ENCLOSURE 2

SAFETY EVALUATION REPORT

TRANSNUCLEAR, INC.

STANDARDIZED NUHOMS® HORIZONTAL MODULAR STORAGE SYSTEM FOR IRRADIATED NUCLEAR FUEL

DOCKET No. 72-1004

NUHOMS®-24PTH SYSTEM

AMENDMENT NO. 8

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Docket No. 72-1004
Standardized NUHOMS® Modular Storage System for Irradiated Nuclear Fuel
Certificate of Compliance No. 1004
NUHOMS®-24PTH SYSTEM
Amendment No. 8

SUMMARY

By application dated September 19, 2003, as supplemented on January 22, 2004, July 6, 2004, August 16, 2004, September 17, 2004, October 11, 2004, January 14, 2005, March 15, 2005, June 10, 2005, and July 20, 2005, 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). The requested change was to add a new system designated as the NUHOMS®-24PTH System to the Standardized NUHOMS® System.

The 24PTH system consist of new or modified components: (1) the 24PTH dry shielded canister (DSC); (2) a new 24PTH DSC basket design; (3) a modified horizontal storage module (HSM), designated the HSM-H; and (4) a modified transfer cask, designated the OS 197FC TC. The 24PTH is designed to store fuel with a maximum average burnup of up to 62 GWd/MTU; maximum average initial enrichment of 5.0 wt. %; minimum cooling time of 3.0 years; and maximum heat load of 40.8 kW per DSC.

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. 8 changes to the CoC are indicated by change bars in the margins.

1.0 GENERAL DESCRIPTION

The TN NUHOMS®-24PTH System consists of the following components: (1) a new dual purpose Dry Shielded Canister (DSC), with three alternate configurations, -24PTH-S, -24PTH-L, and -24PTH-S-LC; (2) a new 24PTH basket design with two options, with and without aluminum inserts; (3) a modified version of the Horizontal Storage Module (HSM) Model 102, designated as HSM-H; (4) OS197FC Transfer Cask (TC), which is similar to the OS197/OS197H except it has a modified top lid that allows air circulation during transfer operations based on the heat load. The DSC is designed to store up to 24 intact or up to 12 damaged and the balance intact PWR fuel assemblies with or without control components (B&W 15x15, WE 17x17, CE 15x15, WE 15x15, CE 14x14, and WE 14x14). The spent fuel is limited to a maximum assembly average initial enrichment of 5.0 wt %, a maximum assembly average burn up of 62,000 MWd/MTU, and a minimum cooling time of 3.0 years. The 24PTH-S and 24PTH-L DSC configurations are short and long cavity shell assemblies designed for a maximum heat load of 40.8 kW. The third DSC configuration is the 24PTH-S-LC, designed to be accommodated inside the Standardized NUHOMS® TC for onsite transfer. It is modified with lead shield plugs instead of steel and is designed for a maximum heat load of 24 kW.

1.1 Updated FSAR Revision

TN submitted a proposed Safety Analysis Report (SAR) for the Standardized NUHOMS Horizontal Modular Storage for Irradiated Nuclear Fuel, Revision 6 as part of the Amendment No. 8 application. On November 19, 2003, as required by 10 CFR 72.248, TN provided the biennial update of the Final Safety Analysis Report (FSAR), Revision 7. In January 2004, Amendment Nos. 5 and 6 to the Standardized NUHOMS System were issued. In March 2004, Amendment No. 7 was issued. In April 2004, TN submitted another application for an amendment to CoC No. 1004, which has been included in proposed Amendment No. 8. To support the review for that application the staff requested an updated FSAR reflecting approved Amendment Nos. 5, 6, and 7. TN submitted FSAR Revisions 7a and 8 to support that application review.

2.0 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 are described in SAR Section P.2.3.

2.2 Design Basis for SSCs Important to Safety

The 24PTH DSC design criteria summary includes the range of spent fuel types and configurations to be stored, and design criteria for environmental conditions and natural phenomena.

2.2.1 Spent Fuel Specifications

The allowable contents of the 24PTH DSC include intact (including reconstituted) and /or damaged fuel assemblies meeting the parameters specified in Tables 1-1l and 1-1m of Technical Specification 1.2.1, "Fuel Specifications." The specification includes a maximum burnup of 62 GWd/MTU. The characteristics of the control components are described in SAR Table P.2-2. A detailed description of the allowable fuel and storage configurations is provided in Tables P.2-1 through P.2-13 in the SAR.

2.2.2 External Conditions

Section P.2.2 of the SAR identifies the bounding site environmental conditions and natural phenomena for which the 24PTH DSC is 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 24PTH DSC, is presented in Section P.2.3 of the SAR. Details of the design are provided in Sections P.3 though P.11 of the SAR.

The applicant has designed the 24PTH DSC 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 24PTH DSC and basket design which limits fuel cladding temperatures and maintains a nonoxidizing environment in the cask cavity. The 24PTH DSC is designed to maintain a subcritical configuration during loading, handling, storage, and accident conditions. A combination of soluble boron in the pool, fixed neutron absorbers,and favorable geometry are employed. The 24PTH DSC shell and basket structure are designed, fabricated and inspected in accordance with the ASME B&PV Code, Section III, Subsection NB and NG, respectively, with a few alternative provisions (Ref. 2). However, the applicant has stated that it is their intention to follow the ASME Code requirements as closely

as possible for the design and construction of the DSC shell and the basket structure. The complete list of alternative provisions to the ASME Code and the corresponding justification for the 24PTH DSC shell and the basket structure is provided in Table P.3.1-1 and Table P.3.1-2, respectively. The staff has reviewed the alternative provisions and found that they are acceptable.

2.4 Evaluation Findings

F2.1 The staff concludes that the principal design criteria for the 24PTH DSC 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, Interim Staff Guidance (ISG), and accepted engineering practices. A more detailed evaluation of design criteria and an assessment of the compliance with those criteria is presented in Sections 3 through 12 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.

2. American Society of Mechanical Engineers, ASME Boiler and Pressure Vessel Code, Section III, Subsection NB, NC, NF, NG and Appendices, 1998 Edition including 2000 Addenda.

3.0 STRUCTURAL EVALUATION

This section presents the results of the structural evaluation review of the SAR amendment request for the addition of the 24PTH system to the Standardized NUHOMS® System. The NUHOMS®-24PTH System is designed to accommodate up to 24 intact (or up to 12 damaged and the balance intact) PWR fuel assemblies with a maximum assembly average initial enrichment level of 5.0 wt. %, a maximum assembly average burn-up of 62 GWd/MTU, and a minimum cooling time of 3.0 years. The NUHOMS®-24PTH System is designed with three alternate system configurations; two different types of basket options; and three boron contents in the basket poison plates. The 24PTH system will be able to accommodate a maximum decay heat load of up to 40.8 kW per canister. The NUHOMS®-24PTH System consists of the 24PTH DSC basket and shell assemblies, the HSM-H and HSM Model 102, and the OS197/OS197H/OS197FC Transfer Casks. Thus, the following new or modified components are provided by the amendment request:

- A new Dry Shielded Canister (DSC) which has three alternate configurations
- A new 24PTH DSC basket design, which can be with or without aluminum inserts and low, moderate, or high boron content in the basket poison plates
- A modified version of the Standardized Horizontal Storage Module (HSM) Model 102 designated as HSM-H that provides enhanced shielding and heat rejection capabilities
- An OS197/OS197H Transfer Cask (TC) with a modified top lid to allow air circulation through the TC/DSC annulus during transfer operations. The modified TC is designated as the OS197FC TC.

A complete structural evaluation of the 24PTH DSC shell assembly and basket components and the HSM-H has been performed. The structural evaluation shows that the NUHOMS®-24PTH 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. The structural review was conducted against the appropriate regulations as described in 10 CFR 72.11, 10 CFR 72.122, 10 CFR 146, and 10 CFR 72.236.

3.1 Structural Design of the NUHOMS®-24PTH System

3.1.1 Dry Shielded Canister 24PTH-DSC

The 24PTH DSC canister assembly consists of the 24PTH DSC basket and shell assembly. The 24PTH DSC shell assembly is similar to the NUHOMS® 24P DSC but the nominal DSC shell thickness is reduced to 0.5 inches from 0.625 inches thick. The thickness of the top and bottom cover plates are increased but the thickness of the top and bottom shield plugs are reduced. An optional test port is also added to the top cover plate to allow testing of the inner top cover plate welds and vent and siphon port cover plate welds for leakage. The 24PTH DSC shell assembly is shown on drawings NUH-24PTH-1001-SAR and NUH-24PTH-1002-SAR in Section P.1.5.

The 24PTH basket assembly is shown on drawings NUH-24PTH-1003-SAR and NUH-24PTH-1004-SAR in Section P.1.5. The basket assembly consists of 24 stainless steel tubes, and two types of transition rails. The transition rails provide the transition between the rectangular basket structure and the cylindrical DSC shell. There are four R90 solid aluminum rails located at 0°, 90°, 180°, and 270° and eight R45 steel transition rails located on both sides of 45°, 135°, 225°, and 315° inside the DSC cavity. Sandwiched in between the tubes are aluminum alloy 1100 plates used as heat transfer material, and neutron absorbing plates for criticality control. The tubes are welded at eight elevations along the axial length of the basket to stainless steel insert (strap) plates. The aluminum and neutron absorbing plates, which are arranged in an egg crate configuration, are separated along the basket length by the steel insert plates. The cylindrical shell and the cover plates that form the confinement boundary, as well as the fuel tubes and steel insert plates of the basket assembly are all fabricated from American Society of Mechanical Engineers (ASME) SA240, Type 304 stainless steel.

The 24PTH DSC shell and weldments made during fabrication that affect the confinement boundary of the DSC are fully compliant to the requirements of ASME Sect. III Subsection NB. These include the inner bottom cover plate or forging to shell welds and the circumferential and longitudinal seam welds applied to the shell. The top inner cover plate, or inner top forging of the top shield plug assembly and associated welds, the closure weld applied to cover plates of the vent and the siphon block, and the vent and siphon block to the shell weld, defines the primary confinement boundary at the top end of the 24PTH DSC. These welds are applied using a multiple-layer technique and are liquid penetrant (PT) examined in accordance with ASME Code Case N-595-2 and Section III, NB-5000. The internal basket assembly is designed, fabricated and inspected in accordance with ASME Sect. III, Subsection NG with alternatives as listed in SAR Table P.3.1-2.

During fabrication, leak tests of the 24PTH DSC shell assembly are performed in accordance with American National Standards Institute (ANSI) N14.5-1997, “Leakage Tests on Packages for Shipment of Radioactive Materials," to demonstrate that the shell assembly is leaktight. The DSC inner top closure welds, including the vent and siphon pressure boundary welds, are also leak-tested after fuel loading to demonstrate that ANSI N14.5 leaktight criteria are met following installation of the outer cover plate root pass weld.

The basis for the allowable stresses for the confinement boundary is ASME Code Section III, Division 1, Subsection NB Article NB-3200 for normal and off-normal condition loads, and Appendix F for accident condition loads.

3.1.2 HSM-H Module

The HSM-H module design is similar to the design of HSM Model 102 which is described in Chapter 1 and in the drawings included in Appendix E of the FSAR (Ref. 1). The HSM-H module design has the following improvements for better heat rejection and shielding capabilities:

- Use of a thicker roof
- Use of slotted plates and holes in the DSC support rails to increase airflow
- Increased height of the module
- Use of finned side heat shields option for high heat loads
- Use of louvered top heat shield to minimize airflow resistance

The HSM-H module assembly is shown on Drawing NUH-03-7001-SAR in Section P.1.5. The reinforced concrete for HSM-H is designed in accordance with American Concrete Institute (ACI) 349-97 and is constructed in accordance with ACI 318-95. The structural steel for HSM-H is designed and constructed in accordance with the American Institute of Steel Construction (AISC) Steel Manual and welding will be in accordance with American Welding Society (AWS) D1.1-98.

3.1.3 OS197FC Transfer Cask

The OS197FC TC is a modified version of the OS197/OS197H TC described in the FSAR and in the drawings included in Appendix E of the FSAR.

The top lid of the OS197/OS197H TC is scalloped out at 16 locations on the lid underside (See Figure P.1-5) to provide slots that provide an exit path for air circulation through the TC/DSC annulus. The required modifications to convert OS197/OS197H TC into an OS197FC TC are shown on Drawings NUH-03-8000-SAR and NUH-03-8006-SAR.

3.2 Materials

3.2.1 Materials Description

The applicant provided a general description of the materials of construction in SAR Sections P.1.2, P.3.1, and P.3.3. Additional information regarding the materials, fabrication details and testing programs can be found in SAR Section P.9.1. The staff reviewed the information presented in SAR Table P.3.1-1 and in the License Drawings to determine whether the 24PTH DSC meets the requirements of 10 CFR 72.122(a), (b), (h) and (l), and 72.236(g) and (h). Specifically, the staff reviewed the following material suitability areas: materials selection; brittle fracture; applicable codes and standards; weld design and specifications; and chemical and galvanic corrosion.

3.2.1.1 Structural Materials

Most of the structural components of the 24PTH DSC (e.g., shell, bottom plate, and top plate) are fabricated from Type 304 austenitic stainless steel. The fuel compartment tubes in the 24PTH basket are also fabricated from Type 304 stainless steel. This type of steel was selected because of its high strength, ductility, resistance to corrosion and metallurgical stability. Since there is no ductile-to-brittle transition temperature in the range of temperatures expected to be encountered for this steel, its susceptibility to brittle fracture is negligible. The top shield plug of the 24PTH-S and 24PTH-L DSCs is fabricated from A 36 carbon steel. An electroless nickel coating is applied to the surface of this top shield plug. The top and bottom shield plug assemblies for the 24PTH-S-LC are fabricated from type F304 stainless steel. The staff concludes that the selection of these materials meet the requirements of ASME Boiler Pressure Code. Therefore, these materials are acceptable for use in the DSC.

3.2.1.2 Nonstructural Material

The basket assembly structure consists of a grid assembly of welded stainless steel plates or tubes that make up the fuel compartments. Each fuel compartment accommodates aluminum

and/or neutron absorbing plates for criticality control. The neutron absorber plates for criticality control are either an alloy (e.g., borated aluminum), a metal matrix composite (e.g., BorAlyn, or METAMIC) or BORAL. In accordance with Section P.9.1.7, appropriate acceptance testing will be used to ensure that the neutron absorbers have the minimum specified ^{10}B loading for borated aluminum, Boral, and MMC (BorAlyn, and METAMIC). To ensure that the durability of metal matrix composites is maintained during storage, acceptable material controls (i.e., B_4C volume percent, B_4C weight percent, tensile properties, and theoretical density) have been added to the technical specifications in Table 1-1s.

There are two types of transition rails that provide the transition between the fuel compartments and the DSC shell. The aluminum transition rails (R90 rails) are made of Type 6061 aluminum. The stainless steel rails (R45 rails) consist of welded Type 304 stainless steel plates with optional Type 1100 aluminum inserts between the stiffener plates.

The staff concludes that the aluminum plates used for the grid assembly are suitable for heat transfer. Further, the staff concludes that the neutron absorbers will be adequately durable during the service life of the cask. The acceptance and qualification for the neutron absorbers are discussed in Chapter 9 of this SER.

3.2.1.3 Welds

The DSC cylindrical shell is assembled using full penetration longitudinal welded joints and circumferential welded joints at the junction between the inner bottom plate and the shell. These welds are performed in accordance with ASME Code Section III, Subsection NB-4000, and Section IX. The top outer and inner cover plates or forgings are joined to the shell by partial penetration groove welds. The applicant has taken an alternative to the ASME Code, Section III, with respect to the design of this closure. All top and bottom end closures welds are multiple-layer welds.

The DSC materials of construction (e.g., stainless steel, carbon steel, etc.) are readily weldable using common available welding techniques. The use of an experienced fabricator will ensure that the process chosen for fabrication will yield a durable canister. The DSC welds were well-characterized on the License Drawings, and the standard welding symbols and notations are in accordance with AWS Standard A2.4, “Standard Symbols for Welding, Brazing, and Nondestructive Examination.” The sealing procedures and acceptance tests for welds are discussed in Chapter 8 and 9 of this SER, respectively.

The staff concludes that the welded joints of the DSC meets the requirements of the ASME Code. Although the DSC closure welds are partial penetration welds, this configuration will perform its intended structural and confinement functions.

3.2.1.4 Bolting Materials

The DSC is an all-welded canister.

3.2.1.5 Coatings

No zinc, zinc compounds, or zinc-based coatings are used on the carbon steel top shield plug of the DSC. The shield plug will be coated with an electroless nickel-phosphorous coating,

which has been reviewed by the staff against American Society for Testing and Materials (ASTM) specifications and found acceptable. The coating will protect the steel from excessive oxidation of the surface.

3.2.1.6 Mechanical Properties

SAR Tables P.3.3-1 through P.3.3-9 provide material property data for the major materials including; stainless and carbon steels and aluminum alloys. Most of the values were obtained from ASME Code, Section II, Part D. However, some values were obtained from other acceptable references. The staff independently verified the temperature dependent values for the yield and ultimate stresses, modulus of elasticity, and coefficient of thermal expansion. The staff concludes that these material properties are acceptable and appropriate for the expected load conditions (e.g., static or dynamic, impact loading, hot or cold temperature, wet or dry conditions) during the license period.

3.2.1.7 Chemical and Galvanic Reactions

In SAR Section P.3.4.1, the applicant evaluated whether chemical, galvanic or other reactions between the materials and environment would occur. The staff reviewed the design drawings and applicable sections of the SAR to evaluate the effects, if any, of intimate contact between various materials in the DSC system during all phases of operation. In particular, the staff evaluated whether these contacts could initiate a significant chemical or galvanic reaction that could result in component corrosion or combustible gas generation. Pursuant to NRC Bulletin 96-04, a review of the DSC system, its contents and operating environments has been performed to confirm that no operation (e.g., short term loading/unloading or long-term storage) will produce adverse chemical or galvanic reactions. The DSC is primarily fabricated with stainless and carbon steels and aluminum. The vacuum drying procedures of SAR Section P.8.1.3, (two cycles of sequentially evacuating and backfilling the cask with the inert helium, and the design, configuration and operation of the vacuum drying equipment) will ensure that contamination of the cover gas with air is minimal.
The staff concludes that in this dry, inert environment, the DSC components are not expected to react with one another or with the cover gas. Further, oxidation or corrosion of the fuel (cladding, thimble plug assemblies, burnable poison rod assemblies, etc.) and the DSC internal components will effectively be eliminated during storage.

The applicant identified that small amounts of hydrogen gas may be generated in the DSC prior to the submersion of the transfer cask into the spent fuel pool due to the initial passivation state of the aluminum. The applicant conducted tests on aluminum metal matrix composites coupled with 304 stainless steel. The applicant concluded that the small amounts of hydrogen, which may be generated during the DSC operation, does not result in a safety hazard. To ensure that the safety hazards associated with the ignition of hydrogen gas are mitigated, the procedures of SAR Section P.8.1 are employed to monitor the concentration of hydrogen gas during any welding or cutting operations. The staff concludes that these procedures are adequate to prevent ignition of any hydrogen gas that may be generated during welding operation. Further, the potential reaction of the aluminum with the spent fuel pool water will not impact the ability of the aluminum grid plates and the neutron absorbers to perform their intended function because the loss of aluminum metal is negligible.

3.3 Normal and Off-Normal Conditions

3.3.1 Loads and Loading Conditions

The normal operating loads for the NUHOMS®- 24PTH System components are:

- Dead Weight - The weights of various components of the 24PTH system.
- Pressure Loads - The structural analyses are performed for bounding internal pressure of 15 and 20 psig for normal and off-normal conditions, respectively.
- Thermal Loads - The normal condition temperature distributions for the 24PTH DSC, HSM-H, and OS197/OS197H/OS197FC transfer casks are presented in Sections P.4.6, P4.4, and P4.5, respectively.
- Handling Loads - Handling loads associated with on-site handling, transport, loading and unloading of the DSC is described in SAR Section 8.1.1.1.C. The DSC bottom cover plate and grapple ring assembly are designed to withstand a normal operating insertion force equal to 80,000 pounds and a normal operating extraction force equal to 60,000 pounds.
- Live Loads - A live load of 200 pounds per square foot is conservatively selected to envelope all postulated live loads acting on the HSM-H including the effects of snow and ice. Live loads which may act on the TC are considered negligible.

Table P.3.6-9 shows the off-normal loads for which the NUHOMS®-24PTH System components are designed. For an operating NUHOMS®-24PTH System, off-normal events could occur during fuel loading, TC handling, canister transfer and other operational events. Two off-normal events are defined by the application which bound the range of off-normal conditions. The limiting off-normal events are defined as a jammed DSC during loading or unloading from the HSM Model 102/HSM-H and the extreme ambient temperature of -40° F (winter) and +117° F (summer). These events envelop the range of expected off-normal structural loads and temperatures acting on the DSC, TC, and HSM Model102/HSM-H.

3.3.2 Analysis Methods

3.3.2.1 24PTH DSC Shell Assembly

The 24PTH DSC shell assembly is analyzed using ANSYS finite element models. A top-end half-length model of the DSC shell assembly and a bottom-end half-length model of the DSC shell assembly are utilized. A 90° (i.e., one-quarter) cross sectional segment of the DSC is used to analyze axisymmetric loads and a 180° (one-half) cross sectional segment is used to analyze non-axisymmetric loads. Typical 90° analytical models of the top and bottom halves of the DSC shell assembly are shown in Figure P.3.6-1 and P3.6-2, respectively. A partial view of the 180° model showing the bottom end plate and grapple assembly is shown in Figure P.3.6-3.

For the analysis of the 24PTH-S-LC DSC shell assembly, three ANSYS finite element models are used. The three finite element models are as follows: (1) an axisymmetric model of the

DSC shell assembly, (2) a three-dimensional top-end model with the top shield plug assembly, and (3) a three-dimensional bottom-end model. The axisymmetric model is shown in Figure P.3.6-4. The three-dimensional top and bottom end models are shown in Figure P.3.6-5. The axisymmetric model is a complete model of the 24PTH-S-LC-DSC shell assembly which includes top and bottom shield plug assemblies, covers plates, and the cylindrical shell. The model is used to analyze axisymmetric loads such as vertical dead weight, top/bottom end drop loads, and internal/external pressure loads. The three-dimensional top and bottom end models are half-symmetric (i.e., 180° representations) and are used to analyze non-axisymmetric loads such as thermal loads, side drop loads, and grapple pull/push loads.

3.3.2.2 24PTH Basket Assembly

The structural analysis of the 24PTH basket assembly is performed by using a combination of hand calculations and three-dimensional LS-DYNA finite element models. The LS-DYNA finite element model of the 24PTH basket assembly is shown in Figure P.3.6-6. The model is a 24-inch long section of the basket assembly. This span corresponds to the 24-inch periodicity of the steel insert plates, and twice (12") the periodicity of the stiffener plates in the R45 transition rails. The steel insert plates, steel insert plates-to-tube welds, and a full thickness R45 transition rail stiffener plate is modeled at Z=0.0". The model is extended half way to the next insert plate/weld location to Z=+12.0" and Z= -12.0". Half-thickness R45 stiffeners are included at ends of the model (e.g., Z=±12.0"). The model includes a segment of the DSC shell which is modeled with shell elements. The model allows thermal expansion and applies symmetry boundary conditions at the ends.

3.3.2.3 HSM-H Modules

The NUHOMS® modular storage system has the flexibility of arranging HSM-H modules in arrays of single or double module rows. The structural analysis is performed on a single module of HSM-H, which provides a conservative estimate of the response of the HSM-H structural components for any array configuration. A three-dimensional ANSYS finite element model of the HSM-H, including all the concrete components, as shown in Figure P.3.7-11 is developed for the stress analysis. Included in the model is the steel support structure (e.g., rail and cross members) and a simplified beam model of the 24PTH DSC, as shown in Figure P.3.7-12. The ANSYS eight-node brick element is used to model the concrete structure. The 24PTH DSC and the support structure are modeled using the beam elements with the mass of the 24PTH DSC lumped at the nodes. Linear elastic analyses are performed to determine internal forces and moments. The strength method of ACI 349 is used for the design of the HSM-H reinforced concrete structural components.

3.3.2.4 OS197FC TC

The OS197FC TC is the same as the OS197/OS197H TC with the exception of the cask top lid, which is modified to provide vents around the perimeter of the lid. To address the effects of the lid vent cutouts on the lid stresses, two separate finite element models of a 1/32 (e.g., 11.25°) segment of the lid, one with cutouts and one without the cutouts, are constructed using ANSYS. The two model configurations are shown in Figure P.3.6-11. For purposes of the thermal stress analysis, the TC is evaluated for the bounding temperature distributions resulting from transfer of a 24PTH DSC with heat loads of 40.8 kW with air circulation and 31.2 kW steady state by a three-dimensional ANSYS model of the TC as shown in Figure P.3.6-15.

3.3.3 Analysis Results

The 24PTH DSC shell assembly has been shown to meet the appropriate material stress allowable for the service levels A and B in the ASME Boiler and Pressure Vessel Code, Section III, Division 1, Subsection NB, for Class 1 Components. The maximum calculated DSC shell stresses induced by normal and off-normal load conditions are shown in Table P.3.6-2 for the 24PTH DSCs and Table P.3.6-3 for 24PTH-S-LC DSC. The calculated stresses for each load case are combined in accordance with the load combinations presented in Table P.2-14. The resulting stresses for the controlling load combinations are reported and compared to the allowable stresses in Tables P.3.7-8 and P.3.7-9. It is seen that the calculated stresses are less than the code allowable stresses. Except that the DSC shell primary plus secondary stress intensity under cold transfer loading condition (Load Case TR-2) exceeds the $3S_m$ limit (NB-3222.2) and a simplified elastic-plastic analysis was performed. ASME Section III, Subarticle NB-3228.5 permits the stress intensity to exceed the $3S_m$ limit if certain design conditions are satisfied. The application has shown that the material, temperature, and the loading condition satisfy the requirements of NB-3228.5 for simplified elastic-plastic analysis.

The 24PTH DSC basket assembly normal and off-normal condition stresses are summarized in Table P.3.6-6 and Table P.3.6-7 for basket stainless steel and aluminum components. The SAR provides the stress ratio between the calculated stress and the allowable stress to show compliance to the stress criterion of the ASME Code. Based on the stress ratios shown in Table P.3.6-6 and Table P.3.6-7, it can be concluded that the basket structure meets the allowable stress criterion.

The reinforced concrete and the support structure of the HSM-H are analyzed for the normal, off-normal, and postulated accident conditions using finite element models as described above. Maximum NUHOMS® HSM-H concrete component forces and moments due to a dead load, live load, operational handling loads, off-normal handling loads, and design wind loads are summarized in Table P.3.6-10.

A comparison of the stress analysis result for the unmodified (i.e., no cutouts) and modified (i.e., with cutouts) transfer cask lids is shown in Table P.3.6-11. As shown by these results, the addition of the air vent cutouts has only a small effect (e.g., less than 2.5% based on the controlling stress) on lid stresses. The bounding thermal stresses for each transfer cask component are summarized in Table P.3.6-12. These thermal stresses are combined with bounding mechanical load stresses for OS197FC TC and are summarized in Table P.3.6-13. In Table P.3.6-13, the maximum primary plus secondary stresses are conservatively added by absolute sum, irrespective of location of the stress for each TC component. The combined stresses are then compared to the allowable stresses at 400°F temperature. The maximum stress ratio is 0.95 which occurs at the bottom support ring of the transfer cask.

3.4 Accident Conditions

3.4.1 Design Basis Accident Events and Loads

The design basis accident events specified by ANSI/ANS 57.9, “Design Criteria for an Independent Spent Fuel Storage Installation (Dry Type),” and other credible accidents postulated to affect the safe operation of the NUHOMS® 24PTH Systems are addressed as follows:

- Tornado winds and tornado generated missiles
- Design basis earthquakes
- Design basis floods
- Accidental TC drops with loss of neutron shields
- Lightning effects
- Debris blockages of HSM-H air inlet and outlet opening
- Postulated DSC leakage
- Pressurization due to fuel cladding failure within the DSC
- Reduced HSM air inlet and outlet shielding
- Fire and explosion

The accident condition stresses in the NUHOMS® System components are evaluated and compared with the applicable code limits set forth in FSAR Section 3.2 and SAR Chapter P.2 as applicable. Where appropriate, the accident condition stresses are combined with the normal operating load stresses in accordance with the load combination defined in Chapter P.2.

3.4.2 Analysis Methods

3.4.2.1 Tornado Winds and Tornado Missile

The HSM-H is qualified for maximum design basis tornado (DBT) generated design wind loads of 234 lb/ft^2 and 148 lb/ft^2 on the windward and leeward HSM-H walls, respectively, and a pressure drop of 3 psi. The pressure drop, however, has no effect on the HSM-H, because the HSM-H is an open structure, due to the presence of the inlet and outlet vents. Stability and stress analyses are performed to determine the response of the HSM-H to tornado wind pressure loads. The stability analyses are performed using closed-form calculation methods to determine sliding and overturning response of the HSM-H array. A single HSM-H with both the end and the rear shield walls is conservatively selected for the analyses. The analysis result shows that the overturning moment is smaller than the stabilizing moment and the horizontal force generated by the postulated DBT is smaller than the force required to slide the HSM-H. Thus, it can be concluded that the HSM-H will not overturn or slide during DBT. The stress analyses are performed using ANSYS finite element model of a single HSM-H to determine design forces and moments. The DBT wind pressures are applied to the HSM-H as a uniformly distributed load. The rigidity of the HSM-H in the transverse direction, due to frame and shear wall action of the HSM-H, is the primary load transfer mechanism assumed in the analysis. The bending moments and shear forces at critical locations in the HSM-H concrete components are calculated by performing an analysis using the ANSYS analytical model of the HSM-H.

3.4.2.2 Earthquake

The peak horizontal ground acceleration of 0.30g and the peak vertical ground acceleration of 0.20g are utilized for the design basis seismic analysis of the 24PTH DSC and HSM-H components. Based on the result of the frequency analysis of the HSM-H, the maximum calculated seismic accelerations for the DSC inside the HSM-H are 0.41g and 0.36g in the horizontal directions and 0.20g in the vertical direction. An analysis using these seismic accelerations shows that the DSC will not lift off the support rails inside the HSM-H module. The stresses induced in the DSC shell are conservatively evaluated to seismic accelerations of 1.5g horizontal and 1.0g vertical with the DSC assumed to be resting on a single support rail

inside the HSM-H. The stresses are combined with the deadweight and pressure load stresses and shown in Table P.3.7-10 and Table P.3.7-11 for the seismic evaluation of the -24PTH DSC shell assembly. Seismic loads on the 24PTH basket are enveloped by the 2.0g loads used for the on-site handling evaluation. Thus, specific evaluation for seismic loads is not necessary for the 24PTH basket assembly.

An equivalent static analysis of the HSM-H is performed using the ANSYS finite element model and seismic accelerations of 0.37g horizontally (both longitudinal and transverse directions) and 0.2g vertically. These amplified accelerations are determined based on the frequency analysis of the HSM-H module. The responses for each orthogonal direction are combined using the square root of the sum of the squares (SRSS) method. The seismic analysis results are incorporated in the loading combinations C4C and C4S for the concrete and support steel structure components, respectively, in Table P.3.7-16 and Table P.3.7-17. The applicant performed hand calculations to show the HSM-H module will not overturn or slide during the seismic event.

The effect of a seismic event occurring when a loaded DSC is resting inside the TC has been addressed previously in Section 8.2.3 of the FSAR. Because the weight of the -24PTH DSC is similar to the DSC weight used in Section 8.2.3, it is concluded that the TC/trailer with the -24PTH DSC will not be overturned due to seismic loading.

3.4.2.3 Flood

The design basis flooding load is specified as a 50-foot static head of water and a maximum flow velocity of 15 feet per second. Because the HSM-H is open to the atmosphere, static differential pressure due to flooding is not a design load. The maximum drag force acting on the HSM-H due to a 15-fps flood water velocity is calculated based on drag coefficient for a flat plate to be 8.07 kips/ft. Based on hand calculations, the application shows that the HSM-H will not overturn or slide by the flood water drag force. A minimum of two HSM-H modules adjacent to each other are required to prevent ovrturning.

The external pressure due to the postulated 50-foot flood height is calculated to be 21.7 psi. The DSC shell stresses for the postulated flood condition are determined by using the ANSYS analytical models. The 21.7 psig external pressure is applied to the model as a uniform pressure on the outer surfaces of the top cover plate, DSC shell and the bottom cover plate. The resulting stresses are shown to be considerablely less than the Service Level C allowable stresses. The DSC allowable external pressure is calculated to be 45 psi using the formula presented in NB-3133.3. Since the allowable pressure is more than two times the maximum pressure of 21.7 psi, the DSC shell will not buckle under the postulated 50-foot flood height.

3.4.2.4 Accidental TC Drop and Loss of Neutron Shield

A drop accident for the TC is unlikely but drop scenarios are developed and discussed in the application. The range of drop scenarios selected for evaluation are: (1) a horizontal side drop from a height of 80 inches (e.g., 75g horizontal drop) and (2) a vertical end drop of a maximum 60g impact load. An oblique corner drop is not specifically evaluated assuming the side drop and end drop cases will envelop the corner drop. An analysis has been performed in Section 8.2.5.2 of the FSAR to evaluate the OS197 and OS197H TCs for postulated horizontal and

vertical drop accidents with a static equivalent deceleration of 75g. The analysis was based on payload weights ranging from 97,250 lbs (OS197 TC) to 116,000 lbs (OS197H TC). The maximum total cask payload weight with a dry-loaded 24PTH DSC is approximately 94,000 lbs. Thus, a drop evaluation for an OS197FC TC loaded with the 24PTH DSC based on either the OS197 or OS197H TC drop analysis is acceptable because the 24PTH DSC payload weight is less than the analyzed weight. Loss of the neutron shield will result in increased doses at the independent spent fuel storage installation (ISFSI) boundary. However, it is shown in SAR Chapter P.11, Accident Analysis, that the dose increase is well within the acceptable limits of 10 CFR 72 for an accident condition. In addition, the peak stresses resulting from the accident thermal conditions are acceptable because fatigue is not a concern for the transfer cask.

The ANSYS analytical models of the DSC shell assembly as described in Section P.3.6.1.2 are used to determine the stresses in the shell assembly. Equivalent static analysis has been conservatively used for the drop analyses. Inertia loadings based on forces associated with the 75g deceleration (a horizontal side drop), and 60g (a vertical end drop) is statically applied to the models. The calculated stresses and the code allowable stresses are shown in Tables P.3.7-12 and P.3.7-13. The stress intensity ratios are less than 1.0 as shown in Table P.3.7-15. The stability of the DSC shell for a postulated vertical drop impact was evaluated by the applicant. The maximum shell axial stress in the 24PTH-S/L DSC shell obtained from the 60g end drop analysis is 8.86 ksi and the maximum shell axial stress for the 24PTH-S-LC DSC shell is 8.88 ksi. Because these stresses are less than the allowable stresses, it is concluded that the DSC shell assembly will not buckle for a 60g vertical deceleration load.

The three parts of the 24PTH DSC basket assembly stress evaluation are as follows:

1. Basket assembly horizontal drop stress analysis - which includes evaluation of the fuel compartment tube structure and transition rails using the LS-DYNA model described in Section P.3.6.1.3. Enveloping LS-DYNA stresses in each basket component are listed in Table P.3.7-5 for the postulated 75g horizontal side drop. Table P.3.7-5 includes a comparison of the calculated stresses to Service Level D stress allowable (i.e., ASME Section III, Appendix F, Subarticle F-1340.) As shown in Table P.3.7-5, all stress ratios are less than 1.0 with the highest stress ratio of 0.95 occurring in the R45 transition rail main plate.

2. Basket assembly horizontal drop stability evaluations - which use the LS-DYNA model described in Section P.3.7.4.3.3. The LS-DYNA stability analyses performed for the side drop conditions of the 24PTH basket assembly and the analysis results are summarized in Table P.3.7-7. These analysis results have shown the stability of basket structure under the postulated 75g side drop loading.

3. Basket assembly vertical drop analysis - which includes a stress evaluation of the fuel compartment tube structure and transition rails using hand calculations as described in Section P.3.6.1.3 for vertical deadweight. The stress criteria used for the vertical drop analysis also provides the assurance of structural stability.

3.4.2.5 Blockages of HSM-H Air Inlet and Outlet Openings

This accident conservatively postulates the complete blockage of the HSM-H ventilation air inlet and outlet openings on the HSM-H side walls. The structural consequences due to the weight of the debris blocking the vent openings are negligible and are bounded by postulated HSM-H loads such as the tornado winds or earthquake. The thermal effects of this accident for the HSM-H and the 24PTH DSC are presented in Section P.4. The temperatures determined in Section P.4 are used in the structural evaluation of 24PTH DSC.

The thermal test results conducted by the applicant have shown that the HSM-H concrete component temperature will exceed the ACI 349, A4.2 temperature limits. The applicant has assumed a 10% reduction of strength based on short term (i.e., approximately 40 hours) elevated temperature as defined in ACI 349, Section 9.3. However, in order to ensure that concrete capacity will not be adversely affected by the elevated temperatures, a condition has been placed in the CoC to require that HSM-H concrete tests be performed during fabrication to verify no significant signs of spalling or cracking and that the concrete compressive strength is greater than that assumed in the structural analysis of the HSM-H concrete components.

3.4.2.6 DSC Leakage and Accident Pressurization of DSC

The 24PTH DSC is leak tested to demonstrate it meets the leakage criteria of ANSI N14.5 and the DSC has been evaluated for internal pressures, which would bound the maximum accident pressures calculated in Section P.4.6. However, the applicant has stated that the analysis of the bounding internal pressure (i.e., 120 psig) for the DSC shell assembly will require both the outer and inner top lids acting together to minimize the primary stresses in the inner lid. The analysis results have shown that the DSC pressure boundary will not be breached by meeting the allowable stress criteria for normal, off-normal and accident conditions. Therefore, the 24PTH-DSC is acceptable for the postulated accident condition.

3.4.3 Load Combinations

Normal condition loads are presumed to exist during accident and/or extreme environment events. Thus, the stress intensities at various critical locations for the applicable normal operating condition loads are combined with the stress intensities experienced by the component during a postulated accident or extreme environment event.

3.4.3.1 DSC Load combinations

It is assumed that only one postulated accident event occurs at any given time. The DSC load combination is summarized in Table P.2-14 for the 24PTH DSC. Because the postulated cask drop accidents are by far the most critical, the load combinations for these events envelop all other accident event combinations. (See Table P.3.7-12 and Table P.3.7-13.)

3.4.3.2 TC Load Combinations

Table P.3.7-15 is a summary of OS197/OS197H/OS197FC TC stresses. The table incorporates the thermal stress analysis results for the TCs loaded with a 24PTH DSC. The stress results summarized in Table P.3.7-15 use the stresses due to mechanical loads for OS 197H as

summarized in SAR Chapter P.8. In addition, the allowable stresses have been adjusted for the higher temperatures associated with the TC loaded with a 24PTH DSC.

3.4.3.3 HSM-H Load Combinations

The required strength for critical sections of concrete is calculated in accordance with the requirements of ANSI 57.9 and Chapter 9 of ACI 349, including the strength reduction factors defined in ACI 349, Section 9.3. The load combinations described in Table P.3.7-16 are used to evaluate the reinforced concrete structural components.

A three dimensional ANSYS finite element model of the HSM-H, including all the concrete components, as shown in Figure P.3.7-11 was developed for the stress analysis. Included in the ANSYS concrete structure model is the steel support structure (e.g., rails and cross members) and a simplified beam model of the 24PTH DSC, as shown in Figure P.3.7-12. The ANSYS eight-node brick element (ANSYS element type SOLID73) was used to model the concrete structure. At least four layers of brick elements are used to model each concrete component thickness. The ultimate strength method of ACI 349 is used for the design of the HSM-H reinforced concrete structural components. The concrete design loads are multiplied by load factors and combined to simulate the most adverse loading conditions. Required reinforcement is provided to meet the minimum flexural and shear reinforcement requirements of ACI 349 and to ensure that the design capacity exceeds that required for the factored design loads specified in Table P.3.7-16.

The ultimate capacities of reinforced concrete components are presented in Table P.3.7-18. The individual accident load analysis results of the HSM-H concrete structure are presented in Table P.3.7-19. The comparison of load combination results and section capacities for each concrete component are presented in Table P.3.7-20. It is seen that all load combination results are below the computed section capacities.

3.5 Evaluation Findings

F3.1 The NUHOMS®-24PTH System is described in sufficient detail to enable an evaluation of its structural effectiveness and is designed to accommodate the combined loads of normal, off-normal, accident and natural phenomena events.

F3.2 The NUHOMS®-24PTH System is 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 -24PTH DSC that will prevent retrieval of the DSC.

F3.3 The NUHOMS®-24PTH System is designed and fabricated so that the spent fuel is maintained in a subcritical condition under credible conditions. The configuration of the stored spent fuel is unchanged. Additional criticality evaluations are discussed in Section 6 of this SER.

F3.4 The 24PTH DSC is evaluated to demonstrate that it has a redundant seal and that it will reasonably maintain confinement of radioactive material under normal, off-normal, and credible accident conditions.

F3.5 The NUHOMS®-24PTH System is evaluated and tested to demonstrate that the system has adequate heat removal capacity without active cooling system. Thermal evaluations are discussed in Section 4 of this SER

F.3.6 The SAR describes the materials that are used for structures, systems, and components (SSCs) important to safety and the suitability of those materials for their intended functions in sufficient detail to facilitate evaluation of their effectiveness.

F.3.7 The design of the DSC and the selection of materials adequately protects the spent fuel cladding against degradation that might otherwise lead to gross rupture.

F.3.8 The materials that comprise the DSC will maintain their mechanical properties during all conditions of operation.

F.3.9 The DSC employs materials that are compatible with wet and dry spent fuel loading and unloading operations and facilities. These materials are not expected to degrade over time, or react with one another, during any conditions of storage.

F3.10 The staff concludes that the structural design of the NUHOMS®-24PTH System is in compliance with 10 CFR Part 72 and that the applicable design and acceptance criteria have been satisfied. The structural evaluation provides reasonable assurance that the NUHOMS®-24PTH System will enable safe storage of spent fuel. This finding is based on a review that considered the regulations, appropriate regulatory guides, applicable industry codes and standards, accepted practice and confirmatory analysis.

3.6 Reference

1. Transnuclear, Inc., Final Safety Analysis Report (FSAR) for the Standardized NUHOMS® Horizontal Modular Storage System for Irradiated Nuclear Fuel, Revision 6, October 2001, USNRC Docket Number 72-1004.

4.0 THERMAL EVALUATION

The applicant is seeking approval of the use of the NUHOMS®-24PTH System for the storage of spent fuel. Five heat loading configurations and six basket types are proposed for the dry shielded canister (DSC). The proposed maximum heat load per DSC is 40.8 kW depending on the load configuration. There are also heat load limits per assembly. The applicant completed thermal analyses for the three bounding system configurations.

The new horizontal storage module (HSM-H), is a concrete structure that houses the DSC in a horizontal attitude for long-term storage and has been designed for the storage of spent fuel with high heat loads. The structure incorporates several thermal design variations to the original HSM design.

The objective of the thermal review is to ensure that the temperatures of the cask storage system components will remain within the allowable values for normal, off-normal and accident conditions. This objective includes confirmation that the temperatures of the fuel cladding will be maintained throughout the transfer and storage periods to protect the cladding against degradation which could lead to gross rupture. This review also confirms that the thermal designs of the DSC, TC and the HSM-H have been evaluated using acceptable analytical methods.

4.1 Spent Fuel

The NUHOMS®-24PTH System is designed to store up to 24 intact and/or reconstituted B&W 15x15, WE 17x17, CE 15x15, WE 15x15, CE 14x14, and WE 14x14 class fuel assemblies.

For the PWR fuel assemblies, the allowable temperature limits are based on Interim Staff Guidance -11 (ISG-11), "Cladding Considerations for the Transportation and Storage of Spent Fuel," Revision 2, (July 2002). For normal conditions (long-term) of storage and short-term fuel loading and storage operations (which includes welding of the canister lid and drying with an inert gas, backfilling with inert gas, and transfer of the cask to the storage pad), the temperature limit of the fuel cladding is maintained below 400EC. This is done 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. 2 for a discussion on hydride reorientation.) The applicant established a temperature limit of 570EC (1058EF) for off-normal and hypothetical accident conditions for Zircaloy-4 fuel cladding.

4.2 Cask System Thermal Design

4.2.1 Design Criteria

The design criteria for the 24PTH have been formulated by the applicant to assure that public health and safety will be protected during dry cask spent fuel storage. These design criteria cover the normal storage conditions for the 20-year approval period and postulated off-normal and accident conditions.

Section P.4.1 of the SAR defines several primary thermal design criteria for the system:

- Maximum DSC cavity internal pressures during normal, off-normal and accident conditions must be below the design pressures of 15, 20 and 120 psig, respectively.
- Maximum temperatures of the confinement structural components must not adversely affect the confinement function.
- The allowable cladding temperatures that are applicable for normal, off-normal and accident conditions of storage are taken directly from Interim Staff Guidance No. 11 (ISG-11), Revision 2.

The staff finds that the primary thermal design criteria have been sufficiently defined.

4.2.2 Design Features

To enhance heat rejection and shielding capability, the applicant designed the HSM-H with the following features:

- Use of optimized module internals for heat transfer by enhanced DSC support structure.
- Use of slotted plates and holes in the DSC support rails to increase airflow at the bottom portion of the canister.
- Use of increased module cavity height to increase the stack height and reduce the flow resistance in the cavity.
- Use of the finned side heat shield option at high heat loads to improve convective heat transfer .
- Use of a louvered top heat shield to minimize flow resistance.

To enhance heat rejection, the applicant included options for the DSC that include:

- Use of thick aluminum plates for uninterrupted radial conduction.
- 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.
- Use of aluminum and steel transition rails with aluminum inserts to transfer heat from the basket interior regions to the DSC shell.

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 to cool the DSC. Heated air exits through

vents in the top of the shield block, creating a stack effect.
The DSC cavity is backfilled with helium gas to aid removal of heat from the fuel assemblies and maintain an inert atmosphere.

A metal heat shield is placed around a major portion of the DSC to shield the HSM-H concrete surfaces above and to the side of the DSC from thermal radiation effects.

The staff verified that all methods of heat transfer internal and external to the system are passive. The SAR drawings and summary of material properties provide sufficient detail for the staff to perform an in-depth evaluation of the thermal performance of the system.

4.3 Thermal Load Specifications

SAR Section P.4.1 discusses the thermal loads. Three configurations with bounding heat loads are analyzed for steady state and transient cases for normal, off-normal and accident conditions. The staff reviewed these configurations and has reasonable assurance that the cases are bounding.

4.3.1 Storage and Transfer Conditions

The following tables provide the temperature and insolation conditions that the applicant applied in the thermal analyses.

Table 4-1
Ambient Temperatures

Condition	Temperature (EF)	24 Hour Average (EF)
Normal	0 to 100	
Off-Normal	-40 to 117	105
Accident	-40 to 117	

Table 4-2
Solar Insolation (BTU/hr-in^2)

HSM-H Surface	24 Hour Average Insolation
Roof	0.8537
Front	0.2134

The minimum storage conditions assume no solar insolation. Maximum and minimum daily temperatures are included in TS Section 4.4.3 as siting parameters that must be evaluated by the storage system user.

4.3.2 Accident Analyses

4.3.2.1 Blocked Vents

The complete blockage of the HSM-H ventilation inlet and outlet openings model is described in SAR Sections P.4.4.5 and P.4.8.4. The HSM-H and the DSC are evaluated for the ambient temperatures and insolation values outlined in Tables 4-1 and 4-2 above for accident conditions.

4.3.2.2 Transfer Cask Loss of Neutron Shield and Sunshade

The loss of water in the neutron shield annular region of the transfer cask, no fan convection, and a loss of the required sunshade during transfer operations at the extreme off-normal ambient temperature condition of 117°F (47.3°C) is postulated. This accident starts at steady state temperature conditions. The applicant developed a new model to evaluate the thermal performance of the TC. The model is described in SAR Section P.4.5. The staff reviewed this model and accepted it for the TC thermal analyses.

4.3.2.3 Fire

The third accident condition postulated by the applicant is a fire (SAR Section P.4.5.5.3) that occurs during transfer of the DSC to the HSM-H.

A 15-minute fire with an average flame temperature of 1475EF(800EC) is postulated to be caused by the spillage and ignition of 300 gallons of combustible transporter fuel. The assumed 15-minute duration for the transient evaluation is based on a calculated fire duration for this amount of fuel. The staff finds that this is a reasonable assumption.

Following the fire, the transfer cask is subjected to the prevailing maximum off-normal ambient conditions and a loss of the water neutron shield from the transfer cask is postulated. The analysis is continued to determine peak temperatures of cask components. The applicant states that the results of the fire accident analysis are bounded by the loss of neutron shield accident condition described above. Based on its review, the staff concludes that the thermal loads for the fire accident are acceptable and that the loss of neutron shield accident does bound this accident.

4.3.2.4 Cask Heatup During Loading

The applicant's description of the effects of loading and unloading conditions on the system is provided in SAR Section P.4.7. Three bounding loading conditions were evaluated by the applicant, including heat up of the DSC prior to blowdown, an analysis of heatup of the DSC during vacuum drying, and a steady state analysis of the canister after helium backfill. The applicant also analyzed the unloading condition of a reflood of the DSC.

For heatup of water in the DSC prior to blowdown, the DSC is evaluated for an initial DSC temperature of 215EF. DSC heat loads up to 40.8 kW were analyzed. The heatup analyses neglected radiation within the DSC.

For heatup of the DSC during vacuum drying, the DSC has been drained of water and filled with helium or air. The air and helium calculations used a three dimensional finite element model of the canister. The applicant completed both steady-state and transient analyses. An initial DSC shell temperature of 215EF and a maximum allowable DSC heat load of 40.8 kW were assumed for the analyses. Although portions of this analysis assume the cask is filled with air during vacuum drying and blowdown operations, its use is strictly limited to analysis purposes. Actual vacuum drying and blowdown operations will only be performed under inert gas conditions by using nitrogen or helium. Due to the similarity between the thermal properties of air and nitrogen, the calculations performed by the applicant using air are equally applicable for use of nitrogen.

The applicant also analyzed the effect of reflooding on the DSC during unloading operations. Limits placed on the flow rate of water into the DSC during this evolution will minimize thermal shock and prevent pressurization of the DSC above 20 psig.

The staff reviewed the analysis approach and found it acceptable.

4.4 Model Specification

4.4.1 Configuration

The applicant developed thermal models of the module and the DSC using the ANSYS finite element code. These models are described in SAR Sections P.4.4 and P.4.6, respectively.

4.4.1.1 HSM-H Model

The HSM-H model represents the entire module and DSC shell. The analysis for the HSM-H is performed for a loaded DSC located in the interior of a multiple cask array with a DSC present in two adjacent modules. The DSC internals are not modeled. Instead, a uniform heat flux is applied to the shell surface. The HSM-H top and front surfaces are exposed to prevailing ambient conditions, and the side and back surfaces are modeled as adiabatic to simulate adjacent modules.

4.4.1.2 DSC Basket Section/Fuel Assembly Model

The model is described in SAR Section P.4.6. The applicant developed a detailed full length one half cross section three dimensional model of the DSC basket assembly and fuel cross sections. The outer surface of the DSC is set to a specified temperature distribution determined from the HSM-H model. Each fuel region within the DSC is modeled as a solid with an effective thermal conductivity (described in SAR Section P.4.8).

4.4.1.3 DSC in Transfer Cask Model

This model is described in SAR Section P.4.5. The DSC thermal model is a full length one half cross section three dimensional model that includes the shell, top and bottom (but no internal structures). Computer codes are used to predict the DSC shell and TC temperatures. The maximum DSC shell temperatures are extracted from this model and used in the DSC basket analysis. Several TC alternatives are described in SAR Section P.4.5.

4.4.2 Material Properties

The material properties used in the thermal analysis of the storage cask system are listed in SAR Section P.4.2. The applicant provided a summary of the material compositions and thermal properties for all components used in the system. The material properties given reflect the accepted values of the thermal properties of the materials specified for the construction of the storage system. All material properties provided were within the operating temperature ranges of the storage system components. For homogenized materials such as the fuel assemblies, the applicant described the source from which the effective thermal properties were derived in SAR Section P.4.8.

4.4.3 Boundary Conditions

Boundary conditions were applied to the models described above to analyze the behavior of the systems under normal, off-normal, and accident conditions. The applicant analyzed the shell model of the DSC in the transfer cask and in the HSM-H to obtain shell temperatures for the DSC under all conditions. These shell temperatures were then used in the DSC basket/fuel assembly model to determine a maximum fuel cladding temperature for each set of conditions. Ambient temperature and insolation values were tabulated for all analyzed conditions (see Tables 4-1 and 4-2 above).

4.4.3.1 Accident Conditions - Blocked Vent

For the postulated blocked vent accident conditions (see SAR Section P.4.4.5), the finite element HSM-H model was modified to a transient model, and the inlet and outlet vents were blocked. No convection is considered in the HSM-H cavity, only air thermal conductivity is credited. The boundary conditions include the DSC off-normal condition temperature distribution before the postulated accident, the extreme off-normal ambient temperature of 117EF and maximum insolation.

4.4.3.2 Accident Conditions- Loss of Neutron Shield and Sunshade for Transfer Cask

The applicant completed transfer cask accident analyses for all bounding conditions using the model described in SAR Section P.4.5. The staff reviewed the analysis approaches and accepted them for this application.

4.4.3.3 Accident Conditions-Fire

The postulated fire accident conditions and the model of the DSC in the transfer cask are described in SAR Section P.4.6. The boundary conditions for the fire accident are described in Section 4.3.2.3 above. The boundary conditions include the DSC and transfer cask off-normal condition temperature distribution before the postulated fire and the maximum off-normal ambient conditions after the fire.

4.4.3.4 Cask Heatup Analysis

The cask heatup analysis is described in SAR Section P.4.7. Analysis details are provided in Section 4.3.2.4 above.

4.5 Thermal Analysis

4.5.1 Temperature Calculations

4.5.1.1 Storage Conditions

The system has been analyzed to determine the temperature distribution under long-term storage conditions that envelop normal, off-normal, and accident conditions. The DSC basket is considered to be loaded at design-basis maximum heat loads with PWR assemblies. The HSM-Hs are considered to be arranged in an ISFSI array and subjected to design-basis ambient conditions with insolation. The maximum predicted and allowable temperatures of the components important to safety are discussed in SAR Sections P.4.4 and P.4.6. Low temperature conditions were also considered. The calculated clad temperatures for fuel assemblies are listed in SAR Tables P.4-14, P.4-20 and P.4-25, for normal, off-normal, and accident conditions, respectively. The applicant's analysis of the fuel cladding temperatures for the maximum heat load of 40.8 kW (which bounds other heat loads) showed that the fuel cladding temperatures remain below their respective acceptable temperature limits. Table 4-3 below summarizes the maximum temperatures of key components in the cask for various environmental conditions.

Table 4-3
Maximum Temperatures (EF) of Key Components With 40.8 kW Heat Load

HSM-H Component	Normal Storage	Transfer	Blocked Vent Accident
Concrete	220	N/A	431
Top heat shield	202	N/A	375
Side heat shield	193	N/A	517
DSC shell	439	445	631
Fuel cladding	708	711	881

4.5.1.2 Accident Conditions- Blocked Vents

The blocked vent accident analysis is presented in SAR Section P.4.6.7.1. The analysis predicted the component and cladding temperatures for a 38.5 hour blockage. Results are presented in SAR Table P.4-5 (components) and Table P.4-25 (cladding).

The maximum concrete temperature reported was above the limit specified by the applicant. The applicant committed to testing the concrete used to fabricate the HSM-H. The testing will be conducted at an elevated temperature to demonstrate that the concrete will perform satisfactorily. The results for this accident analysis are summarized in Table 4-3 above. Based on this analysis, the staff finds reasonable assurance that the fuel cladding integrity and the confinement boundary will not be compromised during the blocked vent transient.

4.5.1.3 Accident Conditions- Loss of Neutron Shield and Sunshade for Transfer Cask

The applicant analyzed an accident involving loss of water from the annular neutron shield region of the transfer cask, no fan convection, and loss of required sunshade during the transfer of the DSC to the HSM-H. The temperatures reported by the applicant were below all material limits. The staff reviewed this analysis and accepted it for this application.

4.5.1.4 Accident Conditions - Fire

The applicant analyzed a fire accident for the DSC in the transfer cask using the methodology presented in SAR Section P.4.6.7.3. The initial temperatures for the fire analysis are based on the maximum transfer conditions. The peak temperatures of the key components due to a 15-minute fire with a 40.8 kW decay heat were below the short-term design-basis temperatures. Based on these analyses, the staff has reasonable assurance that the cladding integrity and the confinement boundary will not be compromised during the fire or post-fire transients.

4.5.1.5 Cask Heatup Analyses

SAR Section P.4.6 describes the DSC basket/fuel assembly three-dimensional model used to determine time limits (as a function of heat load) for blowdown and backfilling of the DSC with helium while it is in the TC. The results are documented in SAR Section P.4.7.

The same model was used for the thermal analysis of the vacuum drying process (see SAR Section P.4.7.1). Calculations were completed for air and helium gas mediums.

The staff reviewed these calculations and found reasonable assurance that the temperatures of the components of the DSC will remain within acceptable values.

4.5.2 Pressure Analysis

4.5.2.1 Storage/Off Normal/Accident Conditions

In SAR Section P.4.6.5.4, the applicant evaluated internal pressurization for normal conditions. The applicant assumed a fully loaded DSC. A 1% failure of fuel rods and control components is assumed. For the ruptured rods, a 100 % release of the rod fill gas and a 30 % release of the fission product gasses is postulated. Using the calculated temperatures for the basket and fuel cladding, the applicant used the ideal gas law to calculate the pressure. The applicant calculated a normal condition pressure of 7.1 psig, which is below the applicant's criteria of 15 psig for normal conditions.

In SAR Section P.4.6.6.6, the applicant evaluated the internal pressure of the DSC for off-normal conditions. The off-normal pressure calculation included an assumption of 10% failure of fuel rods and control components. For the ruptured rods, a 100% release of the rod fill gas and a 30% release of the fission product gasses is postulated. The maximum off-normal pressure calculated by the applicant was 13.7 psig.

In SAR Section P.4.6.7.5, the applicant evaluated the internal pressure of the DSC for accident conditions. The accident pressure calculation included a 100% failure of fuel rods and control

components. For the ruptured rods, a 100% release of the rod fill gas and a 30% release of the fission product gasses is postulated. The maximum accident pressure calculated by the applicant was 97.2 psig.

The staff reviewed the applicant's calculations and determined that the applicant used appropriate methods and cover gas temperatures for the analyses. The highest predicted pressure was 97.2 psig at a cavity gas temperature of 653EF for the accident condition, which is below the DSC thermal criteria pressure of 120 psig.

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.

4.5.2.2 Pressure During Unloading of Cask

Pressurization of the DSC is discussed in SAR Section P.4.7.3. Because the DSC is vented during reflood, a rapid pressure build-up is not a concern. The procedure for reflood assures that the flow rate of water into the relatively hot DSC is controlled to avoid exceeding the 20 psig design pressure for this condition.

4.5.2.3 Pressure During Loading of Cask

The applicant has technical specifications and procedures to ensure that the cask pressure remains below design limits.

4.5.3 Confirmatory Analyses

4.5.3.1 Analysis of DSC

The NRC staff and Pacific Northwest National Laboratory (PNNL) personnel completed confirmatory analyses of the performance of the DSC for a heat load of 40.8 kW. The staff used the ANSYS finite element code while PNNL used the COBRA-SFS finite difference thermal-hydraulics code (the COBRA-SFS code has been validated against data gathered from spent fuel assemblies stored at the Idaho National Engineering and Environmental Laboratory). The COBRA-SFS code utilized detailed fuel assembly models, while the ANSYS model used effective conductivity to predict maximum fuel cladding temperatures for different heat loads. The staff model conservatively ignored convection and radiation in the DSC. The results from these analyses were similar. Additionally, they were similar to the applicant's results. All three of the analyses used the same DSC surface temperature distribution boundary conditions, which are based on the HSM-H analysis. Therefore, the validity of the DSC analyses depends on the accuracy of the HSM-H analysis.

4.5.3.2 Analysis of HSM-H

The applicant's HSM-H analysis was described previously in Section 4.4.1.1 of this SER. The analysis utilizes the ANSYS finite element code with several stack effect calculations to characterize aspects of the flow thru the module (see SAR Section P.4.4.3). The staff expressed some concern about the accuracy of similar calculations in previous applications.

To address staff concerns and validate the analysis approach, the applicant conducted a series of tests on a full scale mockup of the HSM-H and DSC shell. These tests demonstrated that the methodology used to evaluate the thermal performance of the HSM-H conservatively overestimated the DSC surface temperatures, but underestimated the temperatures of significant portions of the concrete and heat shields.

The applicant evaluated these issues and modified the model to better predict component temperatures. In addition, the applicant recommended a limit on geometry changes to ensure that the final methodology could accurately predict the thermal characteristics of a modified HSM-H.

The staff reviewed the applicant's test protocols and results, and the modified HSM-H analysis. The staff found reasonable assurance that the final predictions provided conservative temperatures for the DSC shell and acceptable temperatures for the concrete and heat shields.

4.5.4 Conclusion

The staff accepts the applicant's thermal analyses for transfer and storage of fuel as stated in SAR Section P.4.

4.6 Evaluation Findings

F4.1 The staff finds that the thermal SSCs important to safety are described in sufficient detail in Sections P.1 and P.4 of the SAR to enable an evaluation of their effectiveness. Based on the applicant's analyses, there is reasonable assurance that the system is designed with a heat removal capability consistent with its importance to safety. The staff also finds that there is reasonable assurance that analyses of the systems demonstrate that the applicable design and acceptance criteria have been satisfied for the storage of the authorized fuel assemblies.

F4.2 The staff has reasonable assurance that the temperatures of the cask SSCs important to safety will remain within the predicted operating temperature ranges and that cask pressures under normal and accident conditions were determined correctly.

F4.3 The staff has reasonable assurance that the system provides adequate heat removal capacity without active cooling systems.

F4.4 The staff has reasonable assurance that the spent fuel cladding will be protected against degradation that leads to gross ruptures by maintaining the clad temperature below maximum allowable limits and by providing an inert environment in the cask cavity.

F4.5 The staff finds that the thermal design of the system is in compliance with 10 CFR Part 72, and that the applicable design and acceptance criteria have been satisfied. The evaluation of the thermal design provides reasonable assurance that the system will allow safe storage of spent fuel for a certified life of 20 years. This finding is reached on the basis of a review that considered the regulation itself, appropriate regulatory guides, applicable codes and standards, and accepted engineering practices.

5.0 SHIELDING EVALUATION

5.1 Shielding Design Description

The applicant performed a computer shielding analysis to evaluate the shielding effectiveness of the new NUHOMS®-24PTH System for incorporation into the Standardized NUHOMS® -24P System. The NUHOMS® System is a modular canister based spent fuel storage and transfer system that incorporates a new dual purpose Dry Shielded Canister (DSC) with three alternate configurations, a new 24PTH DSC basket design with two alternate options and three varying boron poison plate configurations, and a modified version of the Standardized Horizontal Storage Module (HSM) Model 102, HSM-H. The staff evaluated the proposed addition of these configurations based on information provided in the proposed SAR and the responses to the Request for Additional Information (RAI) questions against the regulatory requirements of 10 CFR Part 72.

The NUHOMS®-24PTH System is designed to store up to 24 intact PWR assemblies or up to 12 damaged and the balance intact PWR assemblies. The 24PTH-L and 24PTH-S-LC DSCs are also designed to store up to 24 intact standard PWR fuel assemblies with or without control components (CC), such as burnable poison rod assemblies (BPRAs), Control Rod Assemblies (CRAs), Thimble Plug Assemblies (TPAs), Axial Power Shaping Rod Assemblies (APSRAs), Orifice Rod Assemblies (ORAs), and Neutron Source Assemblies (NSAs). The 24PTH-S DSC does not store any CCs. Due to the additional gamma source from the CCs, the 24PTH-L bounds the 24PTH-S DSC for shielding purposes.

Dose rates for the 24PTH-L DSC are calculated within both a HSM Model 102 and a HSM-H. Dose rates are also provided for the 24PTH-S-LC within the HSM Model 102. Because the HSM-Model 102 provides less shielding than the HSM-H, and the dose rates bound this scenario, no estimates are made for the 24PTH-S-LC DSC contained in a HSM-H.

The transfer cask (TC) designs are essentially identical with the exception of the top lid. For the shielding analysis of the 24PTH-S and -L DSCs, the OS197FC TC bounds the OS197/OS197H TC.

The licensee makes a special point that while the B&W, CE, and Westinghouse fuel designs are specifically listed as authorized contents for the 24PTH DSC designs other future fuel types may be used provided that an analysis is performed to demonstrate that the limiting features bound the replacement fuel. Any additional fuel designs would need to be formally amended to this analysis.

5.2 Radiation Source Definition

The effect on dose rates of the various configurations of the NUHOMS®-24PTH System were performed for the authorized contents. The bounding fuel assembly was shown by the analysis to be the B&W 15x15 assembly for shielding purposes since it has the highest initial heavy metal loading and ^{59}Co content of the hardware regions as compared to the 14x14, other 15x15, and 17x17 fuel assemblies. The neutron source term is assumed to come from the spontaneous fission of ^{244}Cm since it represents more than 85% of the total neutron source, and for high burnups with short (<5 year) cooling times ^{244}Cm accounts for more than 94% of the total neutron source for all cases.

5.3 Shielding Model

The calculation of dose equivalent rates of the NUHOMS®-24PTH System were performed for the authorized contents under the various configurations listed in the amendment using MCNP4C2 code package with the ENDF/B-VI cross-section data. Sources were developed for all fuel regions using the source term data the licensee developed. As noted in TN's RAI response, dated July 6, 2004, there is no data currently available for fuels with burnups greater than 47 GWd/MTU and up to 62 GWd/MTU. However, the expected uncertainty in the neutron source is provided as ± 11% based on measured data comparisons for ^{244}Cm to SAS2H predictions using the 44-group ENDF/B-V data for burnups up to 46,460 MWd/MTU. For the gamma source term, the uncertainty is ± 5% for the gamma source and resulting dose rates and the basis. Based on these uncertainties, the neutron and gamma source terms are similar to those for fuels with burnups less than 45 GWd/MTU and appears to be conservative when compared to the actual measured values.

5.4 Shielding Analysis

The licensee calculated the dose rates at the surface and the areas surrounding the HSM-H, OS197FC TC, and the Standardized TC for both normal and hypothetical accident scenarios. MCNP4C2 was used to analyze the thick shields and account for streaming through both the HSM-H air vents and the cask/DSC annulus. Surface dose rates were not explicitly calculated for the HSM-Model 102 and were determined by scaling the results. For the modeled cases, bounding loading conditions were utilized in the calculations.

5.5 Evaluation Finding

F5.1 The staff confirmed the applicant's conclusion by reviewing the submitted calculations. Additionally, an independent review was conducted by generating source terms for the B&W 15x15 fuel using SAS2H from the SCALE 4.4a suite of computer codes. The staff's analysis was consistent with the applicant's conclusions. Based on the confirmatory review of the SAR and the licensee's RAI responses, the staff has reasonable assurance that the NUHOMS®-24PTH System as specified will meet the shielding requirements of 10 CFR Part 72.

6.0 CRITICALITY EVALUATION

6.1 Criticality Design

The staff performed a criticality safety review of the proposed amendment to incorporate the new NUHOMS®-24PTH System into the Standardized NUHOMS® System. The NUHOMS®-24PTH System is a modular canister based spent fuel storage and transfer system that incorporates a new dual purpose Dry Shielded Canister (DSC) with three alternate configurations, a new 24PTH DSC basket design with two alternate options and three varying boron poison plate configurations, and a modified version of the Standardized Horizontal Storage Module (HSM) Model 102, HSM-H. The staff evaluated the proposed addition of these configurations based on information provided in the SAR amendment against the regulatory requirements of 10 CFR Part 72.

6.2 Fuel Specification

The NUHOMS®-24PTH System is designed to store up to 24 intact PWR assemblies or up to 12 damaged and balance intact PWR assemblies. The fuel is limited to a maximum assembly average initial enrichment of 5.0 wt%. Criticality safety is ensured by fixed neutron absorbers in the basket, soluble boron in the pool and favorable basket geometry. No burnup credit is taken for spent fuel. The DSC basket uses borated aluminum, aluminum/B_4C metal matrix composite or Boral as its fixed neutron poison material.

6.3 Criticality Analysis

TN performed a comprehensive analysis to determine the most reactive contents allowed in the 24PTH DSC. The -24PTH-S is the most reactive design of the three canister types (-24PTH-S, -24PTH-L, and -24PTH-S-LC), since it contains the shortest "egg crate" section length. The "egg crate" is formed by the aluminum/borated aluminum plates surrounding each fuel compartment tube. The other two canister designs are bounded by the -24PTH-S since the amount of neutron poison per unit length is minimized.

The 24PTH DSC basket can be configured either with aluminum inserts in R45 transition rails (Type 1) or without the aluminum inserts (Type 2). Additionally, there are three varying levels of boron content in the basket poison plates, Type A for low B10, Type B for moderate B10, and Type C for high B10 content. These provide six different basket types, designated as Types 1A, 1B, 1C, 2A, 2B, and 2C.

6.4 Computer Programs

Analyses were performed by the licensee to encompass credible fuel configurations, including normal and hypothetical accident conditions to ensure that k_{eff} + 2σ # 0.95 was met for all analyzed configurations. The fuel may contain various enrichments of ^{235}U (up to a maximum of 5.0 wt%) as specified by fuel type in the CoC and is considered fresh (i.e., no burnup credit is taken) for all criticality calculations to maximize the potential reactivity of the fuel. The licensee used the SCALE 4.4 criticality sequence computer code package using the 44GROUPNDF5 cross-section library for fissile and shielding media in their calculations.

6.5 Benchmark Comparisons

The baseline case evaluated is for the B&W 15x15 Mark B-10 fuel assembly with an initial enrichment of 4.3 wt%, a poison plate loading of 13.5 mg B10/cm2 and a soluble boron concentration of 2500 ppm. This model was used to determine the most reactive fuel assembly for a given enrichment, the most reactive assembly-to-assembly pitch, and to determine the most reactive canister configuration accounting for all tolerances. Once the most reactive configuration was identified, the model was used to determine the maximum allowable initial enrichment for each assembly type as a function of the soluble boron concentration and basket type. Finally, the model was modified to capture the various damaged fuel configurations for each fuel assembly class and to determine the maximum number of damaged fuel assemblies per DSC and the maximum allowable initial enrichment for each assembly type as a function of the soluble boron concentration and fixed poison loading.

Based on the licensee's analysis, the most reactive credible configuration of the B&W Mark B-10 fuel assembly is an infinite array of flooded casks, each containing 24 fuel assemblies, with minimum fuel compartment tube ID, minimum basket structure thickness, and minimum assembly-to-assembly pitch. Calculations were also performed by the licensee to determine the relative reactivity of the various damaged fuel configurations for each fuel assembly class. The most reactive damaged fuel configuration is when the fuel rods are close to optimum pitch and all of the guide and instrument tube locations are replaced with fuel rods, yielding a maximum credible configuration of an array of flooded casks each containing up to 12 damaged fuel assemblies and the remaining intact assemblies with the same minimum measurements listed above. The licensee also evaluated the most reactive configurations identified for both intact and damaged fuel to determine the effect on reactivity due to the difference between the two "egg-crate" configurations.

6.6 Evaluation Findings

F6.1 The staff reviewed the submitted SAR revisions and the SCALE 4.4 code calculations and results supplied by the applicant and recognized that the applicant included conservatism in the modeling parameters for both normal and hypothetical accident conditions. In all instances, the models were consistent in their assumptions and the maximum calculated multiplication factors for actual basket contents were found to be below the 0.95 upper safety limit when the code biases and uncertainties were added, ensuring an adequate margin of safety.

F6.2 The staff performed confirmatory calculations of the normal and the most reactive damaged scenarios using the KENO V.a code and the 238GROUPNDF5 cross section set in the SCALE system of codes. The results of these confirmatory calculations were consistent with those performed by the applicant. In all instances, the calculated k_{eff} was found to be below the 0.95 limit when the code biases and uncertainties were added, ensuring an adequate margin of safety.

F6.3 Based on staff verification of the applicant's supporting analyses and system modeling, the staff finds the NUHOMS®-24PTH System and the modified HSM-H acceptable.

7.0 CONFINEMENT EVALUATION

The confinement review ensures that radiological releases to the environment will be within the limits established by the regulations and that the spent fuel cladding and fuel assemblies will be sufficiently protected during storage against degradation that might otherwise lead to gross ruptures. The staff reviewed the information provided in the SAR to determine whether the NUHOMS®-24PTH DSC System fulfills the following acceptance criteria:

- The design must adequately protect the spent fuel cladding against degradation that might otherwise lead to gross ruptures during storage, or the fuel must be confined through other means such that fuel degradation during storage will not pose operational safety problems with respect to removal of the fuel from storage. [10 CFR 72.122(h)(1)]

- The cask design must provide redundant sealing of the confinement boundary. [10 CFR 72.236(e)]

- Storage confinement systems must allow continuous monitoring, such that the licensee will be able to determine when to take corrective action to maintain safe storage condition. [10 CFR 72.122(h)(4)]

- The design must provide instrumentation and controls to monitor systems that are important to safety over anticipated ranges for normal and off-normal operations. In addition, the applicant must identify those control systems that must remain operational under accident conditions. [10 CFR 72.122(i)]

- SSCs important to safety must be designed to withstand the effects of credible accidents and severe natural phenomena without impairing their capability to perform safety functions. [10 CFR 72.122(b)]

7.1 Confinement Design Characteristics

The staff reviewed the applicant's confinement analyses in SAR Section P.7 and the drawings in SAR Section P.1. The applicant clearly identified the confinement boundary. The confinement boundary includes the stainless steel shell, bottom baseplate, top closure (including the vent and drain port), and the associated welds. There are no bolted closures or mechanical seals in the primary confinement boundary. The DSC is designed, fabricated, and tested in accordance with the applicable requirements of the ASME Code, Section III, Subsection NB, to the maximum extent practicable. Alternatives to the ASME Code, with respect to the confinement boundary, are identified in SAR Table P.3.1-1. The vent/siphon block has two penetrations for the vent and siphon ports which are closed with welded cover plates. The outer top cover plate provides redundant sealing of the confinement system. The system is designed and tested to be leaktight as defined by ANSI N14.5-1997. The outer top cover plate has an optional single penetration to leak test the closure welds. This is closed with a welded cover plate after testing to complete the redundant sealing of the confinement boundary. The welds forming the confinement boundary are described in detail in SAR Sections P.3.1.2.1 and P.7.1.3. The design, testing, inspection, and examination of the welds forming the confinement boundary are described in detail in SAR Section P.7.1.3.

The redundant closure of the DSCs satisfy the requirements of 10 CFR 72.236(e) for redundant sealing of confinement systems.

The applicant’s proposed procedures for drying and evacuating the cask interior during loading operations were reviewed by the staff to ensure that the design is acceptable for the pressures and temperatures that may be experienced during storage. The staff finds that this design, if fabricated and tested in accordance with the SAR requirements, will maintain the confinement boundary. Maintaining a stable vacuum pressure of 3 mm Hg for 30 minutes during vacuum drying provides reasonable assurance that the moisture content in the 24PTH DSCs will be acceptably low during its service life. The 24PTH DSC is designed to be leaktight and is tested to a leak rate of 1×10^{-7} atm cm^3/sec, as defined in ANSI N14.5-1997. This testing confirms that the amount of helium lost from the 24PTH DSC over the approved storage period is negligible. Thus, an adequate amount of helium will remain in the canister to maintain an inert atmosphere and to support the heat transfer during the storage period.

For normal storage conditions, the 24PTH DSC provides multiple confinement barriers for spent fuel assemblies to assure that the confinement system will reasonably maintain confinement of radioactive material. The canisters are backfilled with an inert gas (helium) to protect against cladding degradation. SAR Section P.3 indicates that all confinement boundary components are maintained within their code-allowable stress limits during normal storage conditions.

Welding and weld examinations are evaluated in Section 3.2.1.3 of this SER and include the following; multiple surface and volumetric examinations, pneumatic pressure testing, and leakage rate testing on the finished shell and the inner bottom cover plate at the fabricator; leakage rate testing of the closure welds (inner top cover plate and vent and siphon port cover plates) after loading the spent fuel; and multiple surface and dye penetrant examinations on the redundant confinement boundary.

The applicant described the canister inspection and test acceptance criteria in SAR Section P.9. The closure weld examination and acceptance criteria are included in Technical Specifications (TS) 1.2.4.a and 1.2.5 and have not changed from previously approved specifications in Amendment No. 7. The staff finds that this is acceptable provided that all NDE personnel, both at the fabricator facility and at the loading site, are qualified in accordance with applicable standards and codes such as SNT-TC-1A. This is a requirement of ASME Section V, Article 1, Paragraph T-140.

The staff verified the applicant’s analysis in SAR Section P.3.4 and evaluated any possible chemical and galvanic reactions in Section 3.2.1.7 of this SER and concluded that in this dry, inert environment, the DSC components are not expected to react with one another or with the cover gas. Further, oxidation, or corrosion, of the fuel and the DSC internal components will effectively be eliminated during storage and loading of the DSC.

The all-welded construction of the 24PTH DSCs with the redundant closure, extensive inspection and testing, ensures that no release of radioactive material for normal storage and on-site transfer will occur.

7.2 Confinement Monitoring Capability

For redundant seal welded closures, continuous monitoring of the closure is not necessary because there is no known plausible, long-term degradation mechanism which would cause the seal welds to fail. Periodic surveillance and monitoring of the storage module thermal performance, as well as the licensee's use of radiation monitors are adequate to ensure the continued effectiveness of the confinement boundary. The staff finds this adequate to enable the licensee to detect any closure degradation and take appropriate corrective actions to maintain safe storage conditions.

7.3 Nuclides with Potential Release

Since 24PTH DSCs are designed, fabricated, and tested to meet the leak tight criteria of ANSI N14.5-1997, there is no contribution to the radiological consequences due to a potential release of canister contents.

7.4 Confinement Analysis

The confinement boundary is welded and tested to meet the leak tight criteria of ANSI N14.5-1997 and is shown to maintain confinement during all normal, off-normal, and hypothetical accident conditions. Also, the temperature and pressure of the canister are within the design-basis limits. Therefore, no discernable leakage is credible. As discussed in Section 10 of this SER, the staff finds that the 24PTH DSCs meet the requirements of 10 CFR 72.104(a) and 10 CFR 72.106(b).

7.5 Maximum Pressure Loads

The calculated maximum design basis DSC internal pressures are discussed in SAR Section P.4. The maximum normal operating pressures for the 24PTH DSCs are summarized in SAR Table P.4-19 with a bounding case of 7.1 psig. The maximum normal operating design pressure is 15 psig. The maximum off-normal operating condition pressures are summarized in Table P.4-24 with a bounding case of 13.7 psig. The maximum off-normal design pressure is 20 psig. The maximum accident condition pressures are summarized in Table P.4-29 with bounding cases of 80.4 psig for the 24-PTH-S-LC and 97.2 psig for the 24-PTH-L. The maximum accident design pressure for these two canister configurations are 90 and 120 psig, respectively. For calculating the maximum internal pressures, the applicant assumed that control components were BPRA rods and used the number of BPRA rods from a B&W 15x15 assembly. The applicant assumed that 1% of the fuel or BPRA rods are damaged for normal conditions, up to 10% for off-normal conditions, and 100% following a design basis accident event. A minimum of 100% of the fill gas and 30% of the fission gases (e.g., H-3, Kr and Xe) within the ruptured fuel or BPRA rods are assumed to be available for release into the DSC cavity. The staff agrees with the assumptions used to calculate the maximum internal pressures.

7.6 Misloading

The staff concluded that a misloading or inadvertent placement of a fuel assembly with too high of a heat load in an incorrect location could potentially occur. As a result, the applicant included

additional administrative requirements to help minimize the possibility of a misloading occurring. These additional requirements are included as additional procedural checks in SAR Section P.8.1.2 and to ensure that the probability for misloading of a damaged or intact assembly or control component (if applicable) is essentially eliminated.

7.7 Evaluation Findings

F7.1 Section P.7 of the SAR describes confinement structures, systems, and components important to safety in sufficient detail to permit evaluation of their effectiveness.

F7.2 The design of the 24PTH DSC adequately protects the spent fuel cladding against degradation that might otherwise lead to gross ruptures. Section 4 of the SER discusses the relevant temperature considerations.

F7.3 The design of the 24PTH DSC provides redundant sealing of the confinement system closure joints using dual welds on the canister lid and closure.

F7.4 The 24PTH DSC has no bolted closures or mechanical seals. The confinement boundary contains no external penetrations for pressure monitoring or overpressure protection. No instrumentation is required to remain operational under accident conditions. Because the 24PTH DSC uses an entirely welded redundant closure system, no direct monitoring of the closure is required.

F7.5 The confinement system is leaktight for normal conditions and anticipated occurrences, thus the confinement system will reasonably maintain confinement of radioactive material. Section 10 of the SER shows that the direct dose from the 24PTH DSC satisfies the regulatory requirements of 10 CFR 72.104(a) and 10 CFR 72.106(b).

F7.6 The confinement system has been evaluated by analysis. Based on successful completion of specified leakage tests and examination procedures, the staff concludes that the confinement system will reasonably maintain confinement of radioactive material under normal, off-normal, and credible accident conditions.

F7.7 The staff concludes that the design of the confinement system of the 24PTH DSC is in compliance with 10 CFR Part 72 and that the applicable design and acceptance criteria have been satisfied. The evaluation of the confinement system design provides reasonable assurance that the 24PTH DSC will allow safe storage of spent fuel. This finding 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.

8.0 OPERATING PROCEDURES

The review of the technical bases for the operating procedures is to ensure that the applicant's SAR presents acceptable operating sequences, guidance, and generic procedures for key operations. The procedures for the 24PTH DSC, as described in Section P.8.1 of the SAR are very similar to those previously approved by the staff for the Standardized NUHOMS® System (Ref. 1).

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 24PTH DSC to identify any damage that may have occurred since receipt inspection.

8.1.1 Fuel Specifications

The procedures described in SAR Section P.8.1.2 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 24PTH DSC. It outlines appropriate procedural and administrative controls to preclude a cask misloading.

8.1.2 ALARA

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

8.1.3 Draining, Drying, Filling and Pressurization

SAR Section P.8.1.3 describes draining, drying, filling and pressurization procedures for the 24PTH DSC. 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. The procedures for DCS cavity boron concentration during filling (TS1.2.15c) and DCS vacuum drying time (TS1.2.17c) are specific to the 24PTH design. Sealing operations for dye penetrant testing of the closure welds are performed in accordance with TS 1.2.5.

8.1.4 Welding and Sealing

Welding and sealing operations of the 24PTH DSC are similar to that 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 by TS 1.2.4a for the 24PTH DSC demonstrate that the inner top cover plate is “leak tight” as defined by ANSI N14.5 - 1997 (Ref. 2). Sealing operations invoke TS 1.2.5 for dye penetrant testing of the closure welds.

8.2 Cask Handling and Storage Operations

All handling and transportation events applicable to moving the DSC to the storage location are the same as those previously reviewed by the staff for the Standardized NUHOMS® System and are bounded by Section P.11 of the SAR. 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 Section P.10 of the SAR. 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.

Section P.8 provides the same unloading procedures as those previously approved by the staff for use with the Standardized NUHOMS® System. The procedures provide a caution on reflooding the DSC to ensure that the vent pressure does not exceed 20 psig to prevent damage to the canister.

Section P.8 provides a discussion of ALARA practices that should be implemented during unloading operations; however, detailed procedures incorporating provisions to mitigate the possibility of fuel crud particulate dispersal and fission gas release must be developed by each user.

8.4 Evaluation Findings

F8.1 The 24PTH DSC is compatible with wet loading and unloading. General procedure descriptions for these operations are summarized in Section P.8 of the applicant's SAR. Detailed procedures will need to be developed and evaluated on a site-specific basis.

F8.2 The welded cover plates of the canister allow ready retrieval of the spent fuel for further processing or disposal as required.

F8.3 The DSC geometry and general operating procedures facilitate decontamination. Only routine decontamination will be necessary after the cask is removed from the spent fuel pool.

F8.4 No significant radioactive waste is generated during operations associated with the independent spent fuel storage installation (ISFSI). Contaminated water from the spent fuel pool will be governed by the 10 CFR Part 50 license.

F8.5 No significant radioactive effluents are produced during storage. Any radioactive effluents generated during the cask loading will be governed by the 10 CFR Part 50 license.

F8.6 The technical bases for the general operating procedures described in the SAR are adequate to protect health and minimize danger to life and property. Detailed procedures will need to be developed and evaluated on a site-specific basis.

F8.7 Section 10 of the SER assesses the operational restrictions to meet the limits of 10 CFR Part 20. Additional site-specific restrictions may also be established by the site licensee.

F8.8 The staff concludes that the generic procedures and guidance for the operation of the 24PTH DSC are in compliance with 10 CFR Part 72 and that the applicable acceptance criteria have been satisfied. The evaluation of the operating procedure descriptions provided in the SAR offers reasonable assurance that the cask will enable safe storage of spent fuel. This finding is based on a review that considered the regulations, appropriate regulatory guides, applicable codes and standards, and accepted practices.

8.5 References

1. Transnuclear, Final Safety Analysis Report of the Standardized NUHOMS® Modular Storage System for Irradiated Nuclear Fuel, June 2004, Revision 8.

2. ANSI N14.5-1997, “Radioactive Materials - Leakage Tests on Packages for Shipment.”

9.0 ACCEPTANCE TEST AND MAINTENANCE PROGRAMS

9.1 Acceptance Tests

All materials and components will be procured with certification and supporting documentation to assure compliance with procurement specifications and receipt inspected for visual and dimensional traceability.

9.1.1 Visual and Nondestructive Examination Inspections

The DSC confinement boundary is fabricated and inspected in accordance with ASME Code Section III, Subsection NB to the extent possible. Alternatives to the ASME Code are identified in Chapter 3 of the SAR and include: (1) partial penetration welds of the top outer and inner cover plates of the containment shell joints (Note- this alternative does not apply to other shell confinement welds, i.e., the longitudinal and circumferential welds applied to the DSC shell, and the inner bottom plate cover plate-to-shell weld, which comply with ASME Code, Section III, Subsection NB-4243 and NB-5230), and (2) root and final layer surface liquid penetrant examination of the top outer and inner cover plates of the containment shell welds. The staff reviewed these alternatives, and the corresponding justifications, and found them to be acceptable.

The nondestructive examination (NDE) of weldments is well characterized in the License Drawings and discussed in Sections P.3.1.2.1 and P.9.1.2 of the SAR. Standard NDE symbols and/or notations are used in accordance with AWS 2.4, “Standard Symbols for Welding, Brazing, and Nondestructive Examination.” Fabrication inspection include visual (VT), liquid penetrant (PT), ultrasonic (UT), and radiographic (RT) examinations, as applicable.

9.1.2 Leakage Testing

The 24PTH DSC is designed to be leaktight and is tested to a leak rate of 1×10^{-7} atm cm^3/sec, as defined in ANSI N14.5-1997. The confinement boundary testing includes leakage rate testing on the finished shell and the inner bottom cover plate at the fabricator and leakage rate testing of the closure welds (inner top cover plate and vent and siphon port cover plates) after loading the spent fuel. The staff finds that this is acceptable provided that all personnel performing leak rate testing, both at the fabricator and at the loading site, are qualified in accordance with applicable standards and codes such as SNT-TC-1A.

9.1.3 Neutron Absorber Tests

There are four neutron absorbers (also called poisons) used in the 24PTH DSC basket. They are Boral, borated aluminum, BorAlyn, and Metamic. BorAlyn and Metamic are considered metal Matrix Composites (MMCs).

9.1.4 Qualification Tests

The applicant submitted procedures for qualifying a Metal Matrix Composite for major and minor processing changes.

Major processing changes, such as billet formation by processes other than hot vacuum pressing or CIP/vacuum sintering, or direct rolling of the billet shall be subject to testing. Testing shall include exposure of the absorber to a radiation field to assess the effects of radiolysis, exposure of the absorber material to the full range of service temperatures, and immersion of the fabricated absorber in pool water to simulate the cask environment during loading. Other examples of major processing changes are discussed in Section P.9.1.7.2.2 of the SAR.

Minor process changes that do not have an adverse effect on the particle bonding, microstructure or uniformity of the B_4C particle distribution may be accepted by engineering review. Section P.9.1.7.2.2 discusses these changes.

The staff concluded that the testing for major and minor processing changes will ensure the acceptability and durability of the resulting neutron absorber product over the licensed service life.

9.1.5 Acceptance Testing

Sample coupons from plates are evaluated using chemical analysis and/or neutron attenuation techniques to verify presence, proper distribution, and minimum ^{10}B content as described in Section P.9.1.7 of the SAR. The minimum allowable ^{10}B content are provided in Table P.9-1 of the SAR. Any panel with a ^{10}B loading less than the minimum allowed will be rejected if the acceptance criteria described in SAR P.9.1.7.2.1 are not met.

The staff's acceptance of the neutron absorber test described above is based, in part, on the fact that the criticality analyses assumed only 75% of the minimum required ^{10}B content of the Boral and 90% of the minimum required ^{10}B content of the borated aluminum, BorAlyn, and Metamic.

Installation of the neutron absorber plates on the fuel basket shall be performed in accordance with written and approved procedures. Quality control procedures shall be in place to ensure that the basket tube walls contain neutron absorber plates (i.e., Boral, borated aluminum, BorAlyn, or Metamic) as specified in the SAR Section P.1.5 drawings.

The staff concludes that the acceptance tests are adequate for verifying the presence, proper distribution, and minimum ^{10}B content in the absorber.

9.1.6 Visual Examination

The applicant has also committed to performing dimensional measurements (e.g., plate thickness) and visual examination of the material for evidence of defects such as cracks, porosity, blisters, or foreign inclusions.

9.2 Evaluation Findings

F9.1 The staff concludes that the acceptance tests for the 24PTH DSC system are in compliance with 10 CFR Part 72 and that the applicable acceptance criteria have been satisfied. The evaluation of the acceptance tests and maintenance program provides

reasonable assurance that the cask will allow safe storage of spent fuel throughout its licensed or certified term. 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.

9.3 Reference

1. ANSI N14.5-1997, “American National Standard for Radioactive Materials - Leakage Tests on Packages for Shipment.”

10.0 RADIATION PROTECTION REVIEW

The staff reviewed the radiation protection design features of the NUHOMS®-24PTH system, which will be used with the HSM-H and HSM Model 102 to ensure that the cask will meet the regulatory dose requirements of 10 CFR Part 20, 10 CFR 72.104(a), 10 CFR 72.106(b), 10 CFR 72.212(b), and 10 CFR 72.236(d). This amendment was also reviewed to determine whether the cask fulfills the acceptance criteria listed in Chapter 10 of NUREG-1536, Standard Review Plan for Dry Cask Storage Systems. The staff's conclusions are based on information provided in the proposed Amendment No. 8 SAR.

10.1 Radiation Protection Design Criteria and Design Features

The radiological protection design criteria are the limits and requirements of 10 CFR Part 20, 10 CFR 72.104, and 10 CFR 72.106. 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 staff evaluated the radiation protection design features and design criteria for the NUHOMS®-24PTH system and found them acceptable. The SAR analysis provides reasonable assurance that use of the system can meet the regulatory requirements in 10 CFR Part 20, 10 CFR 72.104(a), and 10 CFR 72.106(b). Other sections of the SER discuss staff's evaluations of the shielding features, confinement systems, and operating procedures.

10.2 Occupational Exposures

Table P.10-1 of the SAR amendment shows the estimated number of personnel, the estimated time, the estimated dose rates, the tasks involved, and the estimated dose to load one design basis -24PTH-L DSC in a HSM-H. The loading operations are identical for the -24PTH-S and -24PTH-S LC DSC. The estimated occupational doses are based on estimations from the direct radiation calculations in SAR Section P.5.4 and on operational experience. The dose estimates indicate that the total occupational dose in loading a single canister with design basis fuel into the HSM is approximately 4.4 person-rem for the -24PTH-L canister and bounds the expected dose for the -24PTH-S and -24PTH-S-LC canisters. The applicant indicated that the general licensees may choose to modify the sequence of operations, and will also use ALARA practices to mitigate occupational exposure.

10.3 Public Exposures Normal and Off-Normal Conditions

SAR Section P.10.2 presents the calculated direct off-site radiation dose rates at various distances ranging from 6.1 to 600 meters from each face of a sample cask array configuration loaded with 24 design basis fuel assemblies for Configuration 2 (see Tables P.10-2 and -3) for the -24PTH-L DSC within a HSM-H and the -24PTH-S-LC DSC within a HSM-Model 102, respectively, for both front and back cask array configurations. The included tables in Section P.10 specify distances at which the regulatory design limit of 25 mrem/yr can be achieved and indicate that arrays loaded with design basis fuel and placed in the two HSM designs are below regulatory limits at approximately 400 meters for most arrays, depending on the specific configuration. This assumes 100% occupancy for 365 days.

The staff evaluated the public dose estimates during normal and off-normal conditions and found them acceptable. The primary dose pathway to individuals beyond the controlled area during normal and off-normal conditions is from direct radiation (including skyshine). The canister is leaktight and the confinement function is not affected by normal or off-normal conditions; therefore, no discernable leakage is credible. A discussion of the staff's evaluation and confirmatory analysis of the shielding calculations are presented in this SER. The staff has reasonable assurance that compliance with 10 CFR 72.104(a) can be achieved by each general licensee. The general licensee using the 24PTH DSC with the HSM must perform a site-specific evaluation, as required by 10 CFR 72.212(b) to demonstrate compliance with 10 CFR 72.104(a). 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 use of engineered features (e.g., berm). In addition, the dose limits in 10 CFR 72.104(a) include 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 each site license.

The 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 in 10 CFR Part 20, Subpart D by evaluations and measurements.

10.4 ALARA

The ALARA objectives, procedures, practices, and policies are referenced in Section P.10 of the SAR amendment and the previously approved FSAR. The ALARA objectives, procedures, practices, and policies of the NUHOMS®-24PTH system are the same as those previously approved. Each licensee will apply its additional site-specific ALARA objectives, policies, procedures, and practices for members of the public and personnel.

The staff evaluated the ALARA assessment of the 24PTH/HSM-H 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, as appropriate. Operational ALARA policies, procedures, and practices are the responsibility of the site licensee as required by 10 CFR Part 20.

10.5 Evaluation Findings

F10.1 The SAR amendment sufficiently describes the radiation protection design bases and design criteria for the structures, systems, and components 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.

F10.3 The SAR amendment sufficiently describes the means for controlling and limiting occupational exposures within the dose and ALARA requirements of 10 CFR Part 20.

F10.4 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 licensee. The 24PTH DSC is designed to assist in meeting these requirements.

F10.5 The staff concludes that the design of the radiation protection system of the NUHOMS®-24PTH system 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 24PTH 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.

11.0 ACCIDENT ANALYSIS EVALUATION

11.1 Dose Limits for Off-Normal Events

SAR Section P.11.1.4 examines the dose consequences for the identified off-normal events. The 24PTH DSC is tested leaktight in accordance with ANSI N14.5 and there will be no breach of the confinement boundary due to off normal conditions. The off-normal radiation conditions are the same as normal conditions analyzed in Chapter P.5 and P.10 of the SAR amendment.

The staff reviewed the consequences of postulated off-normal events with respect to 10 CFR 72.104(a) dose limits, and found them acceptable. The radiation consequences from off-normal events are the same as for normal conditions of operation. The staff has reasonable assurance that the dose to any individual beyond the controlled area will not exceed the limits in 10 CFR 72.104(a) during off-normal conditions (anticipated occurrences). Sections 5, 7, and 10 of this SER further evaluate the radiological doses applicable to off-normal events.

11.2 Dose Limits for Design-Basis Accidents and Natural Phenomena Events

Section 11.2 of the SAR amendment examines the dose consequences for the identified design-basis accidents and natural phenomena events. The 24PTH DSC is tested leaktight in accordance with ANSI N14.5 and there will be no breach of the confinement boundary due to accident conditions.

The staff reviewed the design-basis accident analyses with respect to 10 CFR 72.106(b) dose limits and found them acceptable. The staff has reasonable assurance that the dose to any individual at or beyond the controlled area boundary of 100 meters will not exceed the limits in 10 CFR 72.106(b). Chapters 5, 7, and 10 of the SER further evaluate the estimated radiological doses during accident conditions.

12.0 CONDITIONS FOR CASK USE - TECHNICAL SPECIFICATIONS

The purpose of the review of the technical specifications for the cask is to determine whether the applicant has assigned specific controls to ensure that the design basis of the cask system is maintained during loading, storage, and unloading operations.

12.1 Conditions for Use

The conditions for use of the 24PTH DSC, in conjunction with the Standardized NUHOMS® Storage System, are clearly defined in the CoC and TS.

12.2 Technical Specifications

Based on the addition of the NUHOMS®-24PTH system to the Standardized NUHOMS® Storage System, the TS have been revised to accommodate the new DSC and the fuel types to be stored in the DSC. These changes have been identified in the TS attachment to the CoC.

Table 12-1 lists the TS for use of the NUHOMS®-24PTH system, in concert with the Standardized NUHOMS® Storage System.

12.3 Evaluation of Findings

F12.1 Table 12-1 of this SER lists the TS for the NUHOMS®-24PTH System, 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®-24PTH System, 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.

Table 12-1

Standardized NUHOMS® Horizontal Modular Storage System Technical Specifications for use with the NUHOMS®-24PTH System

13.0 QUALITY ASSURANCE

The purpose of this review and evaluation is to determine whether TN has a quality assurance program that complies with the requirements of 10 CFR Part 20, Subpart G. The staff has previously reviewed and accepted the TN quality assurance program in the Standardized NUHOMS® Horizontal Modular Storage System FSAR.

14.0 DECOMMISSIONING

The decommissioning evaluation was previously reviewed and approved in the Standardized NUHOMS® Horizontal Modular Storage System FSAR. There were no changes proposed by the applicant in the addition of the NUHOMS®-24PTH system.

CONCLUSION

The NRC staff has performed a comprehensive review of the CoC amendment request and found that the addition of the NUHOMS®-24PTH system does not reduce the safety margin for the Standardized NUHOMS® System. The areas of review addressed in NUREG-1536, "Standard Review Plan for Dry Cask Storage Systems," January 1997, are consistent with the applicant's proposed changes. The Certificate of Compliance has been revised to include the TN requested changes. Based on the statements and representations contained in TN's application, as supplemented, the staff concludes that the addition of the NUHOMS®-24PTH system to the approved contents of the Standardized NUHOMS® System meets the requirements of 10 CFR Part 72.

Issued with Certificate of Compliance No. 1004, Amendment No. 8 on December 5, 2005 .