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STANDARDIZED NUHOMS®

Amendment 10 Application

NON-PROPRIETARY

UFSAR Appendix U – 32PTH1 Part 1 of 2

VOLUME 3 OF 4

TRANSNUCLEAR INC.

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U.1 General Discussion

This Appendix to the NUHOMS® Updated Final Safety Analysis Report (UFSAR) addresses the Important to Safety aspects of adding the NUHOMS®-32PTH1 system to the Standardized NUHOMS® system described in the UFSAR.

The NUHOMS®-32PTH1 system is a modular canister based spent fuel storage and transfer system, similar to the Standardized NUHOMS®-24PTH system described in Appendix P of the UFSAR. It is designed to accommodate up to 32 intact (or up to 16 damaged and balance intact) PWR fuel assemblies with or without control components, with characteristics as described in Chapter U.2.

The NUHOMS® 32PTH1 System consists of the following new or modified components:

- A 32PTH1 DSC, with three alternate configurations, described in detail in Section U.1.2, provides confinement, an inert environment, structural support, and criticality control for the 32 PWR fuel assemblies,
- A modified HSM-H module, described in Section U.1.2, is provided for environmental protection, shielding and heat rejection during storage, and
- OS200 or OS200FC TC for onsite transfer of the 32PTH1 DSCs.

The NUHOMS®-32PTH1 Dry Shielded Canister (DSC) is a dual purpose (Storage/-Transportation) canister, with three alternate configurations depending on the canister length: a short length (185.75") DSC designated as Type 32PTH1-S DSC, a medium length (193.0") DSC designated as Type 32PTH1-M DSC, and a long (198.5") DSC designated as Type 32PTH1-L DSC. The 32PTH1 DSC is designed for a maximum heat load of 40.8 kW.

The 32PTH1 DSC basket design is provided with two alternate options: a Type 1 basket with solid aluminum rails and a Type 2 basket with steel transition rails including aluminum inserts. The solid aluminum rail configuration of the Type 1 basket facilitates heat transfer and is the preferred option for canisters with high decay heat loads. For criticality control, the NUHOMS®-32PTH1 basket is provided with three alternate neutron absorber plate materials: a Borated Aluminum alloy, or Boron Carbide/Aluminum Metal Matrix Composite (MMC) or Boral®. In addition, for each neutron absorber material, the NUHOMS®-32PTH1 DSC basket is analyzed for five alternate basket configurations, depending on the boron content provided, to accommodate the various fuel enrichment levels (designated as Type A for the lowest B10 loading to Type E for the highest B10 loading).

The 32PTH1 DSC is stored in a modified version of the Horizontal Storage Module (HSM-H) described in Appendix P of the UFSAR. The diameter of the HSM-H access door is increased to accommodate the larger diameter of the 32PTH1 DSC. In addition, spacers are provided to accommodate the three different lengths of the 32PTH1 DSCs. All of the key design features of the HSM-H which provide enhanced shielding and heat rejection capabilities remain unchanged from those described in Appendix P of the UFSAR.

The OS200 Transfer Cask (TC), used to transfer the 32PTH1 DSC, is a modified version of the OS197 TC described in the UFSAR, with a slightly larger TC cavity diameter of 70.5" and a minimum TC cavity length of 199.25". An alternate option, designated as OS200FC TC, is provided with an optional modified top lid to allow air circulation through the TC/DSC annulus during transfer operations at certain heat loads when time limits for transfer operations cannot be satisfied. This OS200FC TC is very similar to the OS197FC TC described in Appendix P of the UFSAR, except it is larger in diameter and longer in length. The two alternate NUHOMS®-32PTH1 System configurations are summarized below:

System Configuration	32PTH1 DSC Type	Basket Type	Max. Heat Load (kW) per DSC	Transfer Cask	Storage Module
1	32PTH1-S or 32PTH1-M or 32PTH1-L	1A, 1B, 1C, 1D or 1E	40.8	OS200FC	HSM-H
			31.2	OS200	
2	32PTH1-S or 32PTH1-M or 32PTH1-L	2A, 2B, 2C, 2D or 2E	31.2	OS200FC	
			24.0	OS200	

The NUHOMS®-32PTH1 system provides structural integrity, confinement, shielding, criticality control and passive heat removal independent of any other facility structures or components.

The format of this Appendix follows the guidance provided in NRC Regulatory Guide 3.6 1 [1.1]. The analysis presented in this Appendix shows that the NUHOMS®-32PTH1 system meets all the requirements of 10CFR72 [1.2]. A separate analysis will be submitted to address the safety related aspects of transporting spent fuel in the NUHOMS®-32PTH1 DSC in accordance with 10CFR71 [1.3].

Several sections of this Appendix have been identified as "No change". For these sections, the description or analysis presented in the corresponding sections of the UFSAR for the Standardized NUHOMS® system is also applicable to the 32PTH1 system. In addition, Tables and Figures presented in the UFSAR which remain unchanged due to the addition of the 32PTH1 system to the Standardized NUHOMS® system are not repeated in this Appendix.

Note: References to sections or chapters within this Appendix are identified with a prefix U (e.g., Section U.2.3 or Chapter U.2). References to sections or chapters of the UFSAR outside of this Appendix (main body of the UFSAR) are identified with the applicable UFSAR section or chapter number (e.g., Section 2.3 or Chapter 2) or Appendix (e.g., Appendix P). The references used in this Appendix are identified as [X.X] (e.g., [1.1] is Reference 1.1 at the end of Chapter U.1).

U.1.1 Introduction

The NUHOMS®-32PTH1 system is designed to store up to 32 intact (including reconstituted) B&W 15x15, WE 17x17, CE 15x15, WE 15x15, CE 14x14, and WE 14x14 class PWR fuel assemblies. The fuel to be stored is limited to a maximum assembly average initial enrichment of 5.0 wt. % U-235, a maximum assembly average burnup of 62 GWd/MTU, and a minimum cooling time of 3.0 years. Each of the 32PTH1 DSC types is designed to store up to 32 Control Components (CCs) which include Burnable Poison Rod Assemblies (BPRAs), Thimble Plug Assemblies (TPAs), Control Rod Assemblies (CRAs), Rod Cluster Control Assemblies (RCCAs), Axial Power Shaping Rod Assemblies (APSRAs), Orifice Rod Assemblies (ORAs), Vibration Suppression Inserts (VSIs), and Neutron Source Assemblies (NSAs). The design characteristics, including physical and radiological parameters of the payload, are described in Chapter U.2.

Reconstituted assemblies containing up to 10 replacement irradiated stainless steel rods per assembly or 32 lower enrichment UO_2 rods instead of Zircaloy clad enriched UO_2 rods or 32 Zr rods or Zr pellets or unirradiated stainless steel rods are acceptable for storage in 32PTH1 DSC as intact fuel assemblies with a slightly longer cooling time than that required for a standard assembly. The maximum number of reconstituted fuel assemblies with irradiated stainless steel rods per DSC is four.

Provisions have been made for storage of up to 16 damaged fuel assemblies in lieu of an equal number of intact assemblies in the cells located at the center of the 32PTH1 basket. Damaged PWR fuel assemblies are assemblies containing missing or partial fuel rods or fuel rods with known or suspected cladding defects greater than hairline cracks or pinhole leaks. The DSC basket cells which store damaged fuel assemblies are provided with top and bottom end caps to assure retrievability.

The NUHOMS®-32PTH1 system consists of the following new or modified components:

- A 32PTH1 DSC, with three alternate configurations, described in detail in Section U.1.2, provides confinement, an inert environment, structural support, and criticality control for the 32 PWR fuel assemblies,
- A modified HSM-H module, described in Section U.1.2, is provided for environmental protection, shielding and heat rejection during storage, and
- OS200 or OS200FC TC for onsite transfer of the 32PTH1 DSCs.

The NUHOMS®-32PTH1 system requires the use of non-safety related auxiliary transfer equipment similar to those described in Section 1.3.2.2 (for OS200 TC) and Appendix P (for OS200FC TC) of the UFSAR. There is no change to any of the design features of the auxiliary transfer equipment except for the dimension changes necessary to accommodate the larger OS200 TC relative to the OS197 TC.

Approval of the NUHOMS®-32PTH1 system components described in Section U.1.2 is sought under the provisions of 10CFR 72, Subpart L for use under the general license provisions of 10CFR 72, Subpart K. The 32PTH1 system components are intended for storage on a reinforced concrete pad.

U.1.2 General Description of the NUHOMS®-32PTH1 System

U.1.2.1 NUHOMS®-32PTH1 System Characteristics

U.1.2.1.1 NUHOMS®-32PTH1 DSC

Each NUHOMS®-32PTH1 DSC consists of a DSC shell assembly (cylindrical canister shell, canister shell bottom, inner top cover/shield plug, outer top cover) and a basket assembly. A sketch of the NUHOMS®-32PTH1 DSC components is shown in Figure U.1-1.

The 32PTH1 DSC is provided with three alternate configurations depending on the DSC shell assembly length as shown in Table U.1-1.

These three DSC design configurations allow flexibility to accommodate the payload fuel types and control components described in Section U.2, and are compatible with a nominal 125 ton capacity fuel handling crane. The key design parameters and estimated weights of the NUHOMS®-32PTH1 DSC are listed in Table U.1-1.

The 32PTH1 DSC shell assembly geometry and the materials used for its fabrication are shown on drawings NUH-32PTH1-1001-SAR and NUH-32PTH1-1002-SAR included in Section U.1.5.

The 32PTH1 DSC top end closure assembly design is similar to the top end closure design of the 24PTH DSC design shown in Appendix P.1.5 (a shield plug, inner top cover plate and outer top cover plate along with a separate vent and siphon block welded to the DSC shell). As an alternate option, a two part top end closure assembly design, which is nearly identical to the NUHOMS®-32PTH design described in [1.7], is also provided.

The 32PTH1 DSC bottom end closure assembly design is similar to the bottom end closure design of the 24PTH DSC design shown in Appendix P.1.5 (outer bottom cover plate, bottom shield plug, inner bottom cover plate). As an alternate option, a bottom end closure assembly design with bottom end forging assemblies, which is nearly identical to the NUHOMS®-32PTH design described in [1.7], is also provided.

The primary confinement boundary for the NUHOMS®-32PTH1 DSC consists of the DSC shell, the inner top and inner bottom cover plates, the siphon and vent block, the siphon and vent port cover plates, and the associated welds. Figure U.3.1-1 provides a pictorial representation of the confinement boundary for the 32PTH1 DSC. The outer top cover plate and associated welds form the redundant confinement boundary.

The cylindrical shell and the inner bottom cover plate boundary welds are fully compliant to Subsection NB of the ASME Code [1.4] and are made during fabrication. The top closure confinement welds are multi-layer welds applied after fuel loading and comply with the guidelines of ISG-15 [1.6]. The outer top cover plate is welded to the shell subsequent to the leak testing of the confinement boundary to the leak-tight criteria of ANSI N14.5-1997 [1.5]. There are no credible accidents which could breach the confinement boundary of the 32PTH1 DSC as documented in Chapter U.11.

The 32PTH1 DSC basket structure is similar to the 32PTH DSC basket structure described in Reference [1.7] and consists of 32 stainless steel fuel tubes with the space between adjacent tubes sandwiched by aluminum and neutron absorber plates. The absorber plates provide the necessary criticality control. The aluminum plates, together with the absorber plates, provide a heat conduction path from the fuel assemblies to the canister shell. Each fuel tube is welded together at selected elevations along the axial length of the basket through stainless steel insert plates, which separate the aluminum and poison plates arranged in an egg crate configuration. The transition rails provide the transition between the "rectangular" basket structure to the cylindrical DSC shell. There are two basket types: the Alternate 1 basket has solid aluminum transition rails made from aluminum Type 6061. This basket has a maximum heat load capacity of 40.8 kW. The Alternate 2 basket has welded stainless steel transition rails with aluminum plate inserts. This basket has a maximum heat load capacity of 31.2 kW. The transition rails located at 0°, 90°, 180°, and 270° are called the R90 transition rails. The transition rails located at 45°, 135°, 225°, and 275° locations are called the R45 transition rails. The transition rails support the fuel tubes and transfer mechanical loads to the DSC shell. They also provide the thermal conduction path from the basket assembly to the canister shell wall, making the basket assembly efficient in rejecting heat from its payload. The nominal clear dimension of each fuel tube opening is sized to accommodate the limiting assembly with sufficient clearance around the fuel assembly.

The details of the 32PTH1 DSC basket assembly and the materials used for its fabrication are shown on drawing NUH-32PTH1-1003-SAR while the transition rail details are shown in NUH-32PTH1-1004-SAR, included in Section U.1.5.

Damaged fuel is to be stored in the center sixteen fuel compartments only. A top and bottom end cap is installed on each of the 16 fuel compartments which receive a damaged fuel assembly as shown in drawings NUH-32PTH1-1003-SAR.

During dry storage of the spent fuel in the NUHOMS®-32PTH1 system, no active systems are required for the removal and dissipation of the decay heat from the fuel. The NUHOMS®-32PTH1 DSC is designed to transfer the decay heat from the fuel to the canister body via the basket and ultimately to the ambient via either the HSM-H in storage mode or the TCs in the transfer mode.

Each canister is identified by a Mark Number, **W-32PTH1-X-Y-Z**, where:

W is a user specific designation;

X refers to the DSC Type as described previously (X = S, M or L);

Y refers to the basket type (1A, 2A, 1B, 2B, 1C, 2C, 1D, 2D, 1E or 2E) and

Z is a number corresponding to a specific canister.

U.1.2.1.2 NUHOMS®-HSM-H Module

The HSM-H module design for the 32PTH1 system is nearly identical to the design of the HSM-H module provided for the storage of the currently licensed NUHOMS® -24PTH DSC shown on drawing NUH-03-7001-SAR (see Appendix P, Section P.1.5) with the following differences provided to accommodate the 32PTH1 DSC:

- The diameter of the access door is increased to accommodate the 32PTH1 DSC, similar to the 32PTH DSC described in Reference [1.7],
- The thickness of the rail stop at the back end of the DSC support structure is reduced to increase the HSM-H cavity length, and
- Flat stainless steel side and roof heat shields are used.

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

An upgraded version of the NUHOMS® HSM-H design, designated as NUHOMS® HSM-HS, is also provided to allow the use of the NUHOMS® system in locations where higher seismic levels exist. The HSM-HS module is designed to withstand a maximum horizontal acceleration of 1.0g and a maximum vertical acceleration level of 1.0g.

The modifications implemented to the HSM-H design to meet the upgraded seismic criteria are based on a previously licensed AHSM design [1.8], and are as listed below:

- The HSM-HS roof is tied to the base unit by steel rods or clamps in the vertical direction and by an interlocking concrete key located between the underside of the roof to restrain relative movement in the horizontal direction;
- Adjacent HSM-HS modules are tied to each other with ties located at the top (roof-to-roof connections) and at the base (base-to-base connections). A minimum of three modules are required in an HSM-HS array; and
- The ISFSI pad is designed such that the HSM-HS array has 10 feet of space around to allow sliding and retrievability.

Drawing NUH-03-7003-SAR included in Section U.1.5, shows the above features of the NUHOMS® HSM-HS module.

U.1.2.1.3 NUHOMS®-OS200/OS200FC Transfer Cask

The OS200 TC is a modified version of the OS 197 TC described in Section 1.3.2 and Appendix P of the UFSAR and in the drawings included in Appendix E of the UFSAR. The key design modifications provided in the OS200 TC relative to OS197 TC are summarized below:

- The TC diameter and cavity length are increased to accommodate the 32PTH1 DSC,
- The inner TC liner plate thickness is increased to 5/8" from ½",

- The TC structural shell around the upper trunnions is provided with reinforcing pads for additional strength, and
- The water filled TC neutron shield is supported by circumferential stiffener discs.

The OS200 TC component details and materials used for fabrication are shown in Drawings NUH-08-8001-SAR, NUH-08-8002-SAR, and NUH-08-8003-SAR included in Section U.1.5.

The OS200 TC is provided with an optional top lid with design features which enable an exit path for air circulation through the TC/DSC annulus. This external air circulation feature is needed during the transfer mode if decay heat in the 32PTH1 DSC is greater than 31.2 kW and the basket type used is Type 1 (A through F) and specific time limits for transfer are not met, or if the decay heat is greater than 24.0 kW (but not greater than 31.2 kW) and the basket type used is Type 2 (A through F) and specific time limits for transfer are not met.

The TC when used with this optional top lid is designated as OS200FC TC. This alternate top lid design is nearly identical to the top lid of OS197FC TC shown in Figure P.1-5 of Appendix P. The details of the two alternate TC top lids and the materials used for fabrication are shown in Drawing NUH-08-8003-SAR.

To achieve this air circulation, the NUHOMS® TC support skid is provided with two motor-driven redundant industrial grade blowers and associated hoses as shown in Figure P.1-6 of Appendix P. The air circulation system is sized to provide a minimum capacity of 450 cfm.

U.1.2.2 Operational Features

U.1.2.2.1 General Features

The NUHOMS®-32PTH1 DSC is designed to safely store 32 intact (or up to 16 damaged and remaining intact) PWR fuel assemblies with or without control components. The NUHOMS®-32PTH1 DSC is designed to maintain the fuel cladding temperature below allowable limits during normal storage, short-term accident conditions, short-term off-normal conditions and fuel loading/transfer operations.

The criticality control features of the NUHOMS®-32PTH1 DSC are designed to maintain the neutron multiplication factor k-effective less than the upper subcritical limit equal to 0.95 minus benchmarking bias and modeling bias under all conditions.

U.1.2.2.2 Sequence of Operation

The sequence of operations to be performed in loading fuel into the NUHOMS®-32PTH1 DSCs is presented in Chapter U.8.

U.1.2.2.3 Identification of Subjects for Safety and Reliability Analysis

U.1.2.2.3.1 Criticality Prevention

Criticality is controlled by geometry, soluble boron in the spent fuel pool and by utilizing fixed neutron absorber material in the fuel basket. During storage, with the DSC cavity dry and sealed from the environment, criticality control measures within the installation are not necessary because of the low reactivity of the fuel in the dry NUHOMS®-32PTH1 DSC and the assurance that no water can enter the DSC cavity during storage.

U.1.2.2.3.2 Chemical Safety

There are no chemical safety hazards associated with operations of the NUHOMS®-32PTH1 system.

U.1.2.2.3.3 Operation Shutdown Modes

The NUHOMS®-32PTH1 DSC system is a totally passive system so that consideration of operation shutdown modes is unnecessary.

U.1.2.2.3.4 Instrumentation

No change.

U.1.2.2.3.5 Maintenance Techniques

No change.

U.1.2.3 Cask Contents

The NUHOMS®-32PTH1 DSC system is designed to store 32 intact (or up to 16 damaged and remaining intact) PWR fuel assemblies with or without control components. The fuel that may be stored in the NUHOMS®-32PTH1 DSC is presented in Chapter U.2.

Chapter U.3 provides the structural analysis. Chapter U.4 includes the thermal analysis. Chapter U.5 provides the shielding analysis. Chapter U.6 covers the criticality safety of the NUHOMS®-32PTH1 DSC system and its contents, listing material densities, moderator ratios, and geometric configurations.

U.1.3 Identification of Agents and Contractors

Transnuclear, Inc. (TN) provides the design, analysis, licensing support and quality assurance for the NUHOMS®-32PTH1 system. Fabrication of the NUHOMS®-32PTH1 system cask is done by one or more fabricators qualified under TN's quality assurance program described in Chapter U.13. This program is written to satisfy the requirements of 10 CFR 72, Subpart G and covers control of design, procurement, fabrication, inspection, testing, operations and corrective action. Experienced TN operations personnel provide training to utility personnel prior to first use of the NUHOMS®-32PTH1 system and prepare generic operating procedures.

Managerial and administrative controls, which are used to ensure safe operation of the casks, are provided by the host utility. NUHOMS®-32PTH1 system operations and maintenance are performed by utility personnel. Decommissioning activities will also be performed by utility personnel in accordance with site procedures.

TN provides specialized services for the nuclear fuel cycle that support transportation, storage and handling of spent nuclear fuel, radioactive waste and other radioactive materials. TN is the holder of Certificate of Compliance 1004.

U.1.4 Generic Cask Arrays

No change for the HSM-H arrays.

The high seismic HSM-HS design requires that three adjacent HSM-H modules be connected via the roof-to-roof and base-to-base connections provided. The ISFSI pad is designed to allow 10 feet of space for sliding and to facilitate retrievability.

U.1.5 Supplemental Data

The following Transnuclear drawings are enclosed:

1. NUHOMS®-32PTH1 Transportable Canister, for PWR Fuel, Main Assembly, NUH-32PTH1-1001-SAR.

2. NUHOMS®-32PTH1 Transportable Canister, for PWR Fuel, Shell Assembly, NUH-32PTH1-1002-SAR.

3. NUHOMS®-32PTH1 Transportable Canister, for PWR Fuel, Basket Assembly, NUH-32PTH1-1003-SAR.

4. NUHOMS®-32PTH1 Transportable Canister, for PWR Fuel, Transition Rails, NUH-32PTH1-1004-SAR..

5. NUHOMS® 32PTH1 Transportable Canister, for PWR Fuel, Alternate Top Closure, NUH-32PTH1-1005-SAR.

6. Standardized NUHOMS® ISFSI HSM-HS, Main Assembly, NUH-03-7003-SAR.

7. NUHOMS® -OS200 Onsite Transfer Cask, Structural Shell Assembly, NUH-08-8001-SAR.

8. NUHOMS® -OS200 Onsite Transfer Cask, Inner and Outer Shell Assembly, NUH-08-8002-SAR.

9. NUHOMS® -OS200 Onsite Transfer Cask, Main Assembly, NUH-08-8003-SAR.

U.1.6 References

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

1.2 10CFR72, Rules and Regulations, Title 10, Chapter 1, Code of Federal Regulations - Energy, U.S. Nuclear Regulatory Commission, Washington, D.C., "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel and High-Level Radioactive Waste."

1.3 10CFR71, Rules and Regulations, Title 10, Chapter 1, Code of Federal Regulations - Energy, U.S. Nuclear Regulatory Commission, Washington, D.C., "Packaging and Transportation of Radioactive Material."

1.4 American Society of Mechanical Engineers, ASME Boiler And Pressure Vessel Code, Section III, Division 1 - Subsections NB, NG and NF, 1998 edition including 2000 Addenda.

1.5 ANSI N14.5-1997, "Leakage Tests on Packages for Shipment," February 1998.

1.6 U.S. Nuclear Regulatory Commission, Spent Fuel Project Office, Interim Staff Guidance-15, "Materials Evaluation," January 10 2001.

1.7 Transnuclear Inc., NUHOMS® HD Horizontal Modular Storage Systems for Irradiated Nuclear Fuel, Revision 4, NUHOMS® HD SAR, Docket 72-1030.

1.8 Transnuclear Inc., UFSAR, Standardized Advanced NUHOMS® Horizontal Modular Storage Systems for Irradiated Nuclear Fuel, Revision 2, Docket 72-1029.

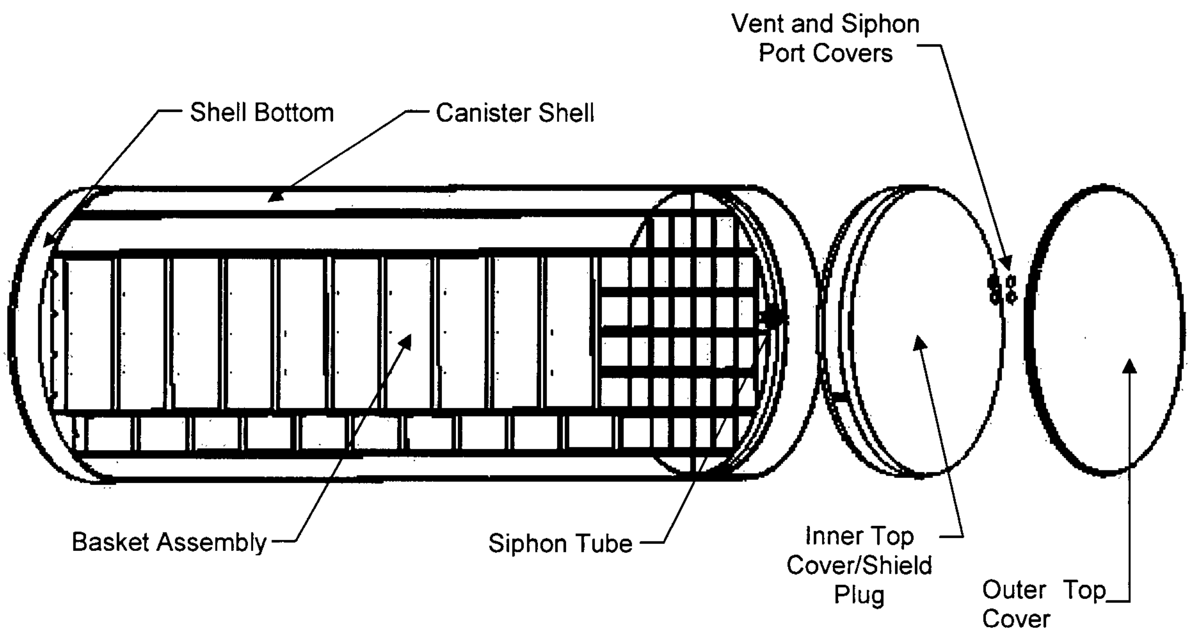
Table U.1-1
Key Design Parameters of the NUHOMS®-32PTH1 System[1]

Parameter	32PTH1 DSC		
	32PTH1-S	32PTH1-M	32PTH1-L
DSC Length (in.), without Grapple	185.75 (Maximum)	193.00 (Maximum)	198.50 (Maximum)
DSC Outside Diameter (in.)	69.75	69.75	69.75
DSC Cavity Length (in.)	164.38 (Minimum)	171.63 (Minimum)	181.38 (Minimum)
DSC Shell Thickness (in.)	0.5	0.5	0.5
DSC Loaded Weight, Dry (kips)	110.0	110.0	110.0
DSC Loaded Weight, Wet[2] (kips)	109.6	113.5	110.4

HSM-H	
HSM-H Overall Length (without shield walls), in.	248
HSM-H Overall Width (without shield walls), in.	116
HSM-H Overall Height, in.	222
HSM-H Single Module Weight, Empty (kips)	307.2
HSM-H Single Module Weight, Loaded (kips)	417.2

OS200 TC	
TC Overall Length, in.	211
TC Overall Outside Diameter, in.	92.11
TC Cavity Inside Diameter, in.	70.5
TC Cavity Length, in.	199.25
TC Lead Thickness, in.	3.5
TC Weight, Empty (kips)	130.3
TC Spacer (kips)	1.3
TC Weight, Dry DSC Loaded (kips)	241.3

Note: (1) Values are based on nominal parameters unless stated otherwise. Nominal values are provided for the limiting configuration.
(2) Wet weight is based on 32PTH1 DSC without top cover plates and top shield plug and OS200 TC without top lid.



Note: Bottom end of 32PTH1 DSC not shown.

Figure U.1-1
NUHOMS®-32PTH1 DSC Components

PROPRIETARY AND SECURITY RELATED INFORMATION WITHHELD UNDER 10 CFR 2.390

ALL DIMENSIONS APPLY AFTER WELDING AND FINAL MACHINING UNLESS OTHERWISE SPECIFIED	TRANSNUCLEAR AN AREVA COMPANY
DIMENSIONS ARE IN INCHES AND DEGREES UNLESS OTHERWISE SPECIFIED. DIMENSIONING IN ACCORDANCE WITH ASME Y14.5M	SAFETY ANALYSIS REPORT NUHOMS® 32PTH1 TRANSPORTABLE CANISTER FOR PWR FUEL MAIN ASSEMBLY
INTERPRETATION OF WELD SYMBOLS PER ANSI / AWS 2.4	DRAWING NO. NUH32PTH1-1001-SAR; SCALE NONE; SHEET 1 OF 3; REVISION 0
U.S. Patent No. 4,780,269 Proprietary Property of Transnuclear, Inc. This drawing may not be disclosed to others in whole or in part, or used for other than the transmitted purpose without written permission of Transnuclear, Inc.	

NUH32PTH1-1001-SAR 2 OF 3

PROPRIETARY AND SECURITY RELATED INFORMATION WITHHELD UNDER 10 CFR 2.390

DRAWING NO. NUH32PTH1-1001-SAR | SHEET 2 OF 3 | REVISION 0

PROPRIETARY AND
SECURITY RELATED INFORMATION
WITHHELD UNDER 10 CFR 2.390

NUH32PTH1-1001-SAR | SHEET 3 OF 3 | REVISION 0

PROPRIETARY AND SECURITY RELATED INFORMATION WITHHELD UNDER 10 CFR 2.390

ALL DIMENSIONS APPLY AFTER WELDING AND FINAL MACHINING UNLESS OTHERWISE SPECIFIED

DIMENSIONS ARE IN INCHES AND DEGREES UNLESS OTHERWISE SPECIFIED. DIMENSIONING IN ACCORDANCE WITH ASME Y14.5M

INTERPRETATION OF WELD SYMBOLS PER ANSI / AWS 2.4

U.S. Patent No. 4,780,269 Proprietary Property of Transnuclear, Inc.

TRANSNUCLEAR
AN AREVA COMPANY

SAFETY ANALYSIS REPORT
NUHOMS®32PTH1
TRANPORTABLE CANISTER
PWR FUEL SHELL ASSEMBLY

DRAWING NO.	SCALE	SHEET	REVISION
NUH32PTH1-1002-SAR	NONE	1 OF 2	0

PROPRIETARY AND
SECURITY RELATED INFORMATION
WITHHELD UNDER 10 CFR 2.390

DRAWING NO.	SHEET	REVISION
NUH32PTH1-1002-SAR	2 OF 2	0

NUH32PTH1-1003-SAR | 1 OF 5

PROPRIETARY AND SECURITY RELATED INFORMATION WITHHELD UNDER 10 CFR 2.390

ALL DIMENSIONS APPLY AFTER WELDING AND FINAL MACHINING UNLESS OTHERWISE SPECIFIED

DIMENSIONS ARE IN INCHES AND DEGREES UNLESS OTHERWISE SPECIFIED. DIMENSIONING IN ACCORDANCE WITH ASME Y14.5M

INTERPRETATION OF WELD SYMBOLS PER ANSI / AWS 2.4

U.S. Patent No. 4,780,269
Proprietary Property of Transnuclear, Inc.
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TRANSNUCLEAR
AN AREVA COMPANY

SAFETY ANALYSIS REPORT
NUHOMS® 32PTH1
TRANSPORTABLE CANISTER
PWR FUEL BASKET ASSEMBLY

DRAWING NO.	SCALE	SHEET	REVISION
NUH32PTH1-1003-SAR	NONE	1 OF 5	0

PROPRIETARY AND
SECURITY RELATED INFORMATION
WITHHELD UNDER 10 CFR 2.390

DRAWING NO. NUH32PTH1-1003-SAR | SHEET 2 OF 5 | REVISION 0

PROPRIETARY AND SECURITY RELATED INFORMATION WITHHELD UNDER 10 CFR 2.390

NUH32PTH1-1003-SAR 4 OF 5

PROPRIETARY AND
SECURITY RELATED INFORMATION
WITHHELD UNDER 10 CFR 2.390

DRAWING NO. NUH32PTH1-1003-SAR SHEET 4 OF 5 REVISION 0

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DIMENSIONS ARE IN INCHES AND DEGREES UNLESS OTHERWISE SPECIFIED. DIMENSIONING IN ACCORDANCE WITH ASME Y14.5M	
INTERPRETATION OF WELD SYMBOLS PER ANSI / AWS 2.4	SAFETY ANALYSIS REPORT NUHOMS® 32PTH1 TRANPORTABLE CANISTER PWR FUEL TRANSITION RAILS
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INTERPRETATION OF WELD SYMBOLS PER ANSI / AWS 2.4	DRAWING NO NUH32PTH1-1005-SAR; SCALE NONE; SHEET 1 OF 5; REVISION 0
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INTERPRETATION OF WELD SYMBOLS PER ANSI / AWS 2.4

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SAFETY ANALYSIS REPORT
STANDARDIZED NUHOMS® ISFSI
HSM-HS
MAIN ASSEMBLY

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NUH-03-7003-SAR	NONE	1 OF 10	0

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PROPRIETARY AND
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DIMENSIONS ARE IN INCHES AND DEGREES UNLESS OTHERWISE SPECIFIED. DIMENSIONING IN ACCORDANCE WITH ASME Y14.5M	SAFETY ANALYSIS REPORT NUHOMS®- OS200 ONSITE TRANSFER CASK STRUCTURAL SHELL ASSEMBLY
INTERPRETATION OF WELD SYMBOLS PER ANSI / AWS 2.4	DRAWING NO. NUH-08-8001-SAR; SCALE NONE; SHEET 1 OF 3; REVISION 0
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NUH-0-8002-SAR 1 OF 3

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INTERPRETATION OF WELD SYMBOLS PER ANSI / AWS 2.4

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TRANSNUCLEAR
AN AREVA COMPANY

SAFETY ANALYSIS REPORT
NUHOMS®- OS200
ONSITE TRANSFER CASK
INNER & OUTER SHELL ASSEMBLY

DRAWING NO.	SCALE	SHEET	REVISION
NUH-08-8002-SAR	NONE	1 OF 3	0

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ALL DIMENSIONS APPLY AFTER WELDING AND FINAL MACHINING UNLESS OTHERWISE SPECIFIED	TRANSNUCLEAR AN AREVA COMPANY
DIMENSIONS ARE IN INCHES AND DEGREES UNLESS OTHERWISE SPECIFIED. DIMENSIONING IN ACCORDANCE WITH ASME Y14.5M	
INTERPRETATION OF WELD SYMBOLS PER ANSI / AWS 2.4	SAFETY ANALYSIS REPORT NUHOMS – OS200 ONSITE TRANSFER CASK MAIN ASSEMBLY
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U.2 Principal Design Criteria

This section provides the principal design criteria for the NUHOMS®-32PTH1 system, which is described in Chapter U.1.

Only those principal design criteria that have changed from the existing UFSAR, Chapter 3, are described in this chapter. Section U.2.1 presents a general description of the spent fuel to be stored. Section U.2.2 provides the design criteria for environmental conditions and natural phenomena. Section U.2.3 provides a description of the systems that have been designated as important to safety. Section U.2.4 discusses decommissioning considerations. Section U.2.5 summarizes the NUHOMS®-32PTH1 DSC and HSM-H design criteria.

U.2.1 Spent Fuel To Be Stored

As described in Chapter U.1, there are three alternate design configurations for the NUHOMS®-32PTH1 DSC depending on the canister length: a short (185.75") DSC designated as 32PTH1-S, a medium (193.00") DSC designated as 32PTH1-M, and a long (198.5") DSC designated as 32PTH1-L DSC. Each of the DSC configurations is designed to store intact (including reconstituted) and/or damaged PWR fuel assemblies as specified in Table U.2-1 and Table U.2-3. The fuel to be stored is limited to a maximum assembly average initial enrichment of 5.0 wt. % U-235. The maximum allowable assembly average burnup is limited to 62 GWd/MTU and the minimum cooling time is 3 years. Each of the DSC types is designed to store Control Components (CCs) with thermal and radiological characteristics as listed in Table U.2-2. The CCs include Burnable Poison Rod Assemblies (BPRAs), Thimble Plug Assemblies (TPAs), Control Rod Assemblies (CRAs), Rod Cluster Control Assemblies (RCCAs), Axial Power Shaping Rod Assemblies (APSRAs), Orifice Rod Assemblies (ORAs), Vibration Suppression Inserts (VSIs), Neutron Source Assemblies (NSAs) and Neutron Sources.

Reconstituted assemblies containing up to 10 replacement irradiated stainless steel rods per assembly or 32 lower enrichment UO_2 rods instead of Zircaloy clad enriched UO_2 rods, or 32 Zr rods or Zr pellets, or unirradiated stainless steel rods are acceptable for storage in 32PTH1 DSC as intact fuel assemblies with a slightly longer cooling time than that required for a standard assembly. The stainless steel rods are assumed to have two-thirds the irradiation time as the remaining fuel rods of the assembly. The reconstituted UO_2 rods are assumed to have the same irradiation history as the entire fuel assembly. The reconstituted rods can be at any location in the fuel assemblies. The maximum number of reconstituted fuel assemblies per DSC is four with irradiated stainless steel replacement rods or 32 with UO_2 replacement rods.

The NUHOMS®-32PTH1 DSCs can also accommodate up to a maximum of 16 damaged fuel assemblies placed in the center cells of the DSC as shown in Figure U.2-1 through Figure U.2-3. Damaged PWR fuel assemblies are assemblies containing missing or partial fuel rods, or fuel rods with known or suspected cladding defects greater than hairline cracks, or pinhole leaks. The extent of damage in the fuel assembly is to be limited such that a fuel assembly is being able to be handled by normal means and retrievability is assured following normal and off-normal conditions. The DSC basket cells which store damaged fuel assemblies are provided with top and bottom end caps to assure retrievability.

A 32PTH1 DSC containing less than 32 fuel assemblies may contain dummy fuel assemblies in the empty slots. The dummy assemblies are unirradiated, stainless steel encased structures that approximate the weight and center of gravity of a fuel assembly.

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

The NUHOMS®-32PTH1 DSCs may store up to 32 PWR fuel assemblies arranged in any of the three alternate heat load zoning configurations (HLZC) as shown in Figure U.2-1 through Figure

U.2-3. The maximum decay heat per fuel assembly and the maximum canister heat load allowed is as specified in Figure U.2-1 through Figure U.2-3. The HLZC 1 with a maximum DSC heat load of 40.8 kW is applicable to Type 1 32PTH1 DSC only. HLZCs 2 and 3 with a maximum DSC heat load of 31.2 kW and 24.0 kW respectively, is applicable to both Type 1 and Type 2 32PTH1 DSCs. The maximum allowed heat load for the various 32PTH1 system configurations are presented in Table U.2-18.

In addition, the NUHOMS®-32PTH1 DSC basket is provided with three alternate neutron absorber plate materials (poison material) for criticality control: Borated Aluminum alloy, Boron Carbide/Aluminum Metal Matrix Composite (MMC) and Boral®. For criticality analysis, 90% of B10 content present in the borated aluminum and MMC poison plates is credited, while only 75% is credited for Boral®. The selection of the poison material does not have any impact on the thermal analysis, since it is based on the limiting thermal conductivity of Boral® as discussed in Section U.4.3.

Each of the two NUHOMS®-32PTH1 DSC basket types is analyzed for several alternate basket configurations for criticality control, depending on the boron loadings analyzed (designated as "A" basket for the lowest B10 loading to "E" basket for the highest B10 loading) and Basket-Type (Type 1 or Type 2).

A summary of the alternate poison loadings considered and the corresponding credit taken in the criticality analysis for each poison material as a function of basket types is presented below:

Poison Type	32PTH1 Basket Type(1)	Poison Loading (B10 mg/cm^2)	% Credit Used in Criticality Analysis
Borated Aluminum Alloy/MMC	1A or 2A	7	90
	1B or 2B	15	
	1C or 2C	20	
	1D or 2D	32	
	1E or 2E	50	
Boral®	1A or 2A	9	75
	1B or 2B	19	
	1C or 2C	25	
	1D or 2D	NA	
	1E or 2E	NA	

(1) Type 1A = Basket Type 1 with solid aluminum transition rails and Type A poison plate configuration;
Type 2A = Basket Type 2 with steel transition rails including aluminum inserts and Type A poison plate configuration.

Table U.2-4 and Table U.2-5 summarize the maximum assembly average initial enrichment as a function of soluble Boron concentration and basket neutron poison requirements for intact and damaged fuel, respectively. Table U.2-6 through Table U.2-11 define the minimum required cooling time after reactor discharge for a fuel assembly without CCs for a given assembly heat load, burnup, and maximum initial enrichment parameters. These tables ensure that the fuel assembly decay heat load is less than that specified for each fuel assembly and that the corresponding radiation source term is bounded by that analyzed in Chapter U.5.

The NUHOMS®-32PTH1 DSC is inerted and backfilled with helium at the time of loading. The maximum fuel assembly weight with CCs that can be accommodated in the 32PTH1-L, 32PTH1-M, and 32PTH1-S is 1,715 lbs, 1,625 lbs, and 1,665 lbs, respectively.

The maximum fuel cladding temperature limit of 400°C (752°F) is applicable to normal conditions of storage and all short term operations from spent fuel pool to ISFSI pad including vacuum drying and helium backfilling of the NUHOMS®-32PTH1 DSC per Interim Staff Guidance (ISG) No. 11, Revision 3 [2.5]. In addition, ISG-11 does not permit repeated thermal cycling of the fuel cladding (limited to less than 10 cycles) with cladding temperature differences greater than 65°C (117°F) during DSC drying, backfilling and transfer operations.

The maximum fuel cladding temperature limit of 570°C (1058°F) is applicable to accidents or off-normal storage thermal transients [2.5].

Calculations were performed to determine the fuel assembly type which was most limiting for each of the analyses including shielding, criticality, thermal and confinement. These evaluations are performed in Chapter U.5, U.6, U.4 and U.7 respectively. The fuel assembly classes considered are listed in Table U.2-3. It was determined that the B&W 15x15 is the enveloping fuel design for the shielding source term calculation because of its total assembly weight and highest initial heavy metal loading. For criticality safety, the B&W 15x15 assembly is the most reactive assembly type for a given enrichment. This assembly is used to determine the most reactive configuration in the DSC. Using this most reactive configuration, criticality analysis for all other fuel assembly classes is performed to determine the maximum enrichment allowed as a function of the soluble boron concentration and fixed poison plate loading. For thermal analysis, the WE 14x14 fuel assembly is limiting for the 32PTH1 DSCs, since it results in the lowest effective fuel thermal conductivity. The confinement analysis is based on B&W 15x15 fuel assembly, since it results in a smaller free volume inside the DSC cavity as compared to a 14x14 fuel assembly.

For calculating the maximum internal pressure in the NUHOMS®-32PTH1 DSC, it is assumed that 1% of the fuel rods are damaged for normal conditions, up to 10% of the fuel rods are damaged for off-normal conditions, and 100% of the fuel rods will be damaged following a design basis accident event [2.1]. A minimum of 100% of the fill gas and 30% of the fission gases within the ruptured fuel rods are assumed to be available for release into the DSC cavity, consistent with NUREG-1536 [2.1].

The maximum internal pressures used in the structural analysis for the NUHOMS®-32PTH1 DSC are 15, 20, and 140 psig for normal, off-normal and accident conditions, respectively, during storage and transfer operations for the 32PTH1 DSCs.

U.2.1.1 General Operating Functions

No change.

U.2.2 Design Criteria for Environmental Conditions and Natural Phenomena

The NUHOMS®-32PTH1 DSC is handled and stored in the same manner as the existing NUHOMS®-24P System. The environmental conditions and natural phenomena are the same as those described in the existing UFSAR, Chapter 3 with a few specific differences which are discussed in detail in this section.

Table U.2-16 summarizes the design criteria for the 32PTH1 DSC and HSM-H. This table also summarizes the applicable codes and standards utilized for design. The design criteria for HSM-H are the same as those described in Chapter P.2

The OS200 TC used for the transfer of 32PTH1 DSC is a modified version of the NUHOMS® OS197 TC described in the UFSAR Section 1.3.2, with an extended total length of 211". The design criteria for the OS200 TC is the same as those described in UFSAR Chapter 3. An alternate option, designed with a modified top lid, is designated as OS200FC TC. The design criteria for OS200/OS200 FC TC are the same as those as described in Section P.3.2.5 of the UFSAR with a few specific differences which are detailed in this section.

U.2.2.1 Tornado Wind and Tornado Missiles

No change to Section P.2.2.1 for HSM-H.

The evaluation of tornado-generated missile loads on the transfer cask summarized in Section 8.2 of the UFSAR remains unchanged.

U.2.2.2 Water Level (Flood) Design

No change.

U.2.2.3 Seismic Design

The seismic design criteria for the HSM-H is consistent with the criteria set forth in Section 3.2.3, with the exception that the NRC Regulatory Guide 1.60 (R.G. 1.60) [2.11] response spectra is anchored to a maximum ground acceleration of 0.30g (instead of 0.25g) for the horizontal components and 0.25g (instead of 0.17g) for the vertical component (i.e., the site ZPA is 0.3g horizontal and 0.25g vertical). The seismic analysis of the HSM-H and 32PTH1 DSC are further discussed in Section U.3.7.

An alternate high seismic design option of the HSM-H has also been provided. The seismic criteria for the high seismic HSM-H (HSM-HS) is an "enhanced" NRC Regulatory Guide 1.60 response spectra anchored at 1.0g maximum horizontal acceleration and 1.0g maximum vertical acceleration shown in Figure U.2-4.

U.2.2.4 Snow and Ice Loading

No change.

U.2.2.5 Combined Load Criteria

The NUHOMS®-32PTH1 system is subjected to the same types of loads as the existing NUHOMS®-24P or -52B System. The load combination criteria for the OS200 TCs for transfer are the same as those shown in the UFSAR Table 3.2-7. The criteria applicable to the NUHOMS®-32PTH1 DSC and HSM-H are discussed in the following subsections.

U.2.2.5.1 NUHOMS®–32PTH1 DSC Structural Design Criteria

The NUHOMS®-32PTH1 DSC is designed using the ASME Boiler and Pressure Vessel Code [2.2] criteria given in the existing UFSAR, Chapter 3, except as noted in the following sections. A summary of the NUHOMS®-32PTH1 DSC load combinations is presented in Table U.2-13.

U.2.2.5.1.1 NUHOMS®–32PTH1 DSC Shell Stress Criteria

The stress limits for the NUHOMS®-32PTH1 DSC shell are taken from the ASME Boiler and Pressure Vessel Code, Section III, Subsection NB, Article NB-3200 [2.2] for normal condition loads (Level A) and NB-3225, Appendix F for accident condition loads (Level D). The stress limits for Level B and Level C are taken from ASME, Section III, Subsection NB, Paragraph NB-3223 and 3224. The 32PTH1 DSC shell stress limits are summarized in Table U.2-14.

Local yielding is permitted at the point of contact where the Level D load is applied. If elastic stress limits cannot be met, the plastic system analysis approach and acceptance criteria of Appendix F of ASME Section III are used.

The allowable stress intensity value, S_m, as defined by the Code is based on the temperature calculated for each service load condition or a bounding temperature.

U.2.2.5.1.2 NUHOMS®–32PTH1 DSC Shell Assembly Stability Criteria

Stability of the 32PTH1 DSC shell assembly is addressed for those load conditions in which the 32PTH1 DSC is under external hydrostatic pressure (e.g., vacuum drying and external flood load cases) and/or axial compression, (e.g., loading the shell due to the shield plug's deadweight). Stability criteria are from ASME Section III, NB-3133.3 and NB-3133.6. Stability for the accident conditions is evaluated by performing a non-linear analysis of the 32PTH1 DSC shell under compression load. The maximum compression g-load obtained from the non-linear analysis is 112.5g.

U.2.2.5.1.3 NUHOMS®–32PTH1 DSC Basket Stress Criteria

The basket fuel compartment tube wall thickness is established to meet thermal, nuclear criticality, and structural requirements. The basket structure provides sufficient rigidity to maintain a subcritical configuration under the applied loads. The 32PTH1 DSC basket stress limits are summarized in Table U.2-15.

No credit is taken for neutron poison plates in any of the stress or stability analyses except for through the thickness compression (bearing) loads.

Normal Conditions

Normal Condition Stress Criteria for Steel Elements

As summarized in Table U.2-15, the normal condition stress criteria for the fuel compartment tubes and the transition rails, is based on Subsection NG of the ASME Code, Section III [2.2].

Normal Condition Stress Criteria for Aluminum Transition Rails

The aluminum transition rail bodies perform their function (support of the fuel compartment tubes) by remaining in place. The loads on the rail bodies are primarily bearing from the fuel compartment tubes. "Failure" of the transition rail would require that the rail no longer provide support to the fuel compartment tubes. Since the aluminum rail bodies are constrained between the DSC shell and the fuel support compartment tubes, this cannot occur.

Therefore, for deadweight and handling condition loads, stress in the aluminum bodies will be compared to the allowable bearing stress, equal to S_y, from NG-3227.1(a). Values of S_y are taken from Table U.3.3-4 for annealed 6061 aluminum material at temperature (as described in Section U.3.3, these yield stresses are lower bound values).

Accident Conditions

Accident Condition Stress Criteria for Steel Elements

As summarized in Table U.2-15 the accident condition (Level D) stress criteria for the fuel support structure and the welded steel transition rails is based on Appendix F of the ASME Code, Section III. Criteria are provided for both linear elastic and elastic-plastic stress analyses.

Accident Condition Criteria for Aluminum Transition Rails

For accident condition loading (i.e., the postulated drops), the aluminum transition rail bodies must support the fuel tubes such that stresses and displacements in the fuel compartment tubes are acceptable. Since, the rail bodies are captured between the fuel compartment tube and the DSC shell, large displacements of the rails are prevented. Thus, no additional checks (of the aluminum) are required for accident/drop loading. Qualification of the fuel tubes demonstrates that the rails perform their intended function.

U.2.2.5.2 NUHOMS® HSM-H Structural Design Criteria

There are no changes to the HSM-H structural design criteria presented in Appendix P.2, except for the modified earthquake loads (EQ) as discussed in Section U.2.2.3 above.

U.2.2.5.3 NUHOMS® OS200 TC Structural Design Criteria

There are no changes to the design criteria presented in Section 3 of the UFSAR for the OS197/OS197H TCs, except for the modified earthquake loads (EQ) of 0.3g horizontal and 0.25g vertical ZPA accelerations as discussed in Section U.2.2.3 and the maximum decay heat load of 40.8 kW for the OS200 TC (similar to the OS197FC TC described in Appendix P).

For the high seismic accident scenario with maximum site accelerations of 1.0g horizontal and 1.0g vertical, the 75g accident drop evaluation criteria is considered bounding.

U.2.3 Safety Protection Systems

U.2.3.1 General

The NUHOMS®-32PTH1 DSC is designed to provide storage of spent fuel for at least 40 years. The DSC cavity is inerted and backfilled with helium and the internal pressure is always above atmospheric during the storage period as a precaution against in-leakage of air, which could be harmful to the fuel. Since the confinement vessel consists of a steel cylinder with an integrally welded bottom closure, and a seal welded top closure that is verified to be leak tight after loading, the DSC cavity gas cannot escape.

Only those features that are not addressed in the existing UFSAR, Chapter 3, or have been revised, are addressed in this Section. Those features include the thermal and nucleonic performance of the poison plates, and their acceptance. The quality category of components of the NUHOMS®-32PTH1 DSC that are "Important to Safety" and "Not Important to Safety" are shown on the drawings listed in Section U.1.5.

U.2.3.2 Protection By Multiple Confinement Barriers and Systems

The NUHOMS®-32PTH1 DSC provides a leak tight confinement of the spent fuel. Although similar to the existing NUHOMS®-24P DSC, sealing of the NUHOMS®-32PTH1 DSC involves leak testing to the criteria of ANSI N14.5 [2.4] after loading and sealing the canister, as described in Chapter U.7.

U.2.3.3 Protection By Equipment and Instrumentation Selection

No change.

U.2.3.4 Nuclear Criticality Safety

U.2.3.4.1 Control Methods for Prevention of Criticality

The design criterion for criticality is that an upper subcritical limit (USL) of 0.95 minus benchmarking bias and modeling bias will be maintained for all postulated arrangements of fuel within the DSC. The intact fuel assemblies are assumed to stay within their basket compartment based on the DSC and basket geometry.

The control method used to prevent criticality is incorporation of poison material in the basket material, soluble boron in the pool and favorable geometry. The quantity and distribution of boron in the poison material is controlled by specific manufacturing and acceptance criteria of the poison plates. The acceptance criteria of the plates is described in Chapter U.9.

The basket has been designed to assure an ample margin of safety against criticality under the conditions of fresh fuel in a DSC flooded with borated pool water. The method of criticality control is in accordance with the requirements of 10CFR72.124 [2.10].

The criticality analyses performed for the 32PTH1 system are described in Chapter U.6.

U.2.3.4.2 Error Contingency Criteria

Provision for error contingency is built into the criterion used in Section U.2.3.4.1 above. The criterion used in the criticality analysis is common practice for licensing submittals. Because conservative assumptions are made in modeling, it is not necessary to introduce additional contingency for error.

U.2.3.4.3 Verification Analysis-Benchmarking

The verification analysis benchmarking used in the criticality safety analysis is described in Chapter U.6.

U.2.3.5 Radiological Protection

No change.

U.2.3.6 Fire and Explosion Protection

No change.

U.2.4 Decommissioning Considerations

No change.

U.2.5 Summary of NUHOMS®-32PTH1 DSC and HSM-H Design Criteria

U.2.5.1 32PTH1 DSC Design Criteria

The NUHOMS®-32PTH1 DSC is designed to store intact and/or damaged PWR fuel assemblies with or without Control Components with assembly average burnup, initial enrichment and cooling time as described in Table U.2-1 and Table U.2-3. The maximum decay heat load of the stored fuel is limited to 1.5 kW per fuel assembly for Type 1 DSC and 0.98 kW for a Type 2 DSC. The maximum heat load per canister is limited to 40.8 kW for a Type 1 DSC and 31.2 kW for a Type 2 DSC in order to keep the maximum fuel cladding temperature below the limit [2.5] necessary to ensure cladding integrity. The fuel cladding integrity is assured by the NUHOMS®-32PTH1 DSC and basket design which limit fuel cladding temperature and maintains a nonoxidizing environment in the DSC cavity as described in Section U.4.

The NUHOMS®-32PTH1 DSC (shell and closure) is designed and fabricated as a Class 1 component in accordance with the rules of the ASME Boiler and Pressure Vessel Code, Section III, Subsection NB [2.2], and the alternative provisions to the ASME Code as described in Table U.3.1-1.

The NUHOMS®-32PTH1 DSC is designed to maintain a subcritical configuration during loading, handling, storage and accident conditions. A combination of fixed neutron absorbers, soluble boron in the pool and favorable geometry are employed to maintain the upper subcritical limit of 0.9411. The fixed neutron absorbers are in the form of plates made from either borated aluminum alloy or MMC or Boral®. The basket is designed and fabricated in accordance with the rules of the ASME Boiler and Pressure Vessel Code, Section III, Subsection NG, Article NG-3200 [2.2] and the alternative provisions to the ASME Code as described in Table U.3.1-2.

The NUHOMS®-32PTH1 DSC is designed to withstand the effects of severe environmental conditions and natural phenomena such as earthquakes, tornadoes, lightning and floods. Chapter U.11 describes the NUHOMS®-32PTH1 DSC behavior under these accident conditions.

The NUHOMS®-32PTH1 DSC design, fabrication and testing are covered by Transnuclear's Quality Assurance Program, which conforms to the criteria in Subpart G of 10CFR72.

U.2.5.2 HSM-H Design Criteria

There is no change to the HSM-H design criteria presented in Appendix P, Chapter P.2 except for the modified seismic loads as discussed in Section U.2.2.

U.2.5.3 OS200 TC Design Criteria

Same as the OS197/OS197H/OS197FC TC described in Section 3 and Appendix P of the UFSAR with modified seismic loads as described in U.2.2.

U.2.6 References

2.1 NUREG-1536, "Standard Review Plan for Dry Cask Storage Systems," 1997.

2.2 American Society of Mechanical Engineers, ASME Boiler And Pressure Vessel Code, Section III, Division 1 - Subsections NB, NG and NF, 1998 edition including 2000 Addenda.

2.3 Young, W.C., "Roark's Formulas for Stress and Strain," 6th Edition, McGraw-Hill Book Company, New York, 1989.

2.4 ANSI N14.5-1997, "Leakage Tests on Packages for Shipment," February 1998.

2.5 Interim Staff Guidance No. 11, Revision 3, "Cladding Considerations for the Transportation and storage of Spent Fuel", dated November 17, 2003, U.S. Nuclear Regulatory Commission

2.6 "Design Basis Tornado for Nuclear Power Plants," Regulatory Guide 1.76, U.S. Atomic Energy Commission, April 1974.

2.7 "Missiles Generated by Natural Phenomenon," Standard Review Plan, NUREG-0800, U.S. Nuclear Regulatory Commission.

2.8 American Society of Civil Engineers, ASCE 7-95, "Minimum Design Loads for Buildings and Other Structures" (formerly ANSI A58.1).

2.9 ANSI/ANS 57.9-1984, "Design Criteria for an Independent Spent Fuel Storage Installation (Dry Storage Type)," American Nuclear Society.

2.10 Title 10, Code of Federal Regulations, Part 72 (10CFR72), "Licensing Requirements for the Storage of Spent Fuel in the Independent Spent Fuel Storage Installation," U.S. Nuclear Regulatory Commission.

2.11 Regulatory Guide 1.60, "Design Response Spectra for Seismic Design of Nuclear Power Plants," U.S. Atomic Energy Commission, Revision 1, December 1973.

2.12 Regulatory Guide 1.61, "Damping Values for Seismic Design of Nuclear Power Plants," U.S. Atomic Energy Commission, October 1973.

2.13 Bechtel Topical Report, "Design of Structures for Missile Impact," BC-TOP-9-A, Revision 2, September 1974.

Table U.2-1
PWR Fuel Specification for the Fuel to be Stored in the NUHOMS®-32PTH1 DSC

PHYSICAL PARAMETERS:	
Fuel Class	Intact or damaged unconsolidated B&W 15x15, WE 17x17, CE 15x15, WE 15x15, CE 14x14, WE 14x14 and CE 16x16 class PWR assemblies (with or without control components) that are enveloped by the fuel assembly design characteristics listed in Table U.2-3. Reload fuel manufactured by other vendors but enveloped by the design characteristics listed in Table U.2-3 is also acceptable.
Fuel Damage	Damaged PWR fuel assemblies are assemblies containing missing or partial fuel rods or fuel rods with known or suspected cladding defects greater than hairline cracks or pinhole leaks. The extent of damage in the fuel assembly is to be limited such that a fuel assembly is being able to be handled by normal means and retrievability is assured following normal and off-normal conditions.
RECONSTITUTED FUEL ASSEMBLIES:	
• Maximum No. of Reconstituted Assemblies per DSC with Irradiated Stainless Steel Rods	4
• Maximum No. of Irradiated Stainless Steel Rods per Reconstituted Fuel Assembly	10
• Maximum No. of Reconstituted Assemblies per DSC with Unlimited Number of Low Enriched UO_2 Rods, or Zr Rods or Zr Pellets or Unirradiated Stainless Steel Rods	32
Control Components (CCs)	• Up to 32 CCs are authorized for storage in 32PTH1-S, 32PTH1-M and 32PTH1-L DSCs. • Authorized CCs include Burnable Poison Rod Assemblies (BPRAs), Thimble Plug Assemblies (TPAs), Control Rod Assemblies (CRAs), Rod Cluster Control Assemblies (RCCAs), Axial Power Shaping Rod Assemblies (APSRAs), Orifice Rod Assemblies (ORAs), Vibration Suppression Inserts (VSIs), and Neutron Source Assemblies (NSAs), and Neutron Sources • Design basis thermal and radiological characteristics for the CCs are listed in Table U.2-2.
No. of Intact Assemblies	≤32
No. and Location of Damaged Assemblies	Up to 16 damaged fuel assemblies. Balance may be in-tact fuel assemblies, or dummy assemblies which are authorized for storage in 32PTH1 DSC. Damaged fuel assemblies are to be placed in the center 16 locations as shown in Figure U.2-1, Figure U.2-2 and Figure U.2-3. The DSC basket cells which store damaged fuel assemblies are provided with top and bottom end caps to assure retrievability.
Maximum Assembly plus CC Weight	1715 lbs

Table U.2-1
PWR Fuel Specification for the Fuel to be Stored in the NUHOMS®-32PTH1 DSC
(Concluded)

THERMAL/RADIOLOGICAL PARAMETERS:	
Allowable Heat Load Zoning Configurations (HLZCs) for each 32PTH1 DSC	Per Figure U.2-1 or Figure U.2-2 or Figure U.2-3.
Burnup, Enrichment, and Minimum Cooling Time for HLZC 1	Per Table U.2-6 for Zone 1 fuel, per Table U.2-6 for Zone 6 fuel, and per Table U.2-10 and Table U.2-9 for Zone 5 fuel (intact fuel), per Table U.2-11 for Zone 5 fuel (damaged fuel).
Burnup, Enrichment, and Minimum Cooling Time for HLZC 2	Per Table U.2-8 for Zone 4 and Zone 3 fuel.
Burnup, Enrichment, and Minimum Cooling Time for HLZC 3	Per Table U.2-7 for Zone 2 fuel.
Maximum Initial Assembly Average Fuel Enrichment	5.0 wt. % U-235
Maximum Decay Heat Limits for Zones 1, 2, 3, 4, 5, and 6 Fuel	Per Figure U.2-1 or Figure U.2-2 or Figure U.2-3.
Decay Heat per DSC	≤40.8 kW for 32PTH1-S, 32PTH1-M and 32PTH1-L DSCs (Type 1 Basket)
	≤ 31.2 kW for 32PTH1-S, 32PTH1-M and 32PTH1-L DSCs (Type 2 Basket)
Maximum Boron Loading	Per Table U.2-17

Table U.2-2
Thermal and Radiological Characteristics for Control Components Stored in the NUHOMS® -32PTH1 DSC

Parameter	BPRAs, NSAs, CRAs, RCCAs, VSIs, APSRAs and Neutron Sources	TPAs and ORAs
Maximum Gamma Source (γ/sec/DSC)	1.25E+15	1.3E+14
Decay Heat (Watts/DSC)	256.0	256.0

Table U.2-3
PWR Fuel Assembly Design Characteristics for the NUHOMS®-32PTH1 DSC

Assembly Class		B&W 15x15	WE 17x17	CE 15x15	WE 15x15	CE 14x14	WE 14x14	CE 16x16
Max Unirradiated Length (in)(1)	32PTH1-S	165.75	165.75	165.75	165.75	165.75	165.75	165.75
	32PTH1-M	171.93	171.93	171.93	171.93	171.93	171.93	171.93
	32PTH1-L	178.3	178.3	178.3	178.3	178.3	178.3	178.3
Fissile Material		UO_2	UO_2	UO_2	UO_2	UO_2	UO_2	UO_2
Maximum MTU/Assembly(2)		0.49	0.49	0.49	0.49	0.49	0.49	0.49
Maximum Number of Fuel Rods		208	264	216	204	176	179	236
Maximum Number of Guide/ Instrument Tubes		17	25	9	21	5	17	5

Notes:
(1) Maximum Assembly + Control Component Length (unirradiated)
(2) The maximum MTU/assembly is based on the shielding analysis. The listed value is higher than the actual.

Table U.2-4
Maximum Assembly Average Initial Enrichment v/s Neutron Poison Requirements for 32PTH1 DSC (Intact Fuel)

Fuel Assembly Class	Maximum Assembly Average Initial Enrichment (wt. % U-235) as a Function of Soluble Boron Concentration and Basket Type (Fixed Poison Loading)					
	Minimum Soluble Boron (ppm)	Basket Type				
		1A or 2A	1B or 2B	1C or 2C	1D or 2D	1E or 2E
WE 17x17 Assembly Class(4)	2000	3.40	3.80	3.90	4.10	4.30
	2300	3.70	4.00	4.20	4.40	4.70
	2400	3.70	4.10	4.30	4.50	4.80
	2500	3.80	4.20	4.40	4.60	4.90
	2800	4.00	4.50	4.70	5.00	5.00
	3000	4.20	4.60	4.80	5.00	5.00
CE 16x16 Assembly Class(5)	2000	3.90	4.30	4.50	4.80	5.00
	2300	4.10	4.60	4.80	5.00	5.00
	2400	4.20	4.70	4.90	5.00	5.00
	2500	4.30	4.80	5.00	5.00	5.00
	2800	4.60	5.00	5.00	5.00	5.00
	3000	4.70	5.00	5.00	5.00	5.00
BW 15x15 Assembly Class(5)	2000	3.30	3.60	3.80	4.00	4.20
	2300	3.50	3.90	4.10	4.30	4.60
	2400	3.60	4.00	4.20	4.40	4.70
	2500	3.70	4.10	4.30	4.50	4.80
	2800	3.90	4.30	4.50	4.80	5.00
	3000	4.10	4.50	4.70	5.00	5.00
CE 15x15 Assembly Class(5)	2000	3.50	3.90	4.00	4.20	4.40
	2300	3.80	4.10	4.30	4.60	4.80
	2400	3.90	4.30	4.40	4.70	4.90
	2500	3.90	4.35	4.50	4.80	5.00
	2800	4.20	4.60	4.80	5.00	5.00
	3000	4.30	4.80	5.00	5.00	5.00

Table U.2-4
Maximum Assembly Average Initial Enrichment v/s Neutron Poison Requirements for 32PTH1 DSC (Intact Fuel)
(Concluded)

Fuel Assembly Class	Maximum Assembly Average Initial Enrichment (wt. % U-235) as a Function of Soluble Boron Concentration and Basket Type (Fixed Poison Loading)					
	Minimum Soluble Boron (ppm)	Basket Type				
		1A or 2A	1B or 2B	1C or 2C	1D or 2D	1E or 2E
WE 15x15 Assembly Class(5)	2000	3.50	3.80	3.90	4.20	4.40
	2300	3.70	4.10	4.20	4.50	4.80
	2400	3.80	4.20	4.40	4.60	4.90
	2500	3.90	4.30	4.50	4.70	5.00
	2800	4.10	4.50	4.70	5.00	5.00
	3000	4.20	4.70	4.90	5.00	5.00
CE 14x14 Assembly Class(6)	2000	3.90	4.40	4.60	4.90	5.00
	2300	4.20	4.70	5.00	5.00	5.00
	2400	4.30	4.80	5.00	5.00	5.00
	2500	4.40	5.00	5.00	5.00	5.00
	2800	4.60	5.00	5.00	5.00	5.00
	3000	4.80	5.00	5.00	5.00	5.00
WE 14x14 Assembly Class(7)	2000	4.20	4.70	4.90	5.00	5.00
	2300	4.50	5.00	5.00	5.00	5.00
	2400	4.60	5.00	5.00	5.00	5.00
	2500	4.70	5.00	5.00	5.00	5.00
	2800	5.00	5.00	5.00	5.00	5.00
	3000	5.00	5.00	5.00	5.00	5.00

Notes:
(1) Not Used.
(2) Not Used.
(3) Not Used.
(4) Reduce Enrichment by 0.05 wt. % U-235 for assemblies with CCs that extend into the active fuel region.
(5) Reduce Enrichment by 0.10 wt. % U-235 for assemblies with CCs that extend into the active fuel region.
(6) Reduce Enrichment by 0.25 wt. % U-235 for assemblies with CCs that extend into the active fuel region.
(7) No reduction in Enrichment required for assemblies with CCs that extend into the active fuel region.

Table U.2-5
Maximum Assembly Average Initial Enrichment v/s Neutron Poison Requirements for 32PTH1 DSC (Damaged Fuel)

Fuel Assembly Class	Maximum Assembly Average Initial Enrichment (wt. % U-235) as a Function of Soluble Boron Concentration and Basket Type (Fixed Poison Loading)					
	Minimum Soluble Boron (ppm)	Basket Type				
		1A or 2A	1B or 2B	1C or 2C	1D or 2D	1E or 2E
WE 17x17 Assembly Class (without CCs)	2000	3.40	3.70	3.80	4.05	4.25
	2300	3.60	3.95	4.10	4.35	4.65
	2400	3.70	4.05	4.20	4.45	4.75
	2500	3.75	4.15	4.30	4.55	4.85
	2800	4.00	4.40	4.60	4.85	5.00
	3000	4.15	4.55	4.75	5.00	5.00
WE 17x17 Assembly Class (with CCs)	2000	3.35	3.65	3.75	4.00	4.20
	2300	3.55	3.90	4.05	4.30	4.55
	2400	3.65	4.00	4.15	4.40	4.70
	2500	3.70	4.10	4.25	4.50	4.75
	2800	3.95	4.35	4.55	4.80	5.00
	3000	4.10	4.50	4.70	5.00	5.00
CE 16x16 Assembly Class (without CCs)	2000	3.65	4.05	4.20	4.50	4.75
	2300	3.90	4.30	4.50	4.80	5.00
	2400	4.00	4.40	4.60	4.90	5.00
	2500	4.05	4.50	4.70	5.00	5.00
	2800	4.30	4.80	5.00	5.00	5.00
	3000	4.50	4.95	5.00	5.00	5.00
CE 16x16 Assembly Class (with CCs)	2000	3.60	3.95	4.10	4.40	4.65
	2300	3.80	4.20	4.40	4.70	4.90
	2400	3.90	4.30	4.50	4.80	5.00
	2500	4.00	4.40	4.60	4.90	5.00
	2800	4.20	4.70	4.90	5.00	5.00
	3000	4.40	4.85	5.00	5.00	5.00

Table U.2-5
Maximum Assembly Average Initial Enrichment v/s Neutron Poison Requirements for 32PTH1 DSC (Damaged Fuel)
(Continued)

Fuel Assembly Class	Maximum Assembly Average Initial Enrichment (wt. % U-235) as a Function of Soluble Boron Concentration and Basket Type (Fixed Poison Loading)					
	Minimum Soluble Boron (ppm)	Basket Type				
		1A or 2A	1B or 2B	1C or 2C	1D or 2D	1E or 2E
WE 15x15 Assembly Class (without CCs)	2000	3.40	3.75	3.90	4.15	4.30
	2300	3.65	4.00	4.20	4.45	4.70
	2400	3.75	4.10	4.30	4.55	4.80
	2500	3.80	4.20	4.40	4.65	4.90
	2800	4.05	4.45	4.60	4.90	5.00
	3000	4.20	4.60	4.80	5.00	5.00
WE 15x15 Assembly Class (with CCs)	2000	3.35	3.65	3.80	4.00	4.20
	2300	3.55	3.90	4.10	4.35	4.60
	2400	3.65	4.00	4.20	4.45	4.70
	2500	3.70	4.10	4.30	4.55	4.80
	2800	3.95	4.35	4.50	4.80	5.00
	3000	4.10	4.50	4.70	5.00	5.00
CE 14x14 Assembly Class (without CCs)	2000	3.70	4.10	4.30	4.60	4.85
	2300	3.95	4.40	4.60	4.95	5.00
	2400	4.05	4.50	4.70	5.00	5.00
	2500	4.15	4.60	4.80	5.00	5.00
	2800	4.40	4.90	5.00	5.00	5.00
	3000	4.55	5.00	5.00	5.00	5.00
CE 14x14 Assembly Class (with CCs)	2000	3.55	3.95	4.10	4.35	4.60
	2300	3.80	4.20	4.40	4.70	4.90
	2400	3.9	4.30	4.50	4.80	5.00
	2500	4.00	4.40	4.60	4.90	5.00
	2800	4.20	4.65	4.90	5.00	5.00
	3000	4.35	4.85	5.00	5.00	5.00

Table U.2-5
Maximum Assembly Average Initial Enrichment v/s Neutron Poison Requirements for 32PTH1 DSC (Damaged Fuel)
(Concluded)

Fuel Assembly Class	Maximum Assembly Average Initial Enrichment (wt. % U-235) as a Function of Soluble Boron Concentration and Basket Type (Fixed Poison Loading)					
	Minimum Soluble Boron (ppm)	Basket Type				
		1A or 2A	1B or 2B	1C or 2C	1D or 2D	1E or 2E
BW 15x15 Assembly Class (without CCs)	2000	3.30	3.60	3.75	3.95	4.20
	2300	3.50	3.90	4.05	4.30	4.50
	2400	3.60	4.00	4.15	4.40	4.65
	2500	3.65	4.05	4.20	4.50	4.75
	2800	3.90	4.30	4.50	4.75	5.00
	3000	4.05	4.45	4.65	5.00	5.00
BW 15x15 Assembly Class (with CCs)	2000	3.20	3.50	3.65	3.90	4.10
	2300	3.40	3.80	3.95	4.20	4.40
	2400	3.50	3.90	4.05	4.30	4.55
	2500	3.60	4.00	4.15	4.40	4.65
	2800	3.80	4.20	4.40	4.65	4.90
	3000	3.95	4.40	4.55	4.90	5.00
CE 15x15 Assembly Class (without CCs)	2000	3.35	3.70	3.80	4.05	4.25
	2300	3.60	3.95	4.10	4.30	4.60
	2400	3.65	4.05	4.20	4.45	4.70
	2500	3.75	4.15	4.30	4.55	4.80
	2800	4.00	4.40	4.60	4.85	5.00
	3000	4.15	4.55	4.75	5.00	5.00
CE 15x15 Assembly Class (with CCs)	2000	3.30	3.65	3.80	4.00	4.20
	2300	3.55	3.90	4.05	4.30	4.55
	2400	3.65	4.00	4.15	4.45	4.65
	2500	3.70	4.10	4.25	4.50	4.80
	2800	3.95	4.35	4.55	4.80	5.00
	3000	4.10	4.55	4.70	5.00	5.00

Table U.2-6

PWR Fuel Qualification Table for Zone 1 Fuel with 0.6 kW per Assembly for the NUHOMS®-32PTH1 DSC (Fuel without CCs)

(Minimum required years of cooling time after reactor core discharge)

Maximum Assembly Average Initial U-235 Enrichment, wt. % (0.7 – 2.6)

Burn Up, GWD/ MTU	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6
10	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
15	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.0	3.0	3.0	3.0	3.0	3.0	3.0
20	5.0	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.0
25									6.0	6.0	6.0	6.0	6.0	6.0	6.0	5.5	5.5	5.5	5.5	5.5
28									7.5	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
30									8.5	8.5	8.5	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
32									10.0	10.0	10.0	9.5	9.5	9.5	9.5	9.5	9.5	9.0	9.0	9.0
34									12.0	12.0	11.5	11.5	11.5	11.5	11.5	11.0	11.0	11.0	11.0	11.0
36									14.5	14.5	14.0	14.0	14.0	14.0	13.5	13.5	13.5	13.0	13.0	13.0
38									17.5	17.0	17.0	17.0	17.0	17.0	16.0	16.0	16.0	16.0	16.0	16.0
39									18.5	18.5	18.5	18.0	18.0	18.0	18.0	18.0	18.0	17.0	17.0	17.0
40									20.0	20.0	20.0	20.0	20.0	20.0	19.0	19.0	18.5	18.5	18.5	18.5
41									22.0	21.5	21.5	21.0	21.0	20.5	20.5	20.0	20.0	20.0	20.0	20.0
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Maximum Assembly Average Initial U-235 Enrichment, wt. % (2.7 – 5.0)

Burn Up, GWD/ MTU	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0
10	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
15	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
20	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
25	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.0	5.0	5.0	5.0	5.0
28	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.0	6.0	6.0
30	8.0	8.0	8.0	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
32	9.0	9.0	9.0	9.0	9.0	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.0	8.0	8.0
34	11.0	11.0	11.0	10.5	10.5	10.5	10.5	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	9.5	9.5	9.5	9.5
36	13.0	13.0	12.5	12.5	12.5	12.5	12.5	12.5	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5
38	16.0	16.0	15.0	15.0	15.0	14.5	14.5	14.5	14.5	14.5	14.5	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	13.5
39	16.5	16.5	16.5	16.5	16.5	16.5	16.0	16.0	16.0	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.5	15.0	15.0	15.0
40	18.5	18.5	17.5	17.5	17.5	17.5	17.5	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	16.0	16.0
41	19.5	19.5	19.5	19.0	19.0	19.0	18.5	18.5	18.5	18.5	18.5	18.5	18.5	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0
42	21.0	21.0	20.5	20.5	20.5	20.5	20.0	20.0	20.0	20.0	20.0	20.0	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5
43	22.5	22.5	22.0	22.0	22.0	21.5	21.5	21.5	21.5	21.5	21.5	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	21.0	20.0
44	24.0	23.5	23.5	23.5	23.0	23.0	23.0	23.0	23.0	23.0	22.5	22.5	22.5	22.5	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0
45	25.5	25.0	25.0	25.0	24.5	24.5	24.5	24.5	24.5	24.0	24.0	24.0	24.0	23.5	23.5	23.5	23.5	23.5	23.5	23.5	23.5	23.5	23.5	23.5
46	27.0	26.5	26.5	26.0	26.0	26.0	26.0	26.0	26.0	25.5	25.5	25.5	25.5	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	24.5
47	28.0	28.0	28.0	27.5	27.5	27.5	27.5	27.0	27.0	27.0	27.0	27.0	26.5	26.5	26.5	26.5	26.5	26.5	26.5	26.5	26.5	26.5	26.5	26.5
48	29.5	29.5	29.5	29.0	29.0	29.0	28.5	28.5	28.5	28.5	28.5	28.5	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0
49				30.5	30.5	30.0	30.0	30.0	30.0	30.0	30.0	29.5	29.5	29.5	29.0	29.0	29.0	29.0	29.0	29.0	29.0	29.0	29.0	29.0
50				31.5	31.5	31.5	31.5	31.0	31.0	31.0	31.0	31.0	31.0	31.0	30.5	30.5	30.5	30.5	30.0	30.0	30.0	30.0	30.0	30.0
51				33.0	33.0	32.5	32.5	32.5	32.5	32.5	32.5	32.0	32.0	32.0	32.0	32.0	31.5	31.5	31.5	31.5	31.5	31.5	31.5	31.5
52					34.5	34.0	34.0	34.0	34.0	33.5	33.5	33.5	33.5	33.5	33.5	33.0	33.0	33.0	33.0	33.0	33.0	32.5	32.5	32.5
53					35.5	35.5	35.5	35.5	35.0	35.0	35.0	35.0	34.5	34.5	34.5	34.5	34.5	34.5	34.5	34.5	34.0	34.0	34.0	34.0
54						36.5	36.5	36.5	36.5	36.5	36.5	36.0	36.0	36.0	36.0	35.5	35.5	35.5	35.5	35.5	35.5	35.5	35.0	35.0
55						38.0	38.0	37.5	37.5	37.5	37.5	37.5	37.0	37.0	37.0	37.0	37.0	37.0	37.0	36.5	36.5	36.5	36.5	36.5
56						39.0	39.0	38.5	38.5	38.5	38.5	38.5	38.5	38.5	38.5	38.5	38.0	38.0	38.0	38.0	38.0	38.0	37.5	37.5
57								40.0	40.0	40.0	40.0	40.0	40.0	39.5	39.5	39.5	39.5	39.5	39.0	39.0	39.0	39.0	39.0	39.0
58								41.0	41.0	41.0	41.0	41.0	41.0	41.0	41.0	41.0	40.5	40.5	40.5	40.5	40.5	40.0	40.0	40.0
59								42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0	41.5	41.5	41.5	41.5	41.5	41.5
60								43.5	43.5	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	43.0	42.5	42.5	42.5
61								44.5	44.5	44.5	44.5	44.5	44.5	44.5	44.5	44.0	44.0	44.0	44.0	44.0	44.0	44.0	43.5	43.5
62								45.5	45.5	45.5	45.5	45.5	45.5	45.5	45.5	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0	45.0

Note: If irradiated stainless steel rods are present in the reconstituted fuel assembly, add an additional year of cooling time for cooling times less than 10 years.

Note: Table U.2-12 provides the explanatory notes and limitations regarding the use of this table.

Table U.2-7

PWR Fuel Qualification Table for Zone 2 Fuel with 0.8 kW per Assembly for the NUHOMS®-32PTH1 DSC (Fuel without CCs)

(Minimum required years of cooling time after reactor core discharge)

Burn Up, GWD/ MTU	Maximum Assembly Average Initial U-235 Enrichment, wt. %																																										
	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0
10	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
15	3.5	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
20	4.5	4.5	4.0	4.0	4.0	4.0	4.0	4.0	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
25									4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
28									5.5	5.5	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
30									6.0	6.0	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
32									6.5	6.5	6.5	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5
34									7.5	7.0	7.0	7.0	7.0	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
36									8.0	8.0	8.0	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
38									9.0	9.0	9.0	9.0	8.5	8.5	8.5	8.5	8.5	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.0	7.0	7.0	7.0	7.0	7.0	7.0
39									10.0	9.5	9.5	9.5	9.5	9.5	9.0	9.0	9.0	9.0	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	7.5	7.5	7.5	7.5	7.5	7.5	7.5
40									10.5	10.5	10.5	10.0	10.0	10.0	9.5	9.5	9.5	9.5	9.5	9.0	9.0	9.0	9.0	9.0	9.0	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
41									11.5	11.5	11.0	11.0	10.5	10.5	10.5	10.5	10.0	10.0	10.0	10.0	10.0	9.5	9.5	9.5	9.5	9.5	9.5	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5
42																					10.5	10.5	10.5	10.0	10.0	10.0	10.0	10.0	10.0	10.0	9.5	9.5	9.5	9.5	9.5	9.5	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
43																					11.5	11.0	11.0	11.0	11.0	11.0	10.5	10.5	10.5	10.5	10.5	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	9.5	9.5	9.5	9.5	9.5
44																					12.0	12.0	12.0	12.0	11.5	11.5	11.5	11.5	11.5	11.0	11.0	11.0	11.0	11.0	11.0	11.0	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5
45																					13.0	13.0	13.0	12.5	12.5	12.5	12.5	12.0	12.0	12.0	12.0	12.0	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.5	11.0	11.0	11.0	11.0
46																					14.0	14.0	14.0	13.5	13.5	13.5	13.5	13.0	13.0	13.0	13.0	13.0	12.5	12.5	12.5	12.5	12.5	12.5	12.5	12.0	12.0	12.0	12.0	12.0
47																					15.0	15.0	15.0	14.5	14.5	14.5	14.5	14.0	14.0	14.0	14.0	14.0	13.5	13.5	13.5	13.5	13.5	13.5	13.0	13.0	13.0	13.0	13.0	13.0
48																					16.5	16.0	16.0	15.5	15.5	15.5	15.5	15.5	15.0	15.0	15.0	15.0	15.0	14.5	14.5	14.5	14.5	14.5	14.5	14.0	14.0	13.5	13.5	13.5
49																								17.0	17.0	16.5	16.5	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	15.5	15.0	15.0	15.0	15.0	15.0	14.5	14.5	14.5
50																								18.0	18.0	18.0	17.5	17.5	17.5	17.5	17.0	17.0	17.0	17.0	17.0	16.5	16.5	16.5	16.5	16.5	16.0	15.5	15.5	15.5
51																								19.0	19.0	19.0	19.0	18.5	18.5	18.0	18.0	18.0	18.0	17.5	17.5	17.5	17.5	17.5	17.0	17.0	17.0	17.0	17.0	17.0
52																									20.0	20.0	20.0	19.5	19.5	19.5	19.5	19.5	19.0	19.0	19.0	19.0	19.0	18.5	18.5	18.5	18.5	18.5	18.5	17.5
53																									21.5	21.0	21.0	21.0	20.5	20.5	20.5	20.5	20.5	20.0	20.0	20.0	20.0	20.0	19.5	19.5	19.5	19.5	19.5	19.0
54																										22.5	22.5	22.0	22.0	21.5	21.5	21.5	21.5	21.0	21.0	21.0	21.0	21.0	20.5	20.5	20.5	20.5	20.5	20.0
55																										23.5	23.5	23.0	23.0	23.0	23.0	23.0	23.0	22.5	22.5	22.5	22.5	22.0	21.5	21.5	21.5	21.5	21.5	21.0
56																										25.0	25.0	24.5	24.5	24.5	24.0	24.0	24.0	24.0	23.5	23.0	23.0	23.0	23.0	23.0	22.5	22.5	22.5	22.5
57																												25.5	25.5	25.5	25.5	25.0	25.0	25.0	25.0	24.5	24.5	24.5	24.5	24.5	23.5	23.5	23.5	23.5
58																												27.0	27.0	26.0	26.0	26.0	26.0	26.0	25.5	25.5	25.5	25.5	25.5	25.0	25.0	25.0	25.0	25.0
59																												27.5	27.5	27.5	27.5	27.5	27.5	27.5	27.0	27.0	27.0	27.0	26.0	26.0	26.0	26.0	26.0	25.5
60																												29.0	28.5	28.5	28.5	28.5	28.0	28.0	28.0	28.0	28.0	28.0	27.5	27.5	27.5	27.5	27.5	27.0
61																												29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.0	29.0	29.0	29.0	29.0	28.0	28.0	28.0	28.0
62																												31.5	30.5	30.5	30.5	30.5	30.5	30.0	30.0	30.0	30.0	30.0	29.5	29.5	29.5	29.5	29.5	29.5

Note: If irradiated stainless steel rods are present in the reconstituted fuel assembly, add an additional year of cooling time for cooling times less than 10 years.

Note: Table U.2-12 provides the explanatory notes and limitations regarding the use of this table.

Table U.2-8
PWR Fuel Qualification Table for Bounding Zone 3 or 4 Fuel with 1.0 kW per Assembly for the NUHOMS®-32PTH1 DSC (Fuel without CCs)

(Minimum required years of cooling time after reactor core discharge)

Burn Up, GWD/ MTU	Maximum Assembly Average Initial U-235 Enrichment, wt. %																																											
	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0
10	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
15	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
20	3.5	3.5	3.5	3.5	3.5	3.5	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
25									4.0	4.0	4.0	4.0	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
28									4.5	4.5	4.5	4.5	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
30									5.0	5.0	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
32									5.5	5.5	5.0	5.0	5.0	5.0	5.0	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.0	4.0	4.0	4.0	4.0	4.0	4.0
34									6.0	6.0	5.5	5.5	5.5	5.5	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
36									6.5	6.5	6.0	6.0	6.0	6.0	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
38									7.5	7.0	7.0	6.5	6.5	6.5	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.0	5.0
39									7.5	7.5	7.0	7.0	7.0	6.5	6.5	6.5	6.5	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5
40									8.0	8.0	7.5	7.5	7.0	7.0	7.0	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	5.5	5.5	5.5	5.5	5.5
41									8.5	8.5	8.0	7.5	7.5	7.5	7.0	7.0	7.0	7.0	7.0	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
42																					7.0	7.0	7.0	7.0	7.0	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.0	6.0	6.0	6.0	6.0
43																					7.5	7.5	7.5	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
44																					8.0	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7:0	7.0	7.0	7.0	6.5	6.5	6.5
45																					8.0	8.0	8.0	8.0	8.0	8.0	8.0	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.0	7.0	7.0	7.0	7.0	7.0	7.0
46																					8.5	8.5	8.5	8.5	8.5	8.5	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
47																					9.0	9.0	9.0	9.0	9.0	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	7.5	7.5
48																					10.0	9.5	9.5	9.5	9.5	9.5	9.0	9.0	9.0	9.0	9.0	9.0	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.0	8.0	8.0
49																								10.0	10.0	10.0	9.5	9.5	9.5	9.5	9.5	9.5	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	8.5	8.5	8.5	8.5
50																								10.5	10.5	10.5	10.5	10.0	10.0	10.0	10.0	10.0	10.0	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.0	9.0	9.0	9.0
51																								11.5	11.5	11.0	11.0	11.0	11.0	10.5	10.5	10.5	10.5	10.5	10.0	10.0	10.0	10.0	10.0	10.0	9.5	9.5	9.5	9.5
52																									12.0	12.0	12.0	11.5	11.5	11.5	11.0	11.0	11.0	11.0	11.0	10.5	10.5	10.5	10.5	10.5	10.5	10.0	10.0	10.0
53																									13.0	12.5	12.5	12.5	12.0	12.0	12.0	12.0	11.5	11.5	11.5	11.5	11.5	11.0	11.0	11.0	11.0	11.0	11.0	10.5
54																										13.5	13.5	13.0	13.0	13.0	12.5	12.5	12.5	12.5	12.5	12.0	12.0	12.0	12.0	12.0	11.5	11.5	11.5	11.5
55																										14.5	14.0	14.0	14.0	13.5	13.5	13.5	13.5	13.0	13.0	13.0	13.0	12.5	12.5	12.5	12.5	12.5	12.0	12.0
56																										15.5	15.0	15.0	15.0	14.5	14.5	14.5	14.0	14.0	14.0	13.5	14.0	13.5	13.5	13.5	13.5	13.0	13.0	13.0
57																												16.0	15.5	15.5	15.5	15.5	15.0	15.0	15.0	14.5	14.5	14.5	14.5	14.0	14.0	14.0	14.0	13.5
58																												17.0	16.5	16.5	16.5	16.0	16.0	16.0	15.5	15.5	15.5	15.5	15.0	15.0	15.0	14.5	14.5	14.5
59																												18.0	17.5	17.5	17.5	17.0	17.0	17.0	16.5	16.5	16.5	16.0	16.0	16.0	16.0	15.5	15.5	15.5
60																												19.0	18.5	18.5	18.0	18.0	18.0	17.5	17.5	17.5	17.5	17.0	17.0	17.0	16.5	16.5	16.5	16.5
61																												20.0	19.5	19.5	19.0	19.5	19.0	18.5	18.5	18.5	18.0	18.0	18.5	18.0	17.5	17.5	17.5	17.5
62																												20.5	20.5	20.5	20.0	20.0	20.0	20.0	19.5	19.5	19.5	19.0	19.0	19.0	18.5	18.5	18.5	18.5

Note: If irradiated stainless steel rods are present in the reconstituted fuel assembly, add an additional year of cooling time for cooling times less than 10 years.

Note: Table U.2-12 provides the explanatory notes and limitations regarding the use of this table.

Table U.2-9

PWR Fuel Qualification Table for Zone 5 Fuel with 1.3 kW per Assembly for the NUHOMS®-32PTH1 DSC (Fuel without CCs)

(Minimum required years of cooling time after reactor core discharge)

Burn Up, GWD/ MTU	Maximum Assembly Average Initial U-235 Enrichment, wt. %																																											
	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0
10	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
15	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
20	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
25									3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
28									3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
30									4.0	4.0	4.0	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
32									4.5	4.0	4.0	4.0	4.0	4.0	4.0	4.0	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
34									4.5	4.5	4.5	4.5	4.5	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
36									5.0	5.0	5.0	4.5	4.5	4.5	4.5	4.5	4.5	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
38									5.5	5.5	5.0	5.0	5.0	5.0	5.0	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
39									6.0	5.5	5.5	5.5	5.0	5.0	5.0	5.0	5.0	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
40									6.0	6.0	5.5	5.5	5.5	5.5	5.0	5.0	5.0	5.0	5.0	5.0	5.0	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
41									6.5	6.0	6.0	6.0	5.5	5.5	5.5	5.5	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
42																					5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
43																					5.5	5.5	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	4.5	4.5	4.5	4.5
44																					5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
45																					5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
46																					6.0	6.0	6.0	6.0	6.0	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.0	5.0	5.0	5.0	5.0
47																					6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5
48																					6.5	6.5	6.5	6.5	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5
49																								6.5	6.5	6.5	6.5	6.5	6.5	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	5.5
50																								7.0	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
51																								7.0	7.0	7.0	7.0	7.0	7.0	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.0	6.0	6.0	6.0
52																									7.5	7.5	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
53																									7.5	7.5	7.5	7.5	7.5	7.5	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	6.5	6.5	6.5	6.5
54																										8.0	8.0	8.0	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
55																										8.5	8.0	8.0	8.0	8.0	8.0	8.0	8.0	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.0	7.0	7.0
56																										8.5	8.5	8.5	8.5	8.5	8.5	8.0	8.0	8.0	8.0	8.0	8.0	8.0	7.5	7.5	7.5	7.5	7.5	7.5
57																												9.0	9.0	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
58																												9.5	9.5	9.0	9.0	9.0	9.0	9.0	9.0	8.5	8.5	8.5	8.5	8.5	8.5	8.0	8.0	8.0
59																												10.0	10.0	9.5	9.5	9.5	9.5	9.5	9.0	9.0	9.0	9.0	9.0	9.0	8.5	8.5	8.5	8.5
60																												10.5	10.5	10.0	10.0	10.0	10.0	10.0	9.5	9.5	9.5	9.5	9.5	9.0	9.0	9.0	9.0	9.0
61																												11.0	11.0	11.0	10.5	10.5	10.5	10.5	10.0	10.0	10.0	10.0	10.0	10.0	9.5	9.5	9.5	9.5
62																												11.5	11.5	11.5	11.5	11.0	11.0	11.0	10.5	10.5	10.5	10.5	10.5	10.0	10.0	10.0	10.0	10.0

Note: If irradiated stainless steel rods are present in the reconstituted fuel assembly, add an additional year of cooling time for cooling times less than 10 years.

Note: Table U.2-12 provides the explanatory notes and limitations regarding the use of this table.

Table U.2-10
PWR Fuel Qualification Table for Zone 6 Fuel with 1.5 kW per Assembly for the NUHOMS®-32PTH1 DSC (Fuel without CCs)
(Minimum required years of cooling time after reactor core discharge)

Burn Up, GWD/ MTU	Maximum Assembly Average Initial U-235 Enrichment, wt. %																																											
	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5.0
10	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
15	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
20	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
25									3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
28									3.5	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
30									3.5	3.5	3.5	3.5	3.5	3.5	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
32									4.0	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
34									4.0	4.0	4.0	4.0	4.0	4.0	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
36									4.5	4.5	4.5	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
38									5.0	5.0	4.5	4.5	4.5	4.5	4.5	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
39									5.0	5.0	5.0	5.0	4.5	4.5	4.5	4.5	4.5	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
40									5.5	5.0	5.0	5.0	5.0	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	3.5
41									5.5	5.5	5.5	5.0	5.0	5.0	5.0	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
42																					4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
43																					4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
44																					5.0	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.0	4.0	4.0	4.0
45																					5.0	5.0	5.0	5.0	5.0	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
46																					5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
47																					5.5	5.5	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
48																					5.5	5.5	5.5	5.5	5.5	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	4.5	4.5
49																								5.5	5.5	5.5	5.5	5.5	5.5	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
50																								5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
51																								6.0	6.0	6.0	6.0	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.0	5.0	5.0
52																									6.0	6.0	6.0	6.0	6.0	6.0	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5
53																									6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5
54																										6.5	6.5	6.5	6.5	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	5.5	5.5	5.5
55																										6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
56																										7.0	7.0	7.0	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.0	6.0	6.0	6.0	6.0
57																												7.0	7.0	7.0	7.0	7.0	7.0	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
58																												7.5	7.5	7.5	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	6.5	6.5	6.5	6.5	6.5	6.5
59																												7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.0	7.0	7.0	7.0	7.0	7.0	7.0	6.5	7.0
60																												8.0	8.0	8.0	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.0	7.0	7.0	7.0	7.0
61																												8.5	8.0	8.0	8.0	8.0	8.0	8.0	8.0	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
62																												8.5	8.5	8.5	8.5	8.5	8.5	8.0	8.0	8.0	8.0	8.0	8.0	8.0	7.5	7.5	7.5	7.5

Note: If irradiated stainless steel rods are present in the reconstituted fuel assembly, add an additional year of cooling time.

Note: Table U.2-12 provides the explanatory notes and limitations regarding the use of this table.

Table U.2-11

PWR Fuel Qualification Table for Zone 5 with Damaged Fuel with 1.2 kW per Fuel Assembly for the NUHOMS® -32PTH1 DSC (Fuel without CCs)

(Minimum required years of cooling time after reactor core discharge)

Burn Up, GWD/MTU	Maximum Assembly Average Initial U-235 Enrichment, wt. %																																											
	0.7	0.8	0.9	1	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3	3.1	3.2	3.3	3.4	3.5	3.6	3.7	3.8	3.9	4	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	4.9	5
10	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
15	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
20	3.5	3.5	3.5	3.5	3.5	3.5	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
25									3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
28									4.0	4.0	4.0	4.0	4.0	4.0	4.0	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
30									4.5	4.5	4.5	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
32									5.0	5.0	4.5	4.5	4.5	4.5	4.5	4.5	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
34									5.5	5.5	5.0	5.0	5.0	5.0	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
36									6.0	6.0	5.5	5.5	5.5	5.5	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
38									6.5	6.5	6.0	6.0	6.0	6.0	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	4.5	4.5
39									7.0	6.5	6.5	6.5	6.0	6.0	6.0	6.0	6.0	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
40									7.0	7.0	6.5	6.5	6.5	6.5	6.0	6.0	6.0	6.0	6.0	6.0	6.0	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.0	5.0	5.0	5.0	5.0
41									7.5	7.0	7.0	7.0	6.5	6.5	6.5	6.5	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5
42																					6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5	5.5
43																					6.5	6.5	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	5.5	5.5	5.5	5.5
44																					6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
45																					6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
46																					7.0	7.0	7.0	7.0	7.0	7.0	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.0	6.0	6.0	6.0	6.0
47																					7.5	7.5	7.5	7.5	7.5	7.0	7.0	7.0	7.0	7.0	7.0	7.0	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
48																					8.0	8.0	8.0	8.0	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	6.5	6.5	6.5
49																								8.0	8.0	8.0	8.0	8.0	8.0	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.0	7.0	7.0	7.0
50																								8.5	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
51																								9.0	9.0	8.5	8.5	8.5	8.5	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	7.5	7.5	7.5	7.5
52																									9.5	9.5	9.0	9.0	9.0	9.0	8.5	8.5	8.5	8.5	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
53																									9.5	9.5	9.5	9.5	9.5	9.5	9.0	9.0	9.0	9.0	9.0	9.0	8.5	8.5	8.5	8.5	8.5	8.5	8.5	8.0
54																										10.0	10.0	10.0	9.5	9.5	9.5	9.5	9.5	9.5	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0	9.0
55																										11.0	10.5	10.5	10.5	10.0	10.0	10.0	10.0	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.5	9.0	9.0	9.0
56																										11.0	11.0	11.0	11.0	11.0	11.0	10.5	10.5	10.5	10.5	10.0	10.5	10.0	10.0	10.0	10.0	9.5	9.5	9.5
57																												11.5	11.5	11.0	11.0	11.0	11.0	11.0	11.0	11.0	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.0
58																												12.5	12.0	12.0	12.0	11.5	11.5	11.5	11.5	11.0	11.0	11.0	11.0	11.0	11.0	10.5	10.5	10.5
59																												13.0	13.0	12.5	12.5	12.5	12.5	12.5	12.0	12.0	12.0	11.5	11.5	11.5	11.5	11.0	11.0	11.0
60																												13.5	13.5	13.0	13.0	13.0	13.0	13.0	12.5	12.5	12.5	12.5	12.5	12.0	12.0	12.0	12.0	12.0
61																												14.5	14.0	14.0	13.5	14.0	13.5	13.5	13.0	13.0	13.0	13.0	13.0	13.0	12.5	12.5	12.5	12.5
62																												15.0	15.0	15.0	14.5	14.5	14.5	14.5	14.0	14.0	14.0	13.5	13.5	13.5	13.0	13.0	13.0	13.0

Note: If irradiated stainless steel rods are present in the reconstituted fuel assembly, add an additional year of cooling time for cooling times less than 10 years.

Note: Table U.2-12 provides the explanatory notes and limitations regarding the use of this table.

Table U.2-12
Notes for Tables U.2-6 through U.2-11

- Burnup = Assembly Average burnup.
- Use burnup and enrichment to lookup minimum cooling time in years. Licensee is responsible for ensuring that uncertainties in fuel enrichment and burnup are correctly accounted for during fuel qualification.
- Round burnup UP to next higher entry, round enrichments DOWN to next lower entry.
- Fuel with an assembly average initial enrichment less than 0.7 (or less than the minimum provided above for each burnup) and greater than 5.0 wt.% U-235 is unacceptable for storage.
- Fuel with a burnup greater than 62 GWd/MTU is unacceptable for storage.
- Fuel with a burnup less than 10 GWd/MTU is acceptable for storage after 3-years cooling.
- See Figure U.2-1 through Figure U.2-3 for a description of the Heat Load Zoning Configurations.
- For reconstituted fuel assemblies with UO2 rods and/or Zr rods or Zr pellets and/or stainless steel rods rods, use the assembly average equivalent enrichment to determine the minimum cooling time.
- The cooling times for damaged and intact assemblies are identical.
- Example: An intact fuel assembly without CCs, with a decay heat load of 1.5 kW or less, an initial enrichment of 3.65 wt. % U-235 and a burnup of 41.5 GWd/MTU is acceptable for storage after a 4.0 year cooling time as defined by 3.6 wt. % U-235 (rounding down) and 42 GWd/MTU (rounding up) in Table U.2-10.

Table U.2-13
Summary of 32PTH1-DSC Load Combinations

Load Case	Horizontal DW		Vertical DW		Internal Pressure	External Pressure	Thermal Condition	Lifting Loads	Other Loads	Service Level
	DSC	Fuel	DSC	Fuel						
Non-Operational Load Cases										
NO-1 Fab. Leak Testing	--	--	--	--	--	14.7 psig	70°F	--	155 kip axial	Test
NO-2 Fab. Leak Testing	--	--	--	--	15x1.5 = 23 psig				155 kip axial	Test
NO-3 DSC Uprighting	x	--	--	--	--	--	70°F	x	--	A
NO-4 DSC Vertical Lift	--	--	x	--	--	--	70°F	x	--	A
Fuel Loading Load Cases										
FL-1 DSC/Cask Filling	--	--	Cask	--	--	Hydrostatic	140°F Cask	x	x	A
FL-2 DSC/Cask Filling	--	--	Cask	--	Hydrostatic	Hydrostatic	140°F Cask	x	x	A
FL-3 DSC/Cask Xfer	--	--	Cask	--	Hydrostatic	Hydrostatic	140°F Cask	--	--	A
FL-4 Fuel Loading	--	--	Cask	x	Hydrostatic	Hydrostatic	140°F Cask	--	--	A
FL-5 Xfer to Decon	--	--	Cask	x	Hydrostatic	Hydrostatic	140°F Cask	--	--	A
FL-6 Inner Cover plate Welding	--	--	Cask	x	Hydrostatic	Hydrostatic	140°F Cask	--	--	A
FL-7 Fuel Deck Seismic Loading	--	--	Cask	x	Hydrostatic	Hydrostatic	140°F Cask	--	Note 10	D
Draining/Drying Load Cases										
DD-1 DSC Blowdown/Pressure Test	--	--	Cask	x	Hydrostatic+ 20[14] psig	Hydrostatic	140°F Cask	--	--	B
DD-2 Vacuum Drying	--	--	Cask	x	0 psia	Hydrostatic+ 14.7psig	140 F Cask	--	--	B
DD-3 Helium Backfill	--	--	Cask	x	20 psig	Hydrostatic	140°F Cask	--	--	B
DD-4 Final Helium Backfill	--	--	Cask	x	3.5 psig	Hydrostatic	140°F Cask	--	--	B
DD-5 Outer Cover Plate Weld	--	--	Cask	x	3.5 psig	Hydrostatic	140°F Cask	--	--	B
Transfer Trailer Loading										
TL-1 Vertical Xfer to Trailer	--	--	Cask	x	15 psig	--	0°F Cask	--	--	A
TL-2 Vertical Xfer to Trailer	--	--	Cask	x	15 psig	--	140°F Cask	--	--	A
TL-3 Laydown	Cask	X	--	--	15 psi g	--	0°F Cask	--	--	A
TL-4 Laydown	Cask	X	--	--	15 psig	--	106°F Cask	--	--	A

Table U.2-13
Summary of 32PTH1-DSC Load Combinations (Continued)

Load Case	Horizontal DW		Vertical DW		Internal Pressure	External Pressure	Thermal Condition	Handling Loads	Other Loads	Service Level
	DSC	Fuel	DSC	Fuel						
Transfer To/From ISFSI										
TR-1 Axial Load - Cold	Cask	X	--	--	15.0 psig	--	0°F Cask	1g Axial	--	A
TR-2 Transverse Load - Cold	Cask	X	--	--	15.0 psig	--	0°F Cask	1g Transverse	--	A
TR-3 Vertical Load - Cold	Cask	X	--	--	15.0 psig	--	0°F Cask	1g Vertical	--	A
TR-4 Oblique Load - Cold	Cask	X	--	--	15.0 psig	--	0°F Cask	½ g Axial + ½ g Trans + ½ g Vert.	--	A
TR-5 Axial Load - Hot	Cask	X	--	--	15.0 psig	--	106°F Cask	1g Axial	--	A
TR–6 Transverse Load - Hot	Cask	X	--	--	15.0 psig	--	106°F Cask	1g Trans.	--	A
TR-7 Vertical Load - Hot	Cask	X	--	--	15.0 psig	--	106°F Cask	1g Vertical	--	A
TR-8 Oblique Load - Hot	Cask	X	--	--	15.0 psig	--	106°F Cask	½ g Axial + ½ g Trans + ½ g Vert.	--	A
TR-9 25g Corner Drop	Note 1	Note 1	Note 1	Note 1	20 psig	--	117°F[2] Cask		25g Corner Drop	D
TR-10 75g Side Drop	Note 1	Note 1	--	--	20 psig	--	117°F[2] Cask		75g Side Drop	D
TR-11 Top or Bottom End Drops	Note 12									
TR-12 – Transfer Cask Post Drop Accident - Loss of Neutron Shield, Loss of Sunshade, Loss of Cooling Air	Cask	X	--	--	140 psig	--	106°F[2] Cask	--	100% Failed Fuel-	D
HSM LOADING										
LD-1 Normal Loading - Cold	Cask	X	--	--	15.0 psig	--	0°F Cask	+110 Kip	--	A
LD-2 Normal Loading – Hot	Cask	X	--	--	15.0 psig	--	106°F Cask	+110 Kip	--	A
LD-3 Normal Loading – Hot	Cask	X	--	--	15.0 psig	--	117°F[5]	+110 Kip	--	A
LD-4 Off-Normal Loading – Cold	Cask	X	--	--	20.0 psig	--	0°F Cask	+110 Kip	10% FF	B
LD-5 Off-Normal Loading - Hot	Cask	X	--	--	20.0 psig	--	106°F Cask	+110 Kip	10% FF	B
LD-6 Off-Normal Loading - Ho	Cask	X	--	--	20.0 psig	--	117°F[5]	+110 Kip	10% FF	B
LD-7 Accident Loading[11]	Cask	X	--	--	20.0 psig	--	117°F[5]	+110 Kip	10% FF	C/D

Table U.2-13
Summary of 32PTH1-DSC Load Combinations
(continued)

	Horizontal DW		Vertical DW		Internal Pressure	External Pressure	Thermal Condition	Handling Loads	Other Loads	Service Level[8]
	DSC	Fuel	DSC	Fuel						
HSM STORAGE										
HSM-1 Off-Normal	HSM	X	--	--	20.0 psig	--	-40° F HSM	--	--	B
HSM-2 Normal Storage	HSM	X	--	--	15.0 psig	--	0° HSM	--	--	A
HSM-3 Off-Normal	HSM	X	--	--	20.0 psig	--	117° HSM	--	--	B
HSM-4 Off-Normal Temp. + Failed Fuel	HSM	X	--	--	20.0 psig	--	117°F HSM	--	10% FF	C
HSM-5 Blocked Vent Storage	HSM	X	--	--	140.0 psig	--	117°F HSM/BV[4]	--	--	D
HSM-6 B.V. + 10% Failed Fuel Storage	HSM	X	--	--	140.0 psig	--	117°F HSM/BV[4]	--	10% FF	D
HSM-7 Earthquake Loading – Cold	HSM	X	--	--	20.0 psig	--	-40°F HSM	--	EQ Standard	C
HSM-8 Earthquake Loading – Hot	HSM	X	--	--	20.0 psig	--	117°F HSM	--	EQ Standard	C
HSM-7A Earthquake Loading – Cold	HSM	X			20.0 psig		-40°F HSM		EQ High	D
HSM-8A Earthquake Loading – Hot	HSM	X			20.0 psig		117°F HSM		EQ High	D
HSM-9 Flood Load (50' H_2O) – Cold	HSM	X	--	--	0 psig	22 psig	0°F HSM	--	Flood[3]	C
HSM-10 Flood Load (50' H_2O) - Hot	HSM	X	--	--	0 psig	22 psig	106°F HSM	--	Flood[3]	C

HSM UNLOADING	Horizontal DW		Vertical DW		Internal Pressure	External Pressure	Thermal Condition	Handling Loads	Other Loads	Service Level
	DSC	Fuel	DSC	Fuel						
UL-1 Normal Unloading - Cold	HSM	X	--	--	15.0 psig	--	0°F HSM	-80 Kip	--	A
UL-2 Normal Unloading – Hot	HSM	X	--	--	15.0 psig	--	106°F HSM	-80 Kip	--	A
UL-4 Off-Normal Unloading – Cold	HSM	X	--	--	20.0 psig	--	-40°F HSM	-80 Kip	10% FF	B
UL-5 Off-Normal Unloading - Hot	HSM	X	--	--	20.0 psig	--	117°F HSM	-80 Kip	10% FF	B

HSM UNLOADING / REFLOOD	Horizontal DW		Vertical DW		Internal Pressure[13]	External Pressure	Thermal Condition	Handling Loads	Other Loads	Service Level
	DSC	Fuel	DSC	Fuel						
RF-1 32PTH1 DSC Reflood	--	--	Cask	X	140.0 psig (max)	Hydrostatic	117°F Cask	--	--	D

Table U.2-13
Summary of 32PTH1-DSC Load Combinations
(Concluded)

Summary of 32PTH1-DSC Load Combinations Notes:

1. 75g drop acceleration includes gravity effects. Therefore, it is not necessary to add an additional 1.0g load.
2. For Level D events, stress allowables are based considering the maximum temperature of the component (Thermal stresses are not limited for level D events and maximum temperatures give minimum allowables) or the actual temperature distribution (basket).
3 Flood load is an external pressure equivalent to 50 feet (164m) of water.
4. BV = HSM Vents are blocked. The BV accident pressure, based on the blocked vent temperature condition and 10% failed rods, is bounded by the transfer case post drop accident pressure.
5. At temperature over 100°F a sunshade is required over the Transfer Cask. Temperatures for these cases are enveloped by the 100° F (without sunshade) case.
6. This pressure assumes 10% release of the fuel cover gas and 30% of the fission gas. Since unloading requires the HSM door to be removed, the pressure and temperatures are based on the normal (unblocked vent) condition.
7. Not Used.
8. Secondary stresses, including thermal stresses, need not be considered for Levels C and D load combinations.
9. Level C load combination is with off-normal 20.0 psig internal pressure. Level D load combination is with accident pressure of 140.0 psig.
10. Fuel deck for standard seismic loads are assumed enveloped by handling loads.
11. Load Cases UL-8 envelop loading cases where the insertion loading of 110 kips is considered with an off-normal pressure (for Level C) and accident pressure (for Level D) (the insertion force is opposed by internal pressure).
12. The top end drop and bottom end drop are not credible events under P72, therefore these drop analyses are not required. However, consideration of 75g end drops (for P71 conditions) and the 75g side drop to conservatively envelop the effects of a 25g corner drop.
13. Reflood pressure is limited to 20 psig. For analysis purposes a 140 psig pressure is considered.
14. The blowdown pressure is 15 psig (consistent with the 15 psig normal design pressure). However, the analysis is performed using 20 psig pressure.

Table U.2-14
Summary of Stress Criteria for Subsection NB Pressure Boundary Components

(e.g., DSC Shell and Cover Plates)

Service Level	Stress Category
Level A[(1)(2)]	$P_m \le 1.0S_m$ $P_L \le 1.5S_m$ $P_m\ (or\ P_L) + P_b \le 1.5S_m$ $P_m\ (or\ P_L) + P_b + Q \le 3.0S_m$
Level B[(1)(3)]	$P_m \le 1.0S_m$ $P_L \le 1.5S_m$ $P_m\ (or\ P_L) + P_b \le 1.5S_m$ $P_m\ (or\ P_L) + P_b + Q \le 3.0S_m$
Level C[(4)]	$P_m \le \max(1.2S_m, 1.0S_y)$ $P_L \le \max(1.8S_m, 1.5S_y)$ $P_m\ (or\ P_L) + P_b \le \max(1.8S_m, 1.5S_y)$ $P_m\ (or\ P_L) + P_b + Q \le note\ 4$
Carbon Steel Components (e.g., Shield Plugs)	
Level D[(4)] Elastic Analysis	$P_m \le 0.7S_u$ $P_m\ (or\ P_L) + P_b \le 1.0S_u$
Level D[(4)] Plastic Analysis	$P_m \le 0.7S_u$ $P_m\ (or\ P_L) + P_b \le 0.9S_u$
Austenitic Steel Components (e.g., Shell)	
Level D[(4)] Elastic Analysis	$P_m \le \min(2.4S_m, 0.7S_u)$ $P_m\ (or\ P_L) + P_b \le \min(3.6S_m, 1.0S_u)$
Level D[(4)] Plastic Analysis	$P_m \le \max(0.7S_u, S_y + (S_u - S_y)/3)$ $P_m\ (or\ P_L) + P_b \le 0.9S_u$

Notes:

1. The secondary stress limit may be exceeded provided the criteria of NB-3228.5 are satisfied.
2. There are no specific limits on primary stresses for Level A events. However, the stresses due to primary loads during normal service must be computed and combined with the effects of other loadings in satisfying other limits. See NB-3222.1.
3. The 10% increase in allowables from NB-3223(a) may be applicable for load combinations for which the pressure exceeds the design pressure.
4. Evaluation of secondary stresses not required for Level C and D events.

Table U.2-15
Summary of Stress Criteria for Subsection NG Components

(e.g., Fuel Compartment Tubes, Transition Rails)

Service Level	Stress Category[5]
Level A/B[1]	$P_m \le 1.0S_m$ $P_m + P_b \le 1.5S_m$ $P_m + P_b + Q \le 3.0S_m$ (*note* 4)
Level C[2] [3] Elastic Analysis	$P_m \le 1.5S_m$ $P_m + P_b \le 2.25S_m$
Level D[2] [6] Elastic Analysis	$P_m \le \min(2.4S_m, 0.7S_u)$ $P_m + P_b \le \min(3.6S_m, 1.0S_u)$
Level D[2] [6] Plastic Analysis	$P_m \le \max(0.7S_u, S_y + 1/3(S_u - S_y))$ $P_m + P_b \le 0.9S_u$

Notes:

1. There are no pressure loads on the basket, therefore the 10% increase permitted by NG-3223(a) for pressures exceeding the design pressure does not apply.
2. Evaluation of secondary stresses not required for Level C and D events.
3. Criteria listed are for elastic analyses, other analysis methods permitted by NG-3224.1 are acceptable if performed in accordance with the appropriate paragraph of NG-3224.1.
4. This limit may be exceeded provided the requirements of NG-3228.3 are satisfied, see NG-3222.2 and NG-3228.3.
5. As appropriate, the special stress limits of NG-3227 are applicable.
6. Level D criteria are taken from ASME Code, Section III, Appendix F. Acceptable criteria for stability are from Section III of the ASME Code Appendix F.

Table U.2-16
Summary of NUHOMS®-32PTH1 DSC and HSM-H Component Design Loadings[1]

Component	Design Load Type	SAR Section Reference	Design Parameters	Applicable Codes
32PTH1-DSC:	---	---	---	ASME Code, 1998 Edition with 2000 Addenda, Section III, Subsection NB and Appendix F (Shell) and Subsections NG, NF and Appendix F (Basket) with alternatives noted in Table U.3.1-1.
	Flood	U.2.2.2	Maximum water height: 50 ft and water velocity of 15'/sec.	10CFR72.122(b)
	Seismic	U.2.2.3	(a) Standard Seismic Criteria: 0.30g Horizontal and 0.25g (b) High Seismic Alternate: 1.0g Horizontal and 1.0g Vertical ground acceleration.	NRC Reg. Guides 1.60 [2.11] and 1.61 [2.12]
	Dead Load	U.3.6.1.2 U.3.6.1.3	Maximum enveloping weight of loaded 32PTH1 DSC: 110,000 lbs.	ANSI 57.9-1984
	Normal and Off-Normal Pressure	U.3.6.1.2 U.3.6.1.3	Enveloping internal pressure of ≤15 psig (Normal) and ≤ 20 psig (Off-Normal)	10CFR72.122(h)
	Test Pressure	U.3.6.1.2	Enveloping internal pressure of 23 psig applied w/o DSC outer top cover plate	10CFR72.122(h)
	Normal and Off-Normal Operating Temperature	U.3.6.1.2 U.3.6.1.3 U.3.6.2.2	Normal: Ambient air temperature 0°F to 106° Off Normal: Ambient air temperature -40°F to 117°F	ANSI 57.9-1984
	Normal Handling Loads	U.3.6.1.2 U.3.6.1.3	1. Hydraulic ram load of 110,000 lb.(DSC HSM insertion) 80,000 lb (DSC HSM extraction) 2. Transfer (to/from ISFSI) Loads of: 2a. +/-1.0g axial 2b. +/-1.0g transverse 2c. +/-1.0g vertical 2d. +/-0.5g axial +/-0.5g transverse +/-0.5g vertical	ANSI 57.9-1984
	Off-Normal Handling Loads	U.3.6.1.2	Hydraulic ram load of: 110,000 lb(DSC HSM insertion) 80,000 lb(DSC HSM extraction)	ANSI-57.9-1984
	Accidental Cask Drop Loads	U.3.7.5	Equivalent static deceleration of 75g for horizontal side drops, and 25g oblique corner drop	10CFR72.122(b)
	Accident Internal Pressure	U.4	Enveloping internal pressure of ≤140 psig based on 100% fuel cladding rupture and fill gas release, 30% fission gas release, and ambient air temperature of 117°F	10CFR72.122(h)

Table U.2-16
Summary of NUHOMS®-32PTH1 DSC and HSM-H Component Design Loadings[1]
(continued)

Component	Design Load Type	SAR Section Reference	Design Parameters	Applicable Codes
HSM-H Module	----	---	----	ACI 349-97, ACI 318-95 (for construction only)
	Flood	U.2.2.5.2.3(C)	Maximum water height: 50 ft. Maximum velocity of water 15'/sec.	10CFR72.122(b)
	Seismic	U.2.2.5.2.3(D)	(a) Standard Seismic Criteria: 0.30g Horizontal and 0.25g Vertical ground acceleration. (b) High Seismic Alternate HSM-HS): 1.0g Horizontal and 1.0g Vertical ground acceleration.	NRC Reg. Guides 1.60 [2.11] and 1.61 [2.12]
	Dead Load	U.2.2.5.2.1(A)	150 pcf concrete structure and weight of support steel structure	ANSI 57.9-1984 [2.9]
	Normal and Off-Normal Operating Temperature	U.2.2.5.2.1(C) U.2.2.5.2.2(A)	Normal: Ambient air temperature 0°F -106°F Off Normal: Ambient air temperature -40°F to 117°F	ANSI 57.9-1984 [2.9]
	Normal Handling Loads	U.2.2.5.2.1(D)	Hydraulic ram load of 80,000 lb.(DSC HSM insertion) 60,000 lb (DSC HSM extraction) on the rails. For HSM-HS corresponding loads are 110,000 lbs. and 80,000 lbs., respectively.	ANSI 57.9-1984 [2.9]
	Off-Normal Handling Loads	U.2.2.5.2.2(B)	Hydraulic ram load of: 80,000 lb (DSC insertion) 80,000 lb (DSC extraction) on both rails. For HSM-HS corresponding loads are 110,000 lbs. and 80,000 lbs., respectively.	ANSI-57.9-1984 [2.9]
	Design Basis Wind Load	U.2.2.5.2.1(E)	Conservatively assumed to be same as tornado generated wind load.	ASCE 7-95 [2.8]
	Live Load	U.2.2.5.2.1(B)	200 psf (including snow and ice load) on the roof DSC weight (110 kips)	ANSI-57.9-1984 [2.9] ASCE 7-95 [2.8]
	Accident Temperature	U.2.2.5.2.3(A)	Ambient air temperature of 117°F with inlet and outlet vents blocked	10CFR72.122(n)
	Tornado Wind Load	U.2.2.5.2.3(B)	Maximum wind speed of 360 mph and a pressure drop of 3 psi	ASCE 7-95 [2.8] NRC Regulatory Guide 1.76 [2.6]
	Tornado Missile Load	U.2.2.5.2.3(B)	See Section U.2.2.1.3 for missiles considered.	NUREG-0800 Section 3.5.1.4 [2.7]

Note:
(1) The design criteria for the TC remain unchanged from the UFSAR (UFSAR Table 3.2-1).

Table U.2-16
Summary of NUHOMS®-32PTH1 DSC and HSM-H Component Design Loadings[(1)]
(concluded)

Component	Design Load Type	SAR Section Reference	Design Parameters	Applicable Codes
DSC Steel Support Structure	----	----	----	AISC Specification for Structural Steel Buildings
	Dead Weight	U.2.2.5.2.1(A)	Self weight	ANSI 57.9-1984 [2.9]
	Live Load	U.2.2.5.2.1(B)	DSC weight (110 kips)	ANSI-57.9-1984 [2.9]
	Normal and Off-Normal Operating Temperature	U.2.2.5.2.1(C)	Normal: Ambient air temperature 0°F -106°F Off Normal: Ambient air temperature -40°F to 117°F	ANSI 57.9-1984 [2.9]
	Accident Temperature	U.2.2.5.2.3(A)	Ambient temperature of 117°F with inlet and outlet vents blocked	10CFR72.122(n)
	Seismic	U.2.2.5.2.3(D)	(a) Standard Seismic Criteria: 0.30g Horizontal and 0.25g Vertical ground acceleration. (b) High Seismic Alternate: 1.0g Horizontal and 1.0g Vertical ground acceleration.	NRC Reg. Guides 1.60 [2.11] and 1.61 [2.12]
	Normal Handling Loads	U.2.2.5.2.1(D)	Hydraulic ram load of 80,000 lb.(DSC insertion) 60,000 lb (DSC extraction) on both rails. For HSM-HS corresponding loads are 110,000 lbs. and 80,000 lbs., respectively.	ANSI 57.9-1984 [2.9]
	Off-Normal Handling Loads	U.2.2.5.2.2(B)	For steel support structure evaluation, this load is 80,000 lbs. applied to each rail, one rail at a time (for both DSC insertion and retrieval). For HSM-HS corresponding loads are 110,000 lbs. and 80,000 lbs., respectively.	ANSI-57.9-1984 [2.9]

Table U.2-17
B10 Specification for the NUHOMS®-32PTH1 Poison Plates

32PTH1 DSC Basket Type	Minimum B10 Areal Density for Boral® (mg/cm²)	Minimum B10 Areal Density for B-Al[(1)] (mg/cm²)
1A or 2A	9.0	7.0
1B or 2B	19.0	15.0
1C or 2C	25.0	20.0
1D or 2D	N/A	32.0
1E or 2E	N/A	50.0

Note:

(1) B-Al = Metal Matrix Composites and Borated Aluminum Alloys.

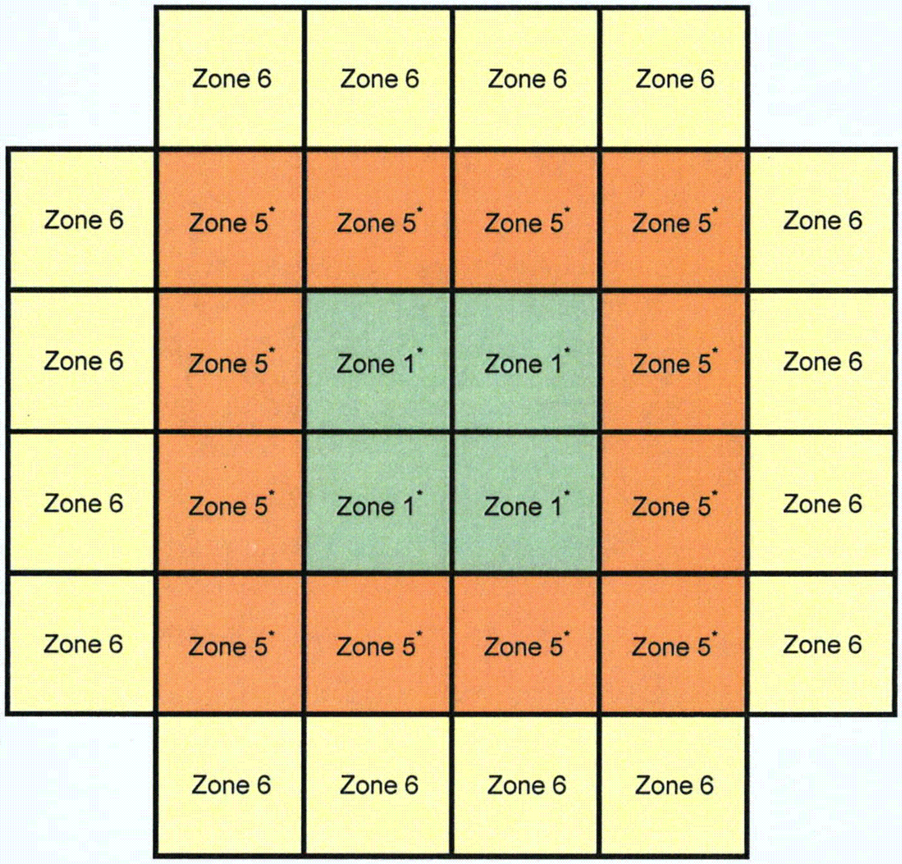
Table U.2-18
Maximum Allowable Heat Load for the NUHOMS®-32PTH1 System

System Configuration	32PTH1 DSC Type	32PTH1 Basket Type[(1),(2)]	HSM Configuration	TC Configuration	Max. Heat Load (kW) per DSC
1	32PTH1-S, 32PTH1-M or 32PTH1-L	1A, 1B, or 1C or 1D or 1E	HSM-H	OS200FC	40.8 (HLZC 1)
				OS200	31.2 (HLZC 2 or HLZC 3)
2	32PTH1-S, 32PTH1-M or 32PTH1-L	2A, 2B, or 2C or 2D or 2E	HSM-H	OS200FC	31.2 (HLZC 2)
				OS200	24.0 (HLZC 3)

Notes:

(1) Basket Type 1 (1A, 1B, 1C, 1D 1E) has aluminum transition rails in the DSC basket.

(2) Basket Type 2 (2A, 2B, 2C, 2D, 2E) has steel transition rails in the DSC basket.



* denotes location where intact or damaged fuel assembly can be stored.

	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
Max. Decay Heat / FA (kW)	0.6	N/A	N/A	N/A	1.3(1)	1.5
Max. Decay Heat / Zone (kW)	2.4	N/A	N/A	N/A	15.6	24.0
Max. Decay Heat / DSC (kW)	40.8(2)					

Notes: (1) 1.2 kW per FA is the maximum decay heat allowed for damaged fuel assemblies.
(2) Adjust payload to maintain 40.8 kW heat load.

Figure U.2-1
Heat Load Zoning Configuration No. 1 for 32PTH1-S, 32PTH1-M and 32PTH1-L DSCs (Type 1 Baskets)

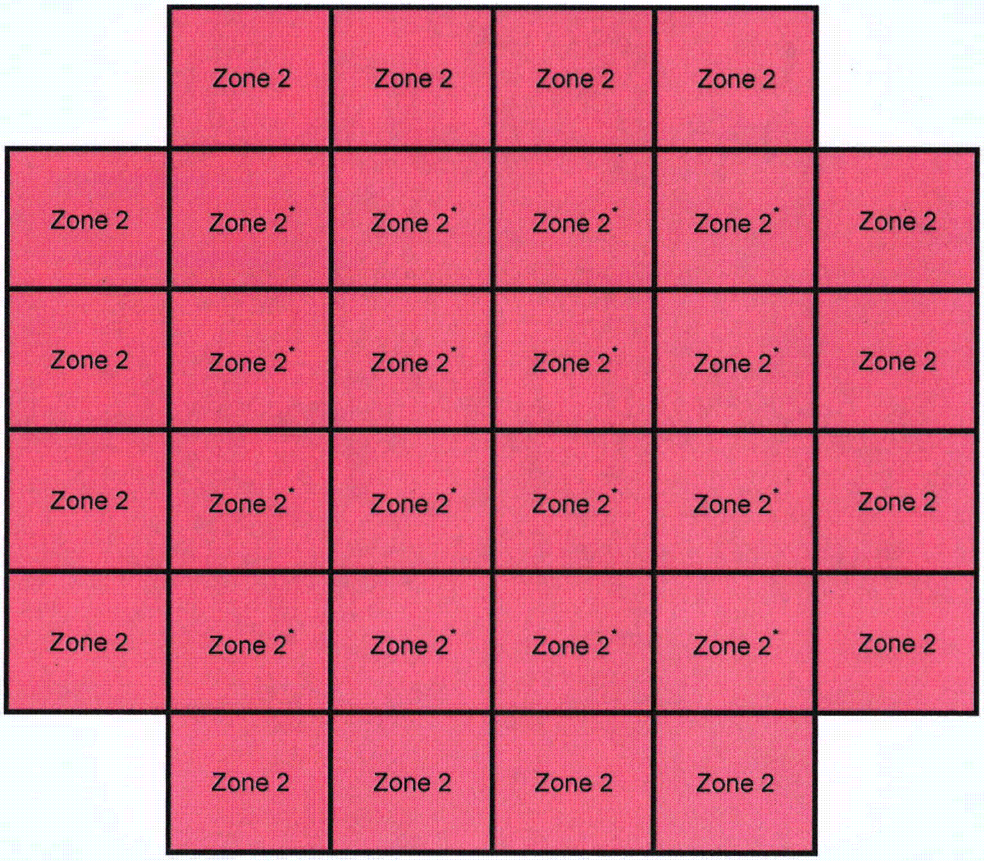
	Zone 4	Zone 4	Zone 4	Zone 4	
Zone 4	Zone 4*	Zone 4*	Zone 4*	Zone 4*	Zone 4
Zone 4	Zone 4*	Zone 3*	Zone 3*	Zone 4*	Zone 4
Zone 4	Zone 4*	Zone 3*	Zone 3*	Zone 4*	Zone 4
Zone 4	Zone 4*	Zone 4*	Zone 4*	Zone 4*	Zone 4
	Zone 4	Zone 4	Zone 4	Zone 4	

* denotes location where intact or damaged fuel assembly can be stored.

	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
Max. Decay Heat / FA (kW)	N/A	N/A	0.96	0.98	N/A	N/A
Max. Decay Heat / Zone (kW)	N/A	N/A	3.84	27.44	N/A	N/A
Max. Decay Heat / DSC (kW)	31.2(1)					

Note: (1) Adjust payload to maintain 31.2 kW heat load.

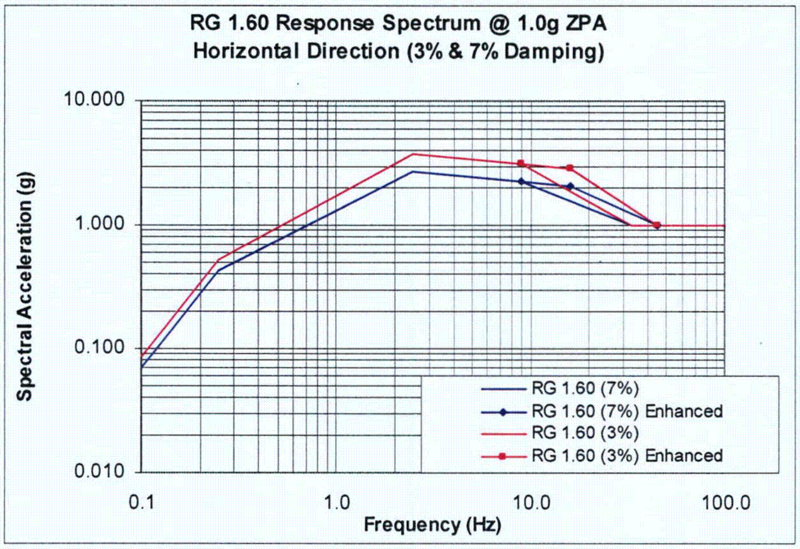
Figure U.2-2
Heat Load Zoning Configuration No. 2 for 32PTH1-S, 32PTH1-M and 32PTH1-L DSCs (Type 1 or Type 2 Baskets)



* denotes location where intact or damaged fuel assembly can be stored.

	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
Max. Decay Heat / FA (kW)	NA	0.8	NA	NA	NA	NA
Max. Decay Heat / Zone (kW)	NA	24.0	NA	NA	NA	NA
Max. Decay Heat / DSC (kW)	24.0					

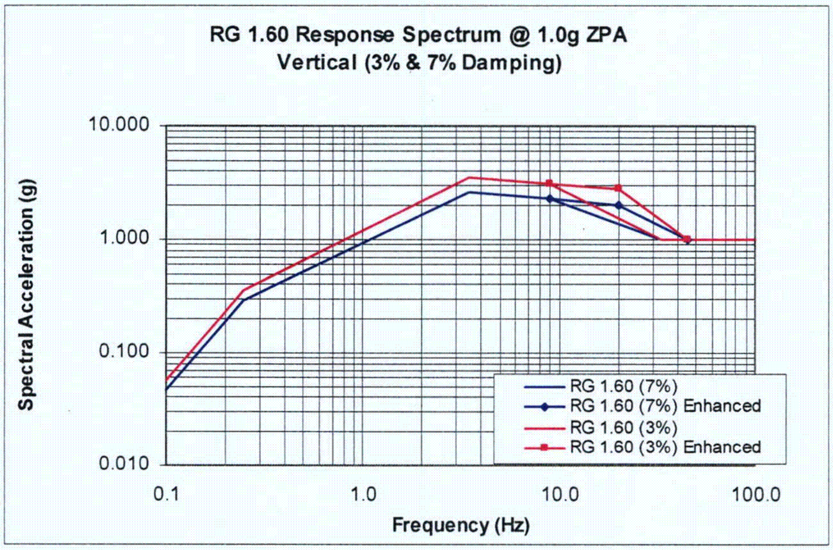
Figure U.2-3
Heat Load Zoning Configuration No. 3 for 32PTH1-S, 32PTH1-M and 32PTH1-L DSCs
(Type 1 or Type 2 Baskets)



HORIZONTAL

RG 1.60 (3%, Horiz. Enhanced)	
Freq (Hz)	**Acc. (g)**
0.10	0.085
0.25	0.529
2.5	3.755
9.0	3.130
16.0	2.885
45.0	1.000
100.0	1.000

RG 1.60 (7%, Horiz. Enhanced)	
Freq (Hz)	**Acc. (g)**
0.10	0.069
0.25	0.432
2.5	2.720
9.0	2.270
16.0	2.093
45.0	1.000
100.0	1.000



VERTICAL

RG 1.60 (3%, Vert. Enhanced)	
Freq (Hz)	**Acc. (g)**
0.10	0.056
0.25	0.353
3.5	3.577
9.0	3.130
20.0	2.797
45.0	1.000
100.0	1.000

RG 1.60 (7%, Vert. Enhanced)	
Freq (Hz)	**Acc. (g)**
0.10	0.046
0.25	0.287
3.5	2.590
9.0	2.270
20.0	2.030
45.0	1.000
100.0	1.000

Figure U.2-4
RG 1.60 Response Spectra with Enhancement in Frequencies above 9.0 Hz

U.3 Structural Evaluation

U.3.1 Structural Design

U.3.1.1 Discussion

This section describes the structural evaluation of the NUHOMS® 32PTH1 system. The NUHOMS® 32PTH1 system consists of the NUHOMS® 32PTH1 DSC, the HSM-H, and the OS200 Transfer Cask (TC).

The 32PTH1 DSC and the OS200 TC are modified versions of the 32PTH DSC and OS187H TC, respectively, described in the HD System SAR under CoC 1030 [3.1]. The modifications implemented consist of increasing the cavity length in both the 32PTH1 and OS200 TC to allow storage of longer fuel assemblies. In addition, optional solid aluminum rails similar to those implemented in the 24PTH DSC described in UFSAR Appendix P, have been added to the 32PTH1 DSC to increase the heat load capacity.

The 32PTH1 DSC is a dual purpose canister that is designed to accommodate up to 32 intact PWR fuel assemblies (or up to 16 damaged assemblies, with the remaining intact) with total heat load of up to 40.8 kW. The HSM-H used with the 32PTH1 DSC is the same as that described in the UFSAR Appendix P for use with the 24PTH DSC, with minor modifications to allow storage of the bigger diameter and longer 32PTH1 DSC. These modifications include use of the door described in Appendix T, and a modified restraint structure at the back end of the steel support structure to allow insertion of the 32PTH1 further back into the HSM-H cavity. In addition, this chapter describes certain modifications made to the HSM-H to increase its seismic capacity. The HSM-H with these modifications is referred to as the "high seismic" HSM-H (HSM-HS) design option. The OS200 TC is similar to the OS197/OS197H/OS197FC TCs described elsewhere in this UFSAR but with an increased diameter, (same diameter as the OS187H TC of the HD system described in [3.1]). In this Appendix, reference to the OS200 is made when there is no option for air circulation in the annulus between DSC air transfer cask, and to OS200FC when air circulation option is used.

Where the new components have an effect on the structural evaluations presented in the UFSAR, the changes are included in this section. Sections that do not have an effect on the evaluations presented in the UFSAR include a statement that there is no change to the UFSAR. In addition, a complete evaluation of the 32PTH1 DSC shell assembly and basket components and the HSM-H has been performed and is summarized in this section. This section also summarizes the OS200 TC stress evaluations.

U.3.1.1.1 General Description of the 32PTH1 DSC

The 32PTH1 DSC shell assembly is shown on drawings NUH32PTH1-1001-SAR and NUH32PTH1-1002-SAR provided in Chapter U.1, Section U.1.5. Chapter U.1, Figure U.1.1-1 shows a schematic view of the 32PTH1 DSC.

There are three design types configurations for the 32PTH1 DSC, as shown in the table below:

32PTH1 DSC Type	DSC Length (Max.)	DSC Cavity Length (Min.)
32PTH1-S	185.75"	164.38"
32PTH1-M	193.00"	171.63"
32PTH1-L	198.50"	181.38"

The 32PTH1 system interfaces with other NUHOMS® System components as follows:

System Configuration	32PTH1[1] DSC Type	Basket Type[2],[3]	Max. Heat Load (kW) per DSC	Transfer Cask	Storage Module
1	32PTH1-S or 32PTH1-M or 32PTH1-L	1A, 1B, 1C, 1D or 1E	40.8	OS200FC	HSM-H
			31.2	OS200	
2	32PTH1-S or 32PTH1-M or 32PTH1-L	2A, 2B, 2C, 2D or 2E	31.2	OS200FC	
			24.0	OS200	

(1) Allows storage of control components.
(2) Basket Type 1 has aluminum basket transition rails.
(3) Basket Type 2 has stainless steel basket transition rails.

32PTH1 DSC Shell Assembly

The NUHOMS® 32PTH1 DSC shell assembly is the same as the NUHOMS® 32PTH DSC documented in [3.1] with the following additional features:

- To allow fabrication flexibility for the storage of additional fuel types, the 32PTH1 may be fabricated of three different overall/internal cavity lengths. These are referred as the 32PTH1-S, 32PTH1-M, and 32PTH1-L DSCs. The 32PTH1-S has the same overall length/cavity dimensions as the 32PTH DSC described in [3.1].

- As an alternative to the two-part top end closure assembly provided in the 32PTH [3.1], an optional configuration for the top end assembly is added. The top end assembly may consist of three separate parts (shield plug, inner top cover plate, outer top cover plate), and a separate vent and siphon block welded to the shell. This optional design configuration is similar to the other standardized NUHOMS® designs (i.e., 24P, 32PT and 24PTH DSCs).

- As an optional configuration, the bottom end assembly may be fabricated of three separate parts (outer bottom cover plate, bottom shield plug, inner bottom cover plate). Similar bottom end forging assemblies as in the 32PTH [3.1] are maintained.

32PTH1 DSC Basket Assembly

The NUHOMS® 32PTH1 basket assembly is shown on drawings NUH32PTH1-1003-SAR and -1004-SAR provided in Chapter U.1, Section U.1.5. The basket assembly is essentially the same as that in the 32PTH DSC [3.1] modified as appropriate to accommodate the variable length dimensions of the 32PTH1 DSC. The basket assembly consists of 32 stainless steel tubes that make up a fuel compartment structure designed to accommodate up to 32 PWR fuel assemblies. The basket assembly consists of the fuel compartment structure, made up of the steel tubes, and the transition rails. Sandwiched in between the tubes are aluminum alloy 1100 plates used as heat transfer material and neutron absorbing plates for criticality control. The tubes are welded to each other along the axial length of the basket at elevations corresponding to the stainless steel insert (strap) plates by autogeneous fusion welds applied through the intermittently placed steel insert plates. The aluminum and neutron absorbing plates, which are arranged in an egg crate configuration, are separated along the basket length by the steel insert plates. No credit is taken for the structural capacity of the aluminum heat transfer plates or neutron absorbing materials in the structural evaluation except for through-thickness bearing (compression) loads.

The basket transition rails provide the transition between the "rectangular" fuel support compartment tubes and the cylindrical internal diameter of the DSC shell. There are two basket assembly types depending on transition rail design configuration. The Type 1 Basket has aluminum transition rails which are made from Type 6061 aluminum alloy. The Type 2 Basket has welded Type 304 stainless steel transition rails with aluminum inserts encased inside and bolted to the stainless steel. The Type 2 Basket is essentially the same as that described in the 32PTH SAR [3.1]. In each basket type, the “R90” transition rails are located on the 0°, 90°, 180° and 270° axes. The “R45” transition rails are located on the 45°, 135°, 225°, and 315° axes. The fuel compartment assembly is identical between these two basket types.

The connections between the transition rails and fuel compartment tubes are designed to allow free thermal expansion of the connected parts.

The basket structure is open at each end such that longitudinal fuel assembly loads are applied directly to the DSC/cask body and not to the basket structure. The fuel assemblies are laterally supported by the fuel compartment tube structure, which is laterally supported by the basket transition rails and the DSC inner shell.

Inside the OS200 TC, the DSC rests on two 3” wide rails ("cask rails"), attached to the inside of the TC at +/-12° from the bottom centerline of the TC. An additional set of cask rails at +/-38° from the bottom centerline provide additional support to the DSC during accident drop conditions. In the HSM-H the DSC is supported by HSM-H DSC support structure rails located at +/-30° from the bottom centerline of the DSC.

The nominal open dimension of each fuel compartment cell is 8.70 in. x 8.70 in. This cross section dimension is sufficient to allow insertion of the controlling fuel assembly with enough clearance. The overall basket length is less than the DSC cavity length to allow for thermal expansion and tolerances.

The 16 fuel compartment tubes in the center of the basket may be loaded with damaged fuel. When storing damaged fuel, end caps are installed at the bottom and top of the basket fuel compartment tube cells to contain the damaged fuel. These end caps are shown in drawing NUH32PTH1-1003-SAR included in Chapter U.1, Section U.1.5.

U.3.1.1.2 Description Changes to the HSM-H to Accommodate the 32PTH1 DSC

The 32PTH1 DSC is stored in the HSM-H horizontal storage module. The HSM-H is described in detail in UFSAR Appendix P when used for storage of the 24PTH DSC with heat load of up to 40.8 kW, and in the HD System SAR [3.1] when used for storage of the 32PTH DSC. This section describes only those aspect of the HSM-H design that are applicable for storage of the 32PTH1 DSC.

The HSM-H is able to accommodate all three 32PTH1 DSC configurations (32PTH1-S, 32PTH1-M and 32PTH1-L). To enable storage of the longest 32PTH1 DSC, the rail stop at the back end of the rail support structure is modified to allow the DSC to sit further back in the rail support structure. This modification is evaluated as part of this chapter and is shown in drawing NUH-03-7001-SAR in Chapter U.1, Section U.1.5.

Other HSM-H changes evaluated in this chapter include:

- Evaluation for increased seismic criteria of 0.25g maximum vertical acceleration (increased from 0.20g evaluated in [3.1]) and,
- Evaluation for HSM-H thermal profiles associated with storage of a 32PTH1 DSC.

As noted in drawing NUH03-7001, only the flat stainless steel heat shields (roof and side heat shields) option is used allowed when the 32PTH1 DSC is stored in the HSM-H. All other concrete and steel components of the HSM-H are the same as those described in [3.1].

U.3.1.1.3 Description of HSM-H "High Seismic" Option

As an option, certain modifications may be implemented in the HSM-H design to increase its seismic capacity from 0.3g maximum horizontal acceleration and 0.25g maximum vertical acceleration to 1.0g maximum accelerations for both the horizontal and the vertical directions. This upgraded HSM-H is referred as the "high seismic" HSM-H or HSM-HS. The seismic criteria for the HSM-HS are described in Chapter U.2. The modifications to the HSM-H necessary to meet the upgraded seismic criteria are described below. These modifications are based on the Advanced NUHOMS® High Seismic AHSM design as described in [3.2].

The modifications made to the HSM-H as described in [3.1] and Appendix P to increase its seismic capacity are summarized as follows:

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

- Adjacent HSM-Hs are tied to each other (a minimum of 3 adjacent HSM-Hs) with module-to-module ties located at the top (roof-to-roof connections) and at the base (base-to-base connections) of the HSM-H. The top ties are integrated into the roof and consist of reinforced concrete tie "beams", with the rebar between adjacent modules mechanically connected. The bottom ties consist of steel rods connecting adjacent base storage units. The top and bottom ties are designed to carry tensile loads to prevent out-of-phase tipping and module-to-module separation. These ties also restrain relative horizontal sliding (front-to-back), and vertical movement (in-phase tipping) between HSMs.
- As with the "standard" HSM-H, the "high seismic" HSM-Hs are not tied to the ISFSI pad and are allowed to slide freely during the seismic event; therefore, the ISFSI pad is designed such that an array made of high seismic HSM-Hs has 10 feet of space around all sides available for sliding and to facilitate retrievability of the 32PTH1 DSC, if necessary, following the postulated design basis earthquake.

U.3.1.1.4 General Description of the OS200 TC

The OS200 TC is based on the OS197/OS197H/OS197FC TCs described in the UFSAR Chapters 3, 4, 8 and Appendix P. Certain design features of the OS200 such as its increased diameter to accommodate the larger diameter 32PTH1 DSC and the neutron panel stiffener ring configuration are based on the OS187H TC described in [3.1].

The shell, or cask body cylinder assembly, is an open ended (at the top) cylindrical unit with an integral closed bottom end. This assembly consists of a concentric inner liner (SA-240, Type 304) and an outer shell (SA-240, Type 304) welded to massive closure flanges (SA-182, Type F304N) at the top and bottom ends. The annulus between the shells is filled with lead shielding. The top cover is bolted to the top flange using 24 1-1/2 in. diameter bolts. A cover plate is provided to seal the bottom hydraulic ram access penetration of the cask (by 12-1/2 in. bolts with O-ring) during fuel loading.

Two lifting trunnions are provided for handling the transfer cask in the plant's fuel/reactor building using a lifting yoke and an overhead crane. Lower support trunnions are provided on the cask for pivoting the transfer cask from/to the vertical and horizontal positions and to support the cask on the skid/transport trailer.

The gross weight of the loaded transfer cask is approximately 120 tons (240.0 kips) including a payload of 55.0 tons (110.0 kips). Table U.3.2-1 and Table U.3.2-2 summarize the 32PTH1 system component weights and OS200 TC component weights, respectively.

Similarly to the OS197FC TC, there is an option available for ambient air tube circulated at the bottom of the OS200FC TC through the ram access opening and distributed to the annular space between the DSC and the TC. The cooling air travels through the TC length and exists through the vent passages around the periphery of the TC top lid, in between the bolt holes. Drawings NUH-08-8001-SAR to NUH-08-8003-SAR describe the geometry and dimensions of the OS200 TC. These drawings are provided in Chapter U.1, Section U.1.5.

U.3.1.2 Design Criteria

The design criteria for the 32PTH1 DSC and OS200 TC and revisions to the HSM-H design criteria are provided in Chapter U.2, Section U.2.2.

U.3.1.2.1 32PTH1 DSC Shell Assembly Confinement Boundary

The primary confinement boundary consists of the DSC shell, the inner top cover plate, the inner bottom cover plate (or the bottom forging of the bottom assembly), the siphon and vent block, the siphon/vent port cover plates, and the associated welds. Figure U.3.1-1 provides a graphic representation of the confinement boundary. The DSC outer top cover plate forms the redundant confinement boundary.

The cylindrical shell and welds made during fabrication of the 32PTH1 DSC that affect the confinement boundary of the DSC are compliant to Subsection NB. These include the inner bottom cover plate (or the bottom forging) to shell weld and the circumferential and longitudinal seam welds applied to the shell.

The top inner cover plate and associated welds, the welds applied to the vent and siphon port covers, and the closure welds applied to the vent & siphon block, define the primary confinement boundary at the top end of the 32PTH1 DSC. These welds are applied using a multiple-layer technique and are liquid penetrant (PT) examined in accordance with ASME Code Section III NB-5000. Alternatives to ASME Code are provided in Table U.3.1-1.

During fabrication, leak tests of the 32PTH1 DSC shell assembly are performed in accordance with leak tight criteria of ANSI N14.5-1997 [3.15] to demonstrate that the shell is leak tight (leakage rate of less than $1x10^{-7}$ std. cm^3/sec). The DSC inner top cover closure welds, including the vent and siphon pressure boundary welds, are also leak tested after fuel loading to demonstrate that the ANSI N14.5 leak tight criteria is met.

The basis for the allowable stresses for the confinement boundary is ASME Code Section III, Division I, Subsection NB Article NB-3200 [3.3] for normal (Level A) condition loads, off-normal (Level B) condition loads and off-normal/accident (Level C) condition loads, and Appendix F for accident (Level D) condition loads. Chapter U.2, Section U.2.2 contains additional design criteria.

U.3.1.2.2 32PTH1 DSC Basket

The basket is designed to meet heat transfer, nuclear criticality, and structural requirements. The basket structure provides sufficient rigidity to maintain a subcritical configuration under the applied loads. The stainless steel fuel compartment tube sections in the NUHOMS® 32PTH1 basket are the primary structural components. The aluminum heat transfer plates and neutron poison plates are the primary heat conductors, and provide the necessary criticality control. The stress analyses of the basket do not take credit for the neutron absorbing/heat transfer plate material. The transition rails provide support to the fuel compartment tube structure for mechanical loads and also transfer heat from the fuel compartment tubes to the DSC shell.

The basket structural design criteria is provided in Chapter U.2, Section U.2.2. The basis for the allowable stresses for the stainless steel components in the basket assembly is Section III, Division 1, Subsection NG of the ASME Code [3.3]:

- Normal conditions are evaluated using criteria from NG-3200.
- Accident conditions are classified as Level D events and are evaluated using stress and stability criteria from Section III, Appendix F of the ASME Code [3.3].

U.3.1.2.3 Alternatives to the ASME Code for the 32PTH1 DSC

The confinement boundary of the NUHOMS® 32PTH1 DSC consists of the DSC shell, the inner top cover plate, the inner bottom cover plate, (or the bottom forging), the siphon and vent block, and the siphon/vent port cover plates. Even though the ASME B&PV code is not strictly applicable to the DSC, it is Transnuclear's (TN's) intent to follow Section III, Subsection NB of the Code as closely as possible for design and construction of the confinement vessel. The DSC may, however, be fabricated by other than N-stamp holders and materials may be supplied by other than ASME Certificate Holders. Thus the requirements of NCA are not imposed. TN's quality assurance requirements, which are based on 10CFR72 Subpart G and NQA-1 are imposed in lieu of the requirements of NCA-3800. The SAR is prepared in place of the ASME design and stress reports. Surveillances are performed by TN and utility personnel rather than by an Authorized Nuclear Inspector (ANI).

The basket is designed, fabricated and inspected in accordance with the ASME Code Subsection NG.

The poison plates and aluminum heat transfer plates are not considered for structural integrity. Therefore, these materials are not required to be Code materials. The quality assurance requirements of NQA-1 are imposed in lieu of NCA-3800. The basket is not Code stamped. Therefore, the requirements of NCA are not imposed. Fabrication and inspection surveillances are performed by TN and utility personnel rather than by an ANI.

A complete list of the alternatives to the ASME Code and corresponding justification for the NUHOMS® 32PTH1 DSC and basket is provided in Table U.3.1-1 and Table U.3.1-2 respectively.

Table U.3.1-1
Alternatives to the ASME Code for the NUHOMS® 32PTH1 DSC Confinement Boundary

Reference ASME Code Section/Article	Code Requirement	Alternatives, Justification & Compensatory Measures
NCA	All	Not compliant with NCA. TN Quality Assurance requirements, which are based on 10CFR72 Subpart G, are used in lieu of NCA-4000. Fabrication oversight is performed by TN and utility personnel in lieu of an Authorized Nuclear Inspector.
NB-1100	Requirements for Code Stamping of Components	The NUHOMS® 32PTH1 DSC shell is designed & fabricated in accordance with the requirements of ASME Code, Section III, Subsection NB and the alternative provisions described in this table. However, Code Stamping is not required. As Code Stamping is not required, the fabricator is not required to hold an ASME "N" or "NPT" stamp, or to be ASME Certified.
NB-2130	Material must be supplied by ASME approved material suppliers.	Material is certified to meet all ASME Code criteria but is not eligible for certification or Code Stamping if a non-ASME fabricator is used. As the fabricator is not required to be ASME certified, material certification to NB-2130 is not possible. Material traceability & certification are maintained in accordance with TN's NRC approved QA program.
NB-4121	Material Certification by Certificate Holder	
NB-4243 and NB-5230	Category C weld joints in vessels and similar weld joints in other components shall be full penetration joints. These welds shall be examined by UT or RT and either PT or MT	The shell to the outer top cover weld, the shell to the inner top cover/shield plug weld (including optional design configurations for the inner top cover as described in the 32PTH1 DSC drawings), and the siphon/vent cover welds, are all partial penetration welds. As an alternative to the NDE requirements of NB-5230, for Category C welds, all of these closure welds are multi-layer welds and receive a root and final PT examination, except for the shell to the outer top cover weld. The shell to the outer top cover weld will be a multi-layer weld and receive multi-level PT examination in accordance with the guidance provided in ISG-15 for NDE. The multi-level PT examination provides reasonable assurance that flaws of interest will be identified. The PT examination is done by qualified personnel, in accordance with Section V and the acceptance standards of Section III, Subsection NB-5000. All of these welds are designed to meet the guidance provided in ISG-15 for stress reduction factor.
NB-1132	Attachments with a pressure retaining function, including stiffeners, shall be considered part of the component.	Outer bottom cover, bottom plate, bottom casing plate, side casing plate, lifting posts, grapple ring, and grapple ring support are outside code jurisdiction; these components together are much larger than required to provide stiffening for the confinement boundary cover. These component welds are subject to root and final PT examinations.

Table U.3.1-1
Alternatives to the ASME Code for the NUHOMS® 32PTH1 DSC Confinement Boundary
(Concluded)

Reference ASME Code Section/Article	Code Requirement	Alternatives, Exception, Justification & Compensatory Measures
NB-6100 and 6200	All pressure retaining components and completed systems shall be pressure tested. The preferred method shall be hydrostatic test.	The NUHOMS® 32PTH1 DSC is not a complete vessel until the top closure is welded following placement of fuel assemblies within the DSC. Due to the inaccessibility of the shell and lower end closure welds following fuel loading and top closure welding, as an alternative, the pressure testing of the DSC is performed in two parts. The DSC shell and inner bottom plate/forging (including all longitudinal and circumferential welds), are pressure tested and examined at the fabrication facility. The shell to the inner top cover/shield plug closure weld (including optional design configurations for the inner top cover as described in the 32PTH1 DSC drawings) is pressure tested and examined for leakage in accordance with NB-6300 in the field. The siphon/vent cover welds are not pressure tested; these welds and the shell to the inner top cover/shield plug closure weld (including Optional design configurations for the inner top cover as described in the 32PTH1 DSC drawings) are helium leak tested after the pressure test. Per NB-6324 the examination for leakage shall be done at a pressure equal to the greater of the design pressure or three-fourths of the test pressure. As an alternative, if the examination for leakage of these field welds, following the pressure test, is performed using helium leak detection techniques, the examination pressure may be reduced to ≥1.5 psig. This is acceptable given the significantly greater sensitivity of the helium leak detection method.
NB-7000	Overpressure Protection	No overpressure protection is provided for the NUHOMS® 32PTH1 DSC . The function of the NUHOMS® 32PTH1 DSC is to contain radioactive materials under normal, off-normal and hypothetical accident conditions postulated to occur during transportation and storage. The NUHOMS® 32PTH1 DSC is designed to withstand the maximum possible internal pressure considering 100% fuel rod failure at maximum accident temperature. The NUHOMS® 32PTH1 DSC is pressure tested in accordance with ISG-15.
NB-8000	Requirements for nameplates, stamping & reports per NCA-8000	The NUHOMS® 32PTH1 DSC nameplate provides the information required by 10CFR71, 49CFR173 and 10CFR72 as appropriate. Code stamping is not required for the NUHOMS® 32PTH1 DSC. In lieu of code stamping, QA data packages are prepared in accordance with the requirements of 10CFR71, 10CFR72 and TN's approved QA program.

Table U.3.1-2
Alternatives to the ASME Code for the NUHOMS® 32PTH1 DSC Basket Assembly

Reference ASME Code Section/Article	Code Requirement	Alternatives, Exception, Justification & Compensatory Measures
NG-1100	Requirements for Code Stamping of Components	The NUHOMS® 32PTH1 DSC baskets are designed & fabricated in accordance with the ASME Code, Section III, Subsection NG as described in the SAR, but Code Stamping is not required. As Code Stamping is not required, the fabricator is not required to hold an ASME N or NPT stamp or be ASME Certified.
NG-2000	Use of ASME Material	The poison material and aluminum plates are not used for structural analysis, but to provide criticality control and heat transfer. They are not ASME Code Class 1 material. Material properties in the ASME Code for Type 6061 aluminum are limited to 400°F to preclude the potential for annealing out the hardening properties. Annealed properties (as published by the Aluminum Association and the American Society of Metals) are conservatively assumed for the aluminum transition rails for use above the Code temperature limits.
NG-2130	Material must be supplied by ASME approved material suppliers.	Material is certified to meet all ASME Code criteria but is not eligible for certification or Code Stamping if a non-ASME fabricator is used. As the fabricator is not required to be ASME certified, material certification to NG-2130 is not possible. Material traceability & certification are maintained in accordance with TN's NRC approved QA program. The poison material and aluminum plates are not certified to ASME requirements.
NG-4121	Material Certification by Certificate Holder	
NG-8000	Requirements for nameplates, stamping & reports per NCA-8000	The NUHOMS® 32PTH1 DSC nameplate provides the information required by 10CFR71, 49CFR173 and 10CFR72 as appropriate. Code stamping is not required for the NUHOMS® 32PTH1 DSC. In lieu of Code stamping, QA Data packages are prepared in accordance with the requirements of 10CFR71, 10CFR72 and TN's approved QA program.
NCA	All	Not compliant with NCA as no Code stamp is used. TN Quality Assurance requirements, which are based on 10CFR72 Subpart G, are used in lieu of NCA-4000. Fabrication oversight is performed by TN and utility personnel in lieu of an Authorized Nuclear Inspector.
NG-3000/ Section II, Part D, Table 2A	Maximum temperature limit for Type 304 plate material is 800°F.	Not compliant with ASME Section II Part D Table 2A material temperature limit for Type 304 steel for the postulated transfer accident case (117°F, loss of sunshade, loss of neutron shield) and blocked vent accident (117°F, 40 hr). The calculated maximum steady state temperatures are 858°F (transfer accident case) and 860°F (blocked vent accident case). The expected reduction in material strength is small (less than 1 ksi by extrapolation), and the only primary stresses in the basket grid are deadweight stresses. The recovery actions following these accident scenarios are as described in Section 8.2 of the UFSAR.

Table U.3.1-2
Alternatives to the ASME Code for the NUHOMS® 32PTH1 DSC Basket Assembly
(Concluded)

Reference ASME Code Section/Article	Code Requirement	Alternatives, Exception, Justification & Compensatory Measures
NG-3352	Table NG 3352-1 lists the permissible welded joints.	The fusion welds between the stainless steel insert plates and the stainless fuel compartment tube are not included in Table NG-3352-1. These welds are qualified by testing. The required minimum tested capacity of the welded connection (at each side of the tube) shall be 45 kips (at room temperature). The capacity shall be demonstrated by qualification and production testing. Testing shall be performed using, or corrected to, the lowest tensile strength of material used in the basket assembly or to minimum specified tensile strength. Testing may be performed on individual welds, or on weld patterns representative of one wall of the tube. ASME Code Section IX does not provide tests for qualification of these type of welds. Therefore, these welds are qualified using Section IX to the degree applicable together with the testing described here. The welds will be visually inspected to confirm that they are located over the insert plates, in lieu of the visual acceptance criteria of NG-5260 which are not appropriate for this type of weld.
		A joint efficiency (quality) factor of 1.0 is utilized for the fuel compartment longitudinal seam welds. Table NG-3352-1 permits a joint efficiency (quality) factor of 0.5 to be used for full penetration weld examined by ASME Section V visual examination (VT). For the 32PTH1 DSC, the compartment seam weld is thin (0.188" thick) and the weld will be made in one pass. Both surfaces of weld (inside and outside) will be fully examined by VT and therefore a factor of 2 x 0.5=1.0, will be used in the analysis. This is justified as both surfaces of the single weld pass/layer will be fully examined, and the stainless steel material that comprises the fuel compartment tubes is very ductile.

Table U.3.1-3

Alternatives to ASME Code to the NUHOMS® OS200 Transfer Cask

(Applies to cask structural components only. Lead shielding, neutron shielding, and neutron shield jacket of the cask are not addressed by this table.)

Reference ASME Code Section/Article	Code Requirement	Alternatives, Exception, Justification & Compensatory Measures
NC-1100	Requirements for Code Stamping of Components	As described in Chapters 3, 8, and Appendix U, Section U.3, the OS200 TC is designed and fabricated to the requirements of Subsection NC, to the maximum extent practical. However, the transfer cask does not have a Code stamp. Code Stamping is not required by 10CFR72 regulation. Therefore, the fabricator is not required to be ASME Certified.
NC-2000	ASME Code Materials are to be used.	The Cask bottom ram access cover plate is made of ASTM A240, a non-ASME material. This cover plate is a water tight closure used during fuel loading/unloading operations in the fuel/reactor building only. This is not a pressure boundary component, and its failure does not result in any public safety concerns.
NC-2130	Material must be supplied by ASME approved material suppliers.	Materials designated as ASME on the Chapter U.1 drawings are obtained by TN approved suppliers with Certified Material Test Reports (CMTR's). Material is certified to meet all ASME Code criteria but is not eligible for Certification or Code Stamping, if a non-ASME fabricator is used. As the fabricator is not required to be ASME certified, material certification to NC-2130 is not possible.
NC-4120	Material Certification by Certificate Holder	Material traceability & certification are maintained in accordance with TN's NRC approved QA program.
NC-5254	Category D joints shall be RT or UT examined.	The trunnion-to-shell weld is a Category D joint which does not allow adequate UT or RT examination. This weld is not a pressure boundary but serves as lifting point for the TC. During fabrication, this weld is progressive PT examined and then load- tested to three times the design load. The weld between the ram access penetration forging and bottom end plate is a Category D joint which does not allow meaningful RT or UT examination. This weld is PT examined root and final layers. This is not a pressure boundary component and its failure does not result in any public safety concerns.
NC-6000	All completed pressure retaining systems shall be pressure tested.	With respect to pressure testing requirements, the transfer cask is not a pressure retaining component. Therefore, no pressure testing is required. However, the liquid neutron shield cavity, cask bottom neutron shield cavity, and the bottom cover plate assembly are pressure and leak tested.
NC-7000	Overpressure Protection	The transfer cask is not a pressure retaining component. Therefore, no overpressure protection is provided for the transfer cask, except that a pressure relief valve is provided for the annular neutron shielding.
NC-8000	Requirements for nameplates, stamping & reports per NCA-8000	The transfer cask nameplate provides the information required by 10CFR72. Code stamping is not required for the transfer cask. QA Data packages are prepared in accordance with the requirements of 10CFR72 and TN's NRC approved QA program.

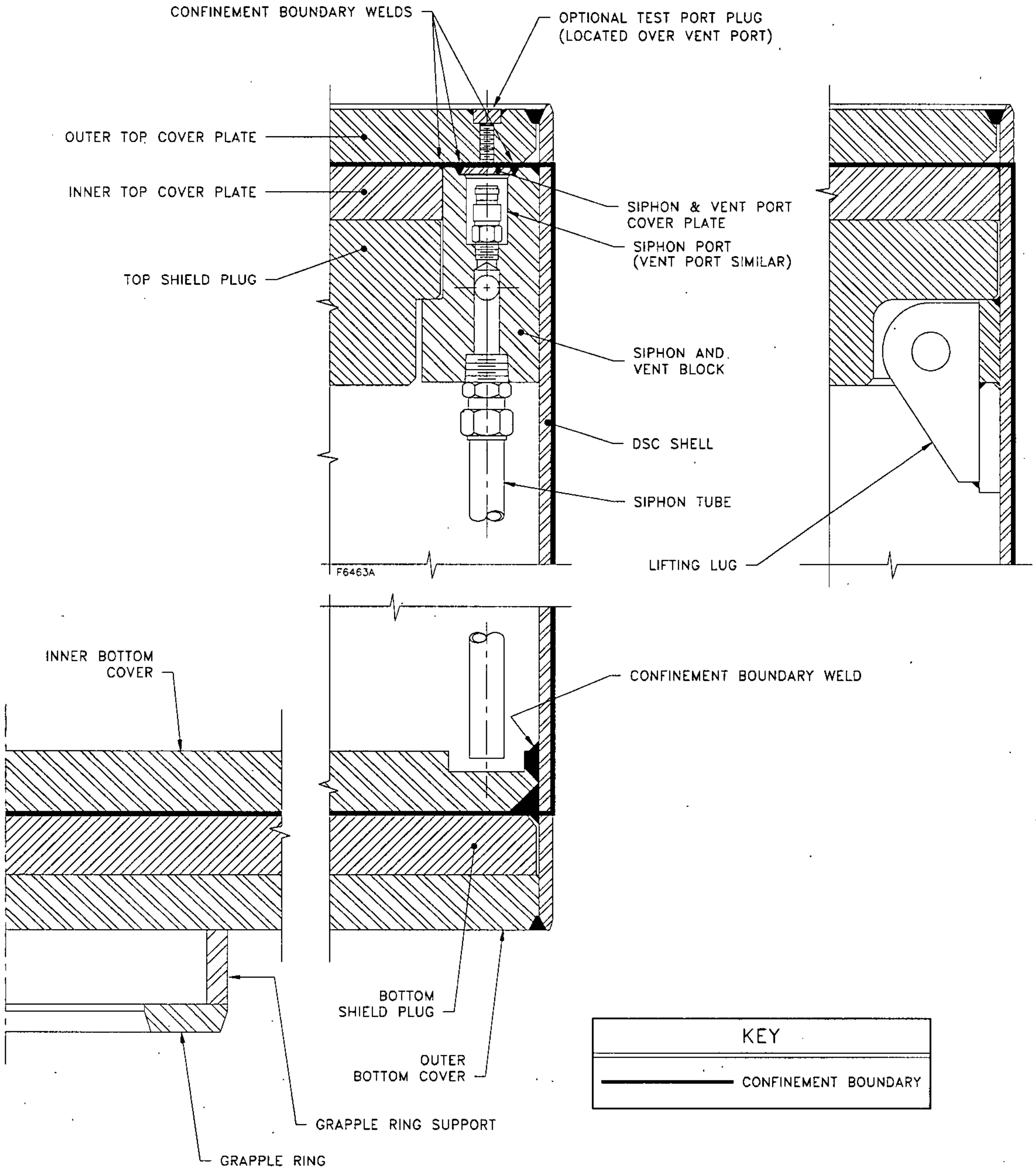


Figure U.3.1-1
32PTH1 DSC Confinement/Pressure Boundary

U.3.2 Weights

Table U.3.2-1 summarizes the weights of the various components of the NUHOMS® 32PTH1 system including DSC, HSM-H and OS200 TC. The deadweights of the components are determined based on nominal dimensions.

Table U.3.2-2 summarizes the weights of the OS200 TC components.

Table U.3.2-1
Summary of the NUHOMS® 32PTH1 System Component Nominal Weights

Component Description	CALCULATED WEIGHT (kips) [1]			
	32PTH1-S	32PTH1-L	32PTH1-M	Line Number
DSC Shell Assembly[2]	28.3	24.1	28.5	1
DSC Top Shield Plug Assembly[3]	12.9	10.8	12.9	2
DSC Internal Basket Assembly[4]	28.3	31.0	29.5	3
Total Empty Weight	**56.6**	**55.1**	**58.0**	4=1+3
32 PWR Spent Fuel Assemblies[5]	≤53.3	≤54.9	≤52.0	5
Total Loaded DSC Weight (Dry)	**110.0**	**110.0**	**110.0**	6=4+5
Water in Loaded DSC (Type 1 basket / Type 2 basket)	10.5/12.5	12.0/14.3	11.1/13.3	7
Total Loaded DSC Weight (Wet)[6],[9]	**107.6/109.6**	**111.2/113.5**	**108.2/110.4**	8=6+7-2
TC Spacer	1.3	--	0.9	9
TC Top Lid	5.4	5.4	5.4	10
TC Empty Weight[7]	130.0	130.0	130.0	11
Total Loaded TC Weight (Dry) [7]	**241.3**	**240.0**	**240.9**	12=6+9+11
Total Loaded TC Weight (Wet) [8] [9]	**232.2/234.2**	**235.8/238.1**	**232.8/235.0**	13=8+11-10
HSM-H Single Module Weight Max. (Empty)	**307.2**	**307.2**	**307.2**	13
HSM-H Single Module Weight Max. (Loaded)	**417.2**	**417.2**	**417.2**	14=6+13

Notes:

1. All numbers are rounded up to the next hundred pounds.
2. Includes top cover plates and shield plug.
3. Weight of top cover plates and shield plug.
4. Bounding weight for Type 1 (aluminum rails) and Type 2 (stainless steel rails) baskets in each DSC type and with combined.
5. Maximum fuel assembly weights are based on the following fuel assembly weights: 1,715 lbs/assembly x 32 = 54,880 lbs for the 32PTH1-L, 1,625 lbs assembly x 32 = 52,000 lbs for the 32PTH1-M, and 1,665 lbs/assembly x 32 = 53,280 lbs for the 32PTH1-S DSCs.
6. Wet DSC weight is without top shield plug and top cover plates.
7. With TC top lid. The neutron shield is filled with demineralized water.
8. Without TC top lid. The neutron shield is filled with demineralized water.
9. Weights are given for 32PTH1 DSCs with weight of water for DSCs with Type 1 basket and Type 2 basket, respectively.

Table U.3.2-2
Summary OS200 Transfer Cask Component Nominal Weights

Transfer Cask Component	Calculated Weight (kips)
Structural Shell	23.73
Inner Liner (including support rails)	7.97
Lead Gamma Shield	66.65
Top Flange	2.63
Bottom Support Ring	3.40
Top Cover Plate	5.36
Bottom Assembly	3.94
Neutron Shield Panel (including water)	13.81
Upper Trunnions (2)	1.45
Lower Trunnions (2)	1.06
Total Transfer Cask Weight	**130.00**

U.3.3 Mechanical Properties of Materials

U.3.3.1 32PTH1 DSC Material Properties

The materials used for fabrication of the 32PTH1 are the same as those used for similar DSC types in previous applications (24PTH). They are presented here only for completeness of this application. The DSC shell and inner and outer top and bottom cover plates are fabricated from Type 304 stainless steel. The top and bottom casing plates of the optional A-36 carbon steel shield plug assembly and made of Type 304 stainless steel plate material. Fabrication options allow the shell assembly's bottom ends to be fabricated from stainless steel forgings (material specification SA182 Type F304). Properties of the forging material are the same as the Type 304 plate material. The properties for the Type 304 material are from ASME Code Section II Part D [3.4] and are listed in Table U.3.3-1.

The DSC shell top and bottom shield plugs are fabricated from A36 carbon steel or Type 304 stainless steel. The properties for A36 carbon steel used in the analysis are from ASME Code Section II Part D [3.4], as listed in Table U.3.3-2.

The fuel compartment tubes in the 32PTH1 basket are fabricated with Type 304 stainless steel. The properties of this material are from ASME Code Section II, Part D [3.4] and are listed in Table U.3.3-1.

The steel transition rails in the 32PTH1 Type 2 Basket are fabricated with Type 304 stainless steel. The properties of this material are from ASME Code Section II, Part D [3.4] and are listed in Table U.3.3-1. Aluminum plates Type 1100 or Type 6061 is encased inside the steel transition rails. Aluminum Type 1100 is used for the rail backplate in the welded stainless steel transition rails.

The aluminum transition rails use sections of Type 6061 aluminum. Analysis properties are taken from [3.5] for annealed aluminum. Use of properties for annealed material ensures that no credit is taken for enhanced properties obtained by heat treatment. The selection of properties for annealed material is based on the possibility that the maximum temperature in the rails may exceed the temperatures for which strength properties are provided (for aluminum) in the ASME Code (see Table U.3.3-4). This is acceptable for the following reasons:

1. The transition rails are not pressure boundary parts. Loading on the rails is primarily bearing and the transition rails are "captured" between the fuel compartment tube structure and the DSC shell. Deformation of the transition rails (to conform to the inside diameter of the DSC shell) will distribute the applied loads and will not adversely impact the basket structure.

2. For applications where the aluminum properties result from heat treatment, it is necessary to limit the maximum temperature to values below which the effects of the heat treatment are maintained. Heat treatment provides significant differences in strength properties at low temperatures. However, as temperature increases, the effect(s) of heat treatment on strength properties decreases. The strength properties used in the design of the 32PTH1 are based on

annealed aluminum. Thus, changes in strength which may occur under exposure to temperatures exceeding 400°F have no adverse impact on the properties used in the design.

For the stress analyses of the 32PTH1 DSC, material properties for the Type 304 steel materials are taken from Table U.3.3-1. For elastic-plastic analyses, the plastic slope of the steel is taken as 0.05E (5% of the elastic modulus at temperature). Figure U.3.3-1 shows the stress-strain relationship used for the elastic-plastic analysis. Properties for the aluminum rails are taken directly from Table U.3.3-5 [3.5]. For elastic-plastic analyses, the plastic slope of the aluminum is taken as 0.01E. This approximates elastic-perfectly plastic properties while providing a small stiffness to enhance analytical stability.

Table U.3.3-6 provides additional material properties.

U.3.3.2 <u>OS200 TC Material Properties</u>

The OS200 TC material properties are the same as those for the OS187H TC described in the HD System SAR under CoC 1030 [3.1].

U.3.3.3 <u>HSM-H Material Properties</u>

The HSM-H or (HSM-HS) material properties are not changed from those documented in Appendix P.

HSM-H material properties are discussed in Appendix P, Section P.3.3. When loaded with a 32PTH1 DSC, the HSM-H (or the HSM-HS) uses top and side heat shields made from Type 304 stainless steel.

U.3.3.4 <u>Materials Durability</u>

The materials used in the fabrication of the NUHOMS® 32PTH1 system are shown in Table U.3.3-1 through Table U.3.3-6 supplemented by those in Chapter 8 and Section P.3.3.3 of the UFSAR. Essentially all of the materials meet the appropriate requirements of the ASME Code, ACI Code, and appropriate ASTM Standards. The durability of the DSC shell assembly and basket assembly stainless steel components and the HSM-H steel components is well beyond the design life of the applicable components. The aluminum material used in the basket is only relied upon for its thermal conductivity and bearing strength properties. The poison material selected for criticality control of the NUHOMS® 32PTH1 system has been tested and is currently in use for similar applications. Additionally, the NUHOMS® 32PTH1 basket assembly resides in an inert helium gas environment for the majority of the design life. The specifications controlling the mix of concrete, specified minimum concrete strength requirements, and fabrication control ensure durability of the materials for this application. Therefore, the materials used in the NUHOMS® 32PTH1 system will maintain the required properties for the design life of the system.

Table U.3.3-1
ASME Code Materials Data For SA-240 Type 304 and SA-182 Type F304 Stainless Steel

Temp. (°F)	E (ksi)	S_m (ksi)	S_y (ksi)	S_u (ksi)	α_{AVG} (x 10^{-6}°F^{-1})
-100	29,100	--	--	--	--
-20	--	20.0	30.0	75.0	--
70	28,300	--	--	--	8.5
100	--	20.0	30.0	75.0	8.6
200	27,600	20.0	25.0	71.0	8.9
300	27,000	20.0	22.4	66.2	9.2
400	26,500	18.7	20.7	64.0	9.5
500	25,800	17.5	19.4	63.4	9.7
600	25,300	16.4	18.4	63.4	9.8
650	--	16.2	18.0	63.4	9.9
700	24,800	16.0	17.6	63.4	10.0
750	--	15.6	17.2	63.3	10.0
800	24,100	15.2	16.9	62.8	10.1

Table U.3.3-2
Materials Data For ASTM A36 Steel

(Properties are taken from ASME Code Section II for SA-36 Steel. The ASME material specification is identical to the ASTM A36 Steel specification.)

Temp. (°F)	E (ksi)	S_m (ksi)	S_y (ksi)	S_u (ksi)	α_{AVG} (x 10^{-6} °F^{-1})
-100	30,200	--	--	--	--
-20	--	19.3	36.0	58.0	--
70	29,500	19.3	36.0	58.0	6.4
100	--	19.3	36.0	58.0	6.5
200	28,800	19.3	33.0	58.0	6.7
300	28,300	19.3	31.8	58.0	6.9
400	27,700	19.3	30.8	58.0	7.1
500	27,300	19.3	29.3	58.0	7.3
600	26,700	17.7	27.6	58.0	7.4
650	--	17.4	26.7	58.0	7.5
700	25,500	17.3	25.8	58.0	7.6
750	--	--	--	57.3	7.7
800	24,200	--	--	53.3	7.8

Table U.3.3-3
Static Mechanical Properties for ASTM B29 Lead

Temp (°F)	E (ksi)	Sy (ksi)		Su (ksi)	α_{avg} ($x10^{-6}$ °F^{-1})
		Tension	Compression	Tension	
-99	2,500	--	--	--	15.28
70	2,340	--	--	--	16.07
100	2,300	0.584	0.49	1.57	16.21
175	2,200	0.509	0.428	1.16	16.58
250	2,090	0.498	0.391	0.844	16.95
325	1,960	0.311	0.32	0.642	17.54
440	1,740	--	--	--	18.5
620	1,360	--	--	--	20.39

Table U.3.3-4
ASME Code Properties for Type 6061 Aluminum

Temperature	Yield Strength (ksi)		E	α
(°F)	A96061-T451	A96061-T651	(ksi)	(x 10^{-6} $°F^{-1}$)
75	16.0	35.0	10,000	12.1
100	16.0	35.0	--	12.4
150	15.7	34.6	--	12.7
200	15.5	33.7	9,600	13.0
250	15.3	32.4	--	13.1
300	15.3	27.4	9,200	13.3
350	15.3	20.0	--	13.4
400	11.6	13.3	8,700	13.6
450	--	--	--	13.8
500	--	--	8,100	13.9
550	--	--	--	14.1
600	--	--	--	14.2

Table U.3.3-5
Analysis Properties for Aluminum Transition Rails

Temperature (°F)	S_u, 6061-O (ksi)	S_y, 6061-O (ksi)	E (ksi)
75	18.0	8.0	9,900
212	18.0	8.0	9,500
300	15.0	8.0	9,100
350	12.0	8.0	8,900
400	10.0	7.5	8,600
450	8.5	6.0	8,300
500	7.0	5.5	7,900
600	5.0	4.2	6,800
700	3.6	3.0	5,500
800	2.8	2.2	--
900	2.2	1.6	--
1000	1.6	1.2	--

Table U.3.3-6
Additional Material Properties

Material Property	Value	Reference [3.4]
Aluminum Density (1100 and 6061)	0.098 lb/in^3	Section II, Part D, Table NF-2
Aluminum Melting Point (Alloy 1100)	1190°F - 1215°F	Section II, Part D, Table NF-2
Aluminum Melting Point (Alloy 6061)	1080°F - 1205°F	Section II, Part D, Table NF-2
Neutron Absorber Density	0.098 lb/in^3	Taken as equal to the density of pure aluminum
Steel Density	0.285 lb/in^3	

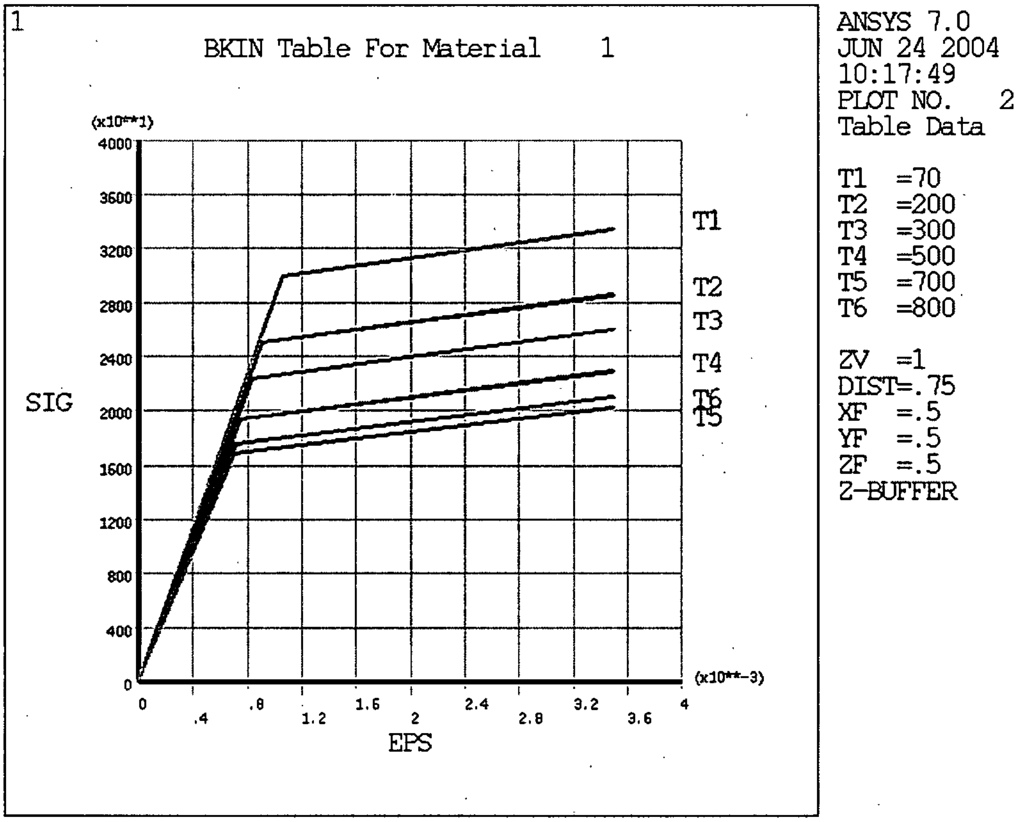


Figure U.3.3-1
Stress-Strain Relationship for SA-240 Type 304 / SA-182 Type F304 Material Used in the Elastic-Plastic Analysis

U.3.4 General Standards for Casks

U.3.4.1 Chemical and Galvanic Reactions

The materials of the 32PTH1 DSC shell and basket have been reviewed to determine whether chemical, galvanic or other reactions among the materials, contents and environment might occur during any phase of loading, unloading, handling or storage. This review is summarized below:

The 32PTH1 DSC is exposed to the following environments:

- During loading and unloading, the DSC is placed inside of the TC. The annulus between the cask and DSC is filled with demineralized water and an inflatable seal is used to cover the annulus between the DSC and cask. The exterior of the DSC will not be exposed to pool water.

- The space between the top of the DSC and inside of the TC is sealed to prevent contamination. For PWR plants the pool water is borated. This affects the interior surfaces of the DSC, the shield plug, and the basket. The TC and DSC are kept in the spent fuel pool for a short period of time, typically about 6 hours to load or unload fuel, and 2 hours to lift the loaded TC/DSC out of the spent fuel pool.

- During storage, the interior of the DSC is exposed to an inert helium environment. The helium environment does not support the occurrence of chemical or galvanic reactions because both moisture and oxygen must be present for a reaction to occur. The DSC is thoroughly dried before storage by a vacuum drying process. It is then backfilled with helium, thus stopping corrosion. Since the DSC is vacuum dried, galvanic corrosion is also precluded as no water is present at the point of contact between dissimilar metals.

- During storage, the exterior of the DSC is protected by the concrete NUHOMS® HSM-H. The HSM-H is vented, so the exterior of the DSC is exposed to the atmosphere. The DSC shell and cover plates are fabricated from austenitic stainless steel and are resistant to corrosion.

The NUHOMS® 32PTH1 DSC materials are shown in the Parts List on Drawings NUH-32PTH1-1001-SAR through NUH-32PTH1-1004-SAR provided in Chapter U.1, Section U.1.5. The DSC shell material is SA-240 Type 304 Stainless Steel. The top and bottom shield plug material is either A36 carbon steel or Type 304 stainless steel. The carbon steel top shield plug is coated with a corrosion resistant electroless nickel coating. Alternatively, the top shield plug may be fabricated from Type 304 stainless steel (without coating). In the optional two-part top closure assembly, the inner top cover/shield plug may be fabricated as a single stainless steel piece or from welded stainless steel plates encasing an A36 carbon steel shield plug. The carbon steel bottom shield plug is sealed within the shell and inner and outer bottom cover plates and, thus, it does not come in contact with the external environment.

The basket fuel compartment structure is composed of tube assemblies made from Type 304 stainless steel. Sandwiched between the tube assemblies are plates of Type 1100 aluminum and neutron absorbing materials composed of either enriched borated aluminum alloy, Boron

Carbide/Aluminum Metal Matrix composite (MMC), natural boron, or Boral® plates. These plates are not fastened to the fuel compartment tube structure but are captured along the axial length of the basket by stainless steel insert plates (straps) that are welded to the fuel compartment tubes.

There are two types of transition rails that provide the transition between the fuel compartment structure and the DSC shell. The aluminum transition rails are made of Type 6061 aluminum. The stainless steel rails consist of welded Type 304 stainless steel plates with aluminum insert plates encased inside the stainless steel rail plates. The transition rails are attached to the grid structure using corrosion resistant fasteners. Similarly, the aluminum insert plates installed are attached using corrosion resistant fasteners.

Potential sources of chemical or galvanic reactions are the interaction between the aluminum, aluminum-based neutron poison and stainless steel within the basket and the pool water. Additionally, an interaction exists with the stainless steel top and bottom plates and the top shield plug.

Behavior of Aluminum in Borated Water

Aluminum is used for many applications in spent fuel pools. In order to understand the corrosion resistance of aluminum within the normal operating conditions of spent fuel storage pools, a discussion of each of the types of corrosion is addressed separately. None of these corrosion mechanisms is expected to occur in the short time period that the cask is submerged in the spent fuel pool.

General Corrosion

General corrosion is a uniform attack of the metal over the entire surfaces exposed to the corrosive media. The severity of general corrosion of aluminum depends upon the chemical nature and temperature of the electrolyte and can range from superficial etching and staining to dissolution of the metal. Figure U.3.4-1 shows a potential-pH diagram for aluminum in high purity water at 77°F and 140°F. The potential for aluminum coupled with stainless steel and the limits of pH for PWR pools are shown in the diagram to be well within the passivation domain at both temperatures. The passivated surface of aluminum (hydrated oxide of aluminum) affords protection against corrosion in the domain shown because the coating is insoluble, non-porous and adherent to the surface of the aluminum. The protective surface formed on the aluminum is known to be stable up to 275°F and in a pH range of 4.5 to 8.5.

The water aluminum reactions are self-limiting because the surface of the aluminum becomes passive by the formation of a protective and impervious coating making further reaction impossible until the coating is removed by mechanical or chemical means.

The ability of aluminum to resist corrosion from boron ions is evident from the wide usage of aluminum in the handling of borax and in the manufacture of boric acid. Aluminum storage racks with Boral plates (aluminum 1100 exterior layer) in contact with 800 ppm borated water showed only small amounts of pitting after 17 years in the pool at the Yankee Rowe Power Plant. These racks maintained their structural integrity.

During immersion in the spent fuel pool, the 32PTH1-DSC basket temperatures are close to the water temperature, which is typically near 80°F, and the pH range is typically 4.0 to 6.5. Based on the above discussion, general corrosion is not expected on the aluminum after the protective coating has been formed.

Galvanic Corrosion

Galvanic corrosion is a type of corrosion which could cause degradation of dissimilar metals exposed to a corrosive environment for a long period of time.

Galvanic corrosion is associated with the current of a galvanic cell consisting of two dissimilar conductors in an electrolyte. The two dissimilar conductors of interest in this discussion are aluminum and stainless steel in borated water. There is little galvanic corrosion in borated water since the water conductivity is very low. There is also less galvanic current flow between the aluminum-stainless steel couple than the potential difference on stainless steel which is known as polarization. It is because of this polarization characteristic that stainless steel is compatible with aluminum in all but severe marine, or high chloride, environmental conditions [3.6].

Pitting Corrosion

Pitting corrosion is the forming of small sharp cavities in a metal surface. The first step in the development of corrosion pits is a local destruction of the protective oxide film. Pitting will not occur on commercially pure aluminum when the water is kept sufficiently pure, even when the aluminum is in electrical contact with stainless steel. Pitting and other forms of localized corrosion occur under conditions like those that cause stress corrosion, and are subject to an induction time which is similarly affected by temperature and the concentration of oxygen and chlorides. As with stress corrosion, at the low temperatures and low chloride concentrations of a spent fuel pool, the induction time for initiation of localized corrosion will be greater than the time that the DSC internal components are exposed to the aqueous environment.

Crevice Corrosion

Crevice corrosion is the corrosion of a metal that is caused by the concentration of dissolved salts, metal ions, oxygen or other gases in crevices or pockets remote from the principal fluid stream, with a resultant build-up of differential galvanic cells that ultimately cause pitting. Crevice corrosion could occur in the basket grid assembly plates around the stainless steel welds. However, due to the short time in the spent fuel pool, this type of corrosion is expected to be insignificant.

Intergranular Corrosion

Intergranular corrosion is corrosion occurring preferentially at grain boundaries or closely adjacent regions without appreciable attack of the grains or crystals of the metal itself. Intergranular corrosion does not occur with commercially pure aluminum and other common work hardened aluminum alloys.

Stress Corrosion

Stress corrosion is failure of the metal by cracking under the combined action of corrosion and stresses approaching the yield stress of the metal. During spent fuel pool operations, the 32PTH1-DSC is upright and there is negligible load on the basket assembly. The stresses on the basket are small, well below the yield stress of the basket materials.

Behavior of Austenitic Stainless Steel in Borated Water

The fuel compartment structure is made from Type 304 stainless steel tubes and the transition rails that support the fuel compartments are made from aluminum Type 6061 and welded Type 304 stainless steel plates. Stainless steel does not exhibit general corrosion when immersed in borated water. Galvanic attack can occur between the aluminum in contact with the stainless steel in the water. However, the attack is mitigated by the passivity of the aluminum and the stainless steel in the short time the pool water is in the DSC. Also the low conductivity of the pool water tends to minimize galvanic reactions.

Stress corrosion cracking in the Type 304 stainless steel welds of the basket is also not expected to occur, since the baskets are not highly stressed during normal operations. There may be some residual fabrication stresses as a result of welding of the stainless steel plates together.

Of the corrosive agents that could initiate stress corrosion cracking in the stainless steel basket welds, only the combination of chloride ions with dissolved oxygen occurs in spent fuel pool water. Although stress corrosion cracking can take place at very low chloride concentrations and at low temperatures such as those in spent fuel pools (less than 10 ppb and 160°F, respectively), the effect of low chloride concentration and low temperature greatly increases the induction time. That is, the time period during which the corrodent is breaking down the passive oxide film on the stainless steel surface is increased. Below 60°C (140°F), stress corrosion cracking of austenitic stainless steel does not occur at all. At 100°C (212 °F), chloride concentration on the order of 15% is required to initiate stress corrosion cracking [3.7]. At 288 °C (550 °F), with tensile stress at 100% of yield in PWR water that contains 100 ppm O_2, time to crack is about 40 days in sensitized 304 stainless steel [3.8]. Thus, the combination of low chlorides, low temperature and short time of exposure to the corrosive environment eliminates the possibility of stress corrosion cracking in the basket and DSC welds.

The chloride content of all expendable materials which come in contact with the basket materials are restricted and water used for cleaning the baskets should be selected for its compatibility with the spent fuel pool water chemistry, and the basket material is restricted to 1.0 ppm chloride.

Behavior of Aluminum Based Neutron Poison in Borated Water

To investigate the use of borated aluminum in a spent fuel pool, tests were performed by Eagle Picher to evaluate its dimensional stability, corrosion resistance and neutron capture ability. These studies showed that borated aluminum performed well in a spent fuel pool environment [3.10].

The 1100 series aluminum component is a ductile metal having a high resistance to corrosion. Its corrosion resistance is provided by the buildup of a protective oxide film on the metal surface when exposed to a water or moisture environment. As stated above, for aluminum, once a stable film develops, the corrosion process is arrested at the surface of the metal. The film remains stable over a pH range of 4.5 to 8.5.

Tests were performed by Eagle Picher which concluded that borated aluminum exhibits a strong corrosion resistance at room temperature in either reactor grade deionized water or in 2000 ppm borated water. The behavior is only slightly different than 1100 series aluminum; hence, satisfactory long-term usage in these environments is expected. Neutron irradiation up to 10^{17} n/cm^2 level did not cause any measurable dimensional changes or any other damage to the material.

At high temperature, the borated aluminum still exhibits high corrosion resistance in the pure water environment. However, at temperatures of 80°C, in 2000 ppm borated water, local pitting corrosion has been observed. At 100°C and room temperature, the pitting attack was less than at 80°C. In all cases, passivation occurs limiting the pit depth.

From tests on pure aluminum, it was found that borated aluminum was more resistant to uniform corrosion attack than pure aluminum. Local pitting corrosion can occur over time, causing localized damage to the borated aluminum.

There are no chemical, galvanic or other reactions that could reduce the areal density of boron in the 32PTH1-DSC neutron poison plates.

Electroless Nickel Plated Carbon Steel

The carbon steel top shield plug of the DSC is plated with electroless nickel. This coating is identical to the coating used on the NUHOMS® 52B DSC. It has been evaluated for potential galvanic reactions in Transnuclear's response to NRC Bulletin 96-04 [3.9]. In PWR pools, the reported corrosion rates are insignificant and are expected to result in a negligible rate of reaction for the NUHOMS® PWR systems.

Lubricants and Cleaning Agents

Lubricants and cleaning agents used on the NUHOMS® 32PTH1 DSC should be selected for compatibility with the spent fuel pool water chemistry and the DSC materials. Never-seez or Neolube (or equivalent) is used to coat the threads and bolt shoulders of the closure bolts. The lubricant should be selected for its ability to maintain lubricity under long-term storage conditions.

The DSC is cleaned in accordance with approved procedures to remove cleaning residues prior to shipment to the storage site. The basket is also cleaned prior to installation in the DSC. The cleaning agents and lubricants have no significant affect on the DSC materials and their safety related functions.

Hydrogen Generation

During the initial passivation state, small amounts of hydrogen gas may be generated in the 32PTH1 DSC. The passivation stage may occur prior to submersion of the TC into the spent fuel pool. Any amounts of hydrogen generated in the DSC will be insignificant and will not result in a flammable gas mixture within the DSC.

The small amount of hydrogen which may be generated during DSC operations does not result in a safety hazard. In order for concentrations of hydrogen in the cask to reach flammability levels, most of the DSC would have to be filled with water for the hydrogen generation to occur, and the lid would have to be in place with both the vent and drain ports closed. This does not occur during DSC loading or unloading operations.

An estimate of the maximum hydrogen concentration can be made, ignoring the effects of radiolysis, recombination, and solution of hydrogen in water. Testing was conducted by Transnuclear [3.11] to determine the rate of hydrogen generation for aluminum metal matrix composite in intermittent contact with 304 stainless steel. The samples represent the neutron poison plates paired with the basket compartment tubes. The test specimens were submerged in deionized water for 12 hours at 70 °F to represent the period of initial submersion and fuel loading, followed by 12 hours at 150 °F to represent the period after the fuel is loaded, until the water is drained. The hydrogen generated during each period was removed from the water and the test vessel and measured. Since the test was performed in deionized water, and the 32PTH1 DSC will be used in borated water, the test results over-predict the hydrogen generation rates.

The test results were:

	12 hours @ 70°F		**12 hours @ 150°F**	
Aluminum MMC/SS304	$cm^3hr^{-1}dm^{-2}$	$ft^3hr^{-1}ft^{-2}$	$cm^3hr^{-1}dm^{-2}$	$ft^3hr^{-1}ft^{-2}$
	0.517	1.696E-4	0.489	1.604E-4

During the welding cycle, the most limiting case for hydrogen concentration is the 32PTH1-L DSC with stainless steel rails because it has the most aluminum surface area. The total surface area of all aluminum components including the neutron absorber plates is 4200 ft^2. After 787 gallons of water has been drained, 1958 ft^2 of aluminum remains submerged. This surface area, combined with the test data at 150°F above result in a hydrogen generation rate of

$$(1.60 \times 10^{-4}\ ft^3/ft^2hr)(1958\ ft^2) \quad = 0.313\ ft^3/hr$$

The minimum free volume of the DSC is 105.1 ft^3, which is equivalent to the 787 gallons of water drained from the DSC cavity. The following assumptions are made to arrive at a conservative estimate of hydrogen concentration:

- All generated hydrogen is released instantly to the plenum between the water and the shield plug, that is, no dissolved hydrogen is pumped out with the water, and no released hydrogen escapes through the open vent port, and

- The welding and backfilling process takes 8 hours to complete.

Under these assumptions, the hydrogen concentration in the space between the water and the shield plug is a function of the time water is in the DSC prior to backfilling with helium. The hydrogen concentration is (0.313 ft^3 H_2/hr)*(8 hr) / (105.1 ft^3) = 2.38%. Monitoring of the hydrogen concentration before and during welding operations is performed to ensure that the hydrogen concentration does not exceed 2.4%, which is well below the ignitable limit of 4%. If the hydrogen concentration exceeds 2.4%, welding operations are suspended and the DSC is purged with an inert gas. In an inert atmosphere, hydrogen will not be generated.

Effect of Galvanic Reactions on the Performance of the System

There are no significant reactions that could reduce the overall integrity of the DSC or its contents during storage. The DSC and fuel cladding thermal properties are provided in Chapter U.4. The surface emissivity of the fuel compartment tube is 0.46, which is typical for non-polished stainless steel surfaces. If the stainless steel is oxidized, this value would increase, improving heat transfer. The fuel rod emissivity value used is 0.80, which is a typical value for oxidized Zircaloy. Therefore, the passivation reactions would not reduce the thermal properties of the component cask materials or the fuel cladding.

There are no reactions that would cause binding of the mechanical surfaces or the fuel to basket compartment boxes due to galvanic or chemical reactions.

There is no significant degradation of any safety components caused directly by the effects of the reactions or by the effects of the reactions combined with the effects of long term exposure of the materials to neutron or gamma radiation, high temperatures, or other possible conditions.

If an independent spent fuel storage installation site is located in a costal salt water marine atmosphere, then any load-bearing carbon steel DSC support structure rail components of any associated HSM-H shall be procured with a minimum 0.20 percent copper content for corrosion resistance.

U.3.4.2 Positive Closure

Positive closure is provided by the OS200 TC. No change.

U.3.4.3 Lifting Devices

The evaluations for the OS200 TC trunnions presented in Section U.3.6.1.6 are based on a critical lift weight of 250,000 lb. As shown in Table U.3.2-1, the maximum critical lift weight with a NUHOMS® 32PTH1 DSC is approximately 241,300 lbs.

U.3.4.4 Heat and Cold

U.3.4.4.1 Summary of Pressures and Temperatures

Temperatures and pressures for the 32PTH1 DSC and basket are calculated in Chapter U.4. Section U.4.4 provides the thermal evaluation of the HSM-H loaded with a 32PTH1 DSC. Section U.4.5 provides the thermal evaluation of the OS200 TC/OS200FC TC loaded with a 32PTH1 DSC. Section U.4.6 provides the thermal evaluation of the 32PTH1 DSC. Section U.4.6 also provides the maximum pressures during normal, off-normal and accident conditions which are used in the evaluations presented later in this chapter. Section U.4.7 provides the thermal evaluation for fuel loading/unloading conditions, including vacuum drying operations.

Tables U.4-15, U.4-20 and U.4-24 summarize the maximum fuel cladding temperatures for normal, off-normal and accident conditions. Tables, U.4-16, U.4-17, U.4-21, U.4-22, U.4-25 and U.4-26 summarize the 32PTH1 DSC maximum component temperatures for normal, off-normal and accident conditions. Tables U.4-19, U.4-23 and U.4-27 summarize the maximum DSC cavity pressures for normal, off-normal, and accident conditions. Tables U.4-28, U.4-29 and U.4-30 summarize fuel cladding and basket component temperatures for vacuum drying conditions.

U.3.4.4.2 Differential Thermal Expansion

Clearances are provided between the various components of the 32PTH1 DSC to accommodate differential thermal expansion and to minimize thermal stress. In the radial direction clearance is provided between the basket outer diameter and DSC cavity inside diameter, and between the poison/aluminum plates and the interfacing basket components. In the axial direction clearances are provided between the DSC cavity and all the basket parts (support structure tube, transition rails). Additionally, the connections between the transition rails and the fuel support structure are designed to permit relative axial growth.

The thermal analyses of the basket for the handling/transfer conditions are described in Section U.4. The thermal analyses are performed to determine the basket/DSC temperatures and thermal expansion for -40°F ambient, 0°F ambient, 117°F ambient and vacuum drying conditions. The temperatures are used to evaluate the effects of axial and radial thermal expansion in the basket/DSC components.

In order to prevent thermal stress, adequate clearance is provided between the following components:

- Fuel Assemblies and DSC Cavity (Section U.3.4.4.2.1)
- Basket Rails and DSC Shell (Section U.3.4.4.2.2)
- Basket and DSC Shell Ends (Section U.3.4.4.2.3)
- Neutron Absorber Plates and Basket Plate Inserts (Section U.3.4.4.2.4)
- Basket Rail Aluminum and DSC Shell Ends (Section U.3.4.4.2.5)

To verify that adequate clearance exists, the thermal expansion of different components are calculated and tabulated in the following sections.

U.3.4.4.2.1 Fuel Assembly and DSC Cavity

This calculation verifies that there is adequate space for thermal expansion of the irradiated fuel Zircaloy clad assemblies within the DSC cavity for all operating conditions. The longest fuel assembly of 178.3" (which corresponds to CE 16x16 PVNGS fuel assembly w/CCs) and the minimum 32PTH1-L cavity length of 181.38" are considered in this analysis. The minimum cold gap available for differential thermal expansion and irradiation growth of the fuel assembly is 181.38 – 178.3 = 3.08".

The clearance for the irradiated fuel assembly within DSC cavity is calculated as the difference between the hot lengths of the 32PTH1 DSC shell cavity and the fuel assembly.

The total hot irradiated fuel assembly length including irradiation growth is determined as:

$$L_{FA\ hot\ irradiated} = L_{FA\ hot} + \Delta L_{FA\ irradiation}$$

where:

$L_{FA\ hot\ irradiated}$	Hot irradiated length of the fuel assembly, in
$L_{FA\ hot}$	Hot Length of the fuel assembly without irradiation growth, in
$\Delta L_{FA\ hot\ irradiated}$	Irradiation growth of the fuel assembly, in

The thermal expansion of the DSC cavity is given by the following formula:

$$L_{DSC\ hot} = L_{DSC\ cold}\,[1 + \alpha_{steel} \cdot (T_{ave} - T_{ref})]$$

where:

$L_{DSC\ hot}$	DSC cavity hot length, in
$L_{DSC\ cold}$	DSC cavity cold length at reference temperature, in *(181.38 in)*
α_{steel}	Thermal expansion coefficient of steel, 1/°F (8.99E-6 /°F @ 224°F)
T_{ref}	Reference temperature, °F *(70°F)*
T_{ave}	DSC shell volumetric average temperature, °F

The fuel assembly hot length $L_{FA\ hot}$ calculation considers thermal expansion of the active fuel and the top and bottom end fittings, with their corresponding average temperatures:

$$L_{FA\ hot} = L_{active\ fuel\ cold}(1 + \alpha_{Zr}(T_{ave\ active\ fuel} - T_{ref})) + L_{fitting\ cold}(1 + \alpha_{Steel}(T_{ave\ fitting} - T_{ref}))$$

where:

$L_{active\ fuel\ cold}$	Cold length of the active fuel, in
α_{Zr}	Zircaloy coefficient of thermal expansion, 1/°F
$T_{ave\ active\ fuel}$	Active fuel volumetric average temperature, °F
$L_{fitting\ cold}$	Cold length of the fuel end fitting, in
$T_{ave\ fitting}$	Fuel end fitting volumetric average temperature, °F

The average temperatures for the active fuel, and the fuel end fittings are calculated for the hottest fuel assembly. The fuel end fittings also include the inactive fuel regions.

The average temperatures of the DSC shell, active fuel region, and fuel end fittings are calculated as:

$$T_{ave\ component} = \frac{\sum (T_i \cdot V_i)_{element}}{\sum V_{i\ element}},$$

where T_i, V_i are temperature and volume of component elements.

The thermal expansion calculations are performed using a bounding average cladding temperature of 613°F and an average shell temperature of 224°F. For the controlling case, the length of the fuel assembly after thermal expansion is 178.65" and the DSC shell hot length is calculated as 181.63". Thus, the gap between the fuel assembly and the DSC ends is: 181.63 - 178.65 = 2.98". This gap is sufficient to accommodate fuel assembly growth due to irradiation, which is estimated to be on the order of 1.1" for high burnup fuel assemblies.

It is therefore concluded that the provision of a 3.08" minimum gap is sufficient and acceptable.

U.3.4.4.2.2 Radial Gap between Basket and DSC Shell

The radial gap between the basket and the DSC shell is evaluated to verify that there is sufficient initial cold gap for the basket to expand radially without imposing significant stress on the DSC shell.

The nominal DSC inner diameter is 68.75". The radial cold gaps (with tolerances) between the basket rails and the 32PTH1 DSC shell can vary between 0.095" and 0.17".

Average volumetric temperatures of the components and the corresponding thermal expansion coefficients are applied to the basket and rail components to calculate the hot annulus gap.

Hot Diametric Gap is

$$ID_1 = ID_{SHELL} \cdot (1 + \alpha_{SHELL}(T_{SHELL} - 70)) - \sum_{n=1}^{N} L_n (T_n - 70) \cdot (1 + \alpha_n)$$

where ID_{SHELL} is the DSC shell inner diameter [in],

n represents a basket component including fuel component, rail, neutron absorber, and rail backplate

N is total number of components considered

L_n is the nominal length of basket component n in the radial direction [in]

T_n is the volumetric average temperature of basket component n [°F]

α_n is the expansion coefficient of basket component n at T_n, [1/°F]

Hot Radial Gap $= ID_1 / 2$

Using the above formula and bounding conditions, the minimum hot radial gap (clearance) is calculated as 0.003 inch. Thus, there is no interference between the basket and the DSC shell.

U.3.4.4.2.3 Axial Gap between Basket and DSC End Assemblies

The total minimum axial cold gap between the basket assembly and the DSC end assemblies is 1.0".

The basket average temperature is conservatively based on the volumetric average temperature of the fuel compartment plate associated with the hottest fuel assembly. The shell average temperature is based on the volumetric average temperature of the DSC shell corresponding to the cavity length. A minimum DSC cavity length of 181.38" is used for the calculation of the basket / DSC and assemblies axial gap reduction. Conservative assumption is that the shell is of the same length as the basket.

Basket / DSC and assemblies axial gap reduction is:

$$L_{DSC\,cavity}\,[(T_{BASKET} - 70)\cdot\alpha_{BASKET} - (T_{SHELL} - 70)\cdot\alpha_{SHELL}]$$

where $L_{DSC\,cavity}$ is DSC cavity length (inches),

T_X is the average temperature of component X, (basket or shell)

α_X is the expansion coefficient of the component X at the average temperature, T_X

Gap reductions calculation, based on the above were performed for all load cases. The largest computed gap reduction is:

= 181.38 (460.7-70) x 9.62e-6 – (182.2-70) x 8.86e-6
= 182.062-181.560 = 0.502"

The calculation shows that the maximum gap reduction due to thermal expansion is 0.502". Therefore, the provided minimum cold gap of 1.0" is sufficient and acceptable.

U.3.4.4.2.4 Axial Gap between Neutron Absorber and Basket Insert Plates

Neutron absorber plates are placed between basket insert plates, and axial gaps are provided between the neutron absorbers and the insert plates to accommodate differential thermal expansion. The minimum total axial cold gap between a neutron absorber plate and the two adjacent insert plates is 0.05" (0.07" nom. +/-0.02"). To calculate the hot gap between these components, the following procedures are applied:

1. The average temperatures of the neutron absorber plates are computed based on the volumetric average temperature of the component. The temperatures of two segments of neutron absorber plates, one vertical and one horizontal, are computed and the bounding average temperature of the two is used.

2. The computed neutron absorber bounding average temperature is also used for the fuel compartment plate. This is conservative because the fuel compartment plate is hotter, being closer to the heat generating fuel assemblies.

3. A nominal length of 13.25" (i.e., 15"-1.75", where the center to center distance between the insert plates is 15" and the width of the insert plate is 1.75") is used for the fuel compartment plate. A length of 13.25"–0.05"=13.20" is used for the neutron absorber plate.

Neutron absorber/basket insert plate axial end gap reduction is

$$L_{\text{Fuel Comp}} \cdot (T_{\text{Fuel Comp}} - 70) \cdot \alpha_{\text{Fuel Comp}} - L_{\text{Neutron Absorber}} (T_{\text{Neutron Absorber}} - 70) \cdot \alpha_{\text{Neutron Absorber}}$$

The largest computed gap reduction is

= 13.25 (820-70) x 1.01e-5 – 13.20 (820-70) x 1.48e-5
= -0.046"

The calculation shows that the maximum gap reduction due to thermal expansion is 0.046". Therefore, the provided minimal cold axial gap of 0.05" is sufficient and acceptable.

U.3.4.4.2.5 Axial Gap between Aluminum Rail and DSC Shell End Components

The minimum total axial cold gap between the basket aluminum rails and the DSC shell end components is 1.0". To calculate the hot gap between the rails and the end components, the following procedure is applied:

1. The average temperatures for R45 and R90 rails are computed conservatively based on the volumetric average temperature of the component. The bounding average temperature for the rail components is used.

2. The DSC shell temperature is based on the volumetric average temperature corresponding to the DSC cavity length.

3. A minimum 32PTH1 DSC cavity length of 181.38" is used for the calculation of the basket / shell gap reduction. A conservative assumption is that the rail component is the same length as the shell.

4. The thermal expansion coefficient of aluminum is used for the rail component.

   Rail / End Assemblies Axial Gap Reduction is

   $$L_{\text{DSC cavity}} \cdot [(T_{\text{SHELL}} - 70 \cdot \alpha_{\text{SHELL}}) - (T_{\text{RAIL}} - 70) \cdot \alpha_{\text{RAIL}}]$$

   where $L_{\text{DSC cavity}}$ is DSC cavity length (inches),

Maximum axial gap reduction between rail and end assemblies is:

= 181.38 [(594-70) x 9.80e-6 – (653-70) x 1.44e-5]
= -0.59"

The maximum gap reduction is 0.59". Thus, the minimal total cold gap of 1.0" between the rail and the end assemblies is sufficient and acceptable.

U.3.4.4.3 Thermal Stress Calculations

The thermal stress evaluations for the 32PTH1 DSC, the HSM-H, and the OS200 TC are provided in Section U.3.6 (for normal and off-normal conditions) and in Section U.3.7 for accident conditions.

Thermal stresses are considered separately and in combination with other loads. Thermal stresses in combination with other loads are addressed as appropriate in Section U.3.6.

U.3.4.4.3.1 32PTH1 DSC Thermal Stress Calculations

Thermal stresses in the 32PTH1 DSC shell assembly are evaluated using ANSYS [3.41] finite element models described in Section U.3.6.1.2 and the results are summarized in Table U.3.6-2.

Thermal stresses in the basket assembly are evaluated using the ANSYS [3.41] [3.50] finite element model described in Section U.3.6.1.3. As described in Section U.3.6.1.3.1, separate ANSYS models are developed for the Type 1 (aluminum rails) and the Type 2 (stainless steel rails) basket assemblies.

Maximum thermal stresses are summarized in Table U.3.6-3 and Table U.3.6-4 for storage conditions and Table U.3.6-5 and Table U.3.6-6 for transfer conditions. As shown by the table, thermal stresses in the 32PTH1 basket are low.

As noted in Section U.3.4.4.2, clearances are provided such that there is free thermal expansion in the axial and radial directions in the basket components.

U.3.4.4.3.2 HSM-H/HSM-HS Thermal Stress Calculations

The thermal stress evaluations of the HSM-H/HSM-HS loaded with a 32PTH1 DSC are described in Section U.3.6 for normal and off-normal conditions and U.3.7 for accident conditions. A summary of the forces and moments in the concrete components due to different thermal load cases are summarized in Table U.3.4-1.

U.3.4.4.3.3 OS200/OS200FC TC Thermal Stress Calculations

The OS200 TC is used for transfer of a 32PTH1 DSC for heat loads of up to 31.2 kW with basket Type 1 or up to 24 kW with basket Type 2. For DSCs with basket Type 1 with heat load above 31.2 kW, or DSCs with basket Type 2 with heat load above 24 kW use of the OS200FC TC is required. The thermal analysis of the TC is based on the bounding temperature profiles for 31.2 kW (steady state with and without air circulation option, if used) and 40.8 kW (with air circulation, if used).

The OS200 thermal stress calculations are described in Section U.3.6.1.5.

Table U.3.4-1
Summary of Thermal Forces and Moments in the HSM-H/HSM-HS Concrete Components

Thermal Case	Concrete Component	Forces/Moments[4]			
		Shear, V_{o1}[1] (kips/ft)	Shear, V_{o2}[1] (kips/ft)	Moment, M_1[2] (kip-in/ft)	Moment, M_2[2] (kip-in/ft)
Normal Thermal (TN)	Rear Wall	3.9	5.0	103.8	227.8
	Side Wall	12.8	8.8	184.6	116.6
	Front Wall	29.6	25.1	1464.4	2024.9
	Roof	5.9	7.7	146.6	382.3
Off-Normal Thermal (TO)[3]	Rear Wall	8.0	8.8	126.4	271.7
	Side Wall	45.1	17.9	240.6	381.9
	Front Wall	47.7	27.6	1777.5	3693.1
	Roof	10.4	23.6	404.4	880.2
Accident Thermal (TA)	Rear Wall	8.0	8.8	126.4	271.7
	Side Wall	45.1	17.9	240.6	381.9
	Front Wall	47.7	27.6	1777.5	3693.1
	Roof	10.4	23.6	404.4	880.2

Notes:

(1) V_{o1} and V_{o2} are out of plane shears.

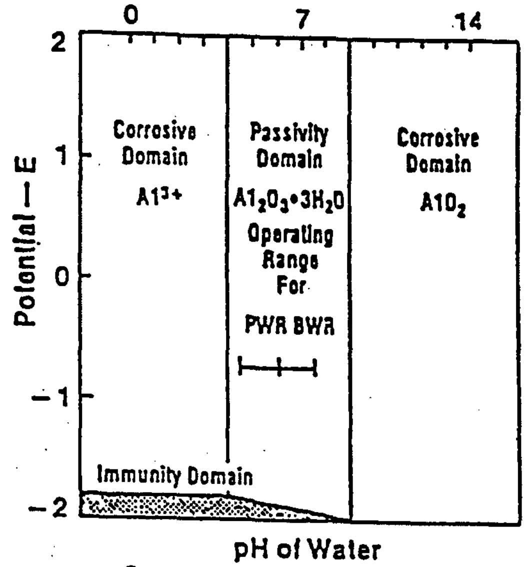
(2) M_1 and M_2 are out of plane moments.

(3) Off-Normal Thermal is bounded by Accident Thermal; Accident Thermal results are used for off-normal thermal case.

(4) HSM-HS thermal forces and moments are conservatively used here and in all load combinations

POTENTIAL VERSUS pH DIAGRAM FOR ALUMINUM-WATER SYSTEM

At 25°C (77°F):



At 60°C (140°F):

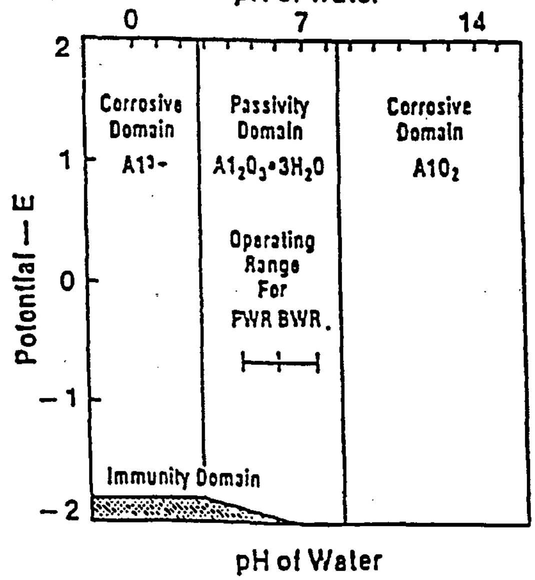


Figure U.3.4-1
Potential Versus pH Diagram for Aluminum-Water System

U.3.5 Fuel Rods

The handling of spent fuel within the nuclear plant will be conducted in accordance with existing fuel handling procedures.

The structural integrity of fuel rod cladding during a side and end drop are evaluated in this section. Presented below is a description of the material properties used, the analyses performed and results obtained which form the basis to conclude that the fuel rod cladding will maintain structural integrity and retain the fuel pellets during these accident scenarios.

U.3.5.1 Material Properties of High Burnup Fuel

The fuel cladding is evaluated based on the mechanical properties obtained from Reference [3.51]. Reference [3.51] provides expressions to calculate the modulus of elasticity and yield strength for both Zircaloy-2 (BWR cladding) and Zircaloy-4 (PWR cladding). These expressions were derived from correlations of experimental results of several different investigations. Assumptions used include the following:

- Neutron fluence is assumed to be 1.2×10^{26} n/m^2. This is above the highest threshold given in Reference [3.51] (7.5×10^{25} n/m^2) and can thus be considered in the high burnup regime. Note that the coefficient for this regime is a constant.
- The strain rate used for this calculation is 0.5 s^{-1} as recommended in Reference [3.32].
- The cold work ratios used (0.0 for Zircaloy-2, 0.5 for Zircaloy-4) are taken from Reference [3.51].
- Oxygen content ratio of the Zircaloy is assumed to be 0.0012 as recommended by Beyer [3.51].

Temperature is a significant factor in the derivation of Zircaloy properties. These properties are calculated over a range of temperatures for both Zircaloy-2 and Zircaloy-4. An example calculation is shown in Appendix T, Section T.3.5 for the NUHOMS® 61BTH system.

The results for Zircaloy-4 (PWR) are presented in Table U.3.5-3.

U.3.5.2 Side Drop Analysis

A. Methodology

A single rod of the fuel assemblies is analyzed for side drop. The model is subjected to lateral loads due to the cladding tube mass and the fuel pellets mass. However, no credit is taken for fuel pellets moment of inertia and the loads are entirely taken by the cladding tube. The fuel cladding was constrained in the lateral direction at the spacer grid locations. The maximum calculated bending plus pressure axial stress is compared with the dynamic yield strength of fuel cladding material Zircaloy-4 at maximum operating temperature.

B. Assumptions

1. No credit is taken for the stiffness of the fuel pellets. It is assumed that the fuel pellets do not contribute to axial or bending stiffness. The fuel pellet weight is assumed to be carried by the fuel cladding during the side drop event.

2. The fuel cladding thickness is reduced by 0.0027 inch to account for oxidation. Reference [3.49] gives an average oxide thickness of 40 μm for high burnup fuel. Conservatively an upper bound oxide thickness of 120 μm is used. In order to calculate the actual thickness reduction, the oxide thickness accumulation is corrected using a Pilling-Bedworth factor of 1.75 [Reference 3.49, page 426], as shown below:

$$(120/1.75) \times 10^{-6}\text{m} \times 39.372 \text{ in/m} = 0.0027 \text{ inch}$$

3. The WE 14x14 Std/ZCA and WE 14x14 Std/OFA fuel claddings bound all of the 14x14 fuel claddings because they have the smallest thickness and the smallest diameter respectively. They also have the largest span length.

4. The WE 15x15 Std/ZC fuel cladding bounds all of the 15x15 fuel claddings because they have the smallest thickness and the smallest diameter respectively. They also have the largest span lengths.

5. The CE 16x16 SCE fuel cladding bounds all of the 16x16 fuel claddings because they have the smallest thickness and the smallest diameter respectively. They also have the largest span lengths.

6. The WE 17x17 Vantage 5 fuel cladding bounds all of the 17x17 fuel claddings because they have the smallest thickness and the smallest diameter respectively. They also have the largest span lengths.

C. Finite Element Model

One fuel rod is modeled in an ANSYS [3.50] finite element model. The fuel cladding is modeled using PIPE16 elements. The weight of the fuel pellets was incorporated by adjusting the equivalent density of the fuel cladding. The fuel cladding was constrained in the lateral direction at spacer grid locations.

The geometry and model data used in the finite element model are summarized in Table U.3.5-1 and Figure U.3.5-1. A finite element model setup is provided in Figure U.3.5-2. Table U.3.5-2 summarizes the element types, real constants and material numbers used in the finite element model. Displacement boundary conditions and loading for WE 14x14 STD/ZCA is shown in Figure U.3.5-3.

D. Material Properties

The following fuel cladding material properties (at 750°F) are used for the side drop analysis:

$E = 9.93 \times 10^6$ psi
$\nu_{xy} = 0.404$
$S_y = 92000$ psi

E. Loading

The accident on-site transfer side drop load is 62.9g [3.1]. The calculated dynamic factors are 0.75 for the 14x14, 15x15, and 17x17 fuel assemblies and 1.7 for 16x16 assemblies. Conservatively 75g acceleration is applied in the lateral direction for accident drop condition. For the 16x16 fuel assembly the results are scaled up to 125g.

F. Results

The resulting detailed displacements, forces and stresses in the model are given in ANSYS result files. Typical bending stress contour plots for the WE 14x14 STD/ZCA are shown on Figure U.3.5-4.

The fuel gas internal pressure is also considered in the calculation. The cladding axial tensile stress due to the gas pressure is added to the bending stress from the side drop analyses. The combined maximum stresses in the cladding are tabulated in Table U.3.5-4, and compared to material yield strength at 750° F. All the calculated stresses are less than the fuel cladding yield strength.

U.3.5.3 <u>End Drop Analysis</u>

Proprietary Information withheld under 10CFR2.390

Proprietary Information withheld under 10CFR2.390

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U.3.5.4 Additional Analysis for Criticality Modeling

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Table U.3.5-1
Model Data

	CE 14x14 Fort Calhoun	CE 14x14 Std	CE 14x14 Calvert Cliffs	CE 14x14 Millstone 2	CE 14x14 St. Lucie	CE 14x14 Main Yankee	Siemens/ Framatome-ANP 14x14 CE	Exxon/ANF 14x14 WE	Exxon/ANF 14x14 CE	Exxon/ANF 14x14 Top Rod	WE 14x14 Std/ZCA (5)	WE 14x14 Std/ZCB	WE 14x14 OFA/LOPAR	WE 14x14 Point Beach / Prairie Isl (9)	WE 14x14 Kewaunee (9)
No. of Fuel Rod(2)	168	164	164	164	164	164	164	179	176	179	179	179	179	179	179
Original Fuel Cladding OD(2) (in)	0.44	0.44	0.44	0.44	0.44	0.44	0.44	0.425	0.44	0.417	0.422	0.422	0.4	0.422	0.422
Fuel Cladding OD (in)(1)	0.4346	0.4346	0.4346	0.4346	0.4346	0.4346	0.4346	0.4196	0.4346	0.4116	0.4166	0.4166	0.3946	0.4166	0.4166
Fuel Cladding ID (in)	0.384	0.384	0.384	0.384	0.384	0.384	0.388	0.365	0.378	0.358	0.377	0.377	0.3514	0.3734	0.3734
Fuel Cladding tkh (in)(1)(2)	0.0253	0.0253	0.0253	0.0253	0.0253	0.0253	0.0233	0.0273	0.0283	0.0268	0.0198	0.0198	0.0216	0.0216	0.0216
Fuel Pellet OD (in) (2)	0.3765	0.3765	0.3765	0.3765	0.3765	0.3765	0.3805	0.3505	0.37	0.35	0.3674	0.3674	0.3444	0.3659	0.3659
Fuel Rod Pitch(2)	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.556	0.58	0.556	0.556	0.556	0.556	0.556	0.556
No. of Spacers(2)	9	9	9	9	9	9	9	9	9	7	7	7	7	7	7
Fuel Cladding, ρ (lb/in^3)(3)	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.27	0.27	0.27	0.27	0.27
Fuel Cldg + Fuel, ρ (lb/in^3)(4)	1.57	1.57	1.57	1.57	1.57	1.57	1.71	1.35	1.40	1.39	1.91	1.91	1.67	1.76	1.76
Spacer Width (2)	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
L_B (2)	1.4	1.322	1.322	1.322	1.322	1.322	1.322	2.10	3.00	0.62	1.63	1.63	1.35	1.49	1.23
L_1 (2)	13.85	10.43	10.43	10.43	10.43	10.43	10.43	17.92	10.54	20.48	22.70	22.70	23.08	22.66	22.66
L_2 (2)	15.31	17.36	17.36	17.36	17.36	17.36	17.36	19.30	17.11	25.69	24.69	24.69	24.69	24.69	24.69
L_3 (2)	15.31	17.36	17.36	17.36	17.36	17.36	17.36	16.21	17.36	24.69	24.69	24.69	24.69	24.69	24.69
L_4 (2)	15.31	17.36	17.36	17.36	17.36	17.36	17.36	14.20	16.36	24.69	24.69	24.69	24.69	24.69	24.69
L_5 (2)	15.31	17.36	17.36	17.36	17.36	17.36	17.36	14.23	17.36	24.69	24.69	24.69	24.69	24.69	24.69
L_6 (2)	15.31	17.36	17.36	17.36	17.36	17.36	17.36	16.40	17.36	17.13	17.18	17.18	16.80	17.46	17.46
L_7 (2)	15.31	17.36	17.36	17.36	17.36	17.36	17.36	20.50	17.36	-	-	-	-	-	-
L_8 (2)	14.67	16.23	16.23	16.23	16.23	16.23	16.23	12.64	16.15	-	-	-	-	-	-
L_9 (2)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
L_{10} (2)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
L_T (2)	1.40	1.32	1.32	1.32	1.32	1.32	1.32	2.10	3.00	0.62	1.63	1.63	1.35	1.49	1.23
Rod Length, L (2)	137.00	147.00	147.00	147.00	147.00	147.00	147.00	149.10	134.06	144.00	152.40	152.40	151.85	152.36	151.83
Active Fuel Length (2)	128	137	136.7	136.7	136.7	136.7	137	142	146.484	152	145.2	145.2	144	144	144

Notes:

(1) Includes 0.0027 in. reduction in cladding thickness to account for oxidation

(2) Source: DOE/RW-0184, Volume 3 of 6, December 1987.

(3) $\rho = [(OD^2_{orig} - ID^2) / (OD^2 - ID^2)] \times \rho_{orig}$ --- $\rho_{orig} = 0.234$ [3.65]

(4) $\rho = \rho_{cladding} + \rho_{fuel} * [OD^2_{fuel\ pellet} / (OD^2 - ID^2)]$ --- $\rho_{fuel} = 0.382$ [3.66]

(5) Grid spacer locations from WE 14x14 Std/ZCB used

(6) Grid spacer locations from WE 17x17 OFA used

(7) Data from CE 16x16 Onofre fuel assembly used; Grid spacers assumed to be distributed uniformly with (

(8) Data from CE 16x16 ANO2 fuel assembly used; Grid spacers assumed to be distributed uniformly with C

(9) Source: DOE/ET/47912-3, "Domestic Light Water Reactor Fuel Design Evolution," September 1981

Table U.3.5-1
Model Data
(Concluded)

B&W 15x15 Mark B	CE 15x15 Palisades	Exxon/ANF 15x15 CE	Exxon/ANF 15x15 WE	WE 15x15 Std/ZC	WE 15x15 LOPAR/OFA /DRFA	CE 16x16 SCE [7]	CE 16x16 PVNGS [8]	WE 17x17 Std	WE 17x17 Vantage 5 [6]	WE 17x17 OFA/LOPAR/ RFA	WE 17x17 Mk Bw
208	204	216	204	204	204	224	232	264	264	264	264
0.43	0.418	0.417	0.424	0.422	0.422	0.382	0.382	0.374	0.36	0.36	0.3767
0.4246	0.4126	0.4116	0.4186	0.4166	0.4166	0.3766	0.3766	0.3686	0.3546	0.3546	0.3713
0.377	0.366	0.357	0.364	0.3736	0.3736	0.332	0.332	0.329	0.315	0.315	0.3287
0.0238	0.0233	0.0273	0.0273	0.0215	0.0215	0.0223	0.0223	0.0198	0.0198	0.0198	0.0213
0.3686	0.358	0.3565	0.3565	0.3659	0.3659	0.325	0.325	0.3225	0.3088	0.3088	0.3198
0.568	0.55	0.55	0.563	0.563	0.563	0.506	0.506	0.496	0.496	0.496	0.496
8	10	10	7	7	7	11	11	8	8	8	8
0.26	0.26	0.26	0.26	0.27	0.27	0.26	0.26	0.27	0.27	0.27	0.27
1.62	1.61	1.42	1.40	1.77	1.77	1.54	1.54	1.71	1.64	1.64	1.58
1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50
1.06	1.0625	1.55	0.72	1.37	1.37	0.5	0.5	1.18	1.53	1.20	1.18
20.63	12.63	12.30	22.73	22.70	23.08	14.35	14.35	22.93	23.39	23.39	22.93
19.63	14.00	13.80	24.69	24.69	24.69	14.35	14.35	19.05	19.05	19.05	19.05
19.59	14.00	14.20	24.69	24.69	24.69	14.35	14.35	19.05	19.05	19.05	19.05
19.59	14.00	14.00	24.69	24.69	24.69	14.35	14.35	19.05	19.05	19.05	19.05
19.59	14.00	14.00	26.19	24.69	24.69	14.35	14.35	19.05	19.05	19.05	19.05
19.59	14.00	14.00	17.13	17.18	16.80	14.35	14.35	19.05	19.05	19.05	18.95
20.94	14.00	14.00	-	-	-	14.35	14.35	19.09	18.60	18.60	19.19
-	14.00	14.00	-	-	-	14.35	14.35	-	-	-	-
-	12.69	12.61	-	-	-	14.35	14.35	-	-	-	-
-	-	-	-	-	-	14.35	14.35	-	-	-	-
1.06	0.63	0.10	0.72	1.37	1.37	0.50	0.50	1.18	1.53	1.20	1.18
153.68	140.00	139.42	152.07	151.88	151.85	161.00	161.00	151.64	152.30	151.64	151.64
141.80	131.4	131.8	144	144	144	150	150	144	144	144	144

Table U.3.5-2
Finite Element Model-Side Drop

		WE 14x14 Std/ZCA	WE 14x14 OFA	WE 15x15 Std/ZC	CE 16x16 SCE	WE 17x17 Vantage 5
Fuel Cladding	ET 1	PIPE16	PIPE16	PIPE16	PIPE16	PIPE16
	Real 1	0.4166, 0.0198	0.3946, 0.0216	0.4166, 0.0215	0.3766, 0.0223	0.3546, 0.0198
Fuel Cladding + Fuel	ET 2	PIPE16	PIPE16	PIPE16	PIPE16	PIPE16
	Real 2	0.4166, 0.0198	0.3946, 0.0216	0.4166, 0.0215	0.3766, 0.0223	0.3546, 0.0198

Table U.3.5-3
Modulus of Elasticity and Yield Stress (0.5 s^{-1} strain rate)

Temperature °F	PWR, Zircaloy-4	
	E, psi	Yield Stress, psi
300	1.22E+07	126102
350	1.19E+07	120769
400	1.17E+07	116272
450	1.14E+07	112390
500	1.12E+07	108921
550	1.09E+07	105683
600	1.07E+07	102512
625	1.06E+07	100904
650	1.04E+07	99259
675	1.03E+07	97560
700	1.02E+07	95793
725	1.01E+07	93944
750	9.93E+06	92000

Table U.3.5-4
Summary of Stress Results for Side Drop

	WE 14x14 Std/ZCA	WE 14x14 OFA	WE 15x15 Std/ZC	CE 16x16 SCE(2)	WE 17x17 Vantage 5
Max Bending Stress, S_b (psi)	73,255	68,822	70,237	37,393	67,977
Internal Pressure (psi)	2,235	2,235	2,235	2,235	2,235
S_{press} (psi)(1)	11,200	9,650	10,271	8,880	9,500
Combined Stress (psi)	84,455	78,472	80,508	46,273	77,477
Yield Stress at 750°F (psi)	92,000	92,000	92,000	92,000	92,000

Notes:

(1) $S_{press} = p \times D_{avg} / 4t$

(2) The DLF for CE 16x16 is 1.7 results into 107g accident transport drop loads. Bending Stress is conservatively scaled to 125g load (22436 x125)/75 = 37,393 psi

Table U.3.5-5
Material Properties Inputs for Finite Element Model-End Drop

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Table U.3.5-6
Summary of End Drop Analysis

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Table U.3.5-7
Results Summary - Plastic Lateral Deformation

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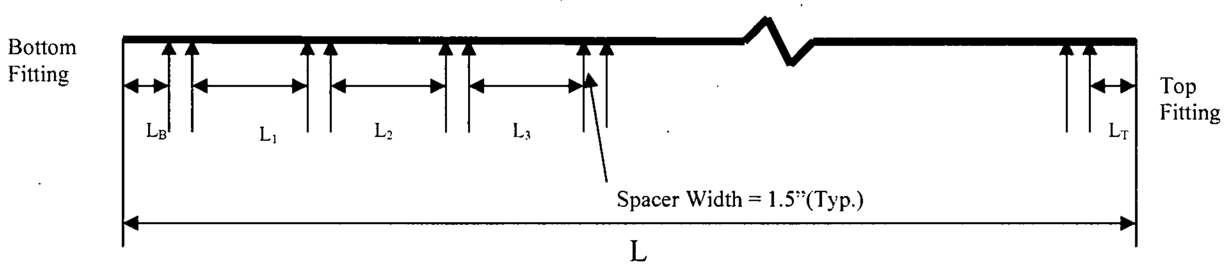

- Dimensions and number of spacers are listed in Table U.3.5-1.

Figure U.3.5-1
32PTH1 Fuel Cladding Geometry

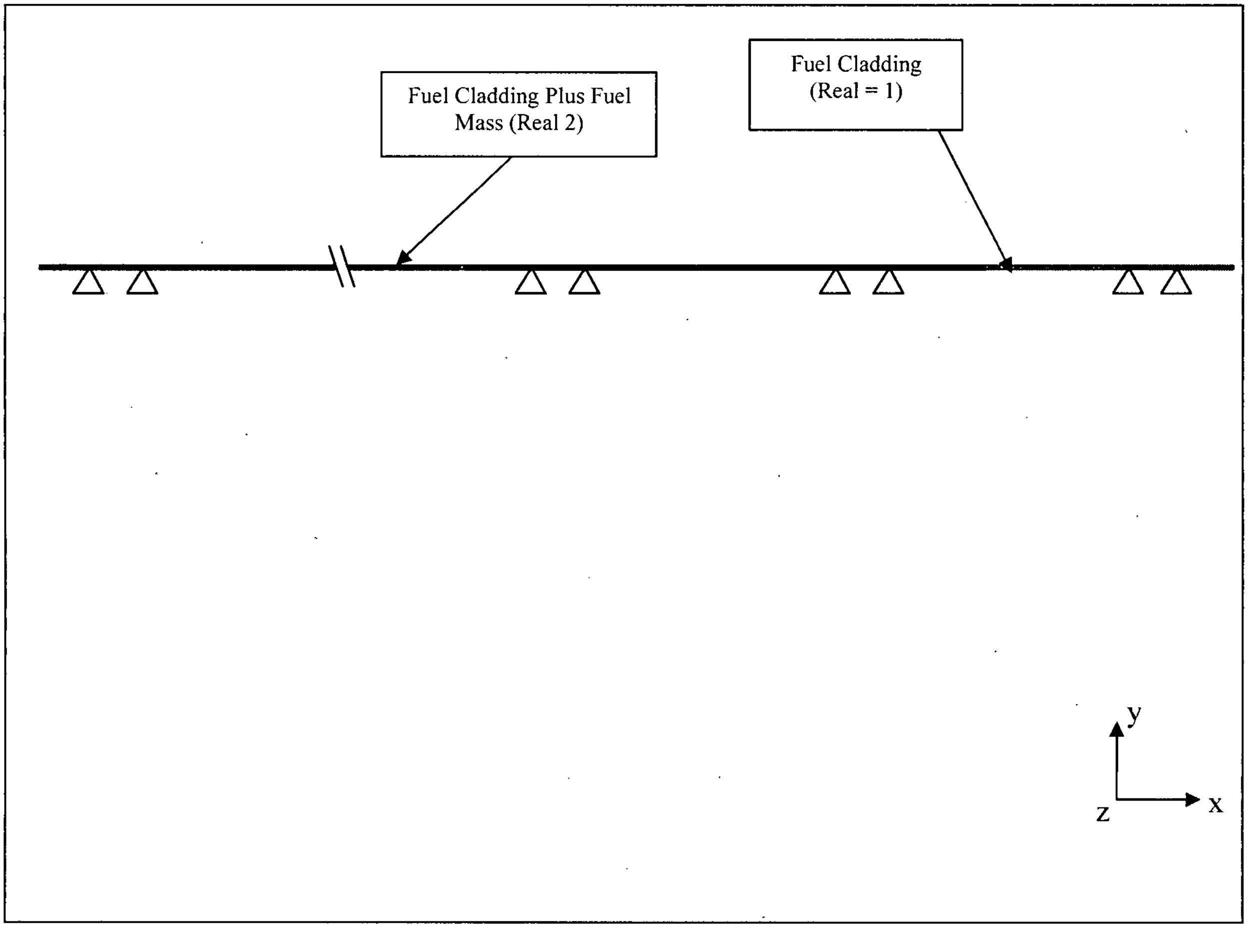

Figure U.3.5-2
Finite Element Model Setup

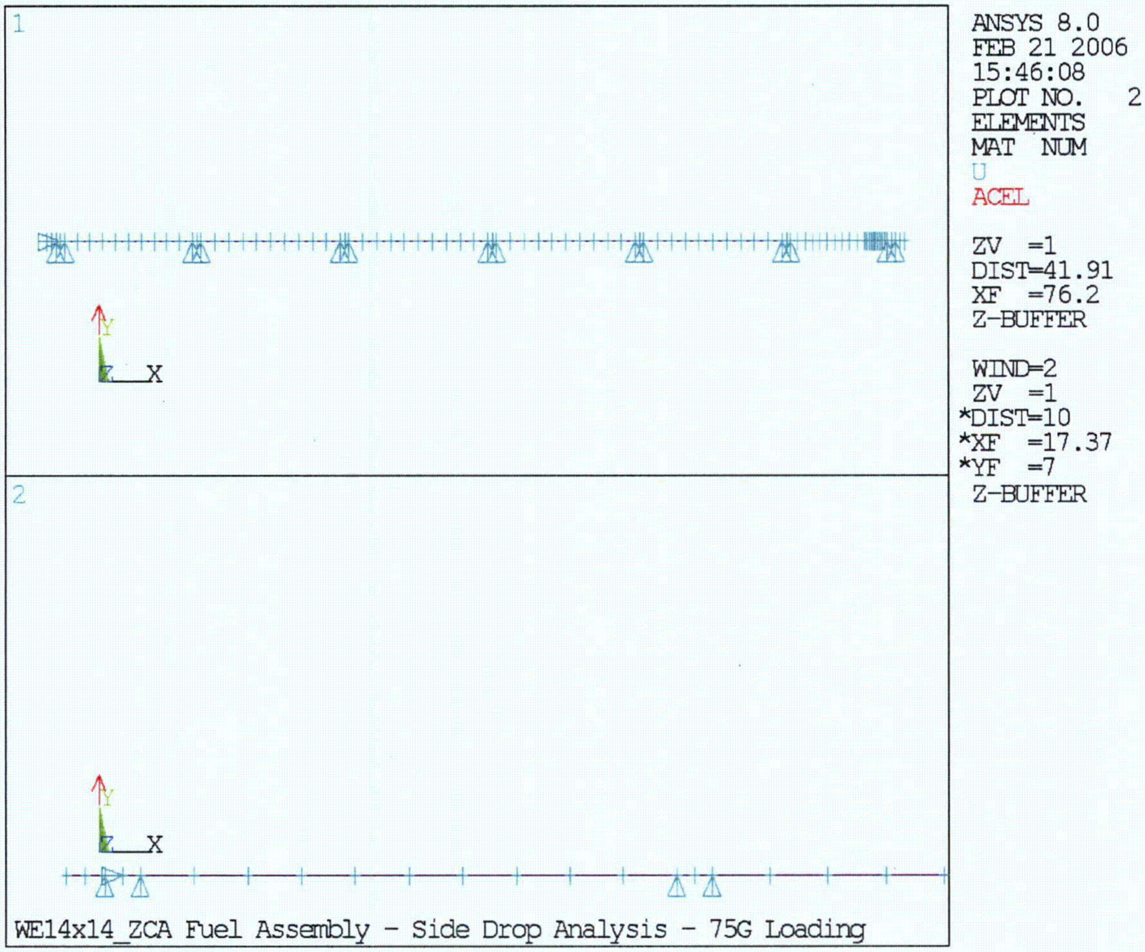

Figure U.3.5-3
Westinghouse 14x14 STD/ZCA Fuel Assembly - Boundary Conditions and Loading

(Bottom figure is an enlarged view of the top span.)

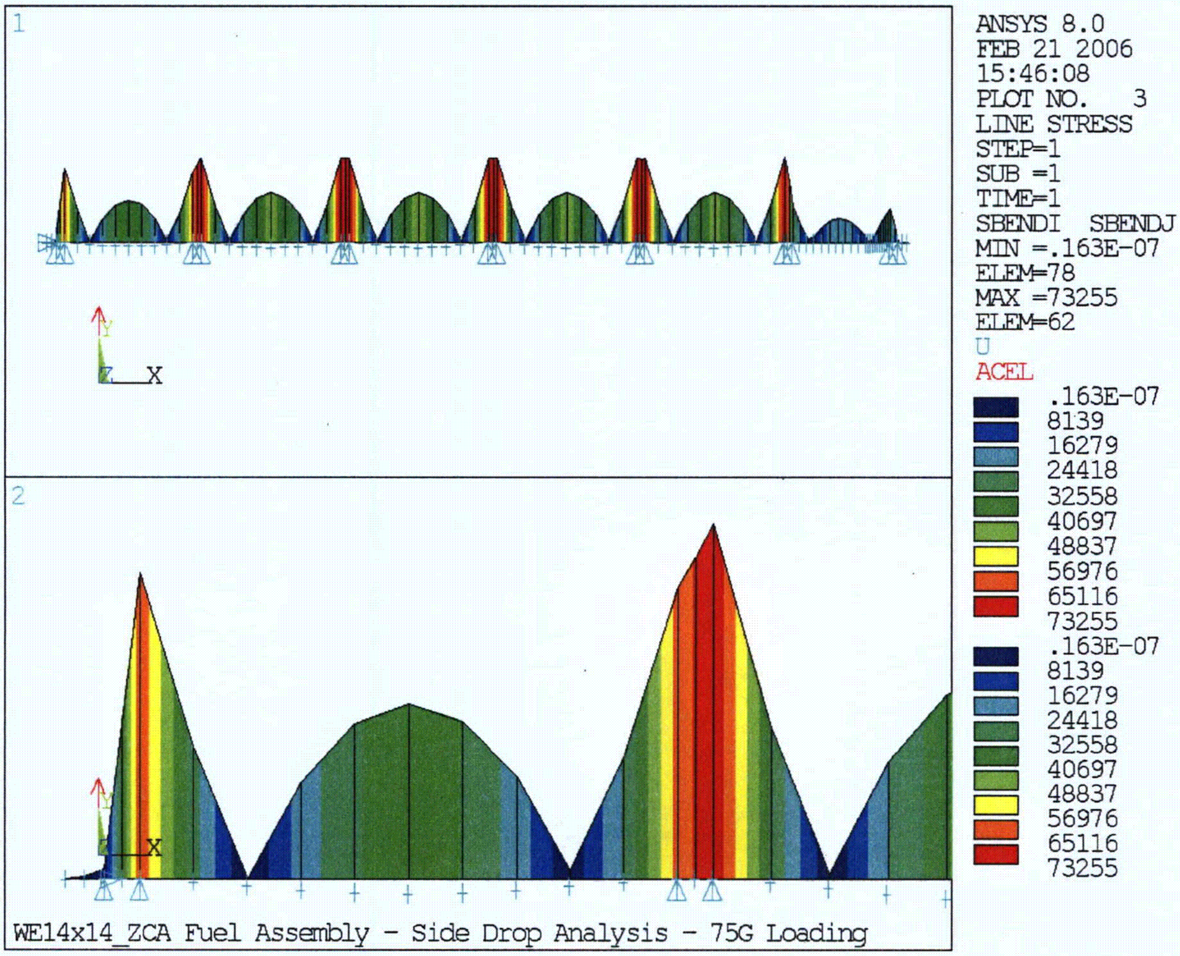

Figure U.3.5-4
Westinghouse 14x14 STD/ZCA Fuel Assembly – Bending Stress at 75g

(Bottom figure is an enlarged view of the top span.)

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Figure U.3.5-5
Finite Element Model for End Drop Analysis

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Figure U.3.5-6
WE 14x14 STD Fuel Assembly - Boundary Condition

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Figure U.3.5-7
Force Response Curve from Reference [3.34]

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Figure U.3.5-8
Force Response Curve Used in Analysis

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Figure U.3.5-9
WE 14x14 STD Fuel Assembly - Node Numbers of Top Three Spans

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Figure U.3.5-10
WE 14x14 STD Fuel Assembly - Lateral Displacement

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Figure U.3.5-11
WE 14x14 STD Fuel Assemblies - Top End Drop - Axial Stress at Span 1

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Figure U.3.5-12
WE 14x14 STD Fuel Assemblies - Top End Drop - Axial Plastic Strain at Span 1

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Figure U.3.5-13
WE 14x14 STD Fuel Assemblies - Top End Drop - Axial Stress at Span 2

Proprietary Information withheld under 10CFR2.390

Figure U.3.5-14
WE 14x14 STD Fuel Assemblies - Top End Drop - Axial Plastic Strain at Span 2

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Figure U.3.5-15
WE 14x14 STD Fuel Assemblies - Top End Drop - Axial Stress at Span 3

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Figure U.3.5-16
WE 14x14 STD Fuel Assemblies - Top End Drop - Axial Plastic Strain at Span 3