

For the PWR fuel assemblies, the allowable temperature limits are based on Interim Staff Guidance No. 11 (ISG-11). For normal (long-term) and off-normal (short-term) conditions of storage, the maximum temperature of the fuel cladding must be maintained below 400°C. For normal and off-normal fuel loading and transfer operations (which include welding of the canister lid and drying with an inert gas, backfilling with inert gas, and transfer of the cask to the storage module), the temperature of the fuel cladding must also be maintained below 400°C (752°F). The purpose of the limit is to ensure that circumferential hydrides in the cladding will not dissolve and go into solution during fuel loading operations, and that re-precipitation of radial hydrides does not occur in the cladding during storage. (See ISG-11, Rev. 3 for a discussion on hydride reorientation.) ISG-11 also establishes a temperature limit of 570°C (1058°F) for Zircaloy-4 fuel cladding for hypothetical accident conditions.

4.3 Cask System Thermal Design

4.3.1 Design Criteria for the 61BTH System

The NUHOMS® 61BTH system is designed to passively reject decay heat during storage and transfer for normal, off-normal and accident conditions while maintaining temperatures and pressures within specified regulatory limits. Table 4.1 summarizes the four limiting system configurations, showing the permitted variations and combinations of DSC basket type, neutron absorber plates, maximum decay heat load, transfer cask configuration, and storage module design.

Table 4.1 NUHOMS® 61BTH System Configurations

System Configuration	61BTH DSC Basket type	Neutron absorber plate Type	Maximum decay heat load (kW)	Transfer cask	Storage Module
1	1	Borated aluminum, MMC, or Boral®	19.4	OS197 or OS197H or OS197FC-B	HSM Model 80 or HSM Model 102 or HSM Model 152 or HSM Model 202 or HSM-H
2		Borated aluminum	22.0		
3	2	Borated aluminum, MMC, or Boral®	27.4	OS197FC-B	HSM-H
4		Borated aluminum	~~32~~ 31.2		

Specific thermal design criteria are established for the thermal analysis of these system configurations, as discussed below.

- Maximum temperatures of the confinement structural components must not adversely affect the confinement function.

- Maximum fuel cladding temperature limit of 400°C (752°F) is applicable to normal conditions of storage and all short-term fuel loading and transfer operations including vacuum drying and helium backfilling of the 61BTH DSC per Interim Staff Guidance (ISG) No. 11, Revision 3.

- No repeated thermal cycling of the fuel cladding with temperature difference greater than 65°C (117°F) during drying and backfilling operations.

- Maximum fuel cladding temperature limit of 570°C (1058°F) is applicable to off-normal storage and accident conditions.

4.3.2 Design Features of the 61BTH System

To enhance heat rejection and shielding capability for the two highest heat load canisters (configurations 3 and 4, see Table 4.1 above), the applicant designed the HSM-H storage module with the following features:

- Twelve evenly spaced 6-inch holes through the web of the I-beam along the axial length of the DSC support structure to increase airflow at the bottom portion of the canister. (Note that in this design, the vented support bar along the contact line between the DSC outer shell and the upper surface of the I-beam is optional. It can be included in a particular storage module, but it is not *required.* Thermal analysis models in the SAR therefore do not include this feature.)

- Increased module cavity height to increase the stack height and reduce the flow resistance in the cavity.

To enhance radial heat transfer within the DSC, the 61BTH design includes:

- Solid aluminum R90 support rails and aluminum plates on the outer face of the stainless steel R45 rails (in the Type 2 basket design) for enhanced radial conduction from the basket to the inner surface of the DSC shell.

- Use of interlocking slotted aluminum and poison plates to form an "eggcrate" type basket that minimizes gaps between components.

- Offsets in the structural steel insert plates to eliminate hot spots.

Within the storage module, the DSC is cooled by buoyancy driven air flow through openings at the base of the HSM-H, which allows ambient air to be drawn into the module. Heated air exits through vents in the top of the shield block in the module ceiling, creating a chimney or "stack" effect. Metal heat shields are placed above and to either side of the DSC to protect the concrete surfaces of the storage module from thermal radiation effects.

The DSC cavity is backfilled with helium gas to aid removal of heat from the fuel assemblies and maintain an inert atmosphere.

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The staff verified that all methods of heat transfer internal and external to the storage system are passive. The only active cooling occurs in the OS197FC-B under off-normal conditions when specific transfer time limits have been exceeded. The SAR drawings and summary of material properties provided sufficient detail for the staff to perform an in-depth evaluation of the thermal performance of the system.

4.3.3 Design Criteria for the 32PTH1 System

The NUHOMS® 32PTH1 DSC is contained within the OS200 or OS200FC TC for loading and transfer operations, and within the HSM-H Storage Module for long-term storage. These systems are designed to passively reject decay heat during storage and transfer for normal, off-normal, and accident conditions while maintaining temperatures and pressures within specified regulatory limits. Specific thermal design criteria are established for the thermal analysis of the systems, as discussed below.

- Maximum temperatures of the confinement structural components must not adversely affect the confinement function.
- Maximum fuel cladding temperature limit of 400°C (752°F) is applicable to normal conditions of storage and all short-term fuel loading and transfer operations, including vacuum drying and helium backfilling of the 32PTH1 DSC, per Interim Staff Guidance (ISG) No. 11, Revision 3.
- Thermal cycling of the fuel cladding must not occur with temperature differences greater than 65 °C (117 °F) during drying and backfilling operations.
- Maximum fuel cladding temperature limit of 570°C (1058°F) is applicable to off-normal storage and accident conditions.

4.3.4 Design Features of the 32PTH1 System

The HSM-H is a modified version of the HSM Model 102, described in the UFSAR. To enhance heat transfer rates due to natural convection around the DSC and increase shielding capability, the applicant designed the HSM-H with the following features:

- Twelve evenly spaced 6-inch holes through the web of the I-beam along the axial length of the DSC support structure to increase airflow at the bottom portion of the canister. (Note that this design does ***not*** include a vented support bar along the contact line between the DSC outer shell and the upper surface of the I-beam.)
- *Increased module cavity height to increase the stack height and reduce the flow resistance in the cavity.*

To enhance radial heat transfer within the DSC, the 32PTH1 design includes:

- Solid aluminum support rails (in the Type 1 basket design) for enhanced radial conduction from the basket to the DSC inner shell surface.
- Basket structure that consists of aluminum and aluminum-alloy poison plates to form *continuous* high-conductivity radial heat transfer paths from the fuel compartment walls to

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plus three words on Page 4-7

The DSC configurations and the associated maximum decay heat loads considered are described in Section T.4.1 of the SAR. The 61BTH DSC with Type 1 basket, which is permitted a maximum decay heat load up to 22 kW, can be transferred within the OS197 or OS197H or OS197FC-B transfer cask. The capability of forced air circulation is not required for the 61BTH DSC with Type 1 basket. The 61BTH DSC with Type 2 basket requires the capability for forced air circulation in the transfer cask when the maximum decay heat load exceeds 22.0 kW (up to a maximum heat load of 31.2 kW). For this configuration, the 61BTH DSC must be within the OS197FC-B transfer cask.

The following ambient conditions are considered for thermal analysis of transfer with the cask vertical, inside the fuel handling facility:

- Maximum normal ambient temperature of 120°F without insolation, and
- Minimum normal ambient temperature of 0°F without insolation.

4.4.1.1.2 OS197FC-B TC Transfer Cask: Off-Normal Conditions

The thermal performance of the 61BTH DSC transfer in the OS197FC-B transfer cask was examined in Section T.4.5.2 of the SAR for the following off normal ambient conditions:

- Maximum ambient temperature of 117°F without insolation (i.e., solar shield in place; horizontal transport)
- Maximum ambient temperature of 120°F for vertical loading within the fuel handling facility.

Technical Specification 1.2.4 for transfer operations specify that a solar shield must be used to provide protection against direct solar radiation for transfer operations when ambient temperature exceeds the normal condition ambient temperature of 100°F. As discussed in Section T.4.5.3.1 of the SAR, the normal transfer conditions are bounded by vertical loading case with off-normal 120°F ambient temperature in the fuel loading area.

4.4.1.1.2.1 Lid Configuration for OS197FC-B TC: External Cooling (Blower Fans)

The OS197FC-B TC differs from the OS197/OS197H/OS197FC TC designs by including a modified top lid and wedge spacers at the ~~bottom of~~ the TC cavity which enable an exit path for air circulation through the TC/DSC annulus. *The external air circulation feature may only be used for specific situations during the transfer mode (outside of normal operations), as defined* in the Technical Specifications (Section 1.2.18b). The relevant criteria are summarized as follows:

- Type 2 basket in the 61BTH DSC, **and**
- Total decay heat is greater than 22.0 kW ~~and~~
- Specific time limits for transfer ~~are exceeded~~

This alternate top lid design is nearly identical to the top lid of OS197FC TC shown in Figure P.1-5 of Appendix P of the NUHOMS® base SAR. The details of the modifications necessary to convert a OS197/OS197H TC into a OS197FC-B TC can be found in the applicant's Drawings NUH-03-8000-SAR and NUH-03-8007-SA, included in Section T.1.5 of the SAR.

The heat loading zone configurations (HLZC) are defined in Figures U.4-1, U.4-2, and U.4-3 of the Appendix U of the SAR submittal. The allowable configurations are outlined below:

- HLZC #1 is a non-uniform loading pattern that is permitted only in the DSC with Type 1 basket (solid aluminum rails). This configuration allows up to 16 assemblies with a maximum decay heat of 1.5 kW, up to 12 assemblies with a maximum decay heat of 1.3 kW, and up to 4 assemblies with a maximum decay heat of 0.6 kW, for a maximum total decay heat of 40.8 kW in the DSC.

- HLZC #2 is a nearly uniform loading pattern that is permitted with either the Type 1 or Type 2 basket. This configuration allows up to 28 assemblies with a maximum decay heat of 0.98 kW and up to 4 assemblies with a maximum decay heat of 0.96 kW, for a maximum total decay heat of 31.2 kW in the DSC.

- HLZC #3 is a uniform loading pattern with maximum decay heat up to 0.8 kW per assembly, for a maximum total decay heat of 24 kW in the DSC. This loading configuration can be used in a DSC with either Type 1 or Type 2 basket.

Forced air cooling must be available in the transfer cask for the DSC with Type 1 basket, when loaded in the HLZC #1 loading pattern with a total decay heat load greater than 31.2 kW (up to 40.8 kW.) Similarly, forced air cooling must be available in the transfer cask for the DSC with Type 2 basket when loaded in the HLZC #2 loading pattern and total decay heat load greater than 24 kW (up to 31.2 kW).

4.4.2.1 Storage and Transfer: Normal and Off-Normal Conditions

The 32PTH1 DSC components were evaluated by the applicant for normal conditions of storage and transfer over the range of design basis ambient temperatures. Boundary conditions for these cases were assumed to occur for a sufficient duration such that a steady-state temperature distribution existed within the 32PTH1 DSC components. The following subsections summarize the peak cladding temperatures reported in the SAR (Revision 3) for normal and off-normal conditions of transfer and storage in the four design basis configurations of the 32PTH1 DSC.

4.4.2.1.1 Transfer Cask (OS200/OS200FC TC): Normal Conditions

Operations involving the OS200 or OS200FC TC occur with the TC/DSC system vertical within the fuel handling facility or horizontal (when loaded onto the transfer skid.) The TC/DSC system is horizontal while in transit to the ISFSI. Operations within the transfer facility are expected to be of short enough duration that analyses presented in the SAR for this configuration are performed as transients. Ambient temperatures in the range of 0° to 120°F are defined as normal transfer conditions for operations within the fuel handling facility. The SAR does not present analysis results for the vertical loading transient under normal conditions. Instead, results are presented for the extreme ambient temperature of 140°F, and these conditions are assumed bounding on normal operations. (See Section 4.4.2.1.2 below for evaluation of off-normal conditions.)

Ambient temperatures in the range of 0°F (without insolation) to 106°F (with insolation) are defined as normal transfer conditions with the TC/DSC horizontal, during transit to the ISFSI. The two limiting configurations that require the availability of forced air circulation (Type 1, HLZC #1, 40 kW and Type 2, HLZC #2, 31.2 kW) are analyzed as transients. The other two limiting configurations, which do not need forced air circulation (Type 1, HLZC #2, 31.2 kW and Type 2,

40.8

HLZC #3), are analyzed assuming steady-state conditions.

The maximum peak cladding temperature for transient conditions, before forced air circulation is activated, is reported at 730°F for the DSC with Type 2 basket, HLZC #2, 31.2 kW decay heat. The maximum steady-state peak cladding temperature where forced air circulation is not required, is reported as 737°F for the DSC with Type 1 basket, HLZC #2, 31.2 kW.

Confirmatory calculations for the TC/DSC system are discussed in Section 4.6.3.2, in connection with evaluation of the modeling approach used to represent the horizontal transfer cask containing the DSC.

4.4.2.1.2 Transfer Cask (OS200/OS200FC TC): Off-Normal Conditions

The thermal performance of the 32PTH1 DSC in the OS200/OS200FC transfer cask is reported in Section U.4.5.1 of the SAR for the following off-normal ambient conditions:

- Maximum ambient temperature of 117°F with solar shield in place, OS200/OS200FC horizontal on transfer skid
- Maximum ambient temperature of 140°F for vertical loading within the fuel handling facility.

Table 4.5 shows the peak cladding temperatures reported for off-normal conditions of transfer, and includes both the vertical loading transient within the fuel handling facility and horizontal transfer to the ISFSI. As with the results for normal conditions presented in Section 4.4.2.1.1, calculations are transients for the two DSC configurations that require forced air circulation if specified time limits are exceeded. Calculations are steady-state for the two configurations that do not require forced air circulation.

Table 4.5. Peak Cladding Temperatures for Off-Normal Transfer Conditions Reported in SAR , Rev. 3

conditions evaluated in SAR (regulatory limit: 752°F)	ambient air	Type 1, HLZC #1, 40.8 kW	Type 1, HLZC #2, 31.2 kW	Type 2, HLZC #2, 31.2 kW	Type 2, HLZC #3, 24 kW
in TC (vertical in transfer facility)--	(°F)	(°F)	(°F)	(°F)	(°F)
extreme ambient (hot)	140	730 (transient)	737	727 (transient)	702
Normal (hot)	120	< 730	< 737	< 727	< 702
in TC (horizontal, in transit to ISFSI)--					
Normal (hot)	106	722 (transient)	713	728 (transient)	680
Normal (cold)	0	717 ~~(transient)~~	665	730 ~~(transient)~~	624
off-normal (hot)	117	722 (transient)	709	730 (transient)	675
off-normal (hot) with FC	117	690		669	

transfer

The results in Table 4.5 are the basis for the applicant's assertion that the extreme ambient condition for the vertical loading transient is bounding for all other conditions of ~~transport~~ for all configurations of the 32PTH1 DSC in the OS200 transfer cask. The reported peak cladding temperatures for the DSC with Type 2, HLZC #2, 31.2 kW decay heat load appears to be inconsistent with this general assertion. The reported value is 727°F for this configuration with the TC vertical in the transfer facility under extreme hot ambient conditions, and is 730°F for the TC horizontal under off-normal hot conditions (with sunshade) in transit to the ISFSI. Because the difference between the two values is small, and since in all cases the peak temperature corresponds to the point at which force air circulation must be activated, it is treated as insignificant.

Confirmatory calculations for the TC/DSC system are discussed in Section 4.6.3.2, in connection with evaluation of the modeling approach used to represent the horizontal transfer cask containing the DSC.

4.4.2.1.2.1 Optional Lid Configuration for OS200 TC: External Cooling (Blower Fans)

The OS200 TC is provided with an optional top lid with design features which enable an exit path for air circulation through the TC/DSC annulus. The external air circulation feature may only be used for specific situations during the transfer mode (outside of normal operations) defined in the Technical Specifications (Section 1.2.18b), and summarized as follows:

- If decay heat in the 32PTH1 DSC is greater than 31.2 kW **and** the basket type used is Type 1 (A through F) **and** specific time limits for transfer are not met, or

- If the decay heat is greater than 24.0 kW (but not greater than 31.2 kW) **and** the basket type used is Type 2 (A through F) **and** specific time limits for transfer are not met.

The TC when used with this optional top lid is designated as OS200FC TC. This alternate top lid design is nearly identical to the top lid of OS197FC TC shown in Figure P.1-5 of Appendix P of the NUHOMS® base SAR.

Confirmatory calculations were performed with a detailed model of the DSC using the COBRA-SFS computational thermal-hydraulics code, to evaluate the conservatism of the peak cladding temperature values reported in the SAR, for off-normal conditions with forced air circulation. Table 4.6 compares the results of the confirmatory calculations with the peak cladding temperatures from the applicant's analyses.

Table 4.6. Confirmatory Calculation Results for Off-Normal Transfer Conditions with Forced Air Circulation vs. Peak Cladding Temperatures Reported in SAR

(regulatory limit: 752°F)	ambient air	Type 1, HLZC #1, 40.8 kW	Type 1, HLZC #2, 31.2 kW	Type 2, HLZC #2, 31.2 kW	Type 2, HLZC #3, 24 kW
In TC (horizontal)--	(°F)	(°F)	(°F)	(°F)	(°F)
from detailed ANSYS model of DSC(1)	117	690	no FC	669	no FC
Confirmatory Results from detailed model of DSC in TC(2)		683	no FC	660	no FC
Difference between SAR and confirmatory results		7 °F		9 °F	

(1) using DSC shell boundary temperatures from ANSYS model of TC with DSC represented as uniform heat flux boundary.

(2)Computational model for these calculations used heat transfer coefficient correlation (plus radiation) to ambient as external boundary condition.

The comparisons in Table 4.6 show that the steady-state peak cladding temperatures with forced air circulation obtained with the detailed ANSYS model of the DSC with temperature boundary conditions from the ANSYS model of the TC are conservative compared to the results obtained with the confirmatory model. With active cooling of the DSC within the transfer cask, the predicted peak cladding temperatures for these two limiting configurations are well below the regulatory limit of 752°F (400°C).

4.4.2.1.3 HSM-H: Normal Conditions

For storage in the HSM-H, the applicant performed analyses only for the Type 1 basket, HLZC #1 (40.8 kW) and for the Type 2 basket, HLZC #2 (31.2 kW) in the DSC. The Type 1 basket, HLZC #2 (31.2 kW) in the DSC and the Type 2 basket, HLZC #3 (24.0 kW) in the DSC are assumed to be bounded by the performed analyses.

The following ambient conditions are considered for thermal analysis of normal storage and transfer cases:

$ Maximum normal ambient temperature of 106°F with insolation, and
$ Minimum normal ambient temperature of 0°F without insolation.

Confirmatory calculations were performed with a detailed model of the DSC using the COBRA-SFS computational thermal-hydraulics code, to evaluate the conservatism of the peak cladding temperature values reported in the SAR. Table 4.7 compares the results of the confirmatory calculations with the peak cladding temperatures from the applicant's analyses.

with the SAR model is significantly conservative. For the DSC with Type 2 basket, HLZC #2, 31.2 kW, the SAR result is not as conservative as the confirmatory calculation result. The significance of this comparison is evaluated further in Section 4.6.3.2 below, in the discussion of modeling issues. However, the overall results of this evaluation indicate that for off-normal conditions, peak cladding temperatures are expected to remain far below the regulatory limit of 1058°F (750°C) for short-term storage conditions, and are not expected to exceed the long-term storage limit of 752°F (400°C).

4.4.2.2 Accident Analyses (32PTH1)

The 32PTH1 DSC was evaluated to determine the thermal response during storage and transfer over a range of design basis accident conditions. The thermal response of the DSC within the HSM-H was also evaluated under the extreme ambient temperature of 133°F with maximum insolation ~~is evaluated~~.

Four accident scenarios were considered for the OS200 TC with the 32PTH1 DSCs. These accident scenarios are described in Section U.4.5.4.2 of the SAR, and are summarized below.

$ The first accident scenario evaluates the effect of interruption of the air circulation system and predicts the heat up rate for the OS200FC TC containing the 32PTH1 DSC with Type 1 basket, HLZC #1, 40.8 kW or with Type 2 basket, HLZC #2, 31.2 kW. (Note that this accident cannot affect the other two configurations of the DSC, since they do not require forced air cooling to maintain temperatures below regulatory limits.) The analysis assumes that the TC and DSC are initially at steady-state under the normal hot condition (117°F ambient, no insolation) with air circulation. At time = 0, the air circulation is assumed to be lost and the system begins to heat up.

$ The second accident scenario evaluates the effect of the loss of the neutron shield water. The transient is initiated from steady-state normal hot condition (117°F ambient, no insolation), so for the two configurations requiring forced air circulation to reach a steady state within regulatory limits (i.e., Type 1, HLZC #1, 40.8 kW and Type 2, HLZC #2, 31.2 kW), the accident scenario also includes loss of air circulation as well as loss of the water in the neutron shield.

$ The third accident scenario evaluates the effect on an undamaged OS200/OS200FC TC of an extreme ambient air temperature of 133°F when loaded with the 32PTH1 with decay heat loads of 40.8 and 31.2 kW. The evaluation addresses the maximum steady-state temperatures that would be achieved without the mitigation of forced air circulation.

$ The fourth accident scenario evaluated for the OS200 TC involves a 15-minute hypothetical fire. The initial temperature condition for the fire accident transient is the same as used for the start of the loss of the neutron shield and loss of air circulation accident scenarios.

Two accident scenarios were evaluated for the HSM-H containing the 32PTH1 DSCs. These accident scenarios are described in Section U.4.6.7 of the SAR, and are summarized below.

$ The first accident scenario postulates an extreme ambient temperature of 133°F with maximum insolation, conservatively assumed to occur over a sufficient duration for a steady-state temperature distribution to develop in the 32PTH1 DSC within the HSM-H.

$ The second accident scenario evaluates the effect of the loss of natural circulation air flow through the HSM-H due to complete blockage of the inlet vent for a period of 40 hours. The transient is initiated from steady-state normal hot condition (117°F ambient, maximum insolation).

4.4.2.2.1 Transfer Cask Accident Evaluations

The thermal performance of the 32PTH1 DSC in the OS200/OS200FC for accident conditions was evaluated primarily using a SINDA/FLUINT half-section of symmetry model of the transfer cask, with the DSC represented using a constant heat flux boundary condition over the ~~exterior~~ interior surface. Insolation is assumed maximum in all accident scenarios, including the fire transient. The resulting DSC shell temperature distribution for the most limiting accident condition is used to define boundary conditions for the detailed ANSYS model of the 32PTH1 DSC basket. This calculation determines the peak cladding temperature for the limiting transfer accident, which is assumed to bound all other transfer accident conditions.

Table 4.9 summarizes the peak DSC shell temperatures obtained for the four transfer accident scenarios, for the various DSC configurations. Since the SINDA/FLUINT model does not yield temperatures for the DSC internal components, the applicant chose to use the peak DSC shell temperature to evaluate and compare the results obtained for the transient calculations.

Table 4.9. Peak DSC Shell Temperatures for Transfer Accident Conditions in SAR

conditions evaluated in SAR	ambient air	Type 1, HLZC #1, 40.8 kW	Type 1, HLZC #2, 31.2 kW	Type 2, HLZC #2, 31.2 kW	Type 2, HLZC #3, 24 kW
in TC (horizontal) ~~-- (regulatory limit: 1058°F)~~	(°F)	(°F)	(°F)	(°F)	(°F)
Loss of air circulation	117	> 450	476 (no FC)	> 420	419 (no FC)
Loss of neutron shield	117	651	578		
fire accident (at end of fire)	117	451 (transient)	421 (transient)		
Post-fire steady-state	117	646	574		
accident ambient	133	558	495		

The DSC with Type 2, HLZC #3, 24 kW decay heat load is assumed bounded by the DSC with Type 2, HLZC #2, 31.2 kW, so no results are presented for this lowest decay heat configuration. Since the DSC shell temperature correlates directly with the internal component temperatures, the results in Table 4.12 can be used to infer that loss of the neutron shield (with loss of forced air circulation, if applicable) is the most limiting of the four specified transient scenarios. This leads to the definition of the bounding accident as loss of the neutron shield water, loss of forced air circulation (if applicable), and loss of sunshade at 117°F ambient temperature. (Note that in all transfer accident scenarios, the sunshade is assumed lost, and insolation is at a maximum.)

4.4.2.2.1.1 Transfer Cask: Bounding Accident

The postulated transfer accident event consists of the 32PTH1 DSC transfer in the OS200 TC in a 117°F ambient environment with loss of the sunshade, loss of the liquid neutron shield, and loss of air circulation (if applicable.) Table 4.9 above shows the results of the evaluations completed by the applicant to establish the predicted thermal response for 32PTH1 DSC decay

4.5 Model Specification

4.5.1 Analysis Model Configuration for Use with the 61BTH System

4.5.1.1 HSM-H Model for Use with the 61BTH System

The analysis model developed by the applicant, described in Section T.4.4.4 of the SAR, determines the HSM-H component temperatures and DSC shell temperature distribution, which is then used in a detailed model of the 61BTH DSC basket (described in Section T.4.6 of the SAR) as boundary conditions to calculate the basket and fuel peak cladding temperatures. The applicant developed a half-symmetry, three dimensional ANSYS® finite element model of the HSM-H loaded with a 61BTH DSC.

The model developed by the applicant is identical to the HSM-H model described in Appendix P, Section P.4.4 of the NUHOMS® base SAR, except for the dimensions of the DSC and HSM-H access port. The model is depicted in Figure T.4-3 of the SAR. The HSM-H model included the DSC shell, shield plugs, the concrete structure, and the heat shields. The DSC contents were not considered for the steady-state analysis runs. The DSC basket and fuel assemblies were homogenized for the blocked vent (accident) transient model. The homogenized basket properties for 61BTH DSC are calculated in Section T.4.8.3 of the SAR.

To define the bounding operating condition for the storage module, the HSM (or HSM-H) is assumed to be located in the middle of a double-row array of modules in a back-to-back arrangement. This is modeled with adiabatic boundary surfaces on the sides and back of the ANSYS representation of the HSM-H module. The solar heat load on the storage module roof and front wall is modeled as described in Appendix P, Section P.4.4.4. The decay heat load due to the DSC is applied as a uniform heat flux on the inner surface of the DSC shell over the equivalent length of the internal basket (162 inches).

The air flow rate and air temperature distribution within the model of the storage module are calculated using the 'stack effect' analysis documented in Appendix P, Section P.4.4.3, modified only to account for the 61BTH DSC dimensions and heat loads. This analysis consists of a simple one-dimensional energy and momentum balance for the air flow path through the storage module, with the heat transfer rate at the DSC shell exterior surface and module component inner surfaces (e.g., concrete walls, heat shields, support rails, and basemat) calculated with local heat transfer coefficient correlations. Thermal radiation effects are ← included ~~conservatively neglected with~~in the module cavity. Free convection around the circumference of the access port and between the outer surface of the DSC cover plate and the inner surface of the storage module door is included in the applicant's model. The model represents free convection heat transfer and thermal radiation to the environment from the front face and roof of the storage module with a single combined total heat transfer coefficient (as documented in Section P.4.9.3 of the NUHOMS® base SAR.)

Air flow rates and temperatures were determined for the 31.2 kW and 22 kW configurations, for normal and off-normal ambient conditions. The temperature values are used as boundary conditions on the DSC external surface elements and HSM-H inner surface elements in calculations with the detailed ANSYS model of the HSM-H described above.

4.5.1.2 61BTH DSC Basket/Fuel Assembly Model

The applicant developed a three dimensional (3D) ANSYS model of the 61BTH DSC, described in Section T.4.6.2 of the SAR, to determine the maximum fuel cladding and DSC component temperatures. The 3D DSC model represents a longitudinally full-length, one-half (180°) cross section of the 61BTH DSC. This model includes the DSC shell, shield plugs, basket, and fuel assemblies.

The 3D models representing the DSC with Type 1 and Type 2 baskets are shown in Figures T.4-22 through T.4-25 in the SAR. The fuel assemblies are modeled as homogenized regions within the fuel compartments. The effective thermal properties for the intact and damaged fuels are calculated in Section T.4.8 of the SAR.

The applicant's ANSYS model is comprised of the shell assembly (including the shell, and top and bottom end assemblies) and the basket assembly (including fuel compartment tubes, aluminum and neutron absorber plates, and the R45 and the R90 transition rails). All these DSC components are modeled using ANSYS SOLID70 elements. Radiation between the rails and the DSC shell is modeled using radiation LINK31 elements. ~~Axial radiation is also considered between the top and bottom surfaces of the fuel assemblies to the shield plugs.~~

The applicant states that the methodology of this analysis model is identical to that used for 24PTH DSC modeling described in Appendix P, Section P.4.6.

The total number of nodes and elements in the ANSYS model are approximately 833,000 for Type 1 and 820,000 for Type 2 baskets. A mesh size of 10x10 is applied in fuel regions. A sensitivity study was performed, and it determined this mesh size to be adequate, as described in Section T.4.6.3. The nominal dimension of the elements used in this region were 0.6", which was more precise than the element size of 0.64" used in the 24PTH DSC model (Appendix P, Section P.4.6.1, of the NUHOMS® base SAR).

The gaps between adjacent basket components were also modeled using SOLID70 elements with helium or air conductivity as appropriate. The material properties from Section T.4.2 of the SAR are used for the fuel region. Within the model, heat is transferred via conduction through fuel regions, fuel compartments, aluminum and neutron absorber plates, and the gas gaps between components. The applicant states that good surface contact is expected between adjacent components within the basket structure. However, the applicant bounds the heat conductance uncertainty between adjacent components due to imperfect contact between the neutron absorber material, aluminum and steel basket components, by assuming uniform gaps along the entire surfaces.

The typical gaps used in the applicant's thermal analysis of the 61BTH DSC are summarized in Section T.4.6.2 of the SAR and depicted in Figures T.4-26 through T.4-28 of the SAR.

4.5.1.2.1 61BTH Loading Configurations

Eight (8) HLZCs are allowed for the 61BTH DSC, as shown in Figures T.2-1 through T.2-8. A maximum of 16 damaged fuel assemblies can be stored in the 61BTH DSC. The DSC model with Type 2 basket can accommodate a maximum total heat load up to 31.2 kW. The DSC model with the Type 2 basket includes eight steel R45 with aluminum liner plates and four solid aluminum R90 rails. The DSC model with the Type 1 basket can accommodate a maximum total heat load of 22.0 kW. In this model, the R45 and R90 rails are stainless steel with thin aluminum shims. The applicable HLZCs for each DSC type are shown in Table 4.2.

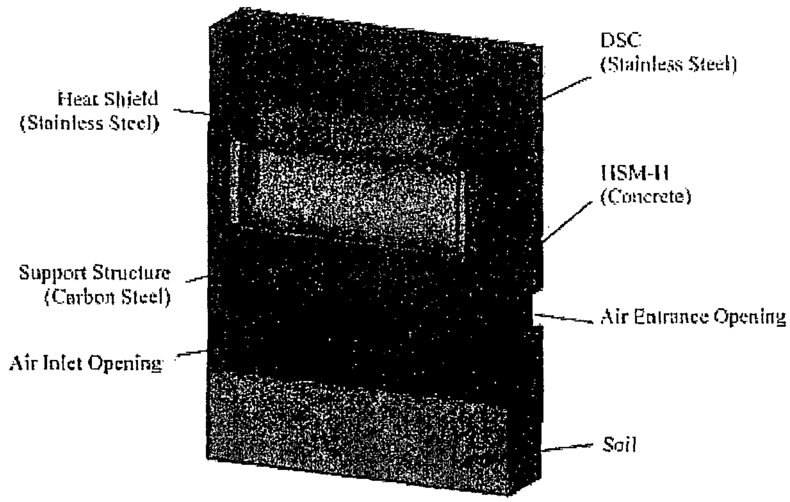

Figure 4.2 Diagram of ANSYS Model of HSM-H (from SAR, Figure U.4-6)

To define the bounding operating condition for the storage module, the HSM-H is assumed to be located in the middle of a double-row array of modules in a back-to-back arrangement. This is modeled with adiabatic boundary surfaces on the sides and back of the ANSYS representation of the HSM-H module. The solar heat load on the HSM-H roof and front wall is modeled as described in Appendix P, Section P.4.4.4 of the NUHOMS® base SAR, with the following insolation values:

HSM-H Surface	Insolation ($gcal/cm^2$)	Averaged over 24 hr ($Btu/hr\text{-}in^2$)
HSM-H roof	800	0.8537
HSM-H front wall	200	0.2134

(from page U.4-16 of the SAR, Section U.4.4.4)

The decay heat load due to the DSC is applied as a uniform heat flux on the inner surface of the DSC shell over the equivalent length of the internal basket (164.5 inches). This approach yields the following uniform heat flux boundary conditions:

- 2.9965 $Btu/hr\text{-}in^2$ for 31.2 kW heat load
- 3.9184 $Btu/hr\text{-}in^2$ for 40.8 kW heat load

The air flow rate and air temperature distribution within the HSM-H are calculated using the 'stack effect' analysis documented in Appendix P, Section P.4.4.3 of the NUHOMS® base SAR, modified only to account for the 32PTH1 DSC dimensions and heat loads. This analysis consists of a simple one-dimensional energy and momentum balance for the air flow path through the HSM-H, with the heat transfer rate at the DSC shell exterior surface and HSM-H component inner surfaces (e.g., concrete walls, heat shields, support rails, and basemat) calculated with local heat transfer coefficient correlations. Thermal radiation effects are ← included ~~conservatively neglected with~~in the HSM-H cavity, and free convection in the cylindrical gap within the access port, between the outer surface of the DSC cover plate and the inner surface of the HSM-H door is also neglected in the applicant's model. The model represents free convection heat transfer and thermal radiation to the environment from the front face and roof of

- the assumption of radially uniform heat transfer rates around the full circumference of each segment of the neutron shield tank annulus
- the assumption that the effect of the stagnant regions at the top and bottom of the annulus (at the line of geometric symmetry) can be ignored

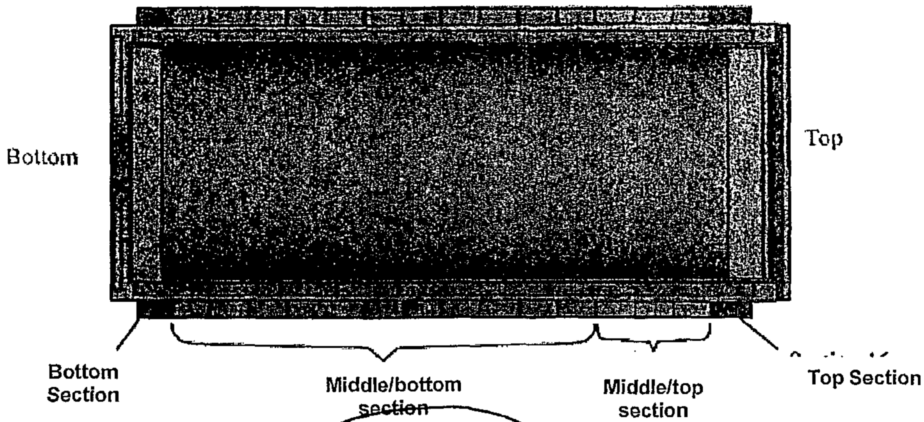

Figure 4.4 Effective Conductivity Regions in SAR Model of OS200 Neutron Shield (adapted from Figure 4-2 of NUHOMS-HD Amendment 1 SAR)

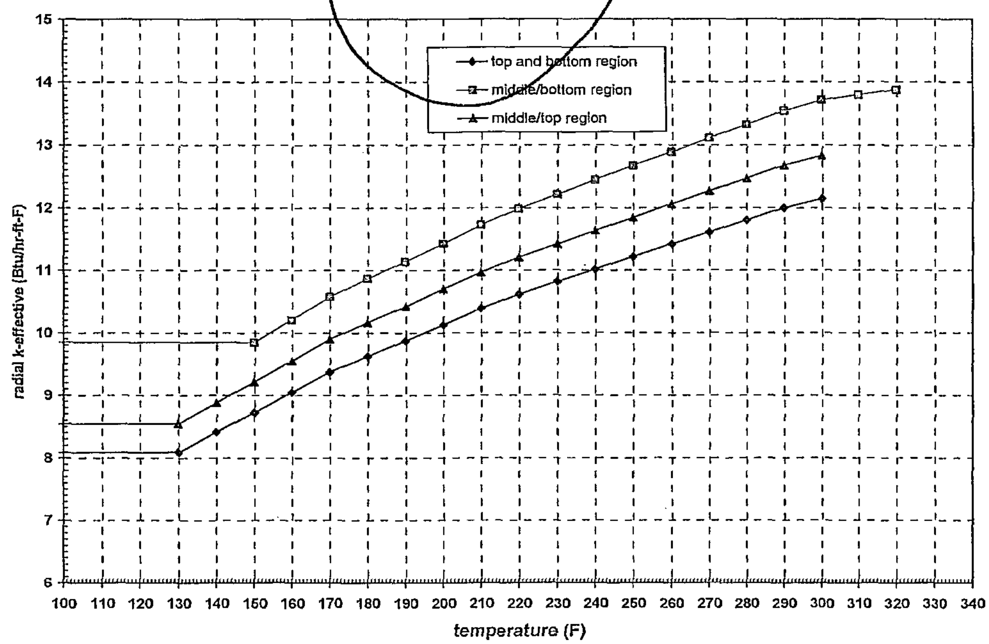

Figure 4.5 Effective Thermal Conductivity in the Radial Direction through OS200 Neutron Shield (SAR model; from p. U.4-10, Section U.4-2)

Figures U.4-17 through U.4-19 of the SAR illustrate the thermal modeling of the cask closure lid and associated NS-3 shielding. The modeling utilizes approximately 1,680 thermal nodes, fuel assemblies, to represent the thermal inertia of the DSC in transient analysis, since transients are evaluated using the SINDA/FLUINT model of the transfer cask. The DSC internal temperatures for transients are determined by steady-state calculations using the detailed ANSYS model of the DSC, with external surface boundary conditions at specified points in the SINDA/FLUINT transient calculation.

In Section T.4.8.4, the applicant notes that in the blocked vent transient, heat transfer to the air within the storage module cavity consists only of free convection within a closed cavity. This convection is conservatively neglected in the storage module cavity in the analysis of the blocked vent transient. Presumably, heat transfer through the air is limited to conduction only, but the applicant does not explicitly state this in the SAR.

4.5.3.1.1 Effective Thermal Conductivity within Neutron Shield

Heat transfer through the liquid of the neutron shield of the transfer cask is represented in the SINDA/FLUINT model with an effective thermal conductivity that is intended to capture the effect of conduction and free convection in the liquid. The applicant makes the argument, based on the trends of Rayleigh number and thermal conductivity as a function of temperature, that the effective thermal conductivity values for the neutron shield calculated for a decay heat load of 24 kW[2] in the DSC within the OS197 TC is conservatively bounding on the neutron shield effective thermal conductivity with 31.2 kW in the DSC.

The staff found several discrepancies with the discussion provided in SAR Section T.4.8.5, which, while not affecting the overall conclusions of the staff regarding the acceptability of the system, should be addressed by the applicant in future submittals. These discrepancies are highlighted below:

- Figure 4.6 compares the water-filled neutron shield effective conductivity from Appendix M to the values reported in Appendix T (Section T.4.2, item 17). Figure 4.7 presents a similar comparison for the ~~air-filled~~ neutron shield effective conductivity from the two sources. Figure 4.6 shows that the effective conductivity values reported in Appendix T of the SAR, for the water-filled neutron shield, are clearly not the same as the values reported in Appendix M. Figure 4.4, however, shows that the values are exactly the same for the air-filled neutron shield. 4.7

- For the water-filled neutron shield, there is also a significant error in the effective conductivity from Appendix T in that the value at 180° fails to approach the value of simple conduction through water (nominally 0.00055 Btu/min-in-F). This behavior is a feature of the compartmentalized neutron shield of the OS197 transfer cask, and would be preserved for any decay heat load in the DSC.

- Since the error in the effective conductivity for the water-filled neutron shield is generally conservative (i.e., except for the bottom segment, the effective conductivity is lower than the values reported in Appendix M), it may not have an adverse effect on the results reported in the SAR Appendix T for the 61BTH DSC in the OS197 transfer cask.

However, this error should be corrected, and the applicant should submit revised documentation and results for the affected calculations with its next UFSAR.

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[2] Note that the SAR Section T.4.8.5 reports the decay heat load in the Appendix M calculations as 22 kW. The actual decay heat load for the 32PT DSC in Appendix M is 24 kW.

4.5.4.1.1 DSC Heat Load Within HSM-H

The circumference of the DSC within the HSM-H is divided into a few regions for convection boundary conditions as shown in Figures T.4-2 and U.4-7 of the SAR. The bulk air temperatures used in the HSM-H model are summarized in Tables T.4-1, and U4-1. No convection is applied in dead zone in DSC shell-support structure interface. Similar to the DSC circumference, the cross section of the HSM-H cavity is divided into different regions to apply the convection boundary conditions.

4.5.4.1.1.1 61BTH DSC Heat Load Within HSM-H

The methodology used for applying the fuel assembly decay heat load is the same as that used in Appendix P, Section P.4.4.4 of the NUHOMS® base SAR. The decay heat load is considered to be distributed evenly on the radial inner surface of the DSC with a length equivalent to the basket length (164"). The applied maximum decay heat flux for the Type 2 DSC is calculated as follows:

$$\text{Decay heat flux} = \frac{Q}{\pi D_i L} \quad \text{Btu/hr-in}^2$$

where,

Q = decay heat load = 31.2 kW
D_i = inner DSC diameter = 66.25"
L = DSC basket length = 164"

Similar calculations are performed for the Type 2 DSC with a decay heat of 27.4 kW, and the Type 1 DSC with decay heat values of 19.4 kW and 22 kW.

4.5.4.1.1.2 32PTH1 DSC Heat Load Within HSM-H

The methodology used for applying the fuel assembly decay heat load is the same as that used in Appendix P, Section P.4.4.4 of the NUHOMS® base SAR. The decay heat load is considered to be distributed evenly on the radial inner surface of the DSC with a length equivalent to the basket length (164.5"). The applied decay heat flux is calculated as follows (from Page U.4-~~17~~ 16 of the SAR):

~~$\dot{q}$ = Heat generation rate = $\frac{Q}{(\pi/4\ D_i^2\ L)}$ Btu/hr-in³~~

~~where:~~

~~Q = decay heat load (31.2 kW/40.8 kW)~~
~~D_i = inner DSC diameter = 68.75"~~
~~L = DSC cavity length = 164.5~~

~~For 31.2 kW heat load, $\dot{q}$ = 0.1743 $\frac{Btu}{hr\text{-}in^3}$~~

~~For 40.8 kW heat load, $\dot{q}$ = 0.2280 $\frac{Btu}{hr\text{-}in^3}$~~

$$\text{Decay heat flux} = \frac{Q}{\pi D_i L} \quad \text{Btu/hr-in}^2$$

where:

Q = decay heat load = 31.2 kW/40.8 kW
D_i = inner DSC diameter = 68.75"
L = DSC basket length = 164.5"

For 31.2 kW heat load, $\dot{q} = 2.9965 \frac{Btu}{hr \cdot in^2}$

For 40.8 kW heat load, $\dot{q} = 3.9184 \frac{Btu}{hr \cdot in^2}$

condition and for transfer accident conditions. A peak ambient temperature of 120°F is considered as hot normal conditions for vertical loading within the fuel handling facility. The analysis in Appendix T does not consider an extreme ambient condition accident for the 61BTH in the OS197 transfer cask.

Insolation on the surface of the transfer cask (or sunshade for ambient temperatures greater than 100°F) is defined as 400 gcal/cm^2 for the cask cylindrical shell, and 200 gcal/cm^2 for the vertical faces of the cask top and bottom. These are applied as a heat flux averaged over twelve hours, with the absorptivity of the surfaces.

4.5.4.3.2 32PTH1 DSC in Transfer Cask

Ambient temperatures in the range of 0 to 106°F are considered as normal, outdoor transfer conditions, while an ambient temperature of 117°F is considered for the off-normal, hot transfer condition and for transfer accident conditions. A peak ambient temperature of 133°F is considered as an accident condition for operations under extreme ambient conditions. The extreme ambient condition accident is not combined with the other transfer accidents.

Insolation on the surface of the transfer cask (or sunshade for ambient temperatures greater than 106°F) is applied as a heat flux with values defined in Table 4.14 below.

Table 4.14

OS200 TC Surface	Insolation (gcal/cm^2)	Applied heating averaged over 12 hours (Btu/hr-ft^2) with absorptivity
Cask Cylindrical Shell	400	72.15
Cask Vertical Ends	200	36.08

4.5.4.4 Accident Conditions

4.5.4.4.1 HSM-H Blocked Vent

The HSM-H model discussed in Sections T.4.4.4 and U.4.4.4 of the SAR (Sections 4.5.1.1 and 4.5.2.1 of this SER) was modified by the applicant to determine the temperature distribution in the HSM-H and the DSC shell for the blocked vent accident case, similar to the methodology described in Appendix P, Section P.4.4.5 of the NUHOMS® base SAR.

The DSC basket including fuel assemblies and the top grid was modeled as two homogenized regions with effective properties for the transient model. Heat generation is applied uniformly on the elements representing the homogenized DSC basket. The effective thermal properties of the homogenized DSC content are calculated in Sections T.4.8.3 and U.4.8.3 of the SAR.

During the blockage of the HSM-H inlet and outlet vents, closed cavity convection will take place within the HSM-H cavity; however, the applicant's analysis considers only the thermal conductivity of air within the HSM-H cavity, neglecting convection ~~and thermal radiation~~ within HSM-H cavity.

The initial temperatures for the blocked vent accident case are identical to the nodal temperatures resulted for the off-normal case with 117°F ambient temperature and maximum solar heat flux.

Table 4.19 Maximum Temperatures (°F) of Key System Components (40.8 kW)					
(Source: SAR Tables U.4-2, U.4-3, U-4.15, and U.4-16, U.4-20, U.4-24, U.4-25)					
Component (HSM-H/DSC)	Normal Storage 106°F Ambient	Off-Normal 117°F Ambient	Normal Transfer 106°F Ambient	Blocked Vent Accident @ 40 Hrs.	Transfer loss of sunshade, neutron shield, & air circulation 117°F Ambient
DSC shell	**484**	**491**	**n/a**	**682**	**n/a**
Concrete	**290**	**301**	**n/a**	**465**	**n/a**
Top heat shield	**264**	**278**	**n/a**	**458**	**n/a**
Side heat shield	**261**	**275**	**n/a**	**515**	**n/a**
DSC Support Rail	**347**	**358**	**n/a**	**603**	**n/a**
32PTH1 DSC with Type 1 Basket – Heat Load Zone Configuration #1					
Fuel cladding	**733**	**741**	**722**	**887**	**886**
Fuel Compartment	**701**	**710**	**683**	**865**	**858**
Neutron Absorber	**701**	**710**	**683**	**865**	**858**
R45 & R90 Rails	**511**	**520**	**506**	**685**	**692**

4.6.1.3 Accident Conditions- Blocked Vents

The blocked vent accident analysis is presented in SAR Sections T.4.4.5, T.4.4.7.2, U.4.4.5, and U.4.4.7.2 (for the HSM-H) and Sections T.4.6.8.1, and U.4.6.7.1 (for the DSCs). The analyses predicted the component and cladding temperatures for a 40 hour blockage. Results of the applicant's calculations are presented in SAR Tables T.4-21 and U.4-24 for fuel cladding, and Tables T.4-22, T.4-23, U.4-25 and U.4-26 for DSC components.

The applicant's results for the 117°F ambient blocked vent conditions for the **61BTH** system demonstrate that the maximum concrete temperature at the end of 40 hours in the blocked vent accident is 426°F for a 31.2 kW heat load. This is above the 350°F limit given in the SRP (NUREG 1536 (Ref. 7)) for accident conditions.

The applicant's results for the 117°F ambient blocked vent conditions for the **32PTH1** system, presented in SAR Table U.4-3, demonstrate that the maximum concrete temperature at the end of 40 hours in the blocked vent accident is 390°F and 458°F for 31.2 kW and 40.8 kW heat loads, respectively. This is above the 350°F limit given in the SRP (NUREG 1536) for accident

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transfer operations. The limiting fuel assembly type considered in the applicant's evaluation is the BW 15x15 fuel assembly with control components (refer to SAR Chapter U.2).

The calculations account for the DSC free volume, the quantities of DSC backfill gas, fuel rod fill gas, and fission products and the average DSC cavity gas temperature. Average helium temperatures within 32PTH1 DSC were calculated based on 32PTH1-S, with Type 1 basket (with aluminum R45 and R90 rails), which bounds thermally 32PTH1-M and 32PTH1-L configurations. The effect of control components (CCs) on the DSC internal pressure is also included in this calculation.

The percentage of CCs rods ruptured during normal, off-normal and accident conditions is assumed to be 1%, 10% and 100%, respectively, similar to the assumptions for the fuel rod rupturing. The maximum amount of gas released to the DSC cavity from the CCs for normal, off-normal and accident conditions is given in Table U.4-33 of the SAR.

The maximum DSC cavity internal pressure limits are summarized in Table 4.21, below:

Table 4.21 Maximum Allowable Pressure

Condition	Maximum Allowable Pressure, psig
Normal (1% rods ruptured)	15
Off-Normal (10% rods ruptured)	20
Accident (100% rods ruptured)	140

4.6.2.3 Normal Conditions of Storage and Transfer

The maximum pressure for normal conditions of storage and transfer occurs when the **61BTH** DSC is in the fuel building during vertical transfer with an ambient temperature of 120°F and no insolation. The average helium temperature is 382°F (842°R) for the Type 1 DSC, and 377°F (837°R) for the Type 2 DSC. (See SAR Table T.4-16.) Per the SRP (NUREG 1536), 1% of the fuel pins are assumed to be ruptured.

The maximum pressure for normal conditions of storage and transfer occurs when the **32PTH1-S** (31.2 kW/HLZC #2) loaded with FAs with control components is in the OS200 transfer cask with an ambient temperature of 106°F and insolation. The average helium temperature is 553°F (1013°R). (See SAR Table U.4-35.) Per the SRP (NUREG 1536), 1% of the fuel pins are assumed to be ruptured.

4.6.2.4 Off-Normal Conditions

4.6.2.4.1 Off-Normal Conditions (61BTH System)

In SAR Section T.4.6.7.6, the applicant evaluated the internal pressure of the DSC for off-normal conditions. The maximum internal pressure for off-normal conditions of storage and transfer occurs when the 61BTH DSC is in the OS197FC-B transfer cask with an ambient temperature of 117°F and sunshade. Per the SRP (NUREG 1536), the percentage of fuel rods ruptured for off-normal cases is 10%.

A summary of the maximum off-normal operating pressures for the 61BTH DSC configurations are presented in SAR Table T.4-20.

4.6.2.4.2 Off-Normal Conditions (31PTH1 System)

In SAR Section U.4.6.6.6, the applicant evaluated the internal pressure of the DSC for off-normal conditions. The maximum internal pressure of 18.65 psig for off-normal conditions of storage and transfer occurs when the 32PTH1-S DSC with Type 1 basket with heat load of 31.2 kW (HLZC #2) loaded with FAs with control components is in vertical OS200 transfer cask in fuel building with an ambient temperature of 140°F and no insolation. Per the SRP (NUREG 1536), the percentage of fuel rods ruptured for off-normal cases is 10%.

A summary of the maximum off-normal operating pressures for the various 32PTH1 DSC configurations are presented in SAR Table U.4-23.

4.6.2.5 Accident Conditions

4.6.2.5.1 Accident Conditions (61BTH System)

In SAR Section T.4.6.8.5, the applicant evaluated the internal pressure of the DSC for accident conditions. The maximum accident pressure for the 61BTH DSC (31.2 kW) during transfer in the OS197FC-B TC under maximum off-normal ambient temperature of 117°F, concurrent with loss of the solar shield, loss of liquid neutron shield, and loss of air circulation.

For this condition the average helium temperature was 615°F (1075°R). Per the SRP (NUREG 1536), the percentage of fuel rods ruptured for this accident event is 100%. During the blocked vent case, the average helium gas temperature was 654°F (1114°R). However, since no DSC drop event can occur in conjunction with a blocked vent event, the maximum fraction of fuel pins that can be ruptured is limited to 10%. Therefore, the maximum block vent accident pressure at 40 hours is bounded by maximum transfer accident pressure.

A summary of the maximum accident operating pressures for the various 61BTH DSC configurations are presented in SAR Table T.4-24.

Based on review of the applicant's pressure analyses, the staff found reasonable assurance that the internal cask pressures remain below the cask design pressure for normal, off-normal, and accident conditions.

4.6.2.5.2 Accident Conditions (32PTH1 System)

In SAR Section U.4.6.7.4, the applicant evaluated the internal pressure of the DSC for accident conditions. The maximum accident pressure of 126.34 psig occurs during the 32PTH 1-S DSC with heat load of 40.8 kW (HLZC #1) transfer in the OS200 TC under maximum off-normal ambient temperature of 117°F, concurrent with loss of the solar shield, loss of liquid neutron shield, and loss of air circulation.

For this condition the average helium temperature was 727°F (1187°R) (see SAR Table U.4-35). Per the SRP (NUREG 1536), the percentage of fuel rods ruptured for this accident event is 100%. During the block vent case, the average helium gas temperature was 727°F (1187°R). However, since no DSC drop event can occur in conjunction with a blocked vent event, the maximum fraction of fuel pins that can be ruptured is limited to 10%. Therefore, the maximum block vent accident pressure at 40 hours is bounded by maximum transfer accident pressure.

A summary of the maximum accident operating pressures for the various 32PTH1 DSC configurations are presented in SAR Table U.4-27.

Based on review of the applicant's pressure analyses, the staff found reasonable assurance that the internal cask pressures remain below the cask design pressure for normal, off-normal, and accident conditions.

4.6.2.6 Pressure During Unloading of Cask

For unloading operations, each DSC is filled with the spent fuel pool water through its siphon port. During this filling operation, the DSC vent port is maintained open with effluents routed to the plant's off-gas monitoring system. The DSC operating procedures recommend that the DSC cavity atmosphere be sampled prior to introducing any reflood water in the DSC cavity.

Initially, the pool water is added to the DSC cavity containing hot fuel and basket components, some of the water will flash to steam causing internal cavity pressure to rise. This steam pressure is released through the vent port. The applicant's procedures specify that the flow rate of the reflood water be controlled such that the internal pressure in the DSC cavity does not exceed 20 psig. This is assured by monitoring the maximum internal pressure in the DSC cavity during the reflood event. The reflood for the DSC is considered as a Service Level D event and the design internal pressure of the DSC is 120 psig for both the 61BTH and the 32PTH1 DSC reflood. Therefore, there is sufficient margin in the DSC internal pressure during the reflooding event to assure that the DSC will not be over pressurized.

The maximum fuel cladding temperature during reflooding event is significantly less than the vacuum drying condition owing to the presence of water/steam in the DSC cavity. The analysis results presented in SAR Table T.4-25 show that the maximum cladding temperature during vacuum drying is 592°F for the 61BTH, and the results presented in SAR Table U.4-28 show that the maximum cladding temperature during vacuum drying is 619°F. Hence, the peak cladding temperature during the reflooding operation will be less than 592°F for the 61BTH, and less than 619°F for the 31PTH1.
s/b 32

To evaluate the effects of the thermal loads on the fuel cladding during reflooding operations, a conservative assumption of high maximum fuel rod temperature of 750°F and a low quench water temperature of 50°F are used.

The staff reviewed the applicant's analysis of reflood operations and found adequate assurance that the DSC pressure would be maintained below applicable limits.

4.6.2.7 Pressure During Cask Loading

As discussed in the previous section, the DSC pressure remains below the limits for all operating conditions. In addition, the applicant is required by their Technical Specifications to have procedures in place to prevent exceeding pressure limits in the DSC during loading.

4.6.3 Confirmatory Analyses

4.6.3.1 Confirmatory Analyses for the 61BTH

No confirmatory analyses were performed by the staff for the 16BTH DSC. The evaluation of the model used in Appendix U to calculate the flow of air, by natural convection in the HSM-H as an element of the calculations to arrive at the DSC shell temperatures applies equally to Appendix T, as the same model is used.

Similarly, the fully coupled 3-dimensional computational fluid dynamics (CFD) model utilizing the Star-CD code from CD-Adapco, Inc. that was developed to evaluate the 32PTH1 DSC in the HSM-H provides indirect confirmation of the analyses with the HSM-H model in Appendix T. The confirmatory analyses with StarCD showed that the HSM-H can accommodate a DSC with a maximum decay heat load of 40.8 kW, which is significantly above the maximum decay heat load allowed in the 61BTH. The StarCD model showed that the applicant's model of the HSM-H is conservative for decay heat loads up to 40.8 kW.

4.6.3.2 Confirmatory Analyses for the 32PTH1

The staff sought to confirm several aspects of the design of the 32PTH1 DSC and the HSM-H for this amendment application. The staff focused on the flow of air, by natural convection, in the HSM-H to arrive at the DSC shell temperatures that were subsequently used for the determination of the peak fuel cladding temperatures for the 32 PTH1 DSC. Transfer conditions were also evaluated.

Summary of efforts:

- Star-CD HSM-H model (Section 4.6.3.2.1)
- Star-CD DSC model (Section 4.6.3.2.2)
- Star-CD Neutron Shield Model (Section 4.6.3.2.3)

4.6.3.2.1 Analysis of HSM-H

The staff built a fully coupled, 3-dimensional computational fluid dynamics (CFD) model utilizing the Star-CD code from CD-Adapco, Inc. The model featured all the geometric details of both the 32 PTH1 DSC as well as the HSM-H storage model. Fuel assemblies were modeled using an effective conductivity approach.

As with the applicant's ANSYS model of the HSM-H documented in the SAR, the HSM-H module was represented in StarCD as hottest central module in double row of adjacent storage units, assuming:

- geometric and heat transfer symmetry about vertical plane through central axis of DSC and module (permits modeling ½ section of DSC and HSM-H storage unit)
- Adiabatic planes assumed on side walls and back wall of HSM-H storage unit
- Natural convection and thermal radiation heat transfer to ambient on front face and top of HSM-H unit external surfaces

Figure 4.8 shows cross-section diagrams of the StarCD model, including the DSC within HSM-H. The detailed noding of the DSC is shown in Figure 4.9. This approach was used for the limiting decay heat load canister configurations:

The applicant used ANISN, a 1-D discrete ordinates code, to examine the relative source strength of each fuel combination, based on the resulting ANISN dose. The applicant subsequently determined the design-basis source term for bounding shielding calculations of the HSM and TC. The applicant stated this method is consistent with the method used to calculate fuel qualification tables for the Standardized NUHOMS® 24PTH as described in Chapter P.5 of Appendix P of the FSAR. As discussed in Section T.5.2.4 of the SAR amendment, the applicant calculated dose rates on the surface of the HSM and TC for the eight Heat Load Zoning Configurations with ANISN. A sketch of the ANISN model for the TC is depicted in Figure T.5-2. The material densities used for the various modeling regions are listed in Table T.5-20. The ANISN model used the CASK-81 22 neutron, 18 gamma cross section library and ANSI/ANS-6.1.1-1977 flux-to-dose conversion factors. An example ANISN input file is included in Section T.5.5.5.

Based on the ANISN calculated doses determined for fuel of various burnup/enrichment/cool time combinations in the OS197FC TC, an example of which is given in Table T.5-29 of the SAR, the applicant determined the configuration that resulted in bounding dose rates for the TC. Canister total source terms were then calculated for the design basis assembly for the design basis burnup/enrichment/cooling time combinations and the loading configuration described in Figure T.2-2. The design-basis burnup/enrichment/cooling time combinations, including model locations, are listed on page T.5-2 of Appendix T of the SAR. The bounding gamma and neutron source terms were then combined in the shielding models to calculate the dose rates.

PAGES T.5-3 AND T.5-4

5.2.2.1 Gamma

Gamma source terms are calculated for each burnup/enrichment combination and are listed in the SAR. The hardware activation analysis considered the cobalt impurities in the assembly hardware. The activated hardware source terms are calculated using the hardware masses listed in the SAR. Although cobalt impurities can vary, the applicant's assumed values are reasonable and acceptable.

5.2.2.2 Neutron

Neutron source terms are calculated for each burnup/enrichment combination and are listed in the SAR. The applicant calculated the neutron source terms for use in the shielding models by multiplying the individual assembly sources by the number of assemblies in the region and then dividing by the appropriate region volume.

5.2.2.3 Confirmatory Analyses

The staff performed confirmatory source term evaluations using the SCALE 5.1 computer code with the SAS2H/ORIGEN-S isotopic depletion and decay sequence with the 44-group ENDF/B-V cross section library. Using irradiation parameter assumptions similar to the applicant's, the staff obtained bounding source terms that were similar to, or bounded by, those determined by the applicant.

U.2-3

5.2.3 NUHOMS® 32PTH1 DSC

The source specification for the NUHOMS® 32PTH1 DSC is presented in Section U.5.2 of SAR Appendix U. The gamma and neutron source term calculations were performed with the SAS2H/ORIGEN-S modules of the SCALE 4.4 computer code. The fuel types considered in this application are listed in Table M.5-1. The B&W 15x15 assembly type was chosen as the design basis fuel assembly because of its assembly weight and it has the highest initial heavy metal loading (0.475 MTU).

0.490

The applicant generated fuel qualification tables for the individual heat loads specified for Configurations 1, 2, and 3 depicted in Figures U.2-1 through U.2-3. The applicant used SAS2H/ORIGEN-S to verify that each fuel combination listed in the SAR, including CCs, resulted in decay source terms below the individual assembly heat limits.

The applicant used ANISN, a 1-D discrete ordnance code, to examine the relative source strength of each fuel combination, based on the resulting ANISN dose. The applicant subsequently determined the design-basis source term for bounding shielding calculations of the HSM and TC. An example ANISN input file is included in Appendix U.5.5.4 of the SAR.

U.5-3

Based on the ANISN calculated doses, the applicant determined the configuration that resulted in bounding dose rates for both the HSM and TC. Canister total source terms were then calculated for the design basis assembly for the design basis burnup /enrichment/cooling time combinations and the loading configuration described in Figure U.2-2. The design-basis burnup/enrichment/cooling time combinations, including model locations, are listed on page U.5-2 of Appendix U of the SAR. The bounding gamma and neutron source terms were then combined in the shielding models to calculate the dose rates.

5.2.3.1 Gamma

Gamma source terms are calculated for each burnup /enrichment combination and are listed in the SAR. The hardware activation analysis considered the cobalt impurities in the assembly hardware, including the in the bounding CCs. The activated hardware source terms are calculated using the hardware masses listed in the SAR. Although cobalt impurities can vary, the applicant's assumed values are reasonable and acceptable.

5.2.3.2 Neutron

Neutron source terms are calculated for each burnup/enrichment combination and are listed in the SAR. The applicant calculated the neutron source terms for use in the shielding models by multiplying the individual assembly sources by the number of assemblies in the region and then dividing by the appropriate region volume.

5.2.3.3 Confirmatory Analyses

The staff performed confirmatory source term evaluations using the SCALE 5.1 computer code with the SAS2H/ORIGEN-S isotopic depletion and decay sequence with the 44-group ENDF/B-V cross section library. Using irradiation parameter assumptions similar to the applicant's, the staff obtained bounding source terms that were similar to, or bounded by, those determined by the applicant. The exterior dose rates are adequately controlled by limits in the CoC for cooling time, and enrichment.

5.3 Shielding Model Specifications

5.3.1 NUHOMS® 61BTH DSC

For all bounding external dose rate calculations, the Monte Carlo n-particle transport code (MCNP) computer code was used. The off-site dose models include various storage module arrays loaded with design basis.

FUEL

5.3.1.1 Shielding and Source Configuration

The radiation source is modeled as an explicit basket with smeared fuel compositions within the basket cells. Conservative material compositions and axial peaking factors are applied. A number of other simplifications and bounding assumptions, that reduce the amount of actual shielding, are discussed in the SAR. The analysis includes streaming paths through the HSM air vents and the TC-DSC gap.

5.3.1.2 Material Properties

The composition and densities of the materials used in the shielding analysis are presented in Tables T.5-19 and T.5-20 of the SAR. Various conservative material representations are used in the shielding model for the HSM and TC. The materials used in the HSM and TC were previously reviewed and found accepted by the staff.

The staff evaluated the shielding models and found them acceptable. The material compositions and densities used were appropriate and provide reasonable assurance that the DSC, TC, and HSM were adequately modeled. In addition, the methodologies used are similar to those previously used to support NUHOMS® storage and transportation applications, and have been accepted by the staff in the past.

5.3.2 NUHOMS® 32PTH1 DSC

For all external dose rate calculations, the Monte Carlo n-particle transport code (MCNP) computer code was used. The off-site dose models include various storage module arrays loaded with design basis.

FUEL

5.3.2.1 Shielding and Source Configuration

The radiation source is modeled as an explicit basket with smeared fuel compositions within the basket cells. Conservative material compositions and axial peaking factors are applied. A number of other simplifications and bounding assumptions, that reduce the amount of actual

5.4.1.2 Flux-to-Dose-Rate Conversion

The SAR uses the ANSI/ANS Standard 6.1.1-1977 flux-to-dose rate conversion factors to calculate dose rates, which are acceptable.

5.4.1.3 Normal Conditions

Appendix T of the SAR presents calculated dose rates for normal condition design-basis dose rates for the HSM and TC. The dose rates for the HSM are dominated by the gamma component. This is expected due to the thick concrete walls of the HSM. Due to the conservatism in the analysis, the staff has reasonable assurance that dose rates will be below the dose rate criteria specified in the TS.

For the transfer cask, there is a significant contribution from neutron radiation to the dose rates, in addition to the more dominant gamma component. Two dose rate calculations were performed for the TC during fuel loading operations, one each for decontamination and welding, as discussed in Section T.5.4.9 of the SAR. Table T.5-5 gives the surface peak dose rate at the top of the DSC as approximately 2190 mrem/hr during welding operations. Exposure from localized peak dose rate may be mitigated by the actual locations of personnel and the use of temporary shielding during loading/unloading operations.

The dose profiles for the TC at various distances show that the dose rates significantly decrease from peak locations to the edges of the top, bottom, and sides of the cask. The calculated average dose rates are below the dose rate criteria specified in the TS, thus the staff has reasonable assurance that the user will be able to meet the TS limits for the transfer cask dose rates.

5.4.1.4 Accident Conditions

Appendix T of the SAR does not identify an accident that significantly degrades the shielding of the HSM. The bounding accident condition for the TC considers loss of the neutron shield and steel neutron shield jacket from the TC. This accident causes a significant increase in the external dose rates. Table T.5-4 of the SAR shows that the maximum dose rate for this accident is approximately 2900 mrem/hr at 1 meter from the cask surface. For an 8 hour recovery time, the estimated dose rate to a member of the public at 500 meters is less than 1 mrem, which meets the regulatory requirements.

5.4.1.5 Occupational Exposures

The analysis in Appendix T of the SAR used the design basis fuel to estimate occupational exposures for the NUHOMS® system. Section T.10 of the SAR presents the estimated occupational exposures that are based on dose rate calculations in Section 5 of Appendix T to the SAR. The staff's evaluation of the occupational exposures is in Section 10 of this SER.

the HSM. The bounding accident condition for the TC considers loss of the neutron shield and steel neutron shield jacket from the TC. This accident causes a significant increase in the external dose rates. Table U.5-2 of the SAR shows that the maximum dose rate for this accident is approximately 3760 mrem/hr at 1 meter from the cask surface. For an 8 hour recovery time, the estimated dose rate to a member of the public at 500 meters is less than 1 mrem, which meets the regulatory requirements.

5.4.2.5 Occupational Exposures

The analysis in Appendix U of the SAR used the design basis fuel to estimate occupational exposures for the NUHOMS® system. Section U.10 of the SAR presents the estimated occupational exposures that are based on dose rate calculations in Section 5 of Appendix T to the SAR. The staff's evaluation of the occupational exposures is in Section 10 of this SER.

5.4.2.6 Off-site Dose Calculations

Section U.10 of the SAR estimates the offsite dose rates from various cask arrays. Section U.10 presents the calculated offsite annual doses for these arrays at distances of 6 to 600 meters based on 100% occupancy exposure time. These generic off-site calculations demonstrate that the NUHOMS® system is capable of meeting the offsite dose criteria of 10 CFR 72.104(a).

Section 10 of this SER evaluates the overall off-site dose rates from the NUHOMS® system. The staff has reasonable assurance that compliance with 10 CFR 72.104(a) can be achieved by general licensees. The general licensee must perform a site-specific evaluation, as required by 10 CFR 72.212(b), to demonstrate compliance. The actual doses to individuals beyond the controlled area boundary depend on several site specific conditions such as fuel characteristics, cask-array configurations, topography, demographics, and atmospheric conditions. In addition, 10 CFR 72.104(a) includes doses from other fuel cycle activities such as reactor operations. Consequently, final determination of compliance with 10 CFR 72.104(a) is the responsibility of the general licensee.

A general licensee will also have an established radiation protection program as required by 10 CFR Part 20, Subpart B, and will demonstrate compliance with dose limits to individual members of the public as required by evaluation and measurements. An engineered feature for radiological protection, such as a berm, is considered important to safety and must be evaluated to determine the applicable quality assurance category.

5.4.2.7 Confirmatory Calculations

The staff performed confirmatory analyses of selected dose rates using the MAVRIC sequence of the SCALE 5.1 code system, with the Monaco three dimensional Monte Carlo shielding analysis code. The staff based its evaluation on the design features and model specifications presented in the drawings shown in SAR Appendix U. Limiting fuel characteristics, and the burnup and cooling time, are included in the TS, as are the dose rates of the TC and HSM. The staff's calculated dose rates were in reasonable agreement with the SAR values or were generally lower due to the applicant's conservative loading assumptions. The staff found that

6.2.3 NUHOMS® 32PT DSC

The applicant revised the allowable contents to allow the following control components (CCs): Control Rod Assemblies (CRAs), Rod Cluster Control Assemblies (RCCAs), Thimble Plug Assemblies (TPAs), Axial Power Shaping Rod Assemblies (APSRAs), Orifice Rod Assemblies (ORAs), Vibration Suppression Inserts (VSIs), Neutron Source Assemblies (NSAs), and Neutron Sources. These additional CCs are bounded by the criticality analysis previously approved for Burnable Poison Rod Assemblies (BPRAs).

6.2.4 NUHOMS® 24PTH DSC

The applicant revised the allowable contents to allow PLSAs for the Westinghouse 15x15 class of fuel assemblies. PLSAs are similar to standard fuel assemblies, however, a portion of the active fuel is replaced by stainless steel rods. This reduces the amount of fuel that would be present in the previously reviewed configuration, and therefore is bounded by the previous safety evaluation.

6.3 Criticality Analysis

6.3.1 NUHOMS® 61BTH DSC

44-GROUP ENDF/B-V

To justify the addition of the ~~new~~ DSC Types 1 & 2, the applicant performed a criticality analysis using the ~~44GROUPNDFB5~~ cross section set with the KENO V.a code in the SCALE 4.4 system. The applicant's criticality models for the NUHOMS® 61BTH DSC are similar to those previously approved for the 61BT DSC described in Appendix K of the UFSAR and are modified to account for the differences in the fixed poison and the basket periphery rails and water holes, and to account for the NUHOMS® 61BTH Type 1 and Type 2 DSC designs. Several models were developed to evaluate the criticality safety of the NUHOMS® 61BTH to ascertain the most reactive fuel configuration for both the intact and damaged conditions for both the NCT and credible HAC. These models looked at single and double breaks as well as rod pitch variations.

For the both the normal and damaged fuel configurations of the NUHOMS® 61BTH DSC, the most reactive fuel was evaluated to be the GE 10x10 fuel assemblies. The normal model consists of 92 intact fuel rods, and included both the gap and the cladding, and two large water holes. In addition, the fuel cladding OD is reduced to conservatively bound fuel manufacturing tolerances, and no credit is taken for the cask neutron shield and outer steel skin. The damaged fuel assembly models assumed 45 intact fuel assemblies and 16 damaged fuel assemblies, located in the four 2x2 compartments in the corners of the basket. It modeled as containing 95 fuel rods and five water pin locations.

The applicant explicitly modeled the fuel assemblies utilizing fresh water in the gap between the pellets and the fuel rod cladding. In addition, the applicant evaluated all combinations of fuel assembly class, basket type, and applicable poison plates. The applicant reduced the total boron content of the modeled poison plates, using 90% credit for the boron in the borated aluminum and the Boron carbide-aluminum metal matrix composite (MMC) poison plates, and 75% credit for the Boral® poison as specified in Section T.9. In all instances the bounding analyses demonstrate that the maximum k_{eff} of the NUHOMS® 61BTH DSC remains below the regulatory limit of 0.95 including all biases and uncertainties for all credible conditions.

238-GROUP ENDF/B-V

The staff performed confirmatory criticality calculations using the SCALE 5 system with the 238GROUPNDFB5 cross section. The staff's model is similar to the applicant's in that it included fresh water in the fuel rod gap, and used the appropriate boron credit of up to 90% for the fixed neutron poison plates. The staff selected the most reactive cases demonstrated by the applicant's analysis for the NUHOMS® 61BTH DSC for both NCT and HAC. In all instances the staff's maximum calculated k_{eff} was consistent with that of the applicant.

Based on the information provided in the application and the staff's own confirmatory analyses, the staff concludes that the NUHOMS® 61BTH DSC meets the acceptance criteria specified in 10 CFR Part 72.

6.3.2 NUHOMS® 32PTH1 DSC

The 32PTH1 DSC has three alternative length configurations designated as Type 32PTH1-S (short length), -M (medium length), or –L (long length), and has a slightly larger diameter than the previously approved DSC to accommodate an increased loading capacity. The NUHOMS® 32PTH1 has two alternate basket types with either aluminum or steel rails, and has three alternate neutron absorber materials, with each material having up to five different ^{10}B loadings, as described above in 6.1.1.2. The NUHOMS® 32PTH1 also utilizes the soluble boron concentration in the spent fuel pool to maintain subcriticality. The NUHOMS® 32PTH1 is stored in a HSM-H module that has the diameter of the access door increased to accommodate the new diameter, and uses spacers to adjust for the various length configurations. In addition, an alternate high-seismic option designated as HSM-HS is added to the NUHOMS® 32PTH1 DSC configuration. Several models were developed to evaluate the criticality safety of the NUHOMS® 32PTH1 DSC to ascertain the most reactive fuel configuration for both the intact and damaged conditions for both the NCT and credible HAC and take account of the fabrication tolerances, fuel clad OD, fuel assembly locations, fuel assembly type, initial enrichments, fixed poison loading, soluble boron concentration and storage of CCs.

For the both the normal and damaged fuel configurations of the NUHOMS® 32PTH1 DSC, the applicant used an analysis methodology similar to that used for the NUHOMS® 24PTH DSC described in Appendix P of the UFSAR to determine the most reactive assembly type for each assembly class, and then determined the most reactive configuration for the basket and fuel assembly position. Then the maximum allowable initial enrichment was found for each fuel assembly class as a function of basket poison type and soluble boron concentration. Since Control Components (CCs) are allowed to be stored in the NUHOMS® 32PTH1 DSCs (including BPRAs, CRAs, TPAs, APSRAs, CEAs, VSAs, ORAs, and NSAs), the CCs were evaluated as authorized contents and no credit was taken for either the cladding or absorbers that may be present in a given CC, and was instead replaced with $^{11}B_4C$.

For the both the normal and damaged fuel configurations of the NUHOMS® 32PTH1 DSC, the most reactive fuel was evaluated to be the B&W 15x15 Mark B-10 fuel assemblies. The normal model consists of 32 fuel assemblies with a minimum fuel compartment tube ID, minimum fuel compartment tube thickness, a poison thickness of 0.075 inches and minimum assembly-to-assembly pitch. For damaged fuel, the most reactive scenario is when the fuel rods are in near optimum pitch for all assembly classes except for the WE 15x15 assemblies, where the double shear scenario is the most reactive configuration.

The applicant explicitly modeled the fuel assemblies utilizing fresh water in the gap between the pellets and the fuel rod cladding. In addition, the applicant evaluated all combinations of fuel assembly class, basket type, and applicable poison plates, with a variable amount of soluble boron in the water based on the enrichment level. The applicant reduced the total boron content of the modeled poison plates, using 90% credit for the boron in the borated aluminum and the Boron carbide-aluminum metal matrix composite (MMC) poison plates, and 75% credit for the Boral® poison as specified in Section U.9. In all instances the bounding analyses demonstrate that the maximum k_{eff} of the NUHOMS® 32PTH1 DSC remains below the regulatory limit of 0.95 including all biases and uncertainties for all credible conditions.

The staff performed confirmatory criticality calculations using the SCALE 5 system with the ~~238GROUPNDFB5~~ 238-GROUP ENDF/B-V cross section. The staff's model is similar to the applicant's in that it included fresh water in the fuel rod gap and used the appropriate boron credit of up to 90% for the fixed neutron poison plates. The staff selected the most reactive cases demonstrated by the applicant's analysis for the NUHOMS® 32PTH1 DSC for both NCT and HAC. In all instances the staff's maximum calculated k_{eff} was consistent with that of the applicant.

Based on the information provided in the application and the staff's own confirmatory analyses, the staff concludes that the NUHOMS® 32PTH1 DSC meets the acceptance criteria specified in 10 CFR Part 72.

6.4 Computer Programs

6.4.1 NUHOMS® 61BTH DSC

The applicant used the three dimensional Monte Carlo SCALE-4.4 package to explicitly model the cask and canister configurations analyzed using the ~~44GROUPNDFB5~~ 44-GROUP ENDF/B-V cross section set with the KENO V.a multigroup code. The applicant appropriately considered the neutron spectrum of the NUHOMS® 61BTH DSC.

6.4.2 NUHOMS® 32PTH1 DSC

The applicant used the three dimensional Monte Carlo SCALE-4.4 package to explicitly model the cask and canister configurations analyzed using the ~~44GROUPNDFB5~~ 44-GROUP ENDF/B-V cross section set with the KENO V.a multigroup code. The applicant appropriately considered the neutron spectrum of the NUHOMS® 32PTH1 DSC.

6.5 Benchmark Comparisons

6.5.1 NUHOMS® 61BTH DSC

The applicant used the CSAS25 module of the SCALE-4.4 package to perform their criticality analysis using the 44-group ENDF/B-V cross-section library because it yielded a small bias as determined by 125 benchmark calculations. The benchmark problems used were representative of commercial light water reactor fuels and utilized water moderation, boron neutron absorbers, unirradiated fuel, close reflection, and uranium oxide fuel. The problems

7 CONFINEMENT EVALUATION

7.1 Confinement Design Characteristics

The NUHOMS® 32PTH1 system is designed to store up to 32 intact PWR fuel assemblies with a heatload of up to 32.1 kW. The NUHOMS® 61BTH system is designed to store up to 61 BWR fuel assemblies with a heat load of up to 40.8 kW. Both systems are designed to accommodate of up to 16 damaged fuel assemblies with the balance of the assemblies being intact. For both systems the maximum average initial enrichment is 5 % weight, the maximum average burnup is 62 GWd/MTU *and the minimum cooling time is 3 years. The resulting source term from these* fuel parameters is significant and would not be bounded by the methods typically employed by the staff to estimate the source term for a postulated release. Hence the applicant has appropriately decided to make the confinement boundary leaktight.

7.2 Confinement Monitoring Capability

The confinement boundary for both systems is comprised of the DSC (dry shielded canister) shell, inner bottom cover plate, inner top cover plate, siphon & vent block, siphon & vent port cover plate, and the welds that join them together. The applicant has stipulated that the confinement boundary is designed and tested to meet the leaktight criteria of ANSI 14.5 (1997) (Ref. 1). The operating procedures Section T.8.1.4 Step 4 and U.8.1.4, Step 4, both require leaktight testing (i.e 10E-7 ref cc/sec) in accordance with Technical Specification 1.2.4a, for the inner top cover plate weld and the vent/siphon port plate weld. Confinement boundary welds made during fabrication of the DSC are all volumetrically inspected in accordance with Section NB of the ASME Code (Ref. 2) to help assure their structural integrity.

It should be noted that these designs employ the use of an optional test port plug in the outer cover plate to leak test the inner top cover plate and vent/siphon welds to the leaktight criteria of ANSI 14.5-1997 (Ref. 1). If this option is not utilized then a temporary helium leak test head is used to test the inner cover plate and vent/siphon welds to the leaktight criteria, prior to installing the outer cover plate. When using the optional test port plug in the outer cover plate, the applicant will first test the inner cover plate and vent/siphon port welds with a less sensitive leak test method to 10^{-4} atm cc/sec thereby saving the operation of installing this temporary helium leak test head. This less sensitive method is used to provide assurance that the inner cover plate welds are not leaking prior to installing the outer cover plate, which would have to be removed to repair any leaking weld.

The applicant has determined the maximum pressures possible under normal, off-normal and accident conditions. For each of these conditions they used the standard SRP assumption of postulating 1%, 10% and 100% rod failure for normal, off-normal and accident conditions, respectively, in the determination of the amount of fission gas and initial rod fill gas contributing to the DSC pressure.

Based on satifactory resolution of the RAIs, the staff finds based on a review of the information provided in the SAR that the confinement system meets the requirements of 10CFR Part 72.

7.3 Evaluation Findings

F7.1 The staff finds based on a review of the information provided in the SAR that the confinement system meets the requirements of 10CFR Part 72.

7.4 References

1. American National Standards Institute, ANSI N14.5-1997, "Leakage tests on Packages for Shipments," January 1997.

2. ASME Boiler and Pressure Vessel Code, Section ~~VIII~~ III, "Rules for Construction of Nuclear Power Plant Components", American Society of Mechanical Engineers.

8 OPERATING PROCEDURES

The review of the technical bases for the operating procedures is to ensure that the applicant's SAR (Ref. 1) presents acceptable operating sequences, guidance, and generic procedures for key operations. The procedures for the 61BTH DSC and 32PTH1 DSC, as described in Sections T.8.1, and U.8.1 of the SAR, respectively, are very similar to those previously approved by the staff for the Standardized NUHOMS® System (Ref. 2).

8.1 Cask Loading

Detailed loading procedures must be developed by each user.

The loading procedures described in the SAR include appropriate preparation and inspection provisions to be accomplished before cask loading. These include cleaning and decontaminating the transfer cask and other equipment as necessary, and performing an inspection of the 61BTH and 32PTH1 DSCs to identify any damage that may have occurred since receipt inspection. The procedures for DSC cavity boron concentration during filling (TS1.2.15d) are specific to the 32PTH1 DSC design.

switch

8.1.1 Fuel Specifications

The procedures described in SAR Section U.8.1.2 for the 61BTH DSC and T.8.1.2 for the 32PTH1 DSC provide for fuel handling operations to be performed in accordance with the general licensee's 10 CFR Part 50 license and requires independent, dual verification, of each fuel assembly loaded into the 61BTH and 32PTH1 DSCs. It outlines appropriate procedural and administrative controls to preclude a cask misloading.

8.1.2 ALARA

switch

The ALARA practices utilized during operations are discussed in Section 10.4 of this SER.

8.1.3 Draining, Drying, Filling and Pressurization

SAR Sections U.8.1.3 and T.8.1.3 describe draining, drying, filling and pressurization procedures for the 61BTH and 32PTH1 DSCs, respectively. These procedures provide reasonable assurance that an acceptable level of moisture remains in the cask and the fuel is stored in an inert atmosphere. The procedures for helium backfill pressure (TS 1.2.3a) are the same as those previously approved by the staff for the Standardized NUHOMS® System. Sealing operations for dye penetrant testing of the closure welds are performed in accordance with TS 1.2.5.

8.1.3.1 Draining a loaded canister under inert atmosphere

During the canister loading/unloading process, an inert environment must be maintained to prevent excessive oxidation of any fuel pellets that may be exposed to the external environment due to cladding breaches. Guidance provided in ISG-22 (Ref. 3) describes staff approved measures to avoid oxidation of any fuel pellets that may be exposed. The applicant has specified in the loading procedures and TS that water removal (or water introduction during unloading) must be accomplished with a helium backfill to preclude air entry. The applicant's procedures satisfy the staff guidance of ISG-22.

The staff finds this operating method to comply with 10 CFR 72.122(h) (Ref. 4).

8.1.3.2 Hydrogen monitoring

During the phases of the loading/unloading operations when water is in the fuel canister, some amount of hydrogen may be evolved as a result of radiolysis and/or the insignificant amount of corrosion which occurs to canister internals. Generally, the amount of hydrogen produced is not significant, but when confined beneath the closure lids, a burnable concentration could accumulate if substantial operational delays occurred while water is in the canister and the lid is in place.

To alleviate this potential problem, hydrogen monitoring and mitigation is now specified by the loading/unloading procedures provided in SAR Chapter 8 and incorporated by reference into the TS.

T.8 for 61BTH and U.8 for 32PTH1

The staff finds this precaution to be acceptable.

8.1.4 Welding and Sealing

Welding and sealing operations of the 61BTH and 32PTH1 DSCs are similar to those previously approved by the staff for other DSCs used with the Standardized NUHOMS® System. The procedures include monitoring for hydrogen during welding operations. As discussed in Section 7.0 of this SER, leak checks performed according to TS 1.2.4a for the 61BTH and 32PTH1 DSCs demonstrate that the inner top cover plate is "leak tight" as defined by ANSI N14.5 - 1997 (Ref. 5). Sealing operations invoke TS 1.2.5 for dye penetrant testing of the closure welds.

8.2 Cask Handling and Storage Operations

8.2 Cask Handling and Storage Operations 8.2 Cask Handling and Storage Operations

All handling and transportation events applicable to moving the 61BTH and 32PTH1 DSCs to the storage location are similar to those previously reviewed by the staff for the Standardized NUHOMS® System and are bounded by Sections T.11 and U.11 of the SAR for the 61BTH and 32PTH1 DSCs, respectively. Technical Specification 1.2.18a and 1.2.18b provide time limits for the completion of transfer operations for the Type 2 61BTH and 32PTH1 DSCs, respectively.

Monitoring operations include daily surveillance of the HSM or HSM-H air inlets and outlets in accordance with either TS 1.3.1, or temperature performance as monitored on a daily basis in accordance with TS 1.3.2.

Occupational and public exposure estimates are evaluated in Sections T.10 and U.10 of the SAR for the 61BTH and 32PTH1 DSCs, respectively. Each cask user will need to develop detailed cask handling and storage procedures that incorporate ALARA objectives of their site-specific radiation protection program.

8.3 Cask Unloading

Detailed unloading procedures must be developed by each user.

the regulations, appropriate regulatory guides, applicable codes and standards, and accepted practices.

8.5 References

1. Transnuclear, Inc., "Application for Amendment 10 of the NUHOMS® Certificate of Compliance No. 1004 for Spent Fuel Storage Casks, Revision 0, January 12, 2007.

2. Transnuclear, Final Safety Analysis Report of the Standardized NUHOMS® Modular Storage System for Irradiated Nuclear Fuel, January 2006, Revision 9.

3. Interim Staff Guidance -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

4. 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. American National Standards Institute, ANSI N14.5-1997, "Leakage tests on Packages for Shipments," January 1997.

9 ACCEPTANCE TEST AND MAINTENANCE PROGRAMS

T.9

U.9

9.1 Acceptance Tests

The acceptance test procedures applicable to the NUHOMS® 61BTH and NUHOMS® 32PTH1 systems are similar to those previously reviewed by the staff for the Standardized NUHOMS® System (Ref. 1) and are bounded by Sections T.11 and U.11 of the SAR (Ref. 2) for the 61BTH and 32PTH1 DSCs, respectively, other than those specifically listed in Section 9.1.1, below.

Chapters T.9 and U.9

9.1.1 Neutron Poison Material Acceptance Tests

The staff has reviewed the procedures and requirements imposed during the manufacturing and testing of the three different neutron poison materials employed by the applicant in the various Standardized NUHOMS® canister models. The staff found no significant changes to the manufacturing or testing of production lots of the three types of neutron poison materials.

Since the neutron poison materials are proprietary materials which are not controlled by any nationally recognized standard, additional controls are necessary to ensure consistency of these materials from batch to batch. To address this need for consistency, the applicant has incorporated by reference into the TS certain sections of SAR Chapter 9. A separate Sub-Chapter 9 discusses each of the different canister designs within this amendment. These chapters discuss the critical parameters and tests that must be controlled to ensure consistency in the production of neutron poison materials. Incorporation of the critical parameters of production and testing into the TS effectively "freezes" the production and testing methods used to manufacture the neutron poisons and avoids any unreviewed changes to manufacturing methods.

The staff finds that the appropriate controls for manufacturing and testing are imposed. There is reasonable assurance that the consistency of these proprietary materials will remain unchanged.

9.2 Evaluation Findings

F9.1 The staff finds that the appropriate controls for manufacturing and testing are imposed. There is reasonable assurance that the consistency of these proprietary materials will remain unchanged.

9.3 References

1. Transnuclear, Final Safety Analysis Report of the Standardized NUHOMS® Modular Storage System for Irradiated Nuclear Fuel, January 2006, Revision 9. 10
2. Transnuclear, Inc., "Application for Amendment 10 of the NUHOMS® Certificate of Compliance No. 1004 for Spent Fuel Storage Casks, Revision 0, January 12, 2007.

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T.11

72.106(b). Section 11 of the amendment request discusses corrective actions for each design-basis accident.

The staff evaluated the public dose estimates from direct radiation from accident conditions and natural phenomena events and found them acceptable. A discussion of the staff's evaluation and any confirmatory analysis of the shielding and confinement analysis is presented in Sections 5 and 7 of this SER. A discussion of the staff's evaluation of the accident conditions and recovery actions are presented in Section 11 of the SER. The staff has reasonable assurance that the effects of direct radiation from bounding design basis accidents and natural phenomena will be below the regulatory limits in 10 CFR 72.106(b).

10.2.5 ALARA

Sections T.5, T.7, and T.10 of the SAR present evidence that the NUHOMS® 61BTH DSC radiation protection design features and design criteria address ALARA requirements, consistent with 10 CFR Part 20 and Regulatory Guides 8.8 (Ref. 5) and 8.10 (Ref. 6). The overall ALARA requirements are discussed in the Standardized NUHOMS® FSAR, and were not reviewed for this amendment. Each site licensee will apply its existing site-specific ALARA policies, procedures, and practices for cask operations to ensure that personnel exposure requirements in 10 CFR Part 20 are met.

The staff evaluated the ALARA assessment of the NUHOMS® 61BTH DSC and found it acceptable. Section 8 of the SER discusses the staff's evaluation of the operating procedures with respect to ALARA principles and practices. Operational ALARA policies, procedures, and practices are the responsibility of the site licensee as required by 10 CFR Part 20. In addition, the TS establish dose rates and surface contamination limits ensure that occupational exposures are maintained ALARA.

10.3 NUHOMS® 32PTH1 DSC

10.3.1 Radiation Protection Design Criteria and Design Features

10.3.1.1 Design Criteria

The radiological protection design criteria are the limits and requirements of 10 CFR Part 20, 10 CFR 72.104, and 10 CFR 72.106. This is consistent with NRC guidance. As required by 10 CFR Part 20 and 10 CFR 72.212, each general licensee is responsible for demonstrating site-specific compliance with these requirements. The TS also establish dose limits for the TC and HSM that are based on calculated dose rate values which are used to determine occupational and off-site exposures.

The TS also establish exterior contamination limits for the DSC to keep contamination levels below 2,200 dpm/100 cm2 for beta and gamma radiation, and 220 dpm/100 cm2 for alpha radiation.

cm^2 cm^2

10 CFR Part 20, Subpart B, and will demonstrate compliance with dose limits to individual members of the public, as required in 10 CFR Part 20, Subpart D by evaluations and measurements.

10.3.4 Public Exposures From Accidents and Events

Section U.11 of the amendment request summarizes the calculated dose rates for accident conditions and natural phenomena events to individuals beyond the controlled area. The confinement function of the canister is not affected by design-basis accidents or natural phenomena events thus there is no release of contents.

The amendment analysis indicates the worst case shielding consequences results in a dose at the controlled area boundary that meets the regulatory requirements of 10 CFR 72.106(b). Section 11 of the amendment request discusses corrective actions for each design-basis accident.

The staff evaluated the public dose estimates from direct radiation from accident conditions and natural phenomena events and found them acceptable. A discussion of the staff's evaluation and any confirmatory analysis of the shielding and confinement analysis is presented in Sections 5 and 7 of this SER. A discussion of the staff's evaluation of the accident conditions and recovery actions are presented in Section 11 of the SER. The staff has reasonable assurance that the effects of direct radiation from bounding design basis accidents and natural phenomena will be below the regulatory limits in 10 CFR 72.106(b).

10.3.5 ALARA

Sections U.5, U.7, and U.10 of the SAR presents evidence that the NUHOMS® 32PTH1 DSC radiation protection design features and design criteria address ALARA requirements, consistent with 10 CFR Part 20 and Regulatory Guides 8.8 (Ref. 5) and 8.10 (Ref. 6). The overall ALARA requirements are discussed in the Standardized NUHOMS® FSAR, and were not reviewed for this amendment. Each site licensee will apply its existing site-specific ALARA policies, procedures, and practices for cask operations to ensure that personnel exposure requirements in 10 CFR Part 20 are met.

The staff evaluated the ALARA assessment of the NUHOMS® 32PTH1 DSC and found it acceptable. Section 8 of the SER discusses the staff's evaluation of the operating procedures with respect to ALARA principles and practices. Operational ALARA policies, procedures, and practices are the responsibility of the site licensee as required by 10 CFR Part 20. In addition, the TS establish dose rates and surface contamination limits ensure that occupational exposures are maintained ALARA.

10.4 Evaluation Findings

F10.1 The SAR amendment sufficiently describes the radiation protection design bases and design criteria for the SSCs important to safety.

F10.2 Radiation shielding and confinement features are sufficient to meet the radiation protection requirements of 10 CFR Part 20, 10 CFR 72.104, and 10 CFR 72.106.

61BTH and 32PTH1 DSCs are

F10.3 The NUHOMS® 32PT DSC is designed to facilitate decontamination to the extent practicable.

61BTH and 32PTH1 DSCs

F10.4 The SAR amendment adequately evaluates the NUHOMS® 32PT DSC and its systems important to safety to demonstrate that they will reasonably maintain confinement of radioactive material under normal, off-normal, and accident conditions.

their

F10.5 The SAR amendment sufficiently describes the means for controlling and limiting occupational exposures within the dose and ALARA requirements of 10 CFR Part 20.

F10.6 Operational restrictions necessary to meet dose and ALARA requirements in 10 CFR Part 20, 10 CFR 72.104, and 10 CFR 72.106 are the responsibility of the site licensee. The NUHOMS® 32PT DSC is designed to assist in meeting these requirements.

F10.7 The staff concludes that the design of the radiation protection system of the NUHOMS® 32PT DSC when used with the HSM, is in compliance with 10 CFR Part 72 and the applicable design and acceptance criteria have been satisfied. The evaluation of the radiation protection system design provides reasonable assurance that the NUHOMS® 32PT DSC will provide safe storage of spent fuel. This finding is based on a review that considered the regulation itself, the appropriate regulatory guides, applicable codes and standards, the applicant's analyses, the staff's confirmatory analyses, and acceptable engineering practices.

61BTH and 32PTH1 DSCs

10.5 References

1. U.S. Code of Federal Regulations, Standards for Protection Against Radiation, Title 10, Part 20.

2. 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.

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

4. Transnuclear, Final Safety Analysis Report of the Standardized NUHOMS® Modular Storage System for Irradiated Nuclear Fuel, January 2006, Revision 9. 10

5. U.S. Nuclear Regulatory Commission, Information Relevant to Ensuring that Occupational Radiation Exposures Will Be As Low As is Reasonably Achievable, Regulatory Guide 8.8, Revision 3, June 1978.

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Table 11-1 Accident Event Safety Evaluation

Accident Event	Safety Analysis Report Sections	Safety Evaluation
Reduced HSM Air Inlet and Outlet Shielding	SAR T.11.2.1 provides the analysis for the 61BTH Type 1 DSC stored in HSM models 80/102. Not applicable to HSM-H used to store 61BTH Type 2 and 32PTH1 DSCs or HSM Models 152 and 202 used to store 61BTH Type 1 DSCs.	HSM Model 152, 202, and HSM-H models are designed with the elimination of the 6-inch gaps between HSMs. Therefore, for these models shifting of the HSM such that an HSM in the middle of the array is separated and rest against the adjacent HSM side wall is not credible. For the HSM models 80/102, TN evaluates the off-site radiological effects that result from a partial loss of adjacent Standardized HSM shielding. This scenario leads to an increase in air scattered and direct doses from the 12 inch gap between the separated HSMs. The increased doses from this event for the 61BTH DSC Type 1 canister are a fraction of the 10 CFR 72.106 requirements.
Earthquake	SAR T.11.2.2 and T.3.7.2 describe the accident evaluation analysis that was revised as a result of the addition of the 61BTH DSC. SAR U.11.2.2, and U.3.7.2 describe the accident evaluation analysis that was revised as a result of the addition of the 32PTH1 DSC and the HSM-HS (high-seismic version of the HSM-H)	SER Section 3 provides an evaluation of the response of the NUHOMS® 61BTH and 32PTH1 Systems to an earthquake
Extreme Wind and Tornado Missiles	SAR T.11.2.3 and T.3.7.1 describe the accident evaluation analysis that was revised as a result of the addition of the 61BTH DSC SAR U.11.2.2, and U.3.7.2 describe the accident evaluation analysis that was revised as a result of the addition of the 32PTH1 DSC and the HSM-HS	SER Section 3 provides an evaluation of the response of the NUHOMS® 61BTH and 32PTH1 Systems to extreme wind and tornado missiles

Accident Event	Safety Analysis Report Sections	Safety Evaluation
Flood	SAR T.11.2.4 and T.3.7.3 for the 61BTH DSCs and HSM-H SAR U.11.2.4 and U.3.7.3 for the 32PTH1 DSC and HSM-H and HSM-HS	SER Section 3
Accidental Transfer Cask Drop	SAR T.11.2.5 and T.3.7.4 for the 61BTH DSC SAR U.11.2.5 and U.3.7.4 for the 32PTH1 DSC	SER Section 3 for the structural analysis, SER Section 4 for the thermal analysis and SER Section 5 for the radiological analysis associated with the loss of neutron shield.
Lightning	SAR T.11.2.6 for the 61BTH System and SAR U.11.2.6 for the 32PTH1 System	There is no change to the analysis provided in Chapter 8.2.6 of the SAR for the lightning analysis. The analysis demonstrates that lightning does not pose a risk to the safe storage of fuel in the Standardized NUHOMS® system. The staff has previously found this analysis to be acceptable and believes the analysis in SAR Chapter 8.2.6 bounds the 61BTH and the 32PTH1 Systems.
Blockage of Air Inlet and Outlet Openings	SAR T.11.2.7, T.4 for the thermal analysis and T.3 for the structural analysis for the 61BTH System SAR U.11.2.7, U.4 for the thermal analysis and U.3 for the structural analysis for the 32PTH1 System.	SER Section 3 for the thermal analysis and SER Section 4 for the structural analysis.
DSC Leakage	SAR T.11.2.8 for the 61BTH DSC SAR U.11.2.8 for the 32PTH1 DSC	DSC leakage is not considered a credible accident scenario. Chapter 7 of the SER provides the confinement evaluation.
Accident Pressurization of DSC	SAR T.11.2.9 for the 61BTH DSC SAR U.11.2.9 for the 32PTH1 DSC	The DSC is designed to withstand pressure as a Level D condition. SER Chapter 4 provides the thermal evaluation. SER Chapter 3 provides the structural evaluation

11.4 References

1. ANSI/ANS 57.9-1984, "Design Criteria for an Independent Spent Fuel Storage Installation (Dry Type), Reaffirmed 2000

2. Transnuclear, Final Safety Analysis Report of the Standardized NUHOMS® Modular Storage System for Irradiated Nuclear Fuel, January 2006, Revision 9.

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1.1.11

12.3.2 TS Section 1.1.2, Hydrogen Monitoring
Hydrogen monitoring and mitigation is now specified by the loading/unloading procedures provided in SAR Chapter 8 and incorporated by reference into the TS.

The staff finds this precaution to be acceptable.

12.3.3 TS Section 1.2.1, Control Components
Control components such as burnable poison rod assemblies (BPRA's) are included as authorized contents. The staff has previously reviewed the potential for chemical or galvanic reactions that could result from the introduction of these materials into the DSC loading and storage environments. The staff has found that there are no materials contained in these control elements which would react adversely with the canister, canister interior components, neutron poison, or fuel cladding.

Therefore, the staff finds that 10 CFR 72.122(c)(4) is satisfied.

12.3.4 TS Section 1.2.1, Neutron Poisons
All canister designs employ a neutron poison to control criticality. All of the poisons employed by the applicant consist of a boron bearing aluminum composite of varying types. The staff has previously reviewed and accepted these proprietary materials. However, since these materials are proprietary and thus not controlled by a nationally recognized standard, their critical characteristics for manufacturing and quality control are incorporated into the TS by reference.

Those critical characteristics are described in several specially marked sections of SAR Chapter 9 for each canister design. These special sections of the SAR are specifically noted within the SAR as license conditions. Thus, those governing paragraphs may not be changed without prior NRC staff review. This effectively "freezes" the manufacturing and acceptance testing for these materials to a known standard, previously reviewed and accepted by the NRC staff. Any changes to the critical characteristics of manufacturing or testing of these materials would require prior NRC review and approval.

The staff finds the specified critical characteristics to be acceptable for controlling the manufacture and testing of these proprietary, important-to-safety materials.

12.3.5 TS Section 1.2.4, Helium leak test
A provision was added to the SAR and incorporated into the TS to extend the helium leakage rate test (limit of 10 exp -4 std cc/sec.) to the vent and drain port covers since these were not previously specifically mentioned in the SAR or TS. Since these welded components are a part of the confinement boundary, they must be tested to ensure they comply with the overall leakage rate limit for the canister design.

Note that TS 1.2.4 applies only to the 24P and 52B DSC's. These DSC's are not considered

reference

"leaktight" as described in the "Basis" section of the TS, thus no helium leakage test to the "leaktight" provisions of 10 exp -7 std cc/sec. in ANSI N14.5 – 1997 (Ref. 1), is required. For these two designs, a leakage test to 10 exp -4 std cc/sec is sufficient.

The staff finds the inclusion of the vent and drain port covers as part of the overall leakage rate measurement test to be in compliance with the staff intent of ISG-18 (Ref. 2).

12.3.6 TS Section 1.2.4a, Helium leak test

The inner top cover seal weld and vent and drain port cover plate welds of the 61BT, 32PT, 24PHB, 61BTH, and 32PTH1 are all helium leakage rate tested to the "leak tight" standard (10 exp -7 std.) cc/sec.) of ANSI N14.5 - 1997.

The staff finds this to be in compliance with the guidance of ISG-15 (Ref. 3) and ISG-18.

12.4 Evaluation of Findings

Based on a review of the submitted information, the staff makes the following findings:

F12.1 Table 12-1 of this SER lists the TS for the NUHOMS® 61BTH and 32PTH1 Systems, in conjunction with the Standardized NUHOMS® Storage System. These TS are included as Appendix A of the CoC.

F12.2 The staff concludes that the conditions for use of the NUHOMS® 61BTH and 32PTH1 Systems, and the change of contents for the 24PTH and 32PT DSC in conjunction with the Standardized NUHOMS® Storage system, identify necessary TS to satisfy 10 CFR Part 72 and that the applicant acceptance criteria have been satisfied. The TS provide reasonable assurance that the cask will provide for safe storage of spent fuel. This finding is reached on the basis of a review that considered the regulation itself, appropriate regulatory guides, applicable codes and standards, and accepted practices.

12.5 References

1. American National Standards Institute, ANSI N14.5-1997, "Leakage tests on Packages for Shipments," January 1997.

2. Interim Staff Guidance – 18 (ISG-18), "The Design and Testing of Lid Welds on Austenitic Stainless Steel Canisters as the Confinement Boundary for Spent Fuel Storage", Revision 1; October, 2008.

3. Interim Staff Guidance – 15 (ISG-15), "Materials Evaluation", Revision 0; January, 2001.

1.1.11 Hydrogen Gas Monitoring for 61BTH and 32PTH1 DSCs
1.1.12 Codes and Standards

Table 12-1

Standardized NUHOMS® Horizontal Modular Storage System Technical Specifications for use with the NUHOMS® 61BTH and 32PTH1 Systems

1.1 General Requirements and Conditions

- 1.1.1 Regulatory Requirements for a General License
- 1.1.2 Operating Procedures
- 1.1.3 Quality Assurance
- 1.1.4 Heavy Loads Requirements
- 1.1.5 Training Module
- 1.1.6 Pre-Operational Testing and Training Exercise
- 1.1.7 Special Requirements for First System in Place
- 1.1.8 Surveillance Requirements Applicability
- 1.1.9 Supplemental Shielding
- 1.1.10 HSM-H Storage Configuration

1.2 Technical Specifications, Functional and Operating Limits

- 1.2.1 Fuel Specifications
- 1.2.2 DSC Vacuum Pressure During Drying
- 1.2.3 24P and 52B DSC Helium Backfill Pressure
- 1.2.3a 61BT, 32PT, 24 PHB, ~~and~~ 24PTH, 61BTH, and 32PTH1 DSC Helium Backfill Pressure
- 1.2.4 24P and 52B DSC Helium Leak Rate of Inner Seal Weld
- 1.2.4a 61BT, 32PT, 24PHB, 24PTH, 61BTH and 32PTH1 DSC Helium Leak Rate of Inner Seal Weld
- 1.2.5 DSC Dye Penetrant Test of Closure Welds
- 1.2.6 Deleted
- 1.2.7 HSM Dose Rates with a Loaded 24P, 52B or 61BT DSC
- 1.2.7a HSM Dose Rates with a Loaded 32PT DSC Only
- 1.2.7b HSM Dose Rates with a Loaded 24PHB DSC Only
- 1.2.7c HSM-H Dose Rates with a Loaded 24PTH-S or 24PTH-L DSC Only
- 1.2.7d HSM or HSM-H Dose Rates with a Loaded 24PTH-S-LC DSC Only
- 1.2.7e HSM -H Dose Rates with a Loaded Type 2 61BTH DSC Only
- 1.2.7f HSM or HSM-H Dose Rates with a Loaded Type 1 61BTH DSC Only
- 1.2.7g HSM-H Dose Rates with a 32PTH1 DSC Only
- 1.2.8 HSM Maximum Air Exit Temperature with a Loaded 24P, 52B, 32PT, 24PHB, or 24PTH-S-LC or a Type 1 61BTH DSC Only
- 1.2.8a HSM-H Maximum Air Exit Temperature with a Loaded 24PTH DSC Only
- 1.2.8b HSM-H Maximum Air Exit Temperature with a Loaded 61BTH DSC
- 1.2.8c HSM-H Maximum Air Exit Temperature with a Loaded 32PTH1 DSC
- 1.2.9 Transfer Cask Alignment with HSM or HSM-H
- 1.2.10 DSC Handling Height Outside the Spent Fuel Pool Building
- 1.2.11 Transfer Cask Dose Rates with a Loaded 24P, 52B, 61BT, or 32 PT DSC
- 1.2.11a Transfer Cask Dose Rates with a Loaded 24PHB DSC
- 1.2.11b Transfer Cask Dose Rates with a Loaded 24PTH-S or 24PTH-L DSC

1.2.11c Transfer Cask Dose Rates with a Loaded 24PTH-S-LC DSC
1.2.11d Transfer Cask Dose Rates with a Loaded 61BTH DSC
1.2.11e Transfer Cask Dose Rates with a Loaded 32PTH1 DSC
1.2.12 Maximum DSC Removable Surface Contamination
1.2.13 TC/DSC Lifting Heights as a Function of Low Temperature and Location
1.2.14 TC/DSC Transfer Operations at High Ambient Temperatures (24P, 52B, 61BT, 32PT, 24PHB, 24PTH, or 61BTH only)
1.2.14a TC/DSC Transfer Operations at High Ambient Temperatures (32PTH1 DSC Only)
1.2.15 Boron Concentration in the DSC Cavity Water for the 24P Design Only
1.2.15a Boron Concentration in the DSC Cavity Water for the 32PT Design Only
1.2.15b Boron Concentration in the DSC Cavity Water for the 24PHB Design Only
1.2.15c Boron Concentration in the DSC Cavity Water for the 24PTH Design Only
1.2.15d Boron Concentration in the DSC Cavity Water for the 32PTH1 Design Only
1.2.16 Provision of TC Seismic Restraint Inside the Spent Fuel Pool Building as a Function of Horizontal Acceleration and Loaded Cask Weight
1.2.17 61BT DSC Vacuum Drying Duration Limit
1.2.17a 32PT DSC Vacuum Drying Duration Limit
1.2.17b 24PHB DSC Vacuum Drying Duration Limit
1.2.17c 24PTH DSC Vacuum Drying Duration Limit
1.2.18 Time Limit for Completion of 24PTH DSC Transfer Operation
1.2.18a Time Limit for Completion of Type 2 61BTH DSC Transfer Operation
1.2.18b Time Limit for Completion of 32PTH1 DSC Transfer Operation

1.3 Surveillance and Monitoring

1.3.1 Visual Inspection of HSM or HSM-H Air Inlets and Outlets (Front Wall and Roof Birdscreen)
1.3.2 HSM or HSM-H Thermal Performance

1.2.19 61BTH and 32PTH1 DSC Bulkwater Removal Medium