TRANSNUCLEAR
AN AREVA COMPANY

October 13, 2005
E-22911

Mr.Joe Sebrosky
Spent Fuel Project Office, NMSS
U S Nuclear Regulatory Commission
11555 Rockville Pike MIS 0-6-F-18
Rockville, MD 20852

Subject: TN Review Comments on the Preliminary Certificate of Compliance 1030 and Preliminary Safety Evaluation Report for the NUHOMS® HD Storage System, Docket No 72-01030 (TAC No L23738).

Reference: Preliminary Certificate of Compliance and Safety Evaluation Report for the NUHOMS® HD System, (TAC No. L23738), dated October 3, 2005.

Dear Mr. Sebrosky:

Enclosed herewith is a marked up copy of the reference documents which reflects TN's review comments. Please note that only those pages with comments have been included herewith.

Should you or your staff require additional information to support review of this application, please do not hesitate to contact me at 410-910-6881 or Mr. U.B. Chopra at 510.744.6053.

Sincerely,

Jayant Bondre

Jayant Bondre, Ph.D
Engineering and Licensing Manager

Docket 72-1030

Enclosures: As stated

1.

b. Description (continued)

The principal component subassemblies of the DSC are the shell with integral bottom cover plate and shield plug and ram/grapple ring, top shield plug, top cover plate, and basket assembly. The 32PTH DSC basket consists of stainless steel square tubes and support strips for structural support, and geometry control; and aluminum/borated aluminum for heat transfer and criticality control. This assembly is designed to hold 32 PWR fuel assemblies. The DSC is designed to slide from the transfer cask into the HSM-H and back without damage to the sliding surfaces.

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The HSM-H is a reinforced concrete unit with penetrations located at the top and bottom of the side walls for air flow. The penetrations are protected from debris intrusions by wire mesh screens during storage operation. The HSM-H has heat shields that provide thermal protection for the HSM-H concrete. The DSC Support Structure, a structural steel frame with rails, is installed within the HSM-H module to provide for sliding the DSC in and out of the HSM-H and to support the DSC within the HSM-H. HSM-Hs are arranged in arrays to minimize space and maximize self-shielding.

The TC is designed and fabricated as a lifting device to meet ANSI N14.6 criteria. It is used for transfer operations within the spent fuel pool building and for transfer operations to/from the HSM-H. The TC is a cylindrical vessel with a bottom end closure assembly and a bolted top cover plate. Two upper lifting trunnions are located near the top of the cask for downending/uprighting and lifting of the cask in the spent fuel pool building. The lower trunnions, located near the base of the cask, serve as the axis of rotation during downending/uprighting operations and as supports during transport to/from the Independent Spent Fuel Storage Installation (ISFSI).

With the exception of the TC, fuel transfer and auxiliary equipment necessary for ISFSI operations are not included as part of the NUHOMS® HD System referenced in this Certificate of Compliance (CoC).

c. Drawings

The drawings for the NUHOMS® HD System are contained in Section 1 of the SAR.

d. Basic Components

The basic components of the NUHOMS® HD System that are important to safety are the DSC, HSM-H, and TC. These components are described in Section 2.5 and Table 2-5 of the SAR.

2. OPERATING PROCEDURES

Written operating procedures shall be prepared for cask handling, loading, movement, surveillance, and maintenance. The user's site-specific written operating procedures shall be consistent with the technical basis described in Chapter 8 of the SAR.

TN comments on the
preliminary SER.

PRELIMINARY SAFETY EVALUATION REPORT

TRANSNUCLEAR INC.,

NUHOMS® HD HORIZONTAL MODULAR STORAGE SYSTEM FOR IRRADIATED NUCLEAR FUEL

DOCKET NO. 72-1030

TRANSNUCLEAR
NUHOMS® HD
HORIZONTAL MODULAR
STORAGE SYSTEM
FOR IRRADIATED NUCLEAR FUEL

DOCKET NO. 72-1030
MODEL NO. NUHOMS® HD
TRANSNUCLEAR, INC.
CERTIFICATE OF COMPLIANCE NO. 1030

SUMMARY

By letter dated May 5, 2004, Transnuclear, Inc. (TN) submitted an application to the U.S. Nuclear Regulatory Commission to obtain a Certificate of Compliance for the NUHOMS® HD System. The staff performed a detailed safety evaluation of the application which is documented in this safety evaluation report (SER). The staff's evaluation and conclusions regarding the acceptability of the NUHOMS® HD System are based on information submitted by TN on May 5, 2004, as supplemented. The staff determined that the NUHOMS® HD System meets the requirements of 10 CFR Part 72.

1.0 GENERAL DESCRIPTION

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

1.1 General Description and Operations Features

The NUHOMS® HD System is based on the Standardized NUHOMS® System described in Certificate of Compliance (CoC) No. 1004. The 32PTH dry shielded canister (DSC) included in this system is similar to the 24PTH DSC submitted for licensing as Amendment No. 8 to the Standard NUHOMS® System.
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The 32PTH DSC will be transferred during loading operations using ~~the~~ OS-187H transfer cask (TC). The OS-187H TC is very similar to the OS-197 and OS-197H TCs described in the final safety analysis report (FSAR) for the Standard NUHOMS® Storage System. The OS-187H TC has a slightly larger diameter and closure containing seals than the OS-197 TC. The 32PTH DSC will be stored in a horizontal storage module (HSM-H). The HSM-H is virtually identical to the HSM-H submitted for licensing as Amendment 8 to the Standard NUHOMS® System.
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1.1.1 Dry Shielded Canister (32PTH DSC)

The 32PTH DSC is designed for a maximum heat load of 34.8 kW. The 32PTH DSC is designed to store ~~up~~ to 32 intact pressurized water reactor (PWR) Combustion Engineering 14x14 (CE 14x14), Westinghouse 15x15 (WE 15x15), Westinghouse 17x17 (WE 17x17), and/or
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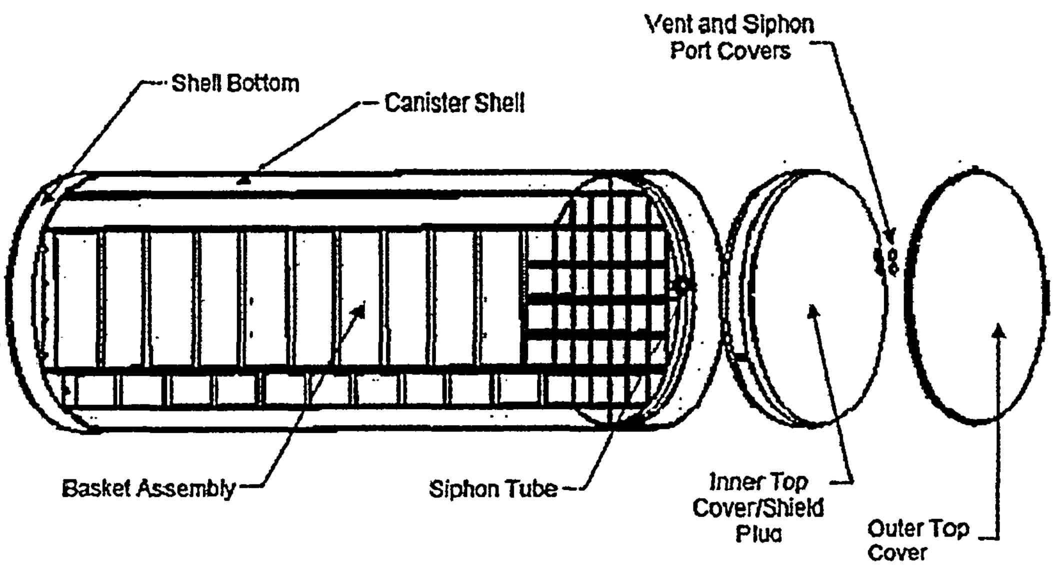
Framatome ANP Advanced MK BW 17x17 fuel assemblies (Fr 17x17) with or without non-fuel assembly hardware (NFAH) like Vibration Suppressor Inserts (VSI), Burnable Poison Rod Assemblies (BPRAs), or Thimble Plug Assemblies (TPAs). The 32PTH DSC is also designed for storage of up to 16 damaged fuel assemblies, and remaining intact assemblies.

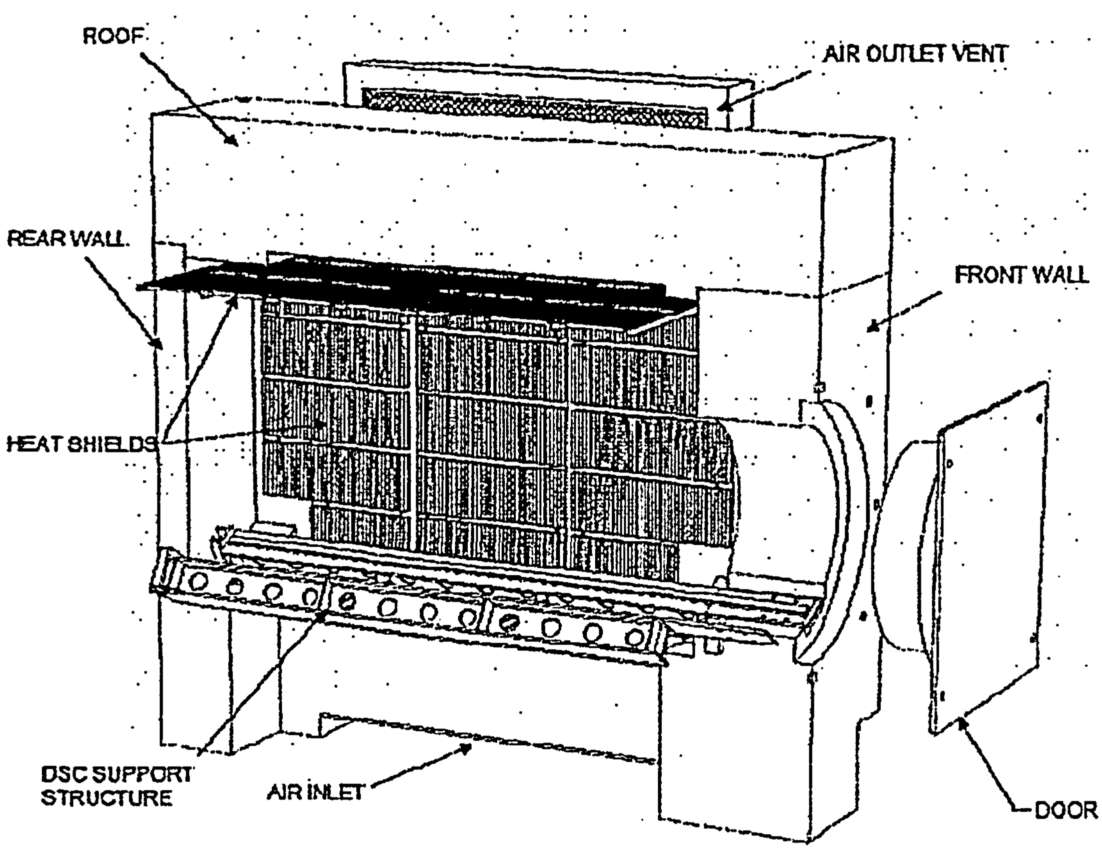
inner top cover/shield plug

The ~~32PTH~~ DSC consists of a stainless steel cylindrical shell with welded ~~top~~ and bottom cover plates which form the confinement boundary. Shield plugs are installed inside of the confinement boundary, at the top and bottom, to provide radiological shielding. Inside of the 32PTH-DSC is a basket assembly that consists of stainless steel square tubes and support strips for structural support, and geometry control; and aluminum/borated aluminum for heat transfer and criticality control. The 32PTH DSC is very similar to the 24PTH DSC.



1.1.2 Horizontal Storage Module (HSM-H)

The HSM-H is constructed of reinforced concrete and structural steel. The key design parameters of the HSM-H are provided in Table 1-1 of the SAR. The HSM-H design is virtually identical to the HSM-H for the NUHOMS® 24PTH DSC included in Amendment 8 to CoC 1004. The HSM-H provides spent fuel decay heat removal, physical and radiological protection for the 32PTH DSC. Ambient air enters the HSM-H through ventilation inlet openings located on both sides of the lower front wall of the HSM-H and circulates around the 32PTH DSC and the heat shields. Air exits through air outlet openings located on each side of the top of the HSM-H.



1.1.3 Transfer System

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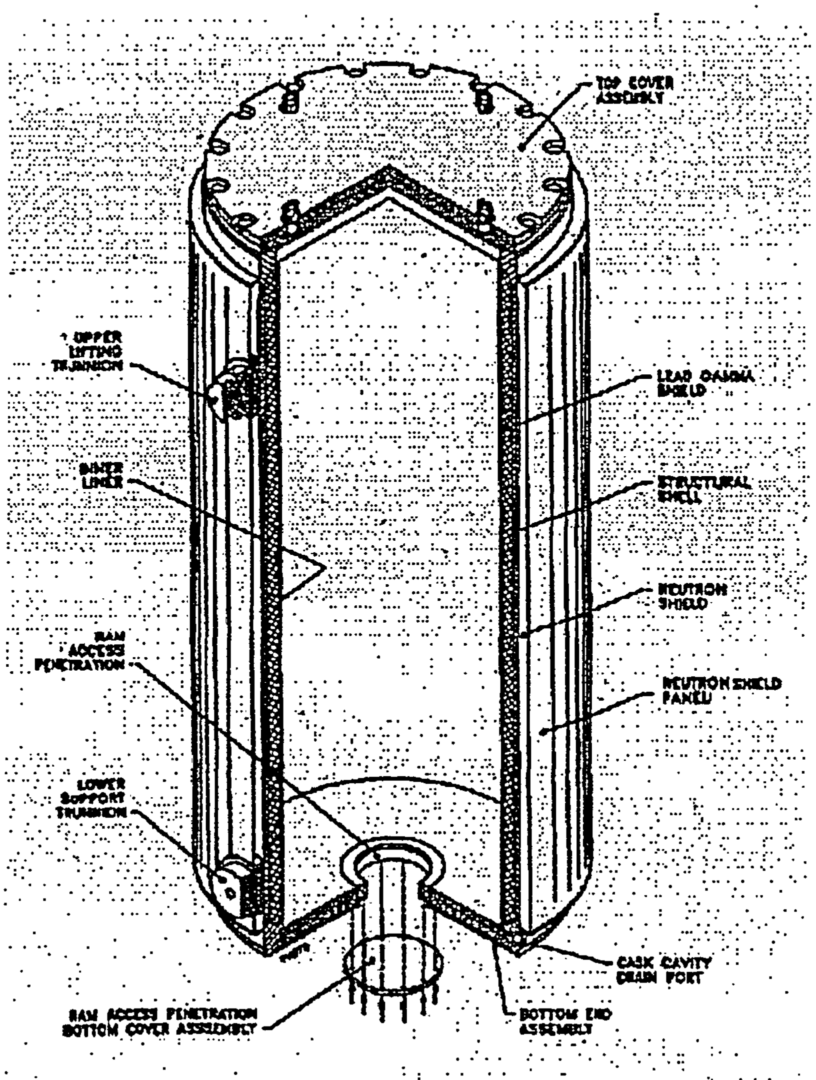
The OS-187H ~~TC, used~~ with the NUHOMS® HD System, provides shielding and protection from potential hazards during 32PTH DSC loading and closure operations and transfer to the HSM-H. The OS-187H TC is very similar to the OS-197 and OS-197H TC described in the FSAR for the Standard NUHOMS® Storage System.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



2.0 PRINCIPAL DESIGN CRITERIA

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

2.1 Structures, Systems, and Components Important to Safety

The SSCs important to safety are discussed in Section 2.5 of the SAR and summarized in Table 2-5 of the SAR. In this table, each component is assigned a safety classification. The SSCs important to safety include the 32PTH DSC, the HSM-H, and the OS-187H TC. The staff agrees with the determinations stated in Section 2.5 of the SAR.

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

2.2.1 Spent Fuel Specifications

The NUHOMS® HD System can store 32 intact or up to 16 damaged with remaining intact, WE 15x15, WE 17x17, FR 17x17 and/or CE 14x14 PWR fuel assemblies. The 32 PWR fuel assemblies can be stored with or without non-fuel assembly hardware which includes burnable poison rod assemblies, vibration suppression inserts or thimble plug assemblies.

The applicant defined damaged fuel and how damaged fuel will be placed into the basket assembly in SAR Section 2.1.1. The applicant also provides the definition of damaged fuel in the Technical Specifications in accordance with guidance contained in Interim Staff Guidance Memorandum-1, Rev.1 (ISG-1, rev. 1) entitled, "Damaged Fuel." The staff reviewed the SAR Section 2.1.1 and the Technical Specification and concludes that the intent of ISG-1, rev. 1 has been satisfied.

The fuel to be stored in the 32PTH DSC is limited to fuel with a maximum initial enrichment of 5.00 weight percent U-235. The maximum allowable burnup is given as a function of initial fuel enrichment but does not exceed 60 GWd/MTU. The minimum cooling time for fuel assemblies is five years.

2.2.2 External Conditions

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

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

Equivalent reload fuel assemblies that are enveloped by the fuel assembly design characteristics listed in Technical Specification Table 2 for a given assembly class are also acceptable for storage.

The staff has determined that the descriptions contain sufficient detail to provide an overview of which conditions, phenomena, and situations required consideration during the evaluation of this SER. Further evaluation of these and other normal, off-normal, and accident conditions are discussed in Sections 3 through 11 of this SER.

2.3 Design Criteria for Safety Protection Systems

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

2.3.1 General

inner top cover/

The NUHOMS® HD System was designed to provide long term storage of spent fuel. The 32PTH DSC cylindrical shell, the top shield plug, and bottom form the pressure retaining confinement boundary for the spent fuel. The 32PTH DSC top closure has redundant welds which join the shell and the top cover plate assemblies to form the confinement boundary. The 32PTH DSC shell and bottom end assembly confinement boundary weld is made during fabrication of the 32 PTH DSC. The top closure confinement welds are made after fuel loading.

2.3.2 Structural

The structural analysis for the 32PTH DSC, HSM-H, and OS187H TC is presented in Section 3 of the SAR. Section 3 of the SAR also describes the ability of these components to perform their design functions during normal and off-normal operating conditions, as well as under postulated accident conditions and extreme natural phenomena. The load combinations considered for combining normal operating, off-normal, and accident loads for the 32PTH DSC, HSM-H, and OS187H TC are discussed in Section 2.2.7 of the SAR.

2.3.3 Thermal

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

2.3.4 Shielding/Confinement/Radiation Protection

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

2.3.5 Criticality

The criticality analysis is presented in Section 6 of the SAR. The design criteria for criticality safety is that the effective neutron multiplication factor upper sub-critical limit of 0.95 minus statistical uncertainties and bias, is limiting for all postulated arrangements of fuel within the

3.0 STRUCTURAL EVALUATION

This section presents the results of the review for the structural evaluation of the NUHOMS® HD System. The NUHOMS® HD System consists of the 32PTH DSC basket and shell assemblies, the HSM-H horizontal storage module, and the OS187H Transfer Cask. The 32PTH DSC is a new dual purpose canister designed to accommodate up to 32 intact PWR fuel assemblies (or up to 16 damaged assemblies, with the remaining intact) and a total heat load of up to 34.8 kW. 17 The HSM-H is an enhanced version of the NUHOMS® Standardized HSM to enable storage of the higher heat load 32PTH DSC. The OS187H is a modified version of the OS197 Transfer Cask with a redesigned shielding panel to improve thermal performance, a shortened cavity length, and increased inside diameter to accommodate the 32PTH DSC. (CoC 1004)

The 32PTH DSC is a cylindrical stainless steel canister backfilled with helium to provide dry storage of the spent fuel assemblies in an inert atmosphere; the HSM-H is a reinforced concrete horizontal storage module that houses and provides environmental protection and shielding to the 32PTH DSC; the OS187H transfer cask is a stainless steel cask with lead shielding that handles and protects the 32PTH DSC during transfer to and from the HSM-H.

A complete structural evaluation of the 32PTH DSC shell assembly and basket components, the HSM-H, and the OS187H transfer cask has been performed. The structural evaluation shows that the NUHOMS® HD system design is compatible with the requirements of 10 CFR 72.236 (Reference 1) 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 72.146, and 10 CFR 72.236.

3.1 Structural Design of the NUHOMS® HD System

3.1.1 Dry Shielded Canister-32PTH DSC

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For the purpose of the structural analysis, the 32PTH DSC is divided into the 32PTH DSC shell assembly and the internal basket assembly. The canister shell assembly and details are shown on drawings 10494-72-1 through 10494-72-7 in Chapter 1, Section 1.5. The shell assembly provides confinement of radioactive materials, encapsulates the fuel in an inert atmosphere (i.e., the canister is backfilled with helium before being sealed by welds), and the top shield plug and the shell bottom provide biological shielding during fuel loading operations and dry storage. The 32PTH DSC shell assembly is designed, fabricated, examined and tested in accordance with the requirements of Section III, Division 1, Subsection NB of the ASME Code. The 32PTH DSC top closure is composed of an outer cover plate and an inner top shield plug. The outer top cover plate and ~~top~~ shield plug are sealed by separate welds. The ~~top~~ shield plug is welded to the 32PTH DSC shell to form the inner pressure boundary. The outer top cover plate is welded to the shell to provide a redundant confinement boundary as required by 10 CFR 72.236(e). Both the inner and outer top cover plate welds are in accordance with the ASME Section III Code Case N-595-3. During fabrication, leak tests of the 32PTH DSC shell assembly are performed in accordance with ANSI N14.5-1997 to demonstrate that the canister shell assembly is leaktight to 1×10^{-7} std. cm³/sec.

inner top cover/ cover/ inner top cover/

The details of the 32PTH DSC basket are shown in drawings 10494-72-8 through 10494-72-12 in Chapter 1, Section 1.5. The basket is an assembly of stainless steel fuel tubes that is designed to accommodate 32 PWR fuel assemblies. The tubes are intermittently fusion welded to Type 304 stainless steel support plates. Neutron poison plates, either a boron-aluminum alloy or a boron carbide aluminum metal matrix composite, are sandwiched between the walls of the fuel tubes and the 304 stainless steel support plates. The neutron poison plates provide criticality control and a heat conduction path from the fuel assemblies to the canister shell. Stainless steel rails are oriented parallel to the axis of the canister and attached to the periphery of the basket to support the basket and maintain its orientation. The basket structure is open at each end and the fuel tubes are nominally 8.70 inches x 8.70 inches in cross section to provide clearances around the fuel assemblies. The overall length of the basket is 162.00 inches which is less than the canister cavity length of 164.50 inches to allow thermal expansions. The basket structure must provide sufficient rigidity to meet heat transfer, nuclear criticality, and structural requirements. The basket design is based on the allowable stresses of Section III, Subsection NG of the ASME Code. Stress limits for Level A through D service conditions are summarized in Table 3-3 of the SAR.

3.1.2 HSM-H Reinforced Concrete Structure

The HSM-H concrete and steel components are designed to the requirements of ACI 349 and the AISC Manual of Steel Construction, respectively. The loads and load combinations are in accordance with those specified in ANSI 57.9. The details of the HSM-H module are shown in drawings 10494-72-100 through 10494-72-109 in Chapter 1, Section 1.5. The HSM-H consists of two separate units: a base storage unit, where the 32PTH DSC is stored, and a top shield block that provides environmental protection and radiation shielding. The top shield block is attached to the base unit by vertical reinforcing bars. Three-foot thick shield walls are installed behind each HSM-H (single row array) and at the ends of each row to provide additional shielding.

3.1.3 OS187H On-Site Transfer Cask

The NUHOMS® -OS187H on-site transfer cask consists of a stainless structural shell, gamma shielding material (cast chemical lead), and solid (~~Vyal-B~~ Resin) and liquid (water) neutron shields. The top cover is bolted to the top flange by 24 -1.5 in. diameter high strength bolts and sealed with ~~Viton~~ O-ring. A cover plate is provided to seal the bottom hydraulic ram access penetration of the cask (by 12-1/2 in. high strength bolts with O-ring) during fuel loading and transferring the DSC to the ISFSI. Detailed design drawings for the OS187H Transfer Cask are provided in drawings 10494-72-15 through 10494-72-21 in Chapter 1, Section 1.5. Sets of upper and lower trunnions, welded to the structural shell of the transfer cask, provide support, lifting, and rotation capabilities for transfer cask operations. The top trunnions are constructed from SA-182 Type FXM-19 and the bottom trunnions are constructed from SA-182 Type 304. The top trunnions are designed, fabricated, and tested in accordance with ANSI N14.6 as critical lifting devices. Consequently they are designed with a factor of safety of six against the material yield strength and a factor of ten against the material ultimate strength. The OS187H TC is designed to meet the criteria of ASME Code Subsection NC for Class 2 Components. Service Level A allowable stress limits are used for all normal and off-normal loadings. Service Level D allowable stress limits are used for load combinations that include postulated accident condition loadings.

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3.2 Materials

The applicant provided a general description of the materials of construction in SAR Sections 1.1,1.2, and 3.1.1.1. Additional information regarding the materials, fabrication details and testing programs can be found in SAR Section 9.1. The staff reviewed the information contained in these Sections; ~~Table~~ Section 3.10, ASME Code Exceptions (Alternatives) and the information presented in the license drawings, to determine whether the NUHOMS HD system meets the requirements of 10 CFR 72.24(c)(3) and (4), 72.122(a), (b), (h) and (l), and 72.236(g) and (h). In particular, the following aspects were reviewed: materials selection; brittle fracture; applicable codes and standards; weld design and specifications; chemical and galvanic corrosion, and cladding integrity.

3.2.1 Structural Materials

Most of the structural components of the 32PTH-DSC (e.g., shell, bottom plate, and top plate) are fabricated from austenitic stainless steel (i.e., Type ~~316~~ 304). The fuel compartment boxes in the 32PTH-DSC basket are also fabricated from austenitic stainless steel. The sections of the stainless steel fuel compartments are fusion welded to Type 304 stainless steel structural plates. This type of steel was selected because of its high strength, ductility, resistance to corrosion and metallurgical stability. Because 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 staff concludes that the selection of these materials meet the requirements of ASME Boiler Pressure Code (Reference 2). Therefore, these materials are acceptable for use in the DSC.

The HSM-H is a free standing reinforced concrete structure designed to provide environmental protection and radiological shielding for the 32PTH DSC. The design of the HSM-H for 32PTH DSC is the same as the HSM-H for Amendment 8 to CoC 1004 for 24PTH DSC that has been approved by staff. The main structural components of the HSM-H are fabricated with reinforced concrete and carbon steel. The HSM-H components are fabricated from American Society for Testing and Materials (ASTM) A 36 steel, a commonly used steel for structural applications, ASTM A 615 reinforcing steel, and ASTM A-992 steel. The minimum specified compressive strength and density is 5000 psi and 145 lb/ft^3, respectively. The staff concludes that the concrete materials meet the requirements of ACI 349, and, the materials comprising the HSM-H are suitable for structural support, shielding, and protection of the 32PTH-DSC from environmental conditions.

Transfer cask structural components (including the inner and outer shells, trunnions, top and bottom covers ~~shield doors~~, etc.) are primarily fabricated from ASME SA 240, chromium and chromium-nickel stainless steel plate, sheet, and strip for pressure vessels and for general applications. This type of steel is a common structural material. The staff concludes that this steel is suitable for use in the transfer cask.

3.2.2 Nonstructural Material

Criticality control in the PWR DSC basket is achieved by including neutron absorbers (also called poisons). The neutron absorber plates provide criticality control and a heat conduction path from the fuel assemblies to the canister shell. The DSC basket is a welded assembly of

3.2.4 Bolting Materials

The DSC is an all-welded canister.

The applicant submitted a brittle fracture analysis for the transfer cask carbon steel bolts. Procurement of the bolts in accordance with the ASME SA-540 Gr. B24 Cl. 1 specification will ensure that the material receives the proper heat treatment and possesses the required mechanical properties. The staff reviewed the analysis performed by the applicant and found it acceptable for this application.

3.2.5 Coatings

Corrosion-resistant coatings are optional on transfer cask alloy steel bolts.

Carbon steel embedments in the HSM-H concrete are coated to protect them from corrosion or they may be stainless steel. Other carbon steel components such as bolts, nuts, tie plates, etc., are also coated for environmental protection.

3.2.6 Material Properties

SAR Tables 3.5 through 3.15 provide mechanical and physical property data for the major structural materials including stainless steels, carbon steel, bolting materials, concrete, and shielding material. In addition, the applicant provided additional material properties in response to a request for additional information on irradiated data used to evaluate high burnup fuel structural integrity. Most of the values in these tables were obtained from ASME Code, Section II, Part D. However, some of the values were obtained from other acceptable references. The staff independently verified the temperature dependent values for the stress allowables, modulus of elasticity, Poisson's ratio, weight density, and coefficient of thermal expansion. Additionally, the staff verified the material strength properties used in the fuel rod integrity evaluation using various technical references. The staff concludes that the material properties are acceptable and appropriate for the expected load conditions (e.g., hot or cold temperature, wet or dry conditions) during the license period.

3.2.7 Chemical and Galvanic Reactions

In Section 3.4 of the SAR, the applicant evaluated whether chemical, galvanic or other reactions among 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 materials of construction 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 components 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. 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 (i.e., cladding) and the DSC internal components will effectively be eliminated during storage.

steel

To ensure that the safety hazards associated with the ignition of hydrogen gas are mitigated, the procedures of SAR Section 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 Conditions of Storage and Transfer

During normal conditions of storage and transfer, the 32PTH DSC is subjected to both storage and transfer loading conditions, while the HSM-H is only subjected to storage loading conditions and the OS187H Transfer Cask is subjected to transfer loading conditions.

3.3.1 Loads and Loading Conditions

3.3.1.1 NUHOMS® 32PTH DSC

The normal condition storage and transfer loads for the 32PTH DSC considered in the structural evaluation are:

- Dead Weight - The DSC maybe in either vertical or horizontal orientation.
- Thermal Loads - 115° F hot, -20° F cold ambient temperatures, and the DSC temperatures during the vacuum drying condition.
- Pressure Loads - Either 30 psig internal pressure or 15 psig external pressure.
- Handling Loads - 2g Axial, 2g Transverse, and 2g vertical are assumed.
- Hydraulic Loads - A 80 kips push or 60 kips pull hydraulic loads are assumed during DSC transfer operation.

The 32PTH DSC normal condition storage and transfer loads and load combinations are described and shown in SAR Appendix 3.9.1, Tables 3.9.1-9 and 3.9.1-10.

3.3.1.2 HSM-H Horizontal Module

HSM-H normal loads are as follows:

- Dead Loads - Dead load includes the weight of the HSM-H concrete structure and the steel structure (the DSC weight is considered as a live load). The dead load is varied by +5% from the estimated value to simulate the most adverse loading condition.
- Live Loads - Live loads include the roof design basis snow and ice loads of 110 psf. A total live load of 200 psf has been assumed in design. The DSC weight is treated as live loads for the concrete and steel components supporting the DSC.

The design basis thermal loads for HSM-H are based on a bounding value of 40.8 kW.

- Thermal Loads - The normal thermal loads on HSM-H include the effects of design basis internal heat loads of the DSC ~~(40.8 kW)~~ and the effects of normal ambient conditions (e.g., 0° F, cold and 100° F, hot).

- Handling Loads - The most significant normal operation loading condition for the HSM-H is the sliding of the DSC between the TC and the HSM-H. It is assumed that an axial load of 80 kips is required for insertion and 60 kips for extraction. The loads are resisted by friction forces developed between the sliding surfaces of the DSC, the TC and the HSM-H supporting rails.

- Wind Loads - This load is conservatively assumed to be enveloped by the tornado generated wind loads. The maximum tornado general wind loads are 234 lb/ft^2 and 148 lb/ft^2 on the windward and leeward HSM-H walls, respectively.

The HSM-H concrete and steel structure design loadings are summarized in SAR Appendix 3.9.9, Tables 3.9.9-1 and 3.9.9-2.

3.3.1.3 OS187H Transfer Cask

For normal operation, the OS187H TC is analyzed for all ~~normal~~ loads such as the dead weight, 115° F hot ambient and -20° F ~~cold~~ ambient environments, 30 psig internal pressures, vacuum drying conditions, and transfer loads. In addition, the OS187H TC is analyzed for a 6g vertical lifting load. Loads that could coexist or be developed during normal operations are combined to simulate the worst loading condition for evaluation. The load combinations are summarized in a load table on SAR Page 3.9.2-18 of Appendix 3.9.2.

3.3.2 Analysis Methods

3.3.2.1 DSC Normal Condition Structural Analysis

The fuel basket and the DSC canister shell assembly are analyzed independently as shown in Appendix 3.9.1 of the application. Three separate finite element models are constructed for the structural evaluation of the fuel basket and four finite element models are used for the structural evaluation of the shell assembly.

The basket stress analysis is performed for normal condition loads during fuel transfer and storage. Finite element structural analysis is performed for the transfer, handling, storage dead weights, and both transfer and storage thermal loads. A 3-dimensional cross-section finite element model is utilized to evaluate the effects of transverse inertial loads on the fuel basket. For vertical dead weight or inertial loads, analytical hand calculations are used for the basket stress analysis.

An enveloping technique of combining various individual loads in a single finite element analysis has been used for the shell assembly stress analysis for several load combination loading conditions. This approach reduces the number of computer runs. However, for some loading combinations, the stress intensities under individual loads are added together to obtain the resultant stress intensities for the specified combined loads. The ANSYS calculated stresses are the total stresses of the combined membrane, bending, and peak stresses. The calculated total stresses are conservatively taken to be either membrane stresses (e.g., P_m) and/or membrane plus bending stresses ($P_L + P_b$) and evaluated against their corresponding ASME code stress limits.

The structural integrity of the fuel cladding for normal condition is evaluated only for the one-foot side drop condition in this application. The one-foot end drop and vibratory loading conditions will be addressed in the 10 CFR 71 application.

3.3.2.2 HSM-H Normal Condition Structural Analysis

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The structural analysis of the HSM-H is based on the bounding values of loads and load combinations. For example, the upper bound weight of the 32PTH DSC (110.0 kips) is used for HSM-H stress evaluation and the lower bound weight of the DSC (72.20 kips) is used for the stability evaluation of the HSM-H. The 32PTH DSC is designed for a maximum heat load of 34.8 kW. However, the design basis thermal load for the HSM-H is based on a bounding value of 40.8 kW decay heat loads as shown in Chapter 3, Section 3.6.2.

Structural evaluation of the HSM-H is the same as presented in Amendment 8 to CoC 1004 for the 24PTH DSC and is included in Appendix 3.9.9, of Chapter 3 of the SAR. A three dimensional finite element model of the HSM-H which includes all the concrete components (rear wall, front wall, two side walls and the roof) was developed for the ANSYS computer program. The DSC was modeled using the beam elements. Plots of the model which includes the concrete structure and support structure are shown in Figures 3.9.9-1 through 3.9.9.3. The connection between the HSM-H concrete structure and the door are designed to allow thermal growth of the door. Thus, the analytical model of the HSM-H for thermal and for thermal stress analysis of the concrete components does not include the door. The ANSYS model for thermal stress analysis is shown in Figure 3.9.9-4.

3.3.2.3 OS187H Transfer Cask Normal Condition Structural Analysis

The OS187H transfer cask structural analyses are based on static or quasi-static linear elastic methods. The stresses and deformations due to the applied loads and load combinations are determined by finite element analysis using the ANSYS computer code. The top cover and the ram access cover bolts are evaluated using the methodology presented in NUREG/CR-6007, "Stress Analysis of Closure Bolts for Shipping Casks." The bolts are analyzed for the bolt preload, gasket seating load, internal pressure, and thermal loads due to temperature changes.

SAR Chapter 3, Appendix 3.9.6 presents the evaluation of the stresses in the NUHOMS®-OS187H transfer cask neutron shield due to all applied loads during fuel loading and transfer operations. A finite element model has been built for the structural analysis of the outer neutron shield shell, end closure, central plates and the transfer cask structural shell. These structural components were modeled with two-dimensional axisymmetric elements. Figures 3.9.6-1, 3.9.6-2 and 3.9.6-3 in SAR Chapter 3, Appendix 3.9.6 show the details of the finite element model of the neutron shield.

3.3.3 Analysis Results

The NUHOMS® 32PTH DSC shell assembly has been shown to meet the appropriate material stress allowable for the service level A 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 storage loads are summarized in SAR Appendix 3.9.1, Tables 3.9.1-20, and 21. The calculated stresses in the canister shell due to normal transfer loading conditions are summarized in SAR Appendix 3.9.1, Tables 3.9.1-11,12,15, and 16. It is seen that the calculated stresses are less than the code allowable stresses.

The fuel basket stress analysis is performed for normal condition loads during fuel transfer and storage. The calculated stresses in the 32PTH DSC fuel basket under normal conditions are summarized and compared with the corresponding ASME code allowable stresses for transfer load cases in SAR Appendix 3.9.1, Table 3.9.1-3 and storage load cases in SAR Appendix 3.9.1, Table 3.9.1-5. Based on these stress analyses, the 32PTH DSC basket is structurally adequate with respect to normal condition transfer and storage loads.

The design of the HSM-H for the 32PTH DSC is the same as the HSM-H for 24PTH DSC (Amendment 8, CoC 1004). The analyses performed for the HSM-H with 24PTH DSC has used bounding values to envelop both 24PTH DSC and 32PTH DSC. Detail geometry descriptions, material properties, loadings, and structural evaluation of the HSM-H is presented in SAR Appendix 3.9.9. Comparison of the highest combined shear forces and moments with the reinforced concrete component capacities are presented in Table 3.9.9-11.

The OS187H transfer cask structural analyses are based on linear elastic methods using the ANSYS computer code. SAR Table 3.9.2-1 of Appendix 3.9.2 summarizes the maximum stresses in the Transfer Cask Body computed for normal conditions of transfer. The maximum stresses in each component are listed along with the normal loading condition that generates the stress. The stresses are evaluated against the ASME Code Subsection NC for Class 2 Components and Service Level A Limits.

3.4 Off-Normal and Accident Conditions

3.4.1 The 32PTH DSC Off-Normal and Accident Conditions Structural Analysis

3.4.1.1 The 32PTH Fuel Basket

The basket stress analyses are performed using a finite element method for the transfer side drop impact loads, as well as, storage seismic loads, and both the transfer and storage thermal load cases. A 3-dimensional cross-section finite element model is utilized to evaluate the effect of transverse inertial loads on the fuel basket.. The calculated stress in the 32PTH DSC fuel basket is summarized and compared with the corresponding ASME code allowable stresses. Table 3.9.1-4a and 3.9.1-4b of SAR Chapter 3 Appendix 3.9.1 have shown the stresses summaries for the transfer accident loads and Table 3.9.1-5 for the storage accident loads.

The application provided structural evaluation of Zircaloy clad fuel cladding stresses due to hypothetical cask drops in SAR section 3.5.3 as follows:

(a) Side Drop

The fuel rod stresses due to the 75g side drop are calculated in TN's response to Part B of the staff's second round RAI 3-13, dated March 25, 2005. TN developed an ANSYS computer model in which the fuel rod was idealized as a continuous beam over multiple supports. The exact dimensions between grid spacers and grid spacer width were modeled. Only the cladding was considered to resist bending, and cladding thickness was reduced by more than 10% to account for cladding oxidation. The full weight of the fuel was included. The results of the analysis, presented in Table 2 of the RAI response, show that the maximum bending stress (66,642 psi) plus the axial stress due to internal pressure (10,289 psi) is 76,931 psi. This stress is less than the yield stress for high burnup fuel cladding, which the staff estimates to be slightly greater than 77,000 psi, considering the effects of temperature and strain rate. Using yield strength as a measure of cladding integrity is conservative. The Staff finds the applicant's assumptions and analyses reasonable and concur with the conclusion that fuel rod integrity is maintained during the 75g side drop.

(b) End or Corner Drops

The end and corner drops are generally not considered credible during storage and transfer operations because the cask will always be in the horizontal orientation. The staff finds this assumption meets the requirements of 10 CFR Part 72; however, an additional safety review by the user of the casks is necessary to demonstrate fuel cladding integrity under 10 CFR Part 50 or to demonstrate that the drop accidents are not credible. In addition, this accident scenario may be credible during transport operations governed under 10 CFR Part 71. Therefore, if these casks will be used for transport operations governed under 10 CFR Part 71, the staff expects that this scenario will be addressed in the 10 CFR Part 71 application for the casks.

3.4.2 HSM-H Off-Normal and Accident Conditions Structural Analysis

The structural analysis of the HSM-H is based on the bounding values of loads and load combinations. A three dimensional finite element model of the HSM-H which includes all the concrete components (rear a wall, front wall, two side walls and the roof) was developed for the ANSYS computer program. The DSC was modeled using the beam elements. Engineering plots of the model which includes the concrete structure and support structure are shown in Figures 3.9.9-1 through 3.9.9.3. The connection between the HSM-H concrete structure and the door are designed to allow thermal growth of the door. Thus, the analytical model of the HSM-H for thermal and for thermal stress analysis of the concrete components does not include the door. The ANSYS model for thermal stress analysis is shown in SAR Chapter 3, Appendix 3.9.9, Figure 3.9.9-4. Section 4.7 of this SER evaluates the thermal modeling of the concrete. The maximum concrete temperature reported during the blocked vent event was above the limit specified by the applicant. Technical Specification 1.2.5.5 requires that the concrete used to fabricate the HSM-H module will be tested at an elevated temperature to demonstrate that the concrete will perform satisfactorily.

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4.2 Cask System Thermal Design

4.2.1 Design Criteria

To establish the heat removal capability, several thermal design criteria are established for the system. These are:

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

- To maintain the stability of the neutron shield resin in the transfer cask (TC) during normal transfer conditions, a maximum allowable average temperature of ~~320°F (160°C)~~ 300°F (149°C) is set for the neutron shield material.

- A maximum fuel cladding temperature limit of 752 °F (400 °C) has been established for normal conditions of storage and for short-term storage operations such as transfer and vacuum drying. During off-normal storage and accident conditions, the fuel cladding temperature limit is 1058 °F (570 °C).

- A maximum temperature limit of 620 °F (327 °C) is considered for the lead in the transfer cask, corresponding to the melting point.

- The ambient temperature range for normal operation is 0 to 100 °F (-18 to 38 °C). The minimum and maximum off-normal ambient temperatures are -20 °F (-29 °C) and 115 °F (46 °C) respectively. In general, all the thermal criteria are associated with maximum temperature limits and not minimum temperatures. All materials can be subjected to a minimum environment temperature of -20 °F (-29 °C) without adverse effects.

- The maximum DSC internal pressure during normal and off-normal conditions must be below the design pressures of 15 psig and 20 psig respectively. For accident cases, the maximum DSC internal pressure must be lower than 70 psig during storage and lower than 120 psig during transfer operation.

4.2.2 Design Features

The NUHOMS® HD is designed to store 32 intact standard PWR fuel assemblies or up to 16 damaged fuel assemblies with the remaining intact with or without Non-Fuel Assembly Hardware (NFAH) as described in Section 2 of the SAR. The characteristics of the spent fuel to be stored in the NUHOMS® HD cask (average burnup, initial enrichment and cooling time) are described in Appendix 4.16.2 of the SAR. The DSC is evacuated and backfilled with helium at the time of loading. The DSC is designed to passively reject decay heat during storage and transfer for normal, off-normal and accident conditions while maintaining component temperatures and pressures within the limits specified by the applicant in the SAR.

4.3 Thermal Load Specifications

The maximum total decay heat load per DSC is 34.8 kW, with a maximum per assembly heat load of 1.5 kW when zoning (preferential loading) is used to distribute the heat load in a nonuniform manner. For CE14x14 fuel assembly types, the maximum total heat load is limited to 33.8 kW. The loading configurations, based on the decay heat that is approved by the staff, are presented in Figure 4-15 of the SAR. The loading requirements described in Section 4.3.1.3 of the SAR are used to develop the bounding loading configurations.

4.4 Model Specifications

4.4.1 Thermal Properties of Materials

Material property tables for the DSC shell, basket, and HSM are included in Section 4.2 of the SAR. The temperature range for the material properties cover the range of temperatures encountered during the thermal analyses. The material properties were verified against material references to be accurate.

4.4.2 Use of Effective Thermal Conductivity Models

4.4.2.1 Spent Fuel Effective Thermal Conductivity

The applicant developed models to simulate the effective thermal properties of the fuel with a homogenized material occupying the entire volume within the basket by using the total fuel active length. The calculated effective thermal conductivity of the fuel assemblies takes credit for conduction and radiation heat transfer only. The bounding fuel assemblies for the ~~transfers~~ transverse and axial conductivities, densities, and specific heats are described in Section 4.8.3 of the SAR. These assemblies were verified by staff to be bounding.

4.4.2.2 Effective Conductivity of Water-Filled Annulus between TC and DSC

The applicant assumed convection in the annulus can be approximated as convection in a vertical rectangular cavity and applied a correlation to calculate the combination of convection and conduction heat transfer in vertical rectangular cavities. According to the applicant's calculations, the presence of convection with the water will enhance the thermal conductivity by a factor of 1.1 to 3 over that computed assuming conduction only through the water-filled annular region.

4.4.2.3 Neutron Shield Region Effective Thermal Conductivity

The neutron shield of the OS187H transfer cask is a water filled annular region that surrounds the cask's structural shell. Annular rings act to divide the water region within the neutron shield into multiple enclosure regions. Effective thermal conductivitity values for these enclosures are obtained by considerating a combination of conduction and convection heat transfer through these regions. Using a series of correlations that were developed to model the heat transfer inside the water region, the applicant computed effective thermal conductivities as a function of the axial length, but not the angular position around the cask circumference. According to the applicant's calculations, the presence of convection with the water will enhance the thermal

All heat transfer across these gaps are by gaseous conduction through the helium backfill gas. Assurance of retaing the backfill gas inside the DSC is achieved by meeting the leak tight criteria. The applicant's model incorporated the effect of the decay heat varying axially along a fuel assembly. The axial heat flux profile utilized is based on the report entitled "Topical Report on Actinide-Only Burnup Credit for PWR Spent Nuclear Fuel Packages," Office of Civilian Radioactive Waste Management, DOE/RW-0472, Revision 2, September 1998.

Within the three dimensional DSC model, heat is transferred via conduction from the fuel basket region to the outer shell region. All heat transfer across the gaps between the plates is by gaseous conduction. The applicant conservatively neglected conduction through some of the gaps between the basket rails. The applicant modeled the DSC using ANSYS finite element analysis code. This code has been verified by NRC staff to be capable of solving steady state and transient thermal analysis in three dimensions.

4.5 Evaluation of Cask Performance for Normal Conditions

The maximum fuel cladding temperature for long term storage is evaluated by the applicant for each of the ~~five~~ Seven decay heat loading zoning configurations that are shown in Figure 4-15 of the SAR. The results obtained are compared with the corresponding ISG-11 fuel cladding temperatures limits for long term storage. According to the results presented in this table, the bounding case corresponds to Type II basket, Configuration #1, which is shown in Table 4-1 of the SAR. For this case a margin of 29 °F (16.1 °C) against the allowable limit of 752 °F (400 °C) per ISG-11 was calculated by the applicant for the maximum fuel cladding temperature. However, all the configurations produce maximum temperatures that are within 23 °F (12.8 °C) of each other. The predicted fuel cladding temperatures for long term storage and normal transfer conditions are not given in the SAR because they are bounded by the off-normal conditions. Under the minimum temperature condition of -20 °F (-28.9 °C), the SSCs important to safety continue to perform their safety function. The maximum calculated pressure without BPRAs for normal storage conditions is 4.8 psig (5.9 psig with BPRAs), and for normal transfer conditions is 5.3 psig (6.4 psig with BPRAs). These pressures are well below the design pressure of 15 psig.

4.6 Evaluation of Cask Performance for Off-Normal Conditions

Maximum calculated temperatures for off-normal storage and transfer are given in Table 4-1 through Table 4-4 of the SAR. According to these tables, the maximum calculated temperature of 723 °F (383.9 °C) was obtained for the transfer case of Lading Configuration #1 Type II basket. Since the Off-normal ambient temperature is higher than the normal ambient temperature, the peak temperature for the off-normal condition bounds the normal condition peak temperature. For off-normal conditions the maximum fuel cladding temperatures are below the allowable fuel cladding temperature limit of 752 °F (400 °C).

The maximum calculated pressure for off-normal conditions corresponds to 9.2 psig (11.2 psig with BPRAs), which is below the DSC off-normal condition design pressure of 20 psig. The average (bulk) temperature in the liquid neutron annulus (water region) is 265 °F (129 °C). This corresponds to a pressure of 23.8 psig. This pressure is less than the set point of the pressure relief valves (40 psig).

4.7 Evaluation of Cask Performance for Accident Conditions

The maximum ~~cask~~ fuel cladding temperature for the fire accident during the transfer case is 1036 °F (557.8 °C), which is below the maximum limit of 1058 °F (570 °C). The maximum calculated fuel cladding temperature for the blocked vent event after 34 hours is 823 °F (439.4 °C), which is below ~~the~~ maximum limit of 1058 °F (570 °C). The maximum concrete temperature reported during the blocked vent event was above the limit specified by the applicant. Technical Specification 2.5.5 requires that the concrete used to fabricate the HSM-H module will be tested at an elevated temperature to demonstrate that the concrete will perform satisfactorily.

The maximum calculated pressure without BPRAs for the accident conditions corresponds to 74.8 psig, which is less than the DSC design pressure limit of 120 psig. The maximum calculated pressure with BPRAs for the accident conditions corresponds to 91.0 psig, which is less than the DSC design pressure limit of 120 psig. The calculated maximum fire transient DSC surface temperature is 790 °F (421 °C). Therefore, the NUHOMS® HD DSC temperatures and pressure calculations for the accident conditions are below the maximum allowable limits.

4.8 Evaluation of Cask Performance for Loading/Unloading Conditions

The maximum cladding temperature reached after 12 hours of completion of vacuum drying when applying Procedure B (as described in the SAR) is 751 °F (399.5 °C). Therefore, backfilling of the transfer cask must start immediately after completion of the vacuum drying if Procedure B is chosen to assure that the maximum cladding temperature remains well below the maximum limit of 752 °F (400 °C) per ISG-11. The NUHOMS® HD DSC only undergoes a one time temperature drop during the backfilling of the DSC with helium gas. Since this is a one time event, the DSC does not undergo any thermal cycling. The maximum fuel cladding temperature during cask reflooding operations will be significantly less than the vacuum drying condition because of the presence of water and/or steam in the DSC cavity.

4.9 Analysis of the HSM Module

The applicant's HSM module analysis model is described in Sections 4.3.1.2, 4.11, 4.12, and 4.13 of the SAR. The analysis utilizes the ANSYS finite element code with several stack effect calculations to characterize aspects of the flow through the module (see SAR Section 4.13). The staff expressed some concerns about the accuracy of this model and of similar calculations in previous applications (Reference 7). In previous applications (Reference 7), the applicant responded by conducting a confirmatory analysis using a different modeling approach (a robust computational fluid dynamics (CFD) program (FLUENT)) to predict the DSC surface and module temperatures, and the module flow patterns. The CFD results (SAR Table P.4-40 of Reference 7) were similar to the ANSYS results for the DSC shell and module base concrete temperatures. However, the CFD results for the roof concrete and top and side heat shields were higher than the ANSYS results (the side heat shield temperature prediction was 44°F (higher)). The applicant stated that the side heat shield temperature difference is directly related to a modeling simplification (that is, the exclusion of the side heat shield fins). The staff agrees that the simplification could be a significant cause for the difference. However, the simplification could have an effect on the flow patterns in the module which could adversely affect the temperature distribution in the module and on the DSC surface.

5.0 SHIELDING EVALUATION

The staff evaluated the capability of the NUHOMS® HD system with the 32PTH DSC to provide adequate protection against direct radiation. The regulatory requirements for providing adequate radiation protection to licensee personnel and members of the public include 10 CFR Part 20 (Reference 1), 10 CFR 72.104, 72.106(b), 72.212, and 72.236(d). Because 10 CFR Part 72 (Reference 2) dose requirements for members of the public also includes effluent releases, and radiation from other uranium fuel-cycle operations, in addition to direct radiation, an assessment of compliance with these regulatory limits is evaluated in Chapter 10 of this SER.

This application was also reviewed to determine whether the NUHOMS® HD System components fulfill the acceptance criteria listed in Section 5 of NUREG-1536, "Standard Review Plan for Dry Cask Storage Systems" (Reference 3).

5.1 Shielding Design Features and Design Criteria

The NUHOMS® HD System, which includes a Horizontal Storage Module (HSM-H) and the OS187H transfer cask, is based on the previously licensed Standardized NUHOMS® System. The HSM-H design is similar to the Standardized NUHOMS® storage module. The NUHOMS® HD System is designed to store up to 32 intact PWR fuel assemblies or ~~16 intact fuel assemblies plus~~ up to 16 damaged fuel assemblies with remaining intact assemblies. The 16 damaged fuel assemblies will be stored in the central location of the basket. The locations with damaged fuel must be closed with specially designed endcaps to contain the failed fuel.

5.1.1 Shielding Design Features

The 32PTH DSC, when used with the NUHOMS® HD System provides both gamma and neutron shielding during loading, transfer, unloading, and storage operations. The 32PTH DSC consists of a 0.5-inch thick steel canister which is sealed on the bottom by 8.75-inch thick steel bottom shield plug, and the top by a total of 12 inches of steel in both ~~lids~~ the top shield plug & cover plates. The transfer cask consists of a 0.5-inch inner steel shell, a 3.6-inch thick lead shield, a 2-inch thick outer steel shell, a 4.56-inch neutron shield, and a 0.19-inch steel skin. The transfer cask lid consists of 2 inches of a neutron absorbing borated resin, and 3.25 inches of steel. The transfer cask bottom closure consists of 2.25 inches of neutron absorbing borated resin and 2.75 inches of steel, except the ram access. The ram access is covered by a one-inch thick steel plate.
1.50

The HSM-H is constructed of thick concrete walls and a shielded access door. The side walls are one foot thick with a three feet thick side shield wall for modules that are at the end of a row. The roof is four feet thick. The rear wall is also one foot thick with a three foot shield wall for modules that are configured as single rows. The front wall is 3.5 feet thick and the module door is constructed of 1-7/8 feet of concrete and 7-7/8 inches of steel. The HSM-H air inlet and outlet paths are designed to minimize radiation streaming. The staff evaluated the NUHOMS® HD System shielding design features and found them to be acceptable. The applicant's analysis provides reasonable assurance that the shielding design of the NUHOMS® HD System meets the regulatory requirements of 10 CFR Part 20, 10 CFR 72.104(a), and 10 CFR 72.106(b).

5.1.2 Shielding Design Criteria

The overall radiological protection design criteria are the regulatory requirements in 10 CFR Part 20 for occupational exposures and maintaining occupational exposures as-low-as-reasonably-achievable (ALARA) and 10 CFR 72.104(a) and 10 CFR 72.106(b) (via 72.226(d) for certificate of compliance holders) for doses around ISFSIs. To show compliance with these regulations, the applicant evaluated the NUHOMS® HD System loaded with spent fuel radiological characteristics shown in Table 2-3 of the SAR.

The SAR analyses provide reasonable assurance that the NUHOMS® HD System can meet the regulatory requirements in 10 CFR Part 20, 10 CFR 72.104(a), and 10 CFR 72.106(b). The applicant provided a radiation protection program in Section 12.5.4, which limits the maximum doses at the front door bird screen, door centerline and the end shield wall exterior consistent with the direct radiation calculations in Chapter 5. Based on the evaluation of an array of storage casks, the applicant has shown that storage casks that meet these dose limits can comply with the dose requirements in 10 CFR Part 72.

5.2 Contents and Source Specification

5.2.1 Contents

A detailed description of the contents for the NUHOMS® HD System can be found in Section 2.1 of the SAR. The contents consist of intact and/or damaged Westinghouse (WE) 15x15, WE 17x17, Framatome ANP Advanced (FR) 17x17 MK BW and Combustion Engineering (CE) 14x14 fuel assemblies. The fuel assemblies can also contain integral control components, including Non-Fuel Assembly Hardware (NFAH) such as Burnable Poison Rod Assemblies (BPRAs), Vibration suppression inserts or Thimble Plug Assemblies (TPAs). Additionally the storage cask can include up to 16 damaged fuel assemblies. The damaged fuel may include missing or partial rods, or rods with known or suspected cladding defects greater than hairline cracks or pinhole leaks. ~~The extent of damage shall be limited such that a fuel pellet is not able to pass through the damaged cladding during handling and retrievability is assured following normal and off-normal conditions.~~ Damaged fuel assemblies are placed in the inner most sixteen basket locations and sealed with top and bottom endcaps to confine any loose material. The technical specification Section 1.1 includes definition of the damaged fuel.

SAR Tables 2-2 and 2-3 describe the characteristics, enrichment, burnup, and cooling times of the fuel assemblies. The maximum allowable burnup is 60,000 MWD/MTU and the minimum cooling time ~~varies from~~ is 5 years to 15 years, based on the burnup, enrichment and fuel zone location, as shown in SAR Table 2-2. SAR Table 2-4 describes the radiological characteristics of the NFAH.

5.2.2 Source Specification

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The source specification is presented in Section 5.2 of the SAR. The gamma and neutron source terms were calculated with the SAS2H (ORIGEN-S) module with the 44-group ENDF/B-~~IV~~ cross section set in the SCALE 4.4 computer code. The applicants source term was generated for a burnup of 60,000 MWD/MTU, a minimum enrichment of 4.0 weight percent ^{235}U and a minimum cooling time of 7 years. This combination of burnup, enrichment and cooling time provides up to 1500 watts of decay heat per assembly and the storage cask can only store up to 8 fuel

If reconstituted fuel assemblies with stainless steel replacement rods undergo further irradiation cycles, their gamma source term will need to bounded by the design basis gamma source term documented in the ~~[illegible]~~ Table 3 of Technical Specifications.

assemblies with this decay heat and radiological characteristics. In the shielding evaluation, the applicant assumed that the all 32 fuel assemblies have this combination of burnup, minimum enrichment and cooling time.

Following the individual gamma and neutron source term determinations, the source terms were utilized in the shielding models to calculate dose rates around the HSM-M and transfer cask.

5.2.2.1 Gamma Source

SAR Tables 5-10, 5-11 and 5-12 provide the SAS2H calculated gamma source terms for the active fuel region, TPAs and BPRAs, respectively. The hardware activation analysis considered the cobalt impurities in the assembly hardware. The amounts of impurities considered in the analysis are presented in SAR Table 5-8 and 5-9. Although cobalt impurities can vary, the applicant's assumed values are reasonable and acceptable. To correct for changes in the neutron flux outside the fuel zone during irradiation, the masses of the materials in the bottom end fitting, plenum, and top end fitting, were multiplied by scaling factors of 0.2, 0.2, and 0.1, respectively. These are the scaling factors recommended in ORNL/TM-11018, "Standard- and Extended-Burnup PWR and BWR Reactor Models for the ORIGEN2 Computer Code," and are considered to provide appropriate values. Based on these results, the FR 17x17 fuel assembly together with the BPRAs ~~from~~ the WE17x17 ~~hardware,~~ provide the design bases gamma source term.
and hardware from MTU loadings of

5.2.2.2 Neutron Source

The SAS2H calculated neutron source term for the fuel assemblies is provided in Table 5-13. Like the gamma source term, the applicant used the FR 17x17 fuel assembly to determine the neutron source term, for the same burnup, minimum enrichment and cooling time.

5.2.2.3 Confirmatory Analyses

The staff reviewed the proposed contents and the hardware cobalt impurities listed in Tables 5-8 and 5-9 of the SAR. The staff has reasonable assurance that the design basis gamma and neutron source terms are acceptable for the NUHOMS® HD System shielding analysis. The staff also reviewed the neutron flux scaling factors for the hardware source terms and found them to be appropriate. The staff performed confirmatory calculations of the source terms for the specified fuel types, burnup conditions, and cooling times. The staff also used the SAS2H module of SCALE 4.4 with the 238-group cross section library. The staff's source term calculations were in agreement with the applicant's.

The exterior dose rates for both the OS187H transfer cask and the HSM-H are adequately controlled by the limits in the Certificate of Compliance for fuel specifications, maximum burnup, and minimum cooling time.

5.3 Shielding Model Specifications

The shielding analyses to determine dose rates around a single HSM-H and transfer cask were performed with MCNP, a three dimensional Monte Carlo code for determining transport of neutrons and gammas. The applicant evaluated three dimensional models for both the HSM-H and the transfer cask.

5.3.1 Shielding and Source Configuration

The source is divided into 18 axial regions as shown in Table 5-20. The axial distribution of the gamma and neutron sources is assumed to follow the relative burnup profile from Reference 4 of Chapter 5. A number of other simplifications and bounding assumptions are discussed in Section 5.4 of the SAR. The analysis includes modeling and evaluating dose rates from potential streaming paths through the HSM-H air vents.

5.3.2 Material Properties

The composition and densities of the materials used in the shielding analysis are presented in Tables 5-15 through 5-19. The homogenized fuel assembly region accounts for the uranium dioxide; cladding and spacers; and steel and other materials present in the incore region of the assembly and associated hardware.

The materials used in modeling the 32PTH DSC, transfer cask, and HSM-H were reviewed and accepted by the staff. The material compositions and densities used were appropriate and provide reasonable assurance that the materials densities were adequately modeled.

5.4 Shielding Analyses Results

5.4.1 Computer Programs

The applicant's shielding analysis was performed with MCNP and is presented in Section 5.4 of the SAR. MCNP is a pointwise code and was used to determine the gamma and neutron dose rates on the surface of the HSM-H and at one and three feet from the transfer cask.

5.4.2 Flux-to-Dose-Rate Conversion

The applicant used the ANSI/ANS Standard 6.1.1-1977 flux-to-dose conversion factors to calculate dose rates. The values listed in this standard are provided in Table 5-14.

5.4.3 Normal Conditions

Tables 5-21 through 5-23 of the SAR present the maximum and average normal condition dose rates for the HSM-H, welding and the transfer cask during, storage, welding and decontamination activities and transfer of the canister from the transfer cask to the storage module. Based on the assumptions used in the analyses, the source term and cooling time of the design basis contents, and the administrative programs established in Section 5.4 of the technical specifications; the staff has reasonable assurance that the user will be able to maintain normal-condition doses ALARA and meet the dose requirements of 10 CFR Part 72.

The expected dose rates for the HSM-H are shown in Table 5-21 and are generally dominated by the gamma component. This is expected due to the thick concrete walls of the HSM-H. The peak dose rates around the HSM-H are 736 mrem/hr on the front bird screen and 13.2 mrem/hr

gamma

aluminum panels and stainless steel straps in an egg-crate type basket design. Neutron absorber panels, consisting of borated aluminum alloy, aluminum-B_4C metal matrix composite, or Boral®, are attached to the aluminum panels in the basket. There are five basket types, each with a different ^{10}B areal density and some with varying panel thicknesses. Only basket types A, B, and C may incorporate Boral® plates. Table 6-7 of the SAR shows the different ^{10}B loadings and panel thicknesses for the five basket types. The applicant stated that 90% credit was taken for the minimum ^{10}B content in the borated aluminum and aluminum-B_4C metal matrix composite panels, while 75% credit was taken for the minimum ^{10}B content in the Boral® panels.

The 32PTH DSC may be loaded with four different soluble boron concentrations in the canister water: 2000, 2300, 2400, and 2500 ppm. A different maximum initial enrichment has been determined for each assembly type, basket type, and soluble boron loading.

The staff reviewed Sections 1, 2, and 6 of the SAR and verified that the design criteria and features important to criticality safety are clearly identified and adequately described. The staff also verified that the SAR contains engineering drawings, figures, and tables that are sufficiently detailed to support an in-depth staff evaluation.

Additionally, the staff verified that the design-basis off-normal and postulated accident events would not have an adverse effect on the design features important to criticality safety. Section 3 of the SAR shows that the basket will remain intact during all normal, off-normal, and accident conditions. Based on the information provided in the SAR, the staff concludes that the NUHOMS® HD System design with the 32PTH DSC meets the double contingency requirements of 10 CFR 72.124(a).

6.2 Fuel Specification

The NUHOMS® HD System 32PTH DSC is designed to store 32 PWR assemblies in each canister. The assembly types allowed are limited to the 14x14, 15x15, and 17x17 PWR fuel assemblies described in Table 6-3 of the SAR. All assemblies, except the CE 14x14, may contain burnable poison rod assemblies (BPRAs), thimble plug assemblies, and vibration suppressor inserts. Fuel assemblies with integral fuel burnable absorber (IFBA) may also be stored. The fuel specifications for the various types of assemblies are listed in Table 12-1 of the TS. Fuel dimensions and weights are listed in Table 12-2 of the TS. The fuel assemblies are described in detail in Table 6-4 of the SAR. The fuel specifications that are most important to criticality safety are:
stet

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

The parameters listed above represent the limiting or bounding parameters for the fuel assemblies. In terms of criticality safety, the most important fuel specification is the fuel initial enrichment. The 32PTH DSC may contain 32 PWR assemblies with maximum initial enrichments up to 5.0 wt% ^{235}U, depending on the DSC basket type, minimum soluble boron concentration in the canister water during loading, and the presence of damaged fuel in the DSC. The maximum initial enrichment for intact and damaged fuel loadings are given in Table 9 12-7 of the TS for all assembly types, and for different basket types and minimum soluble boron concentrations.

or

Specifications on the condition of the fuel are also included in the SAR and TS. The 32PTH DSC is designed to accommodate intact fuel assemblies or up to 16 damaged fuel assemblies, as defined in the TS. The damaged fuel must be placed in the inner 16 fuel assembly positions in the DSC, as shown in Figure 12-1 of the TS. Fuel assembly compartments containing damaged fuel must contain top and bottom end caps, in order to maintain the fuel in a known, subcritical geometry. Reconstituted fuel assemblies, where the fuel pins are replaced by stainless steel or Zircaloy pins that displace the same amount of borated water, may be stored as intact assemblies.

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

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

6.3 Model Specification

6.3.1 Configuration

-H

The NUHOMS® HD System evaluated in this analysis consists of the 32PTH DSC, the OS187H transfer cask (TC), and the horizontal storage module (HSM). The applicant used three-dimensional calculation models in its criticality analyses. The bounding model for each basket type, soluble boron loading, assembly type, and enrichment is based on a 32PTH DSC in the TC, with optimum moderator density. Figures containing the details of the criticality models are provided in Figures 6-1 through 6-19 of the SAR. The models were based on the engineering drawings in Section 1 of the SAR and consider the worst-case dimensional tolerance values. The design-basis off-normal events do not affect the criticality safety design features of the cask system. The neutron shield of the TC was not included in the criticality model; however, unborated water was placed between the casks in an infinite array, as well as in the DSC to TC wall gap. Failure of the damaged fuel assemblies within the fuel compartments and top and bottom end caps was also considered.

The normal condition model combined the most reactive basket dimensions. The applicant performed a series of criticality analyses to determine the most reactive fuel spacing and basket dimension conditions. These analyses were performed with the WE 17x17 Standard assembly, modeled in the 32PTH DSC over a 15.03-inch axial section, including the 13.25-inch neutron absorber plate section and two 1.75-inch sections of perpendicular steel straps. This model included periodic boundary conditions, effectively representing an infinite axial canister.

one of the

The calculation models also conservatively assumed the following:

7.0 CONFINEMENT EVALUATION

The staff reviewed the NUHOMS® HD 32PTH-DSC System confinement features and capabilities to ensure a) that any radiological releases to the environment will be within the limits established in 10 CFR Part 72 (Reference 1), and b) that the spent fuel cladding will be protected against degradation that might lead to gross ruptures during storage, as required in 10 CFR 72.122(h)(1). This ~~amendment~~ application was also reviewed to determine whether the NUHOMS® HD 32PTH DSC System fulfills the acceptance criteria listed in Section 7 of NUREG-1536, "Standard Review Plan for Dry Cask Storage Systems," (Reference 2) and applicable Interim Staff Guidance documents (ISGs) (References 3 and 4). The staff's conclusions are based on information provided in the NUHOMS® HD 32PTH DSC System Safety Analysis Report (SAR).

7.1 Confinement Design Characteristics

The confinement boundary of the NUHOMS® HD 32PTH-DSC is described as follows: the cylindrical shell, the top shield plug/inner cover, the shell bottom, the vent and siphon plates, and the associated welds. An outer top cover plate functions as a redundantly welded barrier for radioactive material confinement, meeting the requirement of 10 CFR Part 72.236(e). All penetrations in the DSC confinement boundary are welded closed.

The fabrication welds of the DSC that are part of the confinement boundary include the multiple-layer weld applied to the shell bottom and the full-penetration welds applied to the cylindrical shell. These welds are inspected via radiographic or ultrasonic means, in accordance with Subsection NB of the ASME Code. The remaining welds are applied using a multi-layer technique during DSC closure operations in accordance with ASME Code and Code Case N-595-3.

7.2 Confinement Monitoring Capability

Periodic surveillance ~~and monitoring~~ of the storage module ~~thermal performance,~~ for blockage of inlet and outlet vents, 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

In lieu of performing leak testing of the closure welds for the inner cover of the top shield plug and the vent and siphon plates, TN has demonstrated that these welds and applicable non-destructive examinations meet the applicable guidelines demonstrating DSC integrity as set forth in ISG-5, Rev. 1 (Reference 3) and ISG-18 (Reference 4). Hence, there is no contribution to the radiological consequences due to a potential release of canister contents.

8.1.4 Welding and Sealing

Welding and sealing operations of the NUHOMS® HD DSCs 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.

8.2 Cask Handling and Storage Operations

All handling and transportation events applicable to moving the NUHOMS® 32PTH DSC to the storage location are similar to those previously reviewed by the staff for the Standardized NUHOMS® System and are bounded by Section 11 of the SAR. Monitoring operations include daily surveillances of the HSM air inlets and outlets, and temperature performance monitoring in accordance with TS requirements.

Occupational and public exposure estimates are evaluated in Section 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 in accordance with TS 1.5.2.4.

8.3 Cask Unloading

Detailed unloading procedures must be developed by each user.

Section 8 of the SAR provides unloading procedures similar to those previously approved by the staff for use with the Standardized NUHOMS® System. The procedures provide for a verification that the boron content for the fill water for the DSC conforms to the TSs. The procedure also monitors for hydrogen during cutting operations.

Section 8 of the SAR includes steps to obtain a sample of the DSC atmosphere and to check for presence of fission gas indicative of degraded fuel. If degraded fuel is suspected, additional measures appropriate for the specific conditions are to be planned, reviewed, and implemented by the user of the cask to minimize exposures to workers and radiological releases to the environment.

8.4 Evaluation Findings

F8.1 The NUHOMS® HD System is compatible with wet loading and unloading. General procedure descriptions for these operations are summarized in Section 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 ~~cask~~ 32PTH DSC allow ready retrieval of the spent fuel for further processing or disposal as required.

F8.3 The NUHOMS® 32PTH DSC geometry and general operating procedures facilitate decontamination. Only routine decontamination will need to be necessary after the cask is removed from the spent fuel pool.

Qualification Tests

Qualification tests are used to demonstrate suitability and durability for a specific application. The applicant presented specifications that will be used to qualify a new borated material or changes to an existing borated material. The staff reviewed the design requirements, tests for durability (e.g., corrosion and thermal damage), and testing to demonstrate the ^{10}B uniformity. The staff finds the qualification tests acceptable for this application.

9.2 Evaluation Findings

F9.1 Sections 9.1.7 of the SAR describes the applicants proposed program for pre-operational testing and initial operations of the neutron absorber in the ~~DSS~~ DSC.

F9.2 SSCs important to safety will be designed, fabricated, erected, tested, and maintained to quality standards commensurate with the importance to safety of the function they are intended to perform. Section 2, Tables 2-5 of the SAR identify the safety importance of SSCs and Section 3 of the SAR presents the applicable standards for their design, fabrication, and testing.

F9.3 The applicant will examine and/or test the ~~DSS~~ DSC to ensure that it does not exhibit any defects that could significantly reduce its confinement effectiveness. Sections 9.1.2 and 9.1.3 of the SAR describes this inspection and testing.

F9.4 The 32PTH DSC will be marked with a data plate indicating its model number, unique identification number, and empty weight. Drawing 10494-72-7 in SAR section 1.2.2 illustrates and describes this data plate.

F9.5 The staff concludes that the acceptance tests and maintenance program for the NUHOMS HD ~~DSS~~ DSC 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 References

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

11.0 ACCIDENT ANALYSIS

The purpose of the review of the accident analyses is to evaluate the applicant's identification and analysis of hazards, as well as the summary analysis of systems responses to both off-normal and accident or design-basis events. This ensures that the applicant has conducted thorough accident analyses as reflected by the following factors:

- identified all credible accidents
- provided complete information in the SAR
- analyzed the safety performance of the cask system in each review area
- fulfilled all applicable regulatory requirements

11.1 Off-Normal Conditions

Off-normal operations are Design Event II as defined by ANSI/ANS 57.9 (Reference 1). These events can be described as not occurring regularly, but can be expected to occur with moderate frequency (on the order of once per year). The NUHOMS® HD System off-normal events are described in Section 11.2 of the SAR. Two off-normal events are identified and analyzed for the NUHOMS® HD System that are defined as bounding the range of off-normal events. These are inadvertent jamming of the DSC while loading or unloading the HSM-H and extreme external ambient temperatures. These events have been analyzed and reported in the appropriate sections of this report such as Sections 3 and 4.

11.2 Accident Events and Conditions

Accident events and conditions are Design Event III and IV as defined in Reference 1. They include natural phenomena and human-induced low probability events. The applicant provided analyses to demonstrate design adequacy for the accident-level events discussed below. The NUHOMS® HD System is designed to accommodate postulated accidents that are described in Section 11 of the SAR. Seven postulated accident conditions are addressed in the section.

11.2.1 Blockage of Air Inlet and Outlet Openings

The NUHOMS® HD System has been designed based on the postulation of the complete blockage of the HSM-H ventilation air inlet and outlet openings. The source of the blockage could be debris accumulation at the openings that was transported by events such as floods or tornadoes. The resulting thermal conditions are analyzed and discussed in Section 4 of this SER. The debris is assumed to remain in place for ~~24~~ hours. The thermal-induced stresses are considered in the loading combinations which are evaluated in Section 3 of this report.

There are no off-site dose consequences resulting from this accident scenario. The on-site dose received by workers from this accident is estimated at no more than one man-rem per 8 hour period during the removal of debris from the vents.

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11.2.2 Accidental Drop of 32PTH DSC Inside the Transfer Cask

The design basis for an accidental drop of the 32PTH DSC is for the occurrence of an accidental drop of the transfer cask while an 32PTH DSC ~~canister~~ loaded with spent fuel is contained within the transfer cask. Handling operations involving hoisting and movement of the on-site transfer cask and the 32PTH DSC are typically performed inside the plant's fuel handling building. These include utilizing the crane for placement of the empty 32PTH DSC into the transfer cask cavity, lifting the transfer cask/32PTH DSC into and out of the plant's spent fuel pool, and placement of the transfer cask/32PTH DSC onto the transport skid/trailer. An analysis of the plant's lifting devices used for these operations, including the crane and lifting yoke, is needed to address a postulated drop accident for the transfer cask and its contents. This analysis is not evaluated in this SER. The postulated drop accident scenarios addressed in the plant's 10 CFR Part 50 licensing basis are plant specific and should be addressed by the licensee.

The transfer cask is transported to the ISFSI in a horizontal configuration. Therefore, the only credible drop accident during storage or transfer operation is a side drop. Nevertheless, the NUHOMS® HD System transfer cask and DSC are evaluated for a postulated end and corner drop to demonstrate structural integrity during transport and plant handling. However, the fuel cladding structural integrity has not been demonstrated for these scenarios.

As stated in Section 3.4.1.1 of this SER, the staff finds this approach (i.e., evaluating the basket, DSC, TC and fuel cladding for a side drop, and the basket, DSC and TC for an end and corner drop) meets the requirements of 10 CFR Part 72. However, for the end drop and corner drop scenario for the fuel cladding an additional safety review by the user of the casks is necessary to demonstrate fuel cladding integrity under 10 CFR Part 50 or to demonstrate that the drop accidents are not credible. In addition, the end drop and corner drop accident scenario may be credible during transport operations governed under 10 CFR Part 71. Therefore, if these casks will be used for transport operations governed under 10 CFR Part 71, the staff expects that the fuel cladding integrity will be addressed in the 10 CFR Part 71 application for the casks.

The accidental transfer cask drop scenarios do not breach the 32PTH DSC confinement boundaries. The function of ~~the function of~~ the transfer cask lead shielding is not compromised by these drops. The transfer cask neutron shield, however, may be damaged in an accidental drop. The bounding accident condition for the transfer cask considers loss of water from the transfer cask water jacket during a cask drop. The doses resulting from this accident are evaluated in Section 5.4.5 of this report and found to be acceptable.

11.2.3 Fire/Explosion

The credible fire is considered to be small and of a short durations such as that due to a fire or explosion from a vehicle or portable crane. Direct engulfment of the HSM-H is considered to be highly unlikely and any fire within the ISFSI boundary while the DSC is in the HSM would be bounded by the fire during the transfer cask movement. The credible fire used as the design basis when the NUHOMS® HD System is being used in the transfer mode is the ignition of 300 gallons spilled onto the ground in such a way as to completely engulf the transfer cask. Subsequent to the fire accident, it is assumed that the seals for the transfer cask lid and the bottom cover plate will burn, and the liquid neutron shield will be released and evaporates tornado driven missiles included a utility pole, steel pipe, an armor piercing artillery shell and a 4000 pound automobile with a 20 square foot frontal area moving at 195 feet per second.

The tornado wind and missile effects on the HSM-H do not breach the confinement boundary. Localized scabbing of the end shield wall may be possible that would have a negligible effect on site boundary dose rates. The tornado wind and missile effects on the transfer cask do not breach the confinement boundary. The missile impact may result in the loss of cask neutron shielding and local deformation/damage of the gamma shielding. The effect of the loss of neutron shielding is bounded by that resulting for a cask drop scenario that is ~~evaluation~~ evaluated in Section 11.2.2 of this SER.

11.3 Evaluation of Findings

F11.1 Structures, systems, and components of the NUHOMS® HD System are adequate to prevent accidents and to mitigate the consequences of accidents and natural phenomena events that do occur.

F11.2 The spacing of casks is discussed in Sections 1.4 of the NUHOMS® HD System FSAR. The staff has previously reviewed and approved the cask spacing to ensure accessibility of the equipment and services required for emergency response.

F11.3 The applicant has evaluated the NUHOMS® HD System to demonstrate that it will reasonably maintain confinement of radioactive material under credible accident conditions.

F11.4 An accident or natural phenomena event will not preclude the ready retrieval of spent fuel for further processing or disposal.

F11.5 The spent fuel will be maintained in a subcritical condition under accident conditions. Neither off-normal nor accident conditions will result in a dose, to an individual outside the controlled area, that exceeds the limits of 10 CFR 72.104(a) or 72.106(b), respectively.

F11.6 The staff concludes that the accident design criteria for the NUHOMS® HD System are in compliance with 10 CFR Part 72 and the accident design and acceptance criteria have been satisfied. The applicant's accident evaluation of the cask adequately demonstrates that it will provide for safe storage of spent fuel during credible accident situations. This finding is reached on the basis of a review that considered independent confirmatory calculations, the regulation itself, appropriate regulatory guides, applicable codes and standards, and accepted engineering practices.

11.4 References

1. American Nuclear Society, ANSI/ANS-57.9, "Design Criteria for an Independent Spent Fuel Storage Installation (Dry Storage Type)," 1992.

2. NRC Regulatory Guide 1.60, "Design Response Spectra for Seismic Design of Nuclear Power Plants," Revision 1, 1973.

TABLE 12-1

NUHOMS® HD System
Technical Specifications

1.0 Use and Applications
- 1.1 Definitions
- 1.2 Logical Connectors
- 1.3 Completion Times
- 1.4 Frequency

2.0 Functional and Operating Limits
- 2.1 Fuel to be Stored in the 32PTH DSC
- 2.2 Functional and Operating Limits Violations

3.0 Limiting Condition for Operation (LCO) and Surveillance Requirement (SR) Applicability
- 3.1 32PTH DSC Fuel Integrity
- 3.2 Cask Criticality Control

4.0 Design Features
- 4.1 Site
- 4.2 Storage System Features
- 4.3 Canister Criticality Control
- 4.4 Codes and Standards
- 4.5 HSM-H Side Heat Shields
- 4.6 Storage Location Design Features

5.0 Administrative Controls
- 5.1 Procedures
- 5.2 Programs
- 5.3 Lifting Controls
- 5.4 HSM-H Dose Rate Evaluation Program
- 5.5 Concrete Testing

15.0 CONCLUSIONS

15.1 Overall Conclusion

The staff performed a detailed safety evaluation of the application for a 10 CFR Part 72 CoC for the NUHOMS® HD System. The staff performed the review in accordance with the guidance in NUREG 1536, "Standard Review Plan for Dry Cask Storage Systems," January 1997. Based on the statements and representations contained in the SAR and the conditions in the CoC, the staff concludes that the NUHOMS® HD System meets the requirements of 10 CFR Part 72.

15.2 Conclusion Regarding the Thermal Analysis of the HSM-H Module

The staff expressed some concerns about the accuracy of the SAR HSM-H thermal analysis methodology and of similar calculations in previous applications (see Transnuclear, Inc. Application for Amendment No. 8 to NUHOMS® Certificate of Compliance (CoC) No. 1004 for Dry Spent Fuel Storage Casks.). The applicant responded by conducting a confirmatory analysis using a different modeling approach (a robust computational fluid dynamics (CFD) program (FLUENT)) to predict the DSC surface and module temperatures, and the module flow patterns. Applicant's confirmatory CFD results for the roof concrete and top and side heat shields were higher than the ~~Ansys~~ ANSYS SAR results. The applicant stated that the side heat shield temperature difference is directly related to a modeling simplification (that is, the exclusion of the side heat shield fins). The staff agrees that the simplification could be a significant cause for the difference. However, the simplification could have an effect on the flow patterns in the module which could adversely affect the temperature distribution in the module and on the DSC surface.

To address staff concerns (and to validate the analysis approach), the applicant conducted a series of tests on a full scale mockup of the module and DSC shell. These tests demonstrated that the methodology used to evaluate the thermal performance of the module 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 module. Based on these findings, the staff included the following condition in CoC No. 1004:

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

Since the NUHOMS®-HD is stored in the same HSM-H module, a similar condition is also included in CoC No. 72-1030.

Issued with Certificate of Compliance No. 1030, on DRAFT.