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February 26, 2025
E-64033

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

Subject: Application for Amendment 5 to NUHOMS® EOS Certificate of Compliance No. 1042, Revision 0 (Docket 72-1042)

In accordance with 10 CFR 72.244, TN Americas LLC herewith submits its application to amend Certificate of Compliance (CoC) No. 1042 for the NUHOMS® EOS System. The scope of Amendment 5 is described in Enclosure 2. Enclosure 3 includes a markup of proposed changes to the CoC document. Enclosure 4 provides a complete revision to the Technical Specifications (TS) with proposed changes indicated by italicized text and revision bars. The CoC 1042 Amendment 4 proposed TS changes currently under NRC review are reflected in the proposed Amendment 5 TS but are not tracked. A proprietary version of the updated final safety analysis report (UFSAR) changed pages and drawings associated with Amendment 5 is included as Enclosure 5 with the proposed UFSAR changes and new pages indicated by italicized text, revision bars, and a footer on each changed page annotated as “72-1042 Amendment 5, Revision 0, February 2025.” A public version of these UFSAR changed pages is provided as Enclosure 6.

Enclosure 7 provides a listing of computer files associated with Amendment 5 and Enclosure 8 contains those computer files. The file structure of the computer files is not compatible with the NRC EIE application process and Enclosure 8 is, therefore, being submitted separately. Since Enclosure 8 contains entirely proprietary information, no public version is provided.

Certain portions of this submittal include proprietary information, which may not be used for any purpose other than to support the NRC staff’s review of the application. In accordance with 10 CFR 2.390, TN Americas LLC is providing an affidavit (Enclosure 1), specifically requesting that this proprietary information be withheld from public disclosure. The submittal also includes security-related information.

Based on recent experience with similar limited amendment scope, no physical changes to the design, and no major appendices being added to the UFSAR, TN requests that the NRC review of this application will result in Amendment 5 becoming effective in August 2026.

TN Americas LLC looks forward to working with the NRC staff on this amendment application. We are prepared to meet with the staff to resolve any questions the staff might have. Should the NRC staff require additional information to support review of this application, please contact Mr. Doug Yates at 434-832-3101, or by email at douglas.yates@orano.group.

Sincerely,

A·Prakash
DO

Prakash Narayanan
Chief Technical Officer

cc: Haimonat Yilma (NRC), Project Manager, Storage and Transportation Licensing Branch, Division of Fuel Management

Enclosures:

1. Affidavit Pursuant to 10 CFR 2.390
2. Description, Justification, and Evaluation of Amendment 5 Changes
3. Proposed Certificate of Compliance No. 1042 Amendment 5, Revision 0 Markup
4. Proposed Technical Specifications, CoC 1042 Amendment 5, Revision 0
5. Proposed Amendment 5, Revision 0 Changes to the NUHOMS® EOS System Updated Final Safety Analysis Report (Proprietary and Security-Related Version)
6. Proposed Amendment 5, Revision 0 Changes to the NUHOMS® EOS System Updated Final Safety Analysis Report (Public Version)
7. Listing of Computer Files Contained in Enclosure 8
8. Computer Files Associated with Certificate of Compliance 1042 Amendment 5, Revision 0 (Proprietary) (contained on one hard drive)

AFFIDAVIT PURSUANT
TO 10 CFR 2.390

State of Maryland:
County of HOWARD:

I, Prakash Narayanan, depose and say that I am Chief Technical Officer of TN Americas LLC, duly authorized to execute this affidavit, and have reviewed or caused to have reviewed the information that is identified as proprietary and referenced in the paragraph immediately below. I am submitting this affidavit in conformance with the provisions of 10 CFR 2.390 of the Commission's regulations for withholding this information.

The information for which proprietary treatment is sought is listed below:

- Enclosure 5 – Portions of certain updated final safety analysis report (UFSAR) chapters and drawings (Proprietary)
- Enclosure 8 – Certain Computer Files Associated with Certificate of Compliance 1042 Amendment 5

This document has been appropriately designated as proprietary.

I have personal knowledge of the criteria and procedures utilized by TN Americas LLC in designating information as a trade secret, privileged, or as confidential commercial or financial information.

Pursuant to the provisions of paragraph (b) (4) of Section 2.390 of the Commission's regulations, the following is furnished for consideration by the Commission in determining whether the information sought to be withheld from public disclosure, included in the above referenced document, should be withheld.

1) The information sought to be withheld from public disclosure involves portions of certain RAI responses and portions of the UFSAR, and supporting calculations, all related to the design of the NUHOMS® EOS System, which are owned and have been held in confidence by TN Americas LLC, or were provided in confidence to TN Americas LLC and have been held in confidence.

2) The information is of a type customarily held in confidence by TN Americas LLC, and not customarily disclosed to the public. TN Americas LLC has a rational basis for determining the types of information customarily held in confidence by it.

3) Public disclosure of the information is likely to cause substantial harm to the competitive position of TN Americas LLC, because the information consists of descriptions of the design and analysis of dry spent fuel storage systems, the application of which provide a competitive economic advantage. The availability of such information to competitors would enable them to modify their product to better compete with TN Americas LLC, take marketing or other actions to improve their product's position or impair the position of TN Americas LLC's product, and avoid developing similar data and analyses in support of their processes, methods, or apparatus.

I declare that the statements set forth in this affidavit are true and correct to the best of my knowledge, information, and belief. I declare under penalty of perjury that the foregoing is true and correct.

Executed on: February 25th, 2025

A·Prakash

Prakash Narayanan
Chief Technical Officer, TN Americas LLC

DESCRIPTION, JUSTIFICATION, AND EVALUATION OF AMENDMENT 5 CHANGES

1.0 INTRODUCTION

The scope of Amendment 5 to Certificate of Compliance (CoC) No. 1042 includes the changes described below.

Change No. 1:

This scope includes the addition of a new heat load zone configuration (HLZC) for the EOS-37PTH, HLZC 14, which allows an increase in the maximum heat load of the EOS-37PTH to 54 kW per dry shielded canister (DSC) for storage in the EOS-HSM and transfer operations in the EOS-TC125/135. HLZC 14 is only permitted in Basket Type 4HA introduced in Amendment 4 to CoC 1042 with Anodized Aluminum. No physical changes are considered for this basket type in this application. An optional support spacer is considered for the Flat Plate Variant of EOS-HSM as described in the application.

Change No. 2:

The following editorial corrections are included as part of this amendment application:

1. Section 2.4.2.1 of the UFSAR has been revised to clarify that the heat load for any single assembly is 4.3 kW for the EOS-37PTH DSC. This is an editorial correction based on HLZC 12 included as part of application for Amendment 4 to CoC 1042.
2. Note 3 of Figure 2-3m has been revised to enhance readability.
3. Technical Specification Figures 1A and 1J have been revised to clarify the location of HLZC 1 and 10 for EOS-37PTH.

Change No. 3:

This change provides clarification regarding acceptance criteria for minor surface imperfections on High-Strength Low-Alloy (HSLA) basket plates within the UFSAR.

2.0 DESCRIPTION OF THE CHANGES

2.1 Changes to the CoC 1042 NUHOMS® EOS System CoC

The table below provides proposed changes to the CoC pages, a brief description of the subject and/or change, and a reference to the scope item from Section 1.0 that relates to the change or changes.

CoC page	CoC Section Number	Description	Change No.
1	N/A	Amendment number changed to 5 and Amendment effective Date changed to “tbd”.	none
2	N/A	Amendment number changed to 5.	none
2	1.b	Removed the mention of a 50.0 kW heat load, rather than update to 54.0 kW, as this part of the CoC is describing the HSMs, and DSC heat loads are not pertinent to the discussion.	1
3	N/A	Amendment number changed to 5.	none
4	N/A	Amendment number changed to 5 and Amendment effective Date changed to “tbd”.	none

Note: The proposed changes to the CoC are contained in Enclosure 3.

2.2 Changes to the NUHOMS® EOS System CoC 1042 Technical Specifications

The table below provides proposed changes to the TS pages with a brief description of the subject and/or change, and a reference to the scope item from Section 1.0 that relates to the change or changes.

TS page	TS Number	Description	Change No.
Cover Page	N/A	Amendment number changed to 5.	none
TOC/LOT/LOF	N/A	Table of Contents, etc. automated updates.	none
2-3	2.1	In the THERMAL PARAMETERS row, the “Decay Heat per DSC” value was changed from 50.0 kW to 54.0 kW.	1
3-7	3.1.3	Time to Transfer Table Note 1 was revised to change the EOS-37PTH DSC heat load values from 50.0 kW to 54.0 kW in two locations.	1
3-8	3.1.3	Actions Table Note 1 was revised to change the EOS-37PTH DSC heat load values from 50.0 kW to 54.0 kW in two locations.	1
F-1	Figure 1A	HLZC 1 was relocated to the UFSAR based on Amendment 4. A note was added indicating that HLZC 1 is now described in the UFSAR to ensure consistency with prior UFSAR revisions.	2
F-10	Figure 1J	HLZC 10 was relocated to the UFSAR based on Amendment 4. A note was added indicating that HLZC 10 is now described in the UFSAR to ensure consistency with prior UFSAR revisions.	2
F-31	Figure 12	Table Note 1 was revised to change the EOS-37PTH DSC maximum heat load value from 50.0 kW to 54.0 kW.	1

2.3 Changes to the NUHOMS® EOS System CoC 1042 UFSAR

The following paragraphs discuss the changed UFSAR areas, based on the changes described in Section 1 above. Editorial changes to correct spelling, grammar, etc. are also made to the changed UFSAR pages where appropriate.

In support of Change 1, changes were made to UFSAR Chapters 1, 2, 3, 4, 5, 6, 8, 9, 10, 12, 13, and new Chapter 4 Appendix 4.9.10, as well as revisions to Drawings EOS01-1010-SAR and EOS01-3000-SAR.

In support of Change 3, a change was made to UFSAR Chapter 10, Section 10.1.7.

3.0 JUSTIFICATION OF THE NEED FOR THESE CHANGES

Change 1 introduces the addition of an HLZC for the EOS-37PTH, HLZC 14, which allows an increase in the maximum heat load of the EOS-37PTH to 54.0 kW per DSC for storage in the EOS-HSM and transfer operations in the EOS-TC125/135.

Change 3 provides clarification to the existing production acceptance criteria for HSLA material.

4.0 EVALUATION OF CHANGES

TN has evaluated the changes described above for structural, thermal, shielding, confinement and criticality adequacy, as applicable, and has concluded that these changes to the NUHOMS® EOS System have no significant effect on safety.

The evaluations for the changes are included in Enclosure 5 (Proprietary version) and Enclosure 6 (Public version) of this submittal.

Enclosure 3 to E-64033

Proposed Certificate of Compliance No. 1042
Amendment 5, Revision 0 Markup

CERTIFICATE OF COMPLIANCE FOR SPENT FUEL STORAGE CASKS

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

Certificate No.	Effective Date	Expiration Date	Docket No.	Amendment No.	Amendment Effective Date	Package Identification No.
1042	6/7/2017	6/7/2037	72-1042	~~4~~ 5	*TBD*	USA/72-1042

Issued To: (Name/Address)

TN Americas LLC
7160 Riverwood Drive, Suite 200
Columbia, Maryland 21046

Safety Analysis Report Title

TN Americas LLC, "Safety Analysis Report for the NUHOMS® EOS Horizontal Modular Storage System for Irradiated Nuclear Fuel"

CONDITIONS

This certificate is conditioned upon fulfilling the requirements of 10 CFR Part 72, as applicable, the attached Appendix A (Technical Specifications), and the conditions specified below:

1. CASK:

   a. Model Nos. NUHOMS® EOS-37PTH, -89BTH, and 61BTH Type 2 DSCs

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

   b. Description

      The NUHOMS® EOS System is certified as described in the safety analysis report (SAR) and in the NRC's safety evaluation report (SER). The NUHOMS® EOS System is a horizontal canister system composed of a steel dry shielded canister (DSC), a horizontal storage module (HSM), and a transfer cask (TC). The welded DSC provides confinement and criticality control for the storage and transfer of irradiated fuel. The concrete module provides radiation shielding while allowing cooling of the DSC and fuel by natural convection during storage. The TC is used for transferring the DSC from/to the spent fuel pool area to/from the HSM and provides radiation shielding during these operations.

The principal component subassemblies of the DSC are the shell with bottom cover plates and bottom shield plug, or bottom forging assembly, ram/grapple ring, top shield plug, top cover plates, and basket assembly. The shell is a welded stainless or duplex steel sealed container with a length that is fuel-specific. The internal basket assembly for the EOS-37PTH and EOS-89BTH DSCs is composed of interlocking slotted plates to form an egg-crate like structure that forms a grid of fuel compartments to house the fuel assemblies. The grid structure is composed of one or more of the following: a steel plate, an aluminum plate and a neutron absorber plate. Basket transition rails, made of aluminum, provide the interface between the rectangular basket structure and the cylindrical DSC shell. The DSC is designed to hold either 37 PWR or 89 BWR fuel assemblies.

The 61BTH Type 2 DSC consists of the DSC shell assembly (cylindrical shell, canister bottom and top cover plates and shield plug assemblies) and a basket assembly. Top grid assemblies have been provided to accommodate hoist ring designs. The transition rails support the fuel assemblies and transfer mechanical loads to the DSC shell. The DSC is designated to hold up to 61 BWR fuel assemblies.

Different DSC basket configurations are provided for the EOS-37PTH DSC, with poison plates containing a borated metal matrix composite (MMC) at differing B-10 concentrations. The EOS-89BTH DSC has basket configurations that differ in the material used for the poison plates, either borated MMC or Boral®, and the concentration of B-10 used.

The 61BTH Type 2 DSC is designated to use one of three types of poison materials in the basket: Borated Aluminum alloy, Boron Carbide/Aluminum MMC or Boral®.

The basket assembly aids in the insertion of the fuel assemblies, enhances subcriticality during loading operations, and provides structural support during a hypothetical drop accident. The DSC is designed to slide from the transfer cask into the HSM and back.

The HSM is *either* a reinforced concrete *or steel-plate composite* unit ~~and is designed to store DSCs with up to 50.0 kW decay heat~~. The HSM has variable lengths to accommodate the range of DSC lengths. There are multiple versions of the HSM, the NUHOMS® EOS-HSM (EOS-HSM*-RC or EOS-HSM-SC*) and the NUHOMS® MATRIX HSM (HSM-MX). When used without distinction, the term HSM refers to the EOS-HSM*-RC and EOS-HSM-SC* as well as the HSM-MX. Because they are geometrically the same design overall, the term EOS-HSM refers to a single module for storage of a single DSC as a single unit (EOS-HSM) or as a split base unit (EOS-HSMS). Only the fabrication details differ. The HSM-MX is an alternate design with a two-tiered, staggered, high-density module, which contains multiple compartments to accommodate multiple DSCs.

The TC is designed and fabricated as a lifting device to meet NUREG-0612 and ANSI N14.6 requirements. It is used for transfer operations within the spent fuel pool area and for transfer operations to/from the HSM. The TC is a multi-walled cylindrical vessel, comprised of a gamma shield and neutron shield layers with a bottom end closure assembly and a bolted top cover plate. There are multiple versions of the TC. The EOS-TC system consists of the EOS-TC135 cask, the EOS-TC125 cask, and the EOS-TC108 cask. The EOS-TC108 is designed with a removable neutron shield for use at nuclear plant sites with space limitations and/or crane capacity limits. Two upper lifting trunnions are located near the top of the cask for downending/uprighting and lifting of the cask in the spent fuel pool area. The lower trunnions, located near the base of the cask, serve as the axis of rotation during downending/uprighting operations and as supports during transfer to/from the independent spent fuel storage installation (ISFSI).

The OS197 transfer cask is used to transfer the 61BTH Type 2 DSC to the HSM-MX. The OS197 includes the OS197H and OS197FC-B variants as described in the TS. The maximum loaded weight for the OS197 TCs and OS197H TCs is 110 tons and 125 tons, respectively.

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

c. Drawings

The drawings for the NUHOMS® EOS System are contained in Section 1.3, Section A.1.3, and Section B.1.3 of the SAR.

d. Principal Components

The principal components of the NUHOMS® EOS System that are important to safety are the DSC, HSM, and TC. These components are described in Section 2.1, Section A.2.1, and Section B.2.1 of the SAR.

2. OPERATING PROCEDURES

Written operating procedures shall be prepared for handling, loading, movement, surveillance and maintenance. The user's site-specific written operating procedures shall be consistent with the technical basis described in Chapter 9, Chapter A.9, and Chapter B.9 of the SAR.

3. ACCEPTANCE TESTS AND MAINTENANCE PROGRAM

Written cask acceptance tests and maintenance program shall be prepared consistent with the technical basis described in Chapter 10, Chapter A.10, and Chapter B.10 of the SAR.

4. QUALITY ASSURANCE

Activities in the areas of design, purchase, fabrication, assembly, inspection, testing, operation, maintenance, repair, modification of structures, systems and components, and decommissioning shall be conducted in accordance with a quality assurance program that satisfies the applicable requirements of 10 CFR Part 72, Subpart G, and that is established, maintained, and executed with regard to the cask system.

5. HEAVY LOADS REQUIREMENTS

Each lift of a DSC and TC must be made in accordance with the existing heavy loads requirements and procedures of the licensed facility at which the lift is made. A plant-specific safety review (under 10 CFR 50.59 or 10 CFR 72.48, if applicable) is required to show operational compliance with NUREG-0612 and or existing plant-specific heavy loads requirements.

If a single failure proof crane is not used, the licensee must evaluate the accidental drop of the shielding components of the TC under 10 CFR 50.59, 10 CFR 72.48, and 10 CFR 72.212, and evaluate the consequences of the accident drops.

6. APPROVED CONTENTS

Contents of the NUHOMS® EOS System must meet the fuel specifications in Appendix A (Technical Specifications).

7. DESIGN FEATURES

Features or characteristics for the site, or cask system must be in accordance with Appendix A (Technical Specifications).

8. CHANGES TO THE CERTIFICATE OF COMPLIANCE

The holder of this certificate who desires to change the certificate or technical specifications shall submit an application for amendment of the certificate or technical specifications.

9. PRE-OPERATIONAL TESTING AND TRAINING EXERCISE

A dry run training exercise of the loading, closure, handling, unloading and transfer of the NUHOMS® EOS System shall be conducted by each licensee prior to the first use of the system to load spent nuclear fuel assemblies. The training exercise shall not be conducted with spent nuclear fuel in the canister. The dry run may be performed in an alternate step sequence from the actual procedural guidelines in Chapter 9, Chapter A.9, and Chapter B.9 of the SAR. The dry run shall include, but need not be limited to the following:

Loading Operations

a. Fuel loading
b. DSC sealing, drying and backfilling operations
c. TC downending and transfer to the ISFSI
d. DSC transfer to the HSM

Unloading Operations
e. DSC retrieval from the HSM
f. Opening of the DSC
g. Flooding of the DSC

Any of the above steps can be omitted if the site has already successfully loaded a NUHOMS® EOS System or another NUHOMS® system.

10. The applicant shall provide the phased array automated ultrasonic testing (PA-AUT) procedure for conducting nondestructive examination of the outer top cover plate-to-dry shielded canister shell weld and the supporting qualification report for the PA-AUT procedure upon American Society for Nondestructive Testing (ASNT) Level III approval to the NRC no less than 60 days prior to use.

11. AUTHORIZATION

The NUHOMS® EOS System, which is authorized by this certificate, is hereby approved for general use by holders of 10 CFR Part 50 licenses for nuclear reactors at reactor sites under the general license issued pursuant to 10 CFR 72.210, subject to the conditions specified by 10 CFR 72.212, this certificate, and the attached Appendix A.

FOR THE NUCLEAR REGULATORY COMMISSION

Yoira Diaz Sanabria, Chief
Storage and Transportation Licensing Branch
Division of Fuel Management
Office of Nuclear Material Safety
and Safeguards

Attachment: Appendix A. Technical Specifications
Dated: *TBD*

Enclosure 4 to E-64033

Proposed Technical Specifications, CoC 1042
Amendment 5, Revision 0

Revision 0 to Amendment 5 Proposed Technical Specifications

CoC 1042

APPENDIX A

NUHOMS® EOS SYSTEM GENERIC TECHNICAL SPECIFICATIONS

Amendment 5

List of Tables

List of Figures

1.0 USE AND APPLICATION

1.1 Definitions

-- NOTE --

The defined terms of this section appear in capitalized type and are applicable throughout these Technical Specifications and Bases.

Term	Definition
ACTIONS	ACTIONS shall be that part of a Specification that prescribes Required Actions to be taken under designated Conditions within specified Completion Times.
BLEU FUEL	Blended Low Enriched Uranium (BLEU) FUEL material is generated by down-blending high enriched uranium (HEU). Because the feedstock contains both unirradiated and irradiated HEU, fresh BLEU fuel has elevated concentrations of U-232, U-234, and U-236.
CONTROL COMPONENTS (CCs)	Authorized CCs include Burnable Poison Rod Assemblies (BPRAs), Thimble Plug Assemblies (TPAs), Control Rod Assemblies (CRAs), Control Element Assemblies (CEAs), Control Spiders, Rod Cluster Control Assemblies (RCCAs), Axial Power Shaping Rod Assemblies (APSRAs), Orifice Rod Assemblies (ORAs), Peripheral Power Suppression Assemblies (PPSAs), Vibration Suppression Inserts (VSIs), Flux Suppression Inserts (FSIs), Burnable Absorber Assemblies (BAAs), Neutron Source Assemblies (NSAs) and Neutron Sources. CCs not explicitly listed are also authorized as long as external materials are limited to zirconium alloys, nickel alloys, and stainless steels. Non-fuel hardware that are positioned within the fuel assembly after the fuel assembly is discharged from the core such as Guide Tubes or Instrument Tube Tie Rods or Anchors, Guide Tube Inserts, BPRA Spacer Plates or devices that are positioned and operated within the fuel assembly during reactor operation such as those listed above are also considered to be authorized CCs.

(continued)

1.1 Definitions (continued)

DAMAGED FUEL	DAMAGED FUEL assemblies are fuel assemblies containing fuel rods with known or suspected cladding defects greater than hairline cracks or pinhole leaks. The extent of damage in the fuel assembly, including non-cladding damage, is to be limited so that a fuel assembly maintains its configuration for normal and off-normal conditions. The extent of cladding damage is also limited so that no release of pellet material is observed during inspection and handling operations in the pool prior to loading operations. DAMAGED FUEL assemblies shall also contain top and bottom end fittings. DAMAGED FUEL assemblies may also contain missing or partial fuel rods.
DRY SHIELDED CANISTER (DSC)	An EOS-37PTH DSC, EOS-89BTH DSC, and 61BTH Type 2 DSC are sealed containers that provide confinement of fuel in an inert atmosphere.
FAILED FUEL	FAILED FUEL is defined as ruptured fuel rods, severed fuel rods, loose fuel pellets, fuel fragments, or fuel assemblies that may not maintain configuration for normal or off-normal conditions. FAILED FUEL may contain breached rods, grossly breached rods, or other defects such as missing or partial rods, missing grid spacers, or damaged spacers to the extent that the assembly may not maintain configuration for normal or off-normal conditions. FAILED FUEL shall be stored in a failed fuel canister (FFC).
FUEL BUILDING	The FUEL BUILDING is the site-specific area or facility where the LOADING OPERATIONS take place.
FUEL CLASS	A FUEL CLASS includes fuel assemblies of the same array size for a particular type of fuel design. For example, WEV 17x17, WEO 17x17, and ANP Advanced MK BW 17x17 fuel assemblies are part of a WE 17x17 FUEL CLASS.

(continued)

1.1 Definitions (continued)

HORIZONTAL STORAGE MODULE (HSM)	An HSM is either a reinforced concrete structure (RC) or a steel-plate composite (SC) for storage of a loaded DSC at a spent fuel storage installation. Where the term “HSM” is used without distinction, this term shall apply to both the EOS-HSM and HSM-MX. The term EOS-HSM refers to the base unit for storage of a single DSC as a single piece (EOS-HSM) or as a split base (EOS-HSMS). When used without distinction, the term EOS-HSM shall refer to both the reinforced concrete and the steel-plate composite variants of the HSM. The term MATRIX (HSM-MX) refers to the two-tiered staggered structure for storage of the DSCs.
INDEPENDENT SPENT FUEL STORAGE INSTALLATION (ISFSI)	The facility within a perimeter fence licensed for storage of spent fuel within HSMs.
INTACT FUEL	Fuel assembly with no known or suspected cladding defects in excess of pinhole leaks or hairline cracks, and with no missing rods.
LOADING OPERATIONS	LOADING OPERATIONS include all licensed activities on a DSC in a TC while it is being loaded with fuel assemblies. LOADING OPERATIONS begin when the first fuel assembly is placed in the DSC and end when the TC is ready for TRANSFER OPERATIONS (i.e., when the cask is in a horizontal position on the transfer trailer.) LOADING OPERATIONS do not include DSC transfer between the TC and the HSM.
LOW-ENRICHED OUTLIER FUEL (LEOF)	LOW-ENRICHED OUTLIER FUEL is PWR and BWR fuel with enrichments below the minimum enrichment specified in Table 7A and Table 18, respectively.
RECONSTITUTED FUEL ASSEMBLY	A RECONSTITUTED FUEL ASSEMBLY is a fuel assembly where one or more fuel rods are replaced by low enriched uranium or natural uranium fuel rods or non-fuel rods.

(continued)

1.1 Definitions (continued)

STORAGE OPERATIONS	STORAGE OPERATIONS include all licensed activities that are performed at the ISFSI, while a DSC containing fuel assemblies is located in an HSM on the storage pad within the ISFSI perimeter. STORAGE OPERATIONS do not include DSC transfer between the TC and the HSM.
TRANSFER CASK (TC)	A TRANSFER CASK (TC) (EOS-TC108, EOS-TC125, EOS-TC135, and OS197/OS197H/OS197FC-B/OS197HFC-B) consists of a licensed NUHOMS® System TC. When used without distinction, the term EOS-TC includes the EOS-TC108, EOS-TC125, and EOS-TC135. The term OS197 includes the OS197/OS197H/OS197FC-B/OS197HFC-B. The TC is placed on a transfer trailer for movement of a DSC to the HSM.
TRANSFER OPERATIONS	TRANSFER OPERATIONS include all licensed activities involving the movement of a TC loaded with a DSC containing fuel assemblies. TRANSFER OPERATIONS begin after the TC has been placed horizontal on the transfer trailer ready for TRANSFER OPERATIONS and end when the DSC is at its destination and/or no longer horizontal on the transfer trailer. TRANSFER OPERATIONS include DSC transfer between the TC and the HSM.
UNLOADING OPERATIONS	UNLOADING OPERATIONS include all licensed activities on a DSC to unload fuel assemblies. UNLOADING OPERATIONS begin when the DSC is no longer horizontal on the transfer trailer and end when the last fuel assembly has been removed from the DSC. UNLOADING OPERATIONS do not include DSC transfer between the HSM and the TC.

1.0 USE AND APPLICATION

1.2 Logical Connectors

PURPOSE

The purpose of this section is to explain the meaning of logical connectors.

Logical connectors are used in Technical Specifications (TS) to discriminate between, and yet connect, discrete Conditions, Required Actions, Completion Times, Surveillances, and Frequencies. The only logical connectors that appear in TS are AND and OR. The physical arrangement of these connectors constitutes logical conventions with specific meanings.

BACKGROUND

Several levels of logic may be used to state Required Actions. These levels are identified by the placement (or nesting) of the logical connectors and by the number assigned to each Required Action. The first level of logic is identified by the first digit of the number assigned to a Required Action and the placement of the logical connector in the first level of nesting (i.e., left justified with the number of the Required Action). The successive levels of logic are identified by additional digits of the Required Action number and by successive indentions of the logical connectors.

When logical connectors are used to state a Condition, Completion Time, Surveillance, or Frequency, only the first level of logic is used, and the logical connector is left justified with the statement of the Condition, Completion Time, Surveillance, or Frequency.

EXAMPLES

The following examples illustrate the use of logical connectors:

EXAMPLE 1.2-1

ACTIONS:

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. LCO (Limiting Condition for Operation) not met.	A.1 Verify… AND A.2 Restore…	

In this example the logical connector AND is used to indicate that when in Condition A, both Required Actions A.1 and A.2 must be completed.

(continued)

1.2 Logical Connectors (continued)

EXAMPLES (continued)

EXAMPLE 1.2-2

ACTIONS:

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. LCO not met.	A.1 Stop… OR A.2 A.2.1 Verify… AND A.2.2 A.2.2.1 Reduce… OR A.2.2.2 Perform… OR A.3 Remove…	

This example represents a more complicated use of logical connectors. Required Actions A.1, A.2, and A.3 are alternative choices, only one of which must be performed as indicated by the use of the logical connector OR and the left justified placement. Any one of these three Actions may be chosen. If A.2 is chosen, then both A.2.1 and A.2.2 must be performed as indicated by the logical connector AND. Required Action A.2.2 is met by performing A.2.2.1 or A.2.2.2. The indented position of the logical connector OR indicates that A.2.2.1 and A.2.2.2 are alternative choices, only one of which must be performed.

1.0 USE AND APPLICATION

1.3 Completion Times

PURPOSE

The purpose of this section is to establish the Completion Time convention and to provide guidance for its use.

BACKGROUND

Limiting Conditions for Operation (LCOs) specify the lowest functional capability or performance levels of equipment required for safe operation of the facility. The ACTIONS associated with an LCO state Conditions that typically describe the ways in which the requirements of the LCO are not met. Specified with each stated Condition are Required Action(s) and Completion Times(s).

DESCRIPTION

The Completion Time is the amount of time allowed for completing a Required Action. It is referenced to the time of discovery of a situation (e.g., equipment or variable not within limits) that requires entering an ACTIONS Condition unless otherwise specified, providing the facility is in a specified condition stated in the Applicability of the LCO. Required Actions must be completed prior to the expiration of the specified Completion Time. An ACTIONS Condition remains in effect and the Required Actions apply until the Condition no longer exists or the facility is not within the LCO Applicability.

Once a Condition has been entered, subsequent subsystems, components, or variables expressed in the Condition, discovered to be not within limits, will <u>not</u> result in separate entry into the Condition unless specifically stated. The Required Actions of the Condition continue to apply to each additional failure, with Completion Times based on initial entry into the Condition.

EXAMPLES

The following examples illustrate the use of Completion Times with different types of Conditions and Changing Conditions.

<u>EXAMPLE 1.3-1</u>

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
B. Required Action and associated Completion Time not met.	B.1 Perform Action B.1 <u>AND</u> B.2 Perform Action B.2	12 hours 36 hours

(continued)

1.3 Completion Times (continued)

EXAMPLES (continued)

Condition B has two Required Actions. Each Required Action has its own separate Completion Time. Each Completion Time is referenced to the time that Condition B is entered.

The Required Actions of Condition B are to complete action B.1 within 12 hours AND complete action B.2 within 36 hours. A total of 12 hours is allowed for completing action B.1 and a total of 36 hours (not 48 hours) is allowed for completing action B.2 from the time that Condition B was entered. If action B.1 is completed within 6 hours, the time allowed for completing action B.2 is the next 30 hours because the total time allowed for completing action B.2 is 36 hours.

EXAMPLES

EXAMPLE 1.3-2

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. One system not within limit.	A.1 Restore system to within limit.	7 days
B. Required Action and associated Completion Time not met.	B.1 Perform Action B.1.	12 hours
	AND	
	B.2 Perform Action B.2.	36 hours

When a system is determined to not meet the LCO, Condition A is entered. If the system is not restored within 7 days, Condition B is also entered and the Completion Time clocks for Required Actions B.1 and B.2 start. If the system is restored after Condition B is entered, Condition A and B are exited, and therefore, the Required Actions of Condition B may be terminated.

(continued)

1.3 Completion Times (continued)

EXAMPLES (continued)

EXAMPLE 1.3-3

ACTIONS

---NOTE--
Separate Condition entry is allowed for each component.

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. LCO not met.	A.1 Restore compliance with LCO.	4 hours
B. Required Action and associated Completion Time not met.	B.1 Perform Action B.1. AND B.2 Perform Action B.2.	6 hours 12 hours

The Note above the ACTIONS Table is a method of modifying how the Completion Time is tracked. If this method of modifying how the Completion Time is tracked was applicable only to a specific Condition, the Note would appear in that Condition rather than at the top of the ACTIONS Table.

The Note allows Condition A to be entered separately for each component, and Completion Times tracked on a per component basis. When a component is determined to not meet the LCO, Condition A is entered and its Completion Time starts. If subsequent components are determined to not meet the LCO, Condition A is entered for each component and separate Completion Times start and are tracked for each component.

IMMEDIATE COMPLETION TIME

When “Immediately” is used as a Completion Time, the Required Action should be pursued without delay and in a controlled manner.

1.0 USE AND APPLICATION

1.4 Frequency

PURPOSE	The purpose of this section is to define the proper use and application of Frequency requirements
DESCRIPTION	Each Surveillance Requirement (SR) has a specified Frequency in which the Surveillance must be met in order to meet the associated Limiting Condition for Operation (LCO). An understanding of the correct application of the specified Frequency is necessary for compliance with the SR. The "specified Frequency" is referred to throughout this section and each of the Specifications of Section 3.0, Limiting Condition for Operation (LCO) and Surveillance Requirement (SR) Applicability. The "specified Frequency" consists of the requirements of the Frequency column of each SR, as well as certain Notes in the Surveillance column that modify performance requirements. Situations where a Surveillance could be required (i.e., its Frequency could expire), but where it is not possible or not desired that it be performed until sometime after the associated LCO is within its Applicability, represent potential SR 3.0.4 conflicts. To avoid these conflicts, the SR (i.e., the Surveillance or the Frequency) is stated such that it is only "required" when it can be and should be performed. With a SR satisfied, SR 3.0.4 imposes no restriction.

(continued)

1.4 Frequency (continued)

EXAMPLES

The following examples illustrate the various ways that Frequencies are specified:

EXAMPLE 1.4-1

SURVEILLANCE REQUIREMENTS

SURVEILLANCE	FREQUENCY
Verify pressure within limit.	12 hours

Example 1.4-1 contains the type of SR most often encountered in the Technical Specifications (TS). The Frequency specifies an interval (12 hours) during which the associated Surveillance must be performed at least one time. Performance of the Surveillance initiates the subsequent interval. Although the Frequency is stated as 12 hours, an extension of the time interval to 1.25 times the stated Frequency is allowed by SR 3.0.2 for operational flexibility. The measurement of this interval continues at all times, even when the SR is not required to be met per SR 3.0.1 (such as when the equipment is determined to not meet the LCO, a variable is outside specified limits, or the unit is outside the Applicability of the LCO). If the interval specified by SR 3.0.2 is exceeded while the facility is in a condition specified in the Applicability of the LCO, the LCO is not met in accordance with SR 3.0.1.

If the interval as specified by SR 3.0.2 is exceeded while the facility is not in a condition specified in the Applicability of the LCO for which performance of the SR is required, the Surveillance must be performed within the Frequency requirements of SR 3.0.2 prior to entry into the specified condition. Failure to do so would result in a violation of SR 3.0.4.

(continued)

1.4 Frequency (continued)

EXAMPLES (continued)

EXAMPLE 1.4-2

SURVEILLANCE REQUIREMENTS

SURVEILLANCE	FREQUENCY
Verify flow is within limits.	Once within 12 hours prior to starting activity AND 24 hours thereafter

Example 1.4-2 has two Frequencies. The first is a one-time performance Frequency, and the second is of the type shown in Example 1.4-1. The logical connector "AND" indicates that both Frequency requirements must be met. Each time the example activity is to be performed, the Surveillance must be performed prior to starting the activity.

The use of "once" indicates a single performance will satisfy the specified Frequency (assuming no other Frequencies are connected by "AND"). This type of Frequency does not qualify for the 25% extension allowed by SR 3.0.2.

"Thereafter" indicates future performances must be established per SR 3.0.2, but only after a specified condition is first met (i.e., the "once" performance in this example). If the specified activity is canceled or not performed, the measurement of both intervals stops. New intervals start upon preparing to restart the specified activity.

(continued)

1.4 Frequency (continued)

EXAMPLES (continued)

EXAMPLE 1.4-3

SURVEILLANCE REQUIREMENTS

SURVEILLANCE	FREQUENCY
------------------- NOTE--------------------- Not required to be met until 96 hours after verifying the helium leak rate is within limit. ---	
Verify EOS DSC vacuum drying pressure is within limit.	Once after verifying the helium leak rate is within limit.

As the Note modifies the required performance of the Surveillance, it is construed to be part of the "specified Frequency." Should the vacuum drying pressure not be met immediately following verification of the helium leak rate while in LOADING OPERATIONS, this Note allows 96 hours to perform the Surveillance. The Surveillance is still considered to be performed within the "specified Frequency."

Once the helium leak rate has been verified to be acceptable, 96 hours, plus the extension allowed by SR 3.0.2, would be allowed for completing the Surveillance for the vacuum drying pressure. If the Surveillance was not performed within this 96 hour interval, there would then be a failure to perform the Surveillance within the specified Frequency, and the provisions of SR 3.0.3 would apply.

2.0 FUNCTIONAL AND OPERATING LIMITS

2.1 Fuel to be Stored in the EOS-37PTH DSC

<u>PHYSICAL PARAMETERS:</u>	
FUEL CLASS	Unconsolidated B&W 15x15, WE 14x14, WE 15x15, WE 17x17, CE 14x14, CE 15x15 and CE 16x16 FUEL CLASS PWR fuel assemblies (with or without CCs) that are enveloped by the fuel assembly design characteristics listed in Table 1.
Number of FUEL ASSEMBLIES with CCs	≤ 37
Maximum Fuel Assembly plus CC Weight	1900 lbs
<u>DAMAGED FUEL ASSEMBLIES:</u>	
Number and Location of DAMAGED FUEL Assemblies	Maximum of 8 DAMAGED FUEL Assemblies. Balance may be INTACT FUEL, empty cells, or dummy assemblies. Number and Location of DAMAGED FUEL assemblies are shown in Figures 1F, 1H, and 1K, and 13. The DSC basket cells which store DAMAGED FUEL assemblies are provided with top and bottom end caps.
<u>FAILED FUEL:</u>	
Number and Location of FAILED FUEL	Maximum of 4 FAILED FUEL locations. Balance may be INTACT FUEL assemblies, empty cells, or dummy assemblies. Number and Location of FAILED FUEL assemblies are shown in Figures 1F, 1H, and 1K, and 13. FAILED FUEL shall be stored in a failed fuel canister (FFC).
Maximum Uranium Loadings per FFC for FAILED FUEL	Per Table 2
<u>RECONSTITUTED FUEL ASSEMBLIES:</u>	
• Limits for transfer in the EOS-TC125/135 <u>AND</u> storage in the EOS-HSM	Per Table 24
• Limits for transfer in the EOS-TC125/135 <u>AND</u> storage in the HSM-MX	≤ 37 RECONSTITUTED FUEL ASSEMBLIES per DSC with a minimum cooling time of 2 years
• Limits for transfer in the EOS-TC108	Per Table 25

(continued)

2.1 Fuel to be Stored in the EOS-37PTH DSC (continued)

BLENDED LOW ENRICHED URANIUM (BLEU) FUEL Assemblies: • Number of BLEU FUEL Assemblies per DSC	 ≤ 37
THERMAL PARAMETERS: Maximum Heat Load Configuration (MHLC) and Decay Heat Calculations	Per Figures 1B, 1C, 1D, 1E AND 1F for transfer in the EOS-TC108 and storage in EOS-HSM. Per Figures 1G, 1H AND 1I for transfer in the EOS-TC108 /TC125/TC135 and storage in HSM-MX. Per Figure 1K for transfer in the EOS-TC108 and storage in HSM-MX. Per Figure 12, which specifies maximum allowable heat loads in a six-zone configuration, for transfer in the EOS-TC125/TC135 and storage in the EOS-HSM. Heat load zoning configurations (HLZCs) enveloped by the MHLC in Figure 12 are allowed for transfer in the EOS-TC125/TC135 and storage in the EOS-HSM. Chapter 2, Section 2.4.3.2 of the UFSAR provides the specific HLZCs. The maximum allowable heat loads may be reduced based on the thermal analysis methodology in the UFSAR to accommodate site-specific conditions. However, the maximum decay heat for each FA shall not exceed the values specified in the aforementioned figures. The licensee is responsible for ensuring that uncertainties in fuel enrichment and burnup are correctly accounted for in the decay heat calculations.

(continued)

2.1 Fuel to be Stored in the EOS-37PTH DSC (continued)

THERMAL PARAMETERS (continued)	For FAs with active fuel length shorter than 144 inches, reduce the maximum heat load per FA in each loading zone of the HLZCs using a scaling factor (SF) as shown below. $$q_{Short\ FA} = q_{Bounding\ FA} \cdot SF,$$ $$SF = \frac{L_{a,Short\ FA}}{L_{a,Bounding\ FA}} \cdot \frac{k_{eff,Short\ FA}}{k_{eff,Bounding\ FA}}.$$ Where, k_{eff}= Effective conductivity for FA, q = Decay heat load per assembly defined for each loading zone, L_a= Active fuel length, SF= Scaling factor (SF) for short FAs. The effective conductivity for the shorter FA should be determined using the same methodology documented in the UFSAR. For FAs with active fuel length greater than 144 inches, no scaling is required and the maximum heat loads listed for each HLZC are applicable.
Decay Heat per DSC	≤ *54.0* kW and as specified for the applicable heat load zone configuration

(continued)

All Indicated Changes are Enclosure 2, Item 1.

2.1 Fuel to be Stored in the EOS-37PTH DSC (continued)

RADIOLOGICAL PARAMETERS:	
Maximum Assembly Average Burnup	62 GWd/MTU
Minimum Cooling Time	For all fuel to be stored in the HSM-MX, minimum cooling time as a function of burnup and enrichment per Table 7B. For all fuel to be stored in the EOS-HSM, minimum cooling time as a function of burnup and enrichment per Table 7C. 1 year for the EOS-TC125/135 2 years for the EOS-TC108
Minimum Assembly Average Initial Fuel Enrichment	As specified in Table 7A as a function of assembly average burnup.
Maximum Planar Average Initial Fuel Enrichment	As specified in Table 4 as a function of minimum soluble boron concentration
Minimum B-10 Concentration in Poison Plates	As specified in Table 5
Number and location of LOW-ENRICHED OUTLIER FUEL (LEOF)	≤ 4 LEOF in the peripheral locations. A minimum of three non-LEOFs shall circumferentially separate LEOFs within the peripheral locations. No limitation for LEOF in the inner locations. The peripheral and inner locations are defined in Figure 3.
CONTROL COMPONENTS (CCs)	
Maximum Co-60 equivalent activity for the CCs.	As specified in Table 3

2.0 FUNCTIONAL AND OPERATING LIMITS

2.2 Fuel to be Stored in the EOS-89BTH DSC

PHYSICAL PARAMETERS: FUEL CLASS	INTACT unconsolidated 7x7, 8x8, 9x9, 10x10, and 11x11 FUEL CLASS BWR assemblies (with or without channels) that are enveloped by the fuel assembly design characteristics listed in Table 6.
NUMBER OF INTACT FUEL ASSEMBLIES Channel Hardware Maximum Uranium Loading Maximum Fuel Assembly Weight with a Channel	≤ 89 Channeled fuel may be stored with or without associated channel hardware. 198 kg/assembly 705 lb
RECONSTITUTED FUEL ASSEMBLIES: • Limits for transfer in the EOS-TC125 • Limits for transfer in the EOS-TC108	 Per Table 22 Per Table 23
BLENDED LOW ENRICHED URANIUM (BLEU) FUEL ASSEMBLIES: • Number of BLEU FUEL Assemblies per DSC	 ≤ 89

(continued)

2.2 Fuel to be Stored in the EOS-89BTH DSC (continued)

<u>THERMAL PARAMETERS:</u>	
Maximum Heat Load Configuration (MHLC) and Decay Heat Calculations	Per Figure 2 for transfer in the EOS-TC108. Per Figure 11, which specifies maximum allowable heat loads in a six-zone configuration, for transfer in the EOS-TC125. Heat load zoning configurations (HLZCs) enveloped by the MHLC in Figure 11 are allowed for transfer in the EOS-TC125 and storage in the EOS-HSM or HSM-MX. Chapter 2, Section 2.4.3.2 of the UFSAR provides the specific HLZCs. The maximum allowable heat loads may be reduced based on the thermal analysis methodology in the UFSAR. However, the maximum decay heat for each FA shall not exceed the values specified in Figure 11. The licensee is responsible for ensuring that uncertainties in fuel enrichment and burnup are correctly accounted for in the decay heat calculations. For FAs with active fuel length shorter than 144 inches, reduce the maximum decay heat for each FA in each loading zone of the HLZCs using a scaling factor (SF) as shown below. $q_{Short\ FA} = q_{Bounding\ FA} \cdot SF,$ $SF = \frac{L_{a,Short\ FA}}{L_{a,Bounding\ FA}} \cdot \frac{k_{eff,Short\ FA}}{k_{eff,Bounding\ FA}}.$ Where, k_{eff} = Effective conductivity for FA, q = Decay heat load per assembly defined for each loading zone, L_a = Active fuel length, SF = Scaling factor for short FAs. The effective conductivity for the shorter FA should be determined using the same methodology documented in the UFSAR. For FAs with active fuel length greater than 144 inches, no scaling is required and the maximum heat loads listed for each HLZC are applicable.
Decay Heat per DSC	≤ 48.2 kW for EOS-TC125 ≤ 41.6 kW for EOS-TC108

(continued)

2.2 Fuel to be Stored in the EOS-89BTH DSC continued)

<u>RADIOLOGICAL PARAMETERS:</u>	
Maximum Assembly Average Burnup	62 GWd/MTU
Minimum Cooling Time	As specified as a function of burnup and enrichment per Table 21. 1.0 year for EOS-TC125 3.0 years for EOS-TC108; See Figure 2 for additional cooling times for HLZC 2 and 3 transferred in the EOS-TC108.
Maximum Lattice Average Initial Fuel Enrichment	Per Table 8
Minimum B-10 Concentration in Poison Plates	Per Table 8
Minimum Assembly Average Initial Fuel Enrichment	As specified in Table 18 as a function of assembly average burnup.
Number and location of LOW-ENRICHED OUTLIER FUEL (LEOF)	≤ 4 LEOF in the peripheral locations. A minimum of six non-LEOFs shall circumferentially separate LEOFs within the peripheral locations. No limitation for LEOF in the inner locations. The peripheral and inner locations are defined in Figure 8.

2.0 FUNCTIONAL AND OPERATING LIMITS

2.3 Fuel to be stored in the 61BTH Type 2 DSC

PHYSICAL PARAMETERS:	
FUEL CLASS	INTACT or DAMAGED or FAILED 7x7, 8x8, 9x9, 10x10 or 11x11 BWR assemblies (with or without channels) that are enveloped by the fuel assembly design characteristics listed in Table 13
Number of INTACT FUEL ASSEMBLIES	≤ 61
Channel Hardware	Chaneled fuel may be stored with or without associated channel hardware.
Maximum Uranium Loading	198 kg/ assembly
Maximum Fuel Assembly Weight with a Channel	705 lbs
DAMAGED FUEL ASSEMBLIES:	
Number and Location of DAMAGED FUEL Assemblies	Maximum of 61 DAMAGED FUEL assemblies as shown in Figure 5. Balance may be INTACT FUEL, empty cells, or dummy assemblies. The DSC basket cells which store DAMAGED FUEL assemblies are provided with top and bottom end caps.
FAILED FUEL:	
Number and Location of FAILED FUEL	Maximum of 4 FAILED FUEL locations as shown in Figure 5 Balance may be INTACT FUEL assemblies, empty cells, or dummy assemblies. FAILED FUEL shall be stored in a failed fuel canister (FFC)
Maximum Uranium Loadings per FFC for FAILED FUEL	Table 14
RECONSTITUTED FUEL ASSEMBLIES:	
• Number of RECONSTITUTED FUEL ASSEMBLIES per DSC	≤ 61
• Maximum number of irradiated stainless steel rods per DSC	120

(continued)

• Maximum number of irradiated stainless steel rods per RECONSTITUTED FUEL ASSEMBLY	10
• Loading restrictions for locations within the basket	Inner and peripheral loading locations are defined in Figure 6. Inner Loading Locations: • RECONSTITUTED FUEL ASSEMBLIES may be loaded in any compartment within the inner locations. Peripheral Loading Locations: • RECONSTITUTED FUEL ASSEMBLIES with ≤ 5 irradiated stainless steel rods per fuel assembly may be loaded into all peripheral locations (i.e., not restricted). • RECONSTITUTED FUEL ASSEMBLIES with > 5 and ≤ 10 irradiated stainless steel rods per fuel assembly shall have at least one fuel assembly that does not contain irradiated stainless steel rods on each peripherally adjacent location (see Figure 7).
<u>BLENDED LOW ENRICHED URANIUM (BLEU) FUEL Assemblies:</u> • Number of BLEU FUEL Assemblies per DSC	 ≤ 61
THERMAL/RADIOLOGICAL PARAMETERS: Heat Load Zone Configuration and Fuel Qualification Maximum Assembly Average Burnup Minimum Cooling Time	 Limitations on decay heats are presented in the respective HLZC tables in Figures 4A through 4J. 62 GWd/MTU For all fuel, minimum cooling time as a function of burnup and enrichment per Table 19. For the peripheral fuel of HLZC 2, 4, 5, 6, 7, and 8 only, minimum cooling time as a function of burnup and enrichment per Table 20. The peripheral and inner locations are defined in Figure 6.

(continued)

Minimum Assembly Average Initial Fuel Enrichment	As specified in Table 18 as a function of assembly average burnup.
Decay Heat per DSC	≤ 31.2 kW
Maximum Lattice Average Initial Enrichment	Per Table 9, Table 10, Table 11 or Table 12
Minimum B-10 Concentration in Poison Plates	Per Table 9, Table 10, Table 11 or Table 12
Number and location of LOW-ENRICHED OUTLIER FUEL (LEOF)	≤ 4 LEOF in the peripheral locations. A minimum of five non-LEOFs shall circumferentially separate LEOFs within the peripheral locations. No limitation for LEOF in the inner locations. The peripheral and inner locations are defined in Figure 6.

2.0 FUNCTIONAL OPERATING LIMITS

2.4 Functional and Operating Limits Violations

If any Functional and Operating Limit of 2.1 or 2.2 or 2.3 is violated, the following ACTIONS shall be completed:

2.4.1 The affected fuel assemblies shall be placed in a safe condition.

2.4.2 Within 24 hours, notify the NRC Operations Center.

2.4.3 Within 60 days, submit a special report which describes the cause of the violation and the ACTIONS taken to restore compliance and prevent recurrence.

3.0 LIMITING CONDITION FOR OPERATION (LCO) AND SURVEILLANCE REQUIREMENT (SR) APPLICABILITY

LIMITING CONDITION FOR OPERATION

LCO 3.0.1	LCOs shall be met during specified conditions in the Applicability, except as provided in LCO 3.0.2.
LCO 3.0.2	Upon discovery of a failure to meet an LCO, the Required Actions of the associated Conditions shall be met, except as provided in LCO 3.0.5. If the LCO is met or is no longer applicable prior to expiration of the specified Completion Time(s), completion of the Required Action(s) is not required, unless otherwise stated.
LCO 3.0.3	Not applicable to a spent fuel storage cask.
LCO 3.0.4	When an LCO is not met, entry into a specified condition in the Applicability shall not be made except when the associated ACTIONS to be entered permit continued operation in the specified condition in the Applicability for an unlimited period of time. This Specification shall not prevent changes in specified conditions in the Applicability that are required to comply with ACTIONS, or that are related to the unloading of a DSC. Exceptions to this Specification are stated in the individual Specifications. These exceptions allow entry into specified conditions in the Applicability when the associated ACTIONS to be entered allow operation in the specified condition in the Applicability only for a limited period of time.
LCO 3.0.5	Equipment removed from service or not in service in compliance with ACTIONS may be returned to service under administrative control solely to perform testing required to demonstrate it meets the LCO or that other equipment meets the LCO. This is an exception to LCO 3.0.2 for the system returned to service under administrative control to perform the testing required to demonstrate that the LCO is met.
LCO 3.0.6	Not applicable to a spent fuel storage cask.
LCO 3.0.7	Not applicable to a spent fuel storage cask.

(continued)

SURVEILLANCE REQUIREMENTS

SR 3.0.1	SRs shall be met during the specified conditions in the Applicability for individual LCOs, unless otherwise stated in the SR. Failure to meet a Surveillance, whether such failure is experienced during the performance of the Surveillance or between performances of the Surveillance, shall be failure to meet the LCO. Failure to perform a Surveillance within the specified Frequency shall be failure to meet the LCO except as provided in SR 3.0.3. Surveillances do not have to be performed on equipment or variables outside specified limits.
SR 3.0.2	The specified Frequency for each SR is met if the Surveillance is performed within 1.25 times the interval specified in the Frequency, as measured from the previous performance or as measured from the time a specified condition of the Frequency is met. For Frequencies specified as “once,” the above interval extension does not apply. If a Completion Time requires periodic performance on a “once per . . .” basis, the above Frequency extension applies to each performance after the initial performance. Exceptions to this Specification are stated in the individual Specifications.
SR 3.0.3	If it is discovered that a Surveillance was not performed within its specified Frequency, then compliance with the requirement to declare the LCO not met may be delayed, from the time of discovery, up to 24 hours or up to the limit of the specified Frequency, whichever is less. This delay period is permitted to allow performance of the Surveillance. If the Surveillance is not performed within the delay period, the LCO must immediately be declared not met, and the applicable Condition(s) must be entered. When the Surveillance is performed within the delay period and the Surveillance is not met, the LCO must immediately be declared not met, and the applicable Condition(s) must be entered.
SR 3.0.4	Entry into a specified condition in the Applicability of an LCO shall not be made unless the LCO's Surveillances have been met within their specified Frequency. This provision shall not prevent entry into specified conditions in the Applicability that are required to comply with ACTIONS or that are related to the unloading of a DSC.

3.1 DSC Fuel Integrity

3.1.1 Fuel Integrity during Drying

LCO 3.1.1 Medium:

Helium shall be used for cover gas during drainage of bulk water (blowdown or draindown) from the DSC.

Pressure:

The DSC vacuum drying pressure shall be sustained at or below 3 Torr (3 mm Hg) absolute for a period of at least 30 minutes following evacuation.

APPLICABILITY: During LOADING OPERATIONS but before TRANSFER OPERATIONS.

ACTIONS:

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. If the required vacuum drying pressure cannot be obtained.	A.1	30 days
	A.1.1 Confirm that the vacuum drying system is properly installed. Check and repair the vacuum drying system as necessary. <u>OR</u>	
	A.1.2 Establish helium pressure of at least 0.5 atm and no greater than 15 psig in the DSC. <u>OR</u>	
	A.2 Flood the DSC with spent fuel pool water or water meeting the requirements of LCO 3.2.1, if applicable, submerging all fuel assemblies.	30 days

(continued)

3.1 DSC Fuel Integrity (continued)

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.1.1	Verify that the DSC vacuum drying pressure is less than or equal to 3 Torr (3 mm Hg) absolute for at least 30 minutes following evacuation.	Once per DSC, after an acceptable NDE of the inner top cover plate to DSC shell weld.

(continued)

3.1 DSC Fuel Integrity (continued)

3.1.2 DSC Helium Backfill Pressure

LCO 3.1.2 DSC helium backfill pressure shall be 2.5 ± 1 psig (stable for 30 minutes after filling) after completion of vacuum drying.

APPLICABILITY: During LOADING OPERATIONS but before TRANSFER OPERATIONS.

ACTIONS:

CONDITION	REQUIRED ACTION	COMPLETION TIME
-----------------NOTE----------------- Not applicable until SR 3.1.2 is performed. --- A. The required backfill pressure cannot be obtained or stabilized.	A.1 A.1.1 Maintain helium atmosphere in the DSC cavity. <u>AND</u> A.1.2 Confirm, check and repair or replace as necessary the vacuum drying system, helium source and pressure gauge. <u>AND</u> A.1.3 Check and repair, as necessary, the seal weld between the inner top cover plate and the DSC shell.	30 days
	<u>OR</u> A.2 Establish the DSC helium backfill pressure to within the limit. If pressure exceeds the criterion, release a sufficient quantity of helium to lower the DSC cavity pressure within the limit. <u>OR</u>	30 days

(continued)

3.1 DSC Fuel Integrity (continued)

CONDITION	REQUIRED ACTION		COMPLETION TIME
	A.3	Flood the DSC with spent fuel pool water or water meeting the requirements of LCO 3.2.1, if applicable, submerging all fuel assemblies.	30 days

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.1.2	Verify that the DSC helium backfill pressure is 2.5 ± 1 psig stable for 30 minutes after filling.	Once per DSC, after the completion of SR 3.1.1 requirement.

(continued)

3.1 DSC Fuel Integrity (continued)

3.1.3 Time Limit for Completion of DSC Transfer

LCO 3.1.3 The time to transfer the DSC to the HSM shall be within the limits.

Additionally, if the DSC and HLZC combination result in a time limit for completion of transfer from the table below, the air circulation system shall be assembled and be verified to be operable within 7 days before commencing the TRANSFER OPERATIONS of the loaded DSC.

DSC MODEL	APPLICABLE HLZC	TIME LIMITS (HOURS)
EOS-37PTH	HLZCs qualified per Figure 12	8(1)
EOS-37PTH	HLZC 3	No Limit
EOS-37PTH	HLZC 1, 2, or 4-11	8(1) (2)
EOS-89BTH	HLZCs qualified per Figure 11	8(1)
EOS-89BTH	HLZC 2	10(1)(3)
EOS-89BTH	HLZC 3	No Limit(3)
61BTH Type 2	HLZC 1, 2, 3, 4, or 9	No limit
61BTH Type 2	5, 6, or 8	23
61BTH Type 2	7 or 10	10

-- NOTE --

1. The time limit for completion of a DSC transfer is defined as the time elapsed in hours after the initiation of draining of TC/DSC annulus water until the completion of insertion of the DSC into the HSM. For transfer of an EOS-DSC, the time limit for transfer operations is determined based on the EOS-37PTH DSC in EOS-TC125 with the maximum allowable heat load of *54* kW or EOS-89BTH DSC in EOS-TC125 with the maximum allowable heat load of 48.2 kW. If the maximum heat load of a DSC is less than *54* kW for EOS-37PTH DSC or 48.2 kW for the EOS-89BTH DSC, a new time limit can be determined to provide additional time for transfer operations. The calculated time limit shall not be less than the time limit specified in LCO 3.1.3. The calculation should be performed using the same methodology documented in the UFSAR.
2. HLZC 2, 4-6 (shown in Figures 1B, 1D-1F) time limits apply for the EOS-37PTH DSC transferred in the EOS-TC108 only. HLZC 7-9 time limits apply for storage in the HSM-MX. If transferring the EOS-37PTH with HLZC 2, 4-6, or 11 in the EOS-TC125/135 and storing in the EOS-HSM, the limits for Figure 12 apply. Time limits also apply for HLZC 1, 2, and 4-11 when storing WE 14 x 14.
3. HLZC 2 and 3 (shown in Figure 2) time limits apply for the EOS-89BTH transferred in the EOS-TC108 only. If transferring the EOS-89BTH with HLZC 2 or 3 in the EOS-TC125, the limits for Figure 11 apply.

(continued)

All Indicated Changes are Enclosure 2, Item 1.

3.1 DSC Fuel Integrity (continued)

APPLICABILITY: During LOADING OPERATIONS AND TRANSFER OPERATIONS.

ACTIONS:

CONDITION	REQUIRED ACTION	COMPLETION TIME
------------------- NOTE ------------------ Not applicable until SR 3.1.3 is performed. -- A. The required time limit for completion of a DSC transfer not met.	A.1 If the TC is in the cask handling area in a vertical orientation, remove the TC top cover plate and fill the TC/DSC annulus with clean water. <u>OR</u>	2 hours
	A.2 If the TC is in a horizontal orientation on the transfer skid, initiate air circulation in the TC/DSC annulus by starting one of the redundant blowers. <u>OR</u>	1 hour (1) (2)
	A.3 Return the TC to the cask handling area and follow required action A.1 above.	5 hours (1) (2)

1. For EOS-37PTH and EOS-89BTH DSCs: If Required Action A.2 is initiated, run the blower for a minimum of 8 hours. After the blower is turned off, the time limit for completion of DSC transfer is 4 hours. If Required Action A.2 fails to complete within one hour, follow Required Action A.3 for the time remaining in the original Required Action A.3 completion time of 5 hours. The minimum duration of 8 hours to run the blower and the time limit of 4 hours after the blower is turned off for completion of the transfer operations are determined based on the EOS-37PTH DSC in EOS-TC125 with the maximum allowable heat load of *54* kW or EOS-89BTH DSC in EOS-TC125 with the maximum allowable heat load of 48.2 kW. If the maximum heat load of a DSC is less than *54* kW for EOS-37PTH DSC or 48.2 kW for the EOS-89BTH DSC, new time limits can be determined to provide additional time for these transfer operations. The calculated time limits shall not be less than 4 hours for completion of transfer operation after the blower is turned off. The calculation should be performed using the same methodology documented in the UFSAR.

2. For 61BTH Type 2 DSC: If Required Action A.2 is initiated, run the blower for a minimum of 8 hours. After the blower is turned off, the time limit for completion of DSC transfer is 4 hours. If Required Action A.2 fails to complete within one hour, follow Required Action A.3 for the time remaining in the original Required Action A.3 completion time of 5 hours. The minimum duration of 8 hours to run the blower and the time limit of 4 hours after the blower is turned off for completion of the transfer operations are determined based on the 61BTH Type 2 DSC in OS197FC-B TC with the maximum allowable heat load of 31.2 kW. If the maximum heat load of a DSC is less than 31.2 kW, new time limits can be determined to provide additional time for these transfer operations. The calculated time limits shall not be less than 4 hours for completion of transfer operation after the blower is turned off. The calculation should be performed using the same methodology documented in the UFSAR.

(continued)

All Indicated Changes are Enclosure 2, Item 1.

3.1 DSC Fuel Integrity (continued)

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.1.3	Verify that the time limit for completion of DSC transfer is met.	Once per DSC, after the initiation of draining of TC/DSC annulus water.

3.2 Cask Criticality Control

3.2.1 Soluble Boron Concentration

LCO 3.2.1 The boron concentration of the spent fuel pool water and the water added to the cavity of a loaded EOS-37PTH DSC shall be at least the boron concentration shown in Table 4 for the basket type and fuel enrichment selected.

APPLICABILITY: During LOADING and UNLOADING OPERATIONS with fuel and liquid water in the EOS-37PTH DSC cavity.

ACTIONS:

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Soluble boron concentration limit not met.	A.1 Suspend loading of fuel assemblies into DSC. AND	Immediately
	A.2	
	A.2.1 Add boron and re-sample, and test the concentration until the boron concentration is shown to be at least that required. OR	Immediately
	A.2.2 Remove all fuel assemblies from DSC.	Immediately

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.2.1.1	Verify soluble boron concentration limit in spent fuel pool water and water to be added to the DSC cavity is met using two independent measurements (two samples analyzed by different individuals) for LOADING OPERATIONS.	Within 4 hours before insertion of the first fuel assembly into the DSC. <u>AND</u> Every 48 hours thereafter while the DSC is in the spent fuel pool or until the fuel has been removed from the DSC.
SR 3.2.1.2	Verify soluble boron concentration limit in spent fuel pool water and water to be added to the DSC cavity is met using two independent measurements (two samples analyzed by different individuals) for UNLOADING OPERATIONS.	Once within 4 hours prior to flooding DSC during UNLOADING OPERATIONS. <u>AND</u> Every 48 hours thereafter while the DSC is in the spent fuel pool or until the fuel has been removed from the DSC.

3.3 Radiation Protection

3.3.1 DSC and TRANSFER CASK (TC) Surface Contamination

LCO 3.3.1 Removable surface contamination on the outer top 1 foot surface of the DSC AND the exterior surfaces of the TC shall not exceed:

a. 2,200 dpm/100 cm^2 from beta and gamma sources; and

b. 220 dpm/100 cm^2 from alpha sources.

APPLICABILITY: During LOADING OPERATIONS

ACTIONS:

-- NOTE --
Separate condition entry is allowed for each DSC and TC.

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Top 1 foot exterior surface of the DSC removable surface contamination limits not met.	A.1 Decontaminate the DSC to bring the removable contamination to within limits.	Prior to TRANSFER OPERATIONS
B. TC removable surface contamination limits not met.	B.1 Decontaminate the TC to bring the removable contamination to within limits	Prior to TRANSFER OPERATIONS

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.3.1.1	Verify that the removable contamination on the top 1 foot exterior surface of the DSC is within limits.	Once, prior to TRANSFER OPERATIONS.
SR 3.3.1.2	Verify by either direct or indirect methods that the removable contamination on the exterior surfaces of the TC is within limits.	Once, prior to TRANSFER OPERATIONS.

4.0 DESIGN FEATURES

The specifications in this section include the design characteristics of special importance to each of the physical barriers and to the maintenance of safety margins in the NUHOMS® EOS System design.

4.1 Site

4.1.1 Site Location

Because this UFSAR is prepared for a general license, a discussion of a site-specific ISFSI location is not applicable.

4.2 Storage System Features

4.2.1 Storage Capacity

The total storage capacity of the ISFSI is governed by the plant-specific license conditions.

4.2.2 Storage Pad

For sites for which soil-structure interaction is considered important, the licensee is to perform site-specific analysis considering the effects of soil-structure interaction. Amplified seismic spectra at the location of the HSM center of gravity (CG) is to be developed based on the soil-structure interaction (SSI) responses. EOS-HSM seismic analysis for the reinforced concrete EOS-HSM (EOS-HSM-RC) information is provided in UFSAR Appendix 3.9.4, Section 3.9.4.9.2. The steel-plate composite EOS-HSM (EOS-HSM-SC) seismic analysis information is provided in UFSAR Appendix 3.9.8, Section 3.9.8.9. HSM-MX seismic analysis information is provided in UFSAR Appendix A.3.9.4, Section A.3.9.4.9.2.

The storage pad location shall have no potential for liquefaction at the site-specific safe shutdown earthquake (SSE) level.

Additional requirements for the pad configuration are provided in Technical Specification 4.5.2.

4.3 Canister Criticality Control

The NUHOMS® EOS-37PTH DSC is designed for the storage of PWR fuel assemblies with a maximum planar average initial enrichment of less than or equal to 5.0 wt. % U-235 taking credit for soluble boron during LOADING OPERATIONS and the boron content in the poison plates of the DSC basket. The EOS-37PTH DSC uses a boron carbide/aluminum metal matrix composite (MMC) poison plate material. The EOS-37PTH DSC has two different neutron poison loading options, A and B, based on the boron content in the poison plates as listed in Table 5. Table 4 also defines the requirements for boron concentration in the DSC cavity water as a function of the DSC basket type for the various FUEL CLASSES authorized for storage in the EOS-37PTH DSC.

The NUHOMS® EOS-89BTH DSC is designed for the storage of BWR fuel assemblies with a maximum lattice average initial enrichment of less than or equal to 5.00 wt. % U-235 taking credit for the boron content in the poison plates of the DSC basket. There are three neutron poison loading options specified for the EOS-89BTH DSC depending on the type of poison material and the B-10 areal density in the plates, as specified in Table 8.

(continued)

4.0 Design Features (continued)

The 61BTH Type 2 DSC is designed for the storage of BWR fuel assemblies with a maximum lattice average initial enrichment of less than or equal to 5.0 wt. % U-235 taking credit for the boron content in the poison plates of the DSC basket. The 61BTH Type 2 DSC has multiple basket configurations based on the absorber material type (borated aluminum alloy, metal matrix composite (MMC), or Boral®) and boron content in the absorber plates as listed in Table 9 through Table 12.

4.3.1 Neutron Absorber Tests

The neutron absorber used for criticality control in the DSC baskets may be one of the following materials:

- Boron carbide/MMC
- BORAL® (EOS-89BTH or 61BTH Type 2 DSCs only)
- Borated aluminum (61BTH Type 2 DSC only)

Acceptance Testing (MMC, BORAL®, and borated aluminum)

B-10 areal density is verified by neutron attenuation testing or by chemical analysis of coupons taken adjacent to finished panels, and isotopic analysis of the boron carbide powder. The minimum B-10 areal density requirements are specified in Table 5 for EOS-37PTH, Table 8 for EOS-89BTH, and Table 9 through Table 12 for 61BTH Type 2 DSCs.

Finished panels are subject to visual and dimensional inspection.

Qualification Testing (MMC only)

MMCs are qualified for use in the NUHOMS® EOS System by verification of the following characteristics.

- The chemical composition is boron carbide particles in an aluminum alloy matrix.
- The form is with or without an aluminum skin.
- The median boron carbide particle size by volume is ≤ 80 microns with no more than 10% over 100 microns.
- The boron carbide content is ≤ 50% by volume.
- The porosity is ≤ 3%.

4.3.2 High Strength Low Alloy Steel for Basket Structure for EOS-37PTH and EOS-89BTH DSCs.

The basket structural material shall be a high strength low alloy (HSLA) steel meeting one of the following requirements A, B, or C:

A. ASTM A829 Gr 4130 or AMS 6345 SAE 4130, quenched and tempered at not less than 1050°F, 103.6 ksi minimum yield strength and 123.1 ksi minimum ultimate strength at room temperature.

B. ASME SA-517 Gr A, B, E, F, or P.

(continued)

4.0 Design Features (continued)

C. Other HSLA steel, with the specified heat treatment, meeting these qualification and acceptance criteria:

   i. If quenched and tempered, the tempering temperature shall be at no less than 1000 °F,

   ii. Qualified prior to first use by testing at least two lots and demonstrating that the fracture toughness value $K_{JIc} \geq 150$ ksi $\sqrt{in}$ at ≤ -40 °F with 95% confidence.

   iii. Qualified prior to first use by testing at least two lots and demonstrating that the 95% lower tolerance limit of yield strength and ultimate strength ≥ the values in UFSAR Table 8-10.

   iv. Meet production acceptance criteria based on the 95% lower tolerance limit of yield strength and ultimate strength at room temperature as determined by qualification testing described in Section 4.3.2.C.iii.

The basket structural material shall also meet one of the following production acceptance criteria for impact testing at ≤ -40 °F:

   a. Charpy testing per ASTM A370, minimum absorbed energy 25 ft-lb average, 20 ft-lb lowest of three (for sub-size specimens, reduce these criteria per ASTM A370-17 Table 9), or

   b. Dynamic tear testing per ASTM E604 with acceptance criterion minimum 80% shear fracture appearance.

4.4 Codes and Standards

4.4.1 HORIZONTAL STORAGE MODULE (HSM)

The reinforced concrete HSM is designed in accordance with the provisions of ACI 349-06. The steel structure of the steel-plate composite HSM is designed and constructed in accordance with the provisions of ANSI/AISC N690-18. The concrete of the steel-plate composite HSM is designed in accordance with provisions of ACI 349-13 and constructed in accordance with ACI 318-08. Code alternatives are discussed in Technical Specification 4.4.4. Load combinations specified in ANSI 57.9-1984, Section 6.17.3.1 are used for combining normal operating, off-normal, and accident loads for the HSM.

(continued)

4.0 Design Features (continued)

4.4.2 DRY SHIELDED CANISTER (DSC) (EOS-37PTH, EOS-89BTH, and 61BTH Type 2)

The DSC confinement boundary is designed, fabricated and inspected to the maximum practical extent in accordance with ASME Boiler and Pressure Vessel Code Section III, Division 1, Subsection NB, NF, and NG, for Class 1 components. The ASME code edition years and any addenda for the various DSC types and relevant subsections are provided in the table below. Code alternatives are discussed in Technical Specification 4.4.4.

DSC Type	**Applicable Code**	**Edition/Year**
EOS-37PTH, EOS-89BTH	ASME B&PV Code, Section III, Division 1, Subsection NB	2010 Edition with Addenda through 2011
61BTH Type 2	ASME B&PV Code, Section III, Division 1, Subsections NB, NG and NF	1998 Edition with Addenda through 2000

4.4.3 TRANSFER CASK

The EOS-TC design stress analysis and OS197 design stress analysis and fabrication, exclusive of the trunnions and the neutron shield enclosures, is performed in accordance with applicable codes as provided in the table below. The stress allowables for the upper trunnions for the EOS-TCs and the upper and lower trunnions for the OS197 conform to ANSI N14.6-1993 for single-failure-proof lifting.

TC	**Applicable Code**	**Edition/Year**
EOS-TC	ASME B&PV Code, Section III, Division 1, Subsection NF for Class 1 supports	2010 Edition with Addenda through 2011
OS197	ASME B&PV Code, Section III, Division 1, Subsection NC for Class 2 vessels	1983 Edition with Winter 1985 Addenda

4.4.4 Alternatives to Codes and Standards

ASME Code alternatives for the EOS-37PTH, EOS-89BTH DSC, and 61BTH Type 2 DSC are listed below:

(continued)

4.0 Design Features (continued)

EOS-37PTH and EOS-89BTH DSC ASME Code Alternatives, Subsection NB

REFERENCE ASME CODE SECTION/ARTICLE	CODE REQUIREMENT	JUSTIFICATION AND COMPENSATORY MEASURES
NCA	All	Not compliant with NCA
NB-1100	Requirements for Code Stamping of Components	The canister shell, the inner top cover, the inner bottom cover or bottom forging assembly, the outer top cover, and the drain port cover and vent port plug are designed and fabricated in accordance with the ASME Code, Section III, Subsection NB to the maximum extent practical. 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-2121	Permitted Material Specifications	Type 2205 and UNS S31803 are duplex stainless steels that provide enhance resistance to chloride-induced stress corrosion cracking. They are not included in Section II, Part D, Subpart 1, Tables 2A and 2B. UNS S31803 has been accepted for Class 1 components by ASME Code Case N-635-1, endorsed by NRC Regulatory Guide 1.84. Type 2205 falls within the chemical and mechanical requirements of UNS S31803. Normal and off-normal temperatures remain below the 600 °F operating limit. Accident conditions may exceed this limit, but only for durations too short to cause embrittlement.
NB-2130 NB-4121	Material must be supplied by ASME approved material suppliers Material Certification by Certificate Holder	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 and certification are maintained in accordance with the NRC approved QA program associated with CoC 1042.
NB-2300	Fracture toughness requirements for material	Type 2205 and UNS S31803 duplex stainless steels are tested by Charpy V-notch only per NB-2300. Drop weight tests are not required. Impact testing is not required for the vent port plug.
NB-2531	Drain port cover; straight beam ultrasonic testing (UT) per SA-578 for all plates for vessel	SA-578 applies to 3/8" and thicker plate only; allow alternate UT techniques to achieve meaningful UT results.
NB- 2531 and NB-2541	Vent port plug UT and liquid penetrant testing (PT)	This plug may be made from plate or bar. Due to its small area, it has no structural function. It is leak tested along with the inner top cover plate after welding. Therefore, neither UT nor PT are required.

(continued)

4.0 Design Features (continued)

EOS-37PTH and EOS-89BTH DSC ASME Code Alternatives, Subsection NB

(continued)

REFERENCE ASME CODE SECTION/ARTICLE	CODE REQUIREMENT	JUSTIFICATION AND COMPENSATORY MEASURES
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 radiographic testing (RT) and either PT or magnetic particle testing (MT).	The shell to the outer top cover plate (OTCP) weld, the shell to the inner top cover weld, and the drain port cover and vent port plug welds are all partial penetration welds. The cover-to-shell welds are designed to meet the guidance provided in NUREG-1536, Revision 1 for the stress reduction factor. Nondestructive examination (NDE) is done by qualified personnel, in accordance with Section V and the acceptance standards of Section III, Subsection NB-5000, except as noted for OTCP weld option 2 ultrasonic examination. As an alternative to the NDE requirements of NB-5230 for Category C welds, all of these closure welds will be multi-layer welds and receive a root and final PT examination, except for the shell to the OTCP weld. <u>OTCP weld option 1</u> The shell to OTCP weld will be a multi-layer weld and receive multi-level PT examination in accordance with the guidance provided in NUREG 1536 Revision 1 for NDE. The multi-level PT examination provides reasonable assurance that flaws of interest will be identified. <u>OTCP weld option 2</u> The shell to the outer top cover plate weld will be examined by UT.
NB-5330	Ultrasonic Acceptance Standards	The UT acceptance criteria for OTCP weld option 2 are: 1. Rounded flaws are evaluated by the acceptance criteria of NB-5331(a). 2. Planar flaws are allowable up to the limit (W – Σhi) ≥ D at any location, where Σhi is the sum of the depth of aligned planar defects, W is the measured weld thickness, and D is the minimum weld depth required by NB-3000. 3. Planar flaws that penetrate the surface of the weld are not allowable.
NB-5520	NDE Personnel must be qualified to the 2006 edition of SNT-TC-1A	Permit use of the Recommended Practice SNT-TC-1A up to the edition as cited in Table NCA-7000-1 of the latest ASME Code edition listed in 10 CFR 50.55a at the time of construction.

(continued)

4.0 Design Features (continued)

EOS-37PTH and EOS-89BTH DSC ASME Code Alternatives, Subsection NB

(continued)

REFERENCE ASME CODE SECTION/ARTICLE	CODE REQUIREMENT	JUSTIFICATION AND COMPENSATORY MEASURES
NB-6000	All completed pressure retaining systems shall be pressure tested	The DSC is not a complete or “installed” pressure 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, shell bottom, including all longitudinal and circumferential welds, is pneumatically tested and examined at the fabrication facility when using the three plate bottom assembly. If using a single piece bottom forging, the fabrication pressure test may be waived although the helium leak test requirement remains in place. The low test pressure test does not stress a single piece bottom and bottom-to-shell weld sufficiently to cause pre-existing defects to propagate into leaks. For the purpose of finding leaks, the helium leak test is far more sensitive than the pressure test. The shell to the inner top cover closure weld is pressure tested and examined for leakage in accordance with NB-6300 in the field. The drain port cover and vent port plug welds will not be pressure tested; these welds and the shell to the inner top cover closure weld 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 EOS-37PTH or EOS-89BTH DSC. The function of the DSC is to contain radioactive materials under normal, off-normal, and hypothetical accident conditions postulated to occur during transportation. The DSC is designed to withstand the maximum internal pressure considering 100% fuel rod failure at maximum accident temperature.

(continued)

4.0 Design Features (continued)

EOS-37PTH and EOS-89BTH DSC ASME Code Alternatives, Subsection NB

(continued)

NB-8000	Requirements for nameplates, stamping and reports per NCA-8000	The EOS-37PTH and EOS-89BTH DSC are stamped or engraved with the information required by 10 CFR Part 72. Code stamping is not required for these DSCs. QA Data packages are prepared in accordance with requirements of the NRC approved QA program associated with CoC 1042.

(continued)

4.0 Design Features (continued)

61BTH Type 2 DSC ASME Code Alternatives for the Confinement Boundary

REFERENCE ASME CODE SECTION/ ARTICLE	CODE REQUIREMENT	ALTERNATIVES, JUSTIFICATION & COMPENSATORY MEASURES
NCA	All	Not compliant with NCA. Quality Assurance is provided according to 10 CFR Part 72 Subpart G in lieu of NCA-4000.
NCA-1140	Use of Code editions and addenda	Code edition and addenda other than those specified in Section 4.4.2 may be used for construction, but in no case earlier than 3 years before that specified in the Section 4.4.2 table. Materials produced and certified in accordance with ASME Section II material specification from Code Editions and Addenda other than those specified in Section 4.4.2 may be used, so long as the materials meet all the requirements of Article 2000 of the applicable Subsection of the Section III Edition and Addenda used for construction.
NB-1100	Requirements for Code Stamping of Components, Code reports and certificates, etc.	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-1132	Attachments with a pressure retaining function, including stiffeners, shall be considered part of the component.	Bottom shield plug and outer bottom cover plate are outside code jurisdiction; these components together are much larger than required to provide stiffening for the inner bottom cover plate; the weld that retains the outer bottom cover plate and with it the bottom shield plug is subject to root and final PT examination.
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 and 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 weld, the siphon and vent cover plate welds, and the vent and siphon block welds to the shell are all partial penetration welds. As an alternative to the NDE requirements of NB-5230 for Category C welds, all of these closure welds will be 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 NUREG-1536 Revision 1 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 will be designed to meet the guidance provided in NUREG-1536 Revision 1 for stress reduction factor.

(continued)

4.0 Design Features (continued)

61BTH Type 2 DSC ASME Code Alternatives for the Confinement Boundary

REFERENCE ASME CODE SECTION/ ARTICLE	CODE REQUIREMENT	ALTERNATIVES, JUSTIFICATION & COMPENSATORY MEASURES
NB-6100 and 6200	All completed pressure retaining systems shall be pressure tested.	The 61BTH Type 2 DSC is not a complete or “installed” pressure vessel until the top closure is welded following placement of Fuel Assemblies with 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 shell bottom (including all longitudinal and circumferential welds) is pressure tested and examined at the fabrication facility. The shell to the inner top cover closure weld are 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 closure weld 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® DSCs. The function of the DSC is to contain radioactive materials under normal, off-normal and hypothetical accident conditions postulated to occur during transportation and storage. The DSC is designed to withstand the maximum possible internal pressure considering 100% fuel rod failure at maximum accident temperature.
NB-8000	Requirements for nameplates, stamping & reports per NCA-8000.	The NUHOMS® DSC nameplate provides the information required by 10 CFR Part 71, 49 CFR Part 173 and 10 CFR Part 72 as appropriate. Code stamping is not required for the DSC. QA data packages are prepared in accordance with the requirements of TN’s approved QA program.
NB-5520	NDE personnel must be qualified to a specific edition of SNT-TC-1A.	Permit use of the Recommended Practice SNT-TC-1A to include up to the most recent 2011 edition.

(continued)

4.0 Design Features (continued)

61BTH Type 2 DSC ASME Code Alternatives for the Basket

REFERENCE ASME CODE SECTION/ ARTICLE	CODE REQUIREMENT	ALTERNATIVES, JUSTIFICATION & COMPENSATORY MEASURES
NCA	All	Not compliant with NCA. Quality Assurance is provided according to 10 CFR Part 72 Subpart G in lieu of NCA-4000.
NCA-1140	Use of Code editions and addenda	Code edition and addenda other than those specified in Section 4.4.2 may be used for construction, but in no case earlier than 3 years before that specified in the Section 4.4.2 table. Materials produced and certified in accordance with ASME Section II material specification from Code Editions and Addenda other than those specified in Section 4.4.2 may be used, so long as the materials meet all the requirements of Article 2000 of the applicable Subsection of the Section III Edition and Addenda used for construction.
NG/NF-1100	Requirements for Code Stamping of Components, Code reports and certificates, etc.	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.
NG/NF-2000	Use of ASME Material	Some baskets include neutron absorber and aluminum plates that are not ASME Code Class 1 material. They are used for criticality safety and heat transfer, and are only credited in the structural analysis with supporting their own weight and transmitting bearing loads through their thickness. 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/NF-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/NF-2130 is not possible. Material traceability and certification are maintained in accordance with TN’s NRC approved QA program.
NG/NF-4121	Material Certification by Certificate Holder	
NG-3352	Table NG-3352-1 lists the permissible welded joints and quality factors.	The fuel compartment tubes may be fabricated from sheet with full penetration seam weldments. Per Table NG-3352-1, a joint efficiency (quality) factor of 0.5 is to be used for full penetration weldments examined in accordance with ASME Section V visual examination (VT). A joint efficiency (quality) factor of 1.0 is utilized for the fuel compartment longitudinal seam welds (if present) with VT examination. This is justified because the compartment seam weld is thin and the weldment is made in one pass; and both surfaces of the weldment (inside and outside) receive 100% VT examination. The 0.5 quality factor, applicable to each surface of the weldment, results is a quality factor of 1.0 since both surfaces are 100% examined. In addition, the fuel compartments have no pressure retaining function and the stainless steel material that comprises the fuel compartment tubes is very ductile.
NG/NF-8000	Requirements for nameplates, stamping & reports per NCA-8000.	The NUHOMS® DSC nameplate provides the information required by 10 CFR Part 71, 49 CFR Part 173 and 10 CFR Part 72 as appropriate. Code stamping is not required for the DSC. QA data packages are prepared in accordance with the requirements of TN’s approved QA program.
NG/NF-5520	NDE personnel must be qualified to a specific edition of SNT-TC-1A.	Permit use of the Recommended Practice SNT-TC-1A to include up to the most recent 2011 edition.

(continued)

4.0 Design Features (continued)

Code alternatives for the HSM concrete specifications are listed below:

REFERENCE ACI349-06/-13, AS APPLICABLE SECTION/ARTICLE	CODE REQUIREMENT	ALTERNATIVES, JUSTIFICATION AND COMPENSATORY MEASURES
Appendix E, Section E.4-Concrete Temperatures, Paragraph E.4.3	Paragraph E.4.3 requires testing of concrete for temperatures higher than those given in Paragraph E.4.1.	The concrete temperature limit criteria in NUREG-1536, Revision 1, Section 8.4.14.2 is used for normal and off-normal conditions. Alternatively, per ACI 349-13, Code Requirements for Nuclear Safety-Related Concrete Structures and Commentary, Section RE.4, the specified compressive strength, which may be tested up to 56 days, is increased to 7,000 psi for HSM fabrication so that any losses in properties (e.g., compressive strength) resulting from long-term thermal exposure will not affect the safety margins based on the specified 5,000 psi compressive strength used in the design calculations. Additionally, also as indicated in Section RE.4, short, randomly oriented steel fibers may be used to provide increased ductility, dynamic strength, toughness, tensile strength, and improved resistance to spalling. The safety margin on compressive strength is 40% for a concrete temperature limit of 300 °F normal and off-normal conditions.
Appendix E, Section E.4-Concrete Temperatures, Paragraph E.4.1	Paragraph E.4.1 specifies that the concrete temperatures for normal operations shall not exceed 150 °F except for local areas such as around penetrations, which are allowed to have increased temperatures not to exceed 200 °F.	The concrete temperature limit criteria in NUREG-1536, Section 8.4.14.2 are used for normal and off-normal conditions. Blended Cement per ASTM C595 may be used in lieu of Portland Cement Type II. • The cement supplier, as of January 2023, will no longer provide cement in accordance with ASTM C150 because the industry is transitioning to a cement with a smaller carbon footprint that includes 10% limestone. • ACI 349-06 identifies several ASTM specifications for cement that are acceptable per the code requirements. ASTM C150 and ASTM C595 are two of the acceptable cement specifications identified in Section 3.2 of ACI 349-06. • Thermal compatibility tests conducted on concrete mixes using the two cement types show comparable strength results with no signs of degradation due to exposure to elevated temperatures.

(continued)

4.0 Design Features (continued)

Code alternatives for the steel-plate composite HSM specifications are listed below:

REFERENCE ANSI/AISC N690	CODE REQUIREMENT	JUSTIFICATION AND COMPENSATORY MEASURES
NB2	Required load combinations for normal, severe environmental, and extreme environmental and abnormal conditions.	The load combinations contained in AISC N690-18 are intended to cover a wide range of structural applications where additional load combinations are used to cover various uncertainties. For the design of dry-storage structures, NUREG 1536, R1 (and the more current NUREG 2215) endorse the load combinations specified in Section 6.17.3.1 of ANSI 57.9-1984 as the most applicable load combinations. Therefore, the use of ANSI 57.9-1984 load combinations in lieu of those specified in AISC-N690-18 is acceptable for this application.
N9.1.1.(a)	For exterior SC walls, the minimum value of the section thickness, t_{sc}, shall be 18 inches (450 mm). For interior SC walls, the minimum t_{sc} shall be 12 inches (300 mm).	As presented in Commentary for Section N9.1.1(a) of N690, the minimum section thickness for exterior SC walls is based on Table 1 of NUREG-0800, Revision 3, Section 3.5.3, Revision 3. It requires minimum 16.9-inch thick (430mm) 4-ksi (28 MPa) reinforced concrete (RC) walls to resist a tornado missile. Conservatively, the SC wall is treated as a RC wall for missile loading. The thinner sections of the door are supported by the front wall of the EOS-HSM-SC during missile impact. Therefore, the door meets the specified minimum thickness value of 18 inches for exterior walls. The minimum thickness for interior walls is based on the maximum reinforcement ratio and minimum faceplate thickness. The specified minimum thickness value of 12 inches is conservatively rounded up from the actual minimum of 10 inches as presented in Commentary for Section N9.1.1(a) of N690. Therefore, the sections of the door and OVC that do not meet the specified thickness value of 12 inches, still meet the 10 inch minimum thickness requirement.
N9.1.1(c)	The reinforcement ratio of SC sections shall have a minimum value of 0.015 and a maximum value of 0.050.	According to AISC Steel Design Guide 32, high reinforcement ratios can potentially result in higher concrete stresses and change the governing in-plane shear limit state from steel faceplate yielding to concrete compression strut failure, which can potentially reduce the strength and ductility of SC walls. The reinforcement ratio for the thin walls of the EOS-HSM-SC minimally (less than 5%) exceeds the ratio of 0.050 and this exceedance facilitates compliance with the faceplate slenderness requirement in Section N9.1.3 of N690-18. The reinforcement ratio for the top segment of the front wall is marginally less than the minimum reinforcement ratio of 0.015 when the effective thickness of the front wall faceplate is considered. Per Commentary Section N9.1.1(c) of N690, use of a very low reinforcement ratio poses concerns regarding handling strength and stiffness in addition to residual stresses due to fabrication operations and concrete casting. These concerns are not applicable because the actual thickness is twice as large as the effective thickness.

(continued)

4.0 Design Features (continued)

Code alternatives for the steel-plate composite HSM specifications are listed below (continued):

REFERENCE ANSI/AISC N690	CODE REQUIREMENT	JUSTIFICATION AND COMPENSATORY MEASURES
N9.1.1.(d)	The specified minimum yield stress of faceplates, F_y, shall not be less than 50 ksi (350 MPa) nor more than 65 ksi (450 MPa).	The door and OVC steel plates are constructed from ASTM A36. As presented in the Commentary for Section N9.1.1(d) of N690, the minimum yield strength of faceplates is intended to prevent premature yielding due to residual stresses from concrete casting and thermally induced stresses. The door and OVC are free to grow when subjected to thermal loads and require a concrete volume of relatively low height resulting in insignificant pressure on the faceplates during casting as compared to a large EOS-HSM-SC wall. Therefore, stresses due to thermal growth and residual stress from concrete casting will not contribute to premature yielding of the faceplates in these components. Additionally, the margins for the door thickness to withstand local damage due to missile attack, ductile capacity for missile impact, and structural adequacy for punching shear are sufficiently large. The OVC has no structural safety function. Therefore, a material meeting the properties of ASTM A36 will have sufficient strength for this application.
N9.1.4b(a)	Steel anchors shall be spaced not to exceed the minimum spacing required to develop the yield strength of the faceplates over the development length.	This requirement ensures that sufficient composite action exists between the steel faceplate and concrete. However, the requirement does not consider the contribution of ties to available shear strength of the SC component, leading to inefficient designs for those components such as thin walls, for which the density of ties tends to be high. Studies based on finite element analysis demonstrate the contribution of ties to the composite action and show that composite action is adequate for the thin walls of the EOS-HSM-SC.
N9.1.4b(b)	Steel anchors shall be spaced not to exceed the minimum spacing required to prevent interfacial shear failure before out-of-plane shear failure of the SC section.	This requirement does not consider the required strength of the SC component but the available out-of-plane strength, leading to inefficient designs in those cases where the demand-to-capacity ratio for out-of-plane shear interaction is low. For the design of the EOS-HSM-SC, this criterion is modified such that the spacing of steel anchors required to prevent interfacial shear failure is deemed adequate if the demand-to-capacity ratio for out-of-plane shear interaction (presented in Section N9.3.6a of N690-18) is below 1.0 when required strength at least 1/3 greater than that determined by structural analysis is used. This approach is validated by laboratory test results.

(continued)

4.0 Design Features (continued)

Code alternatives for the steel-plate composite HSM specifications are listed below (continued):

N9.1.7a(b)	The flange fitted at the end of the sleeve for a fully developed edge at the opening perimeter shall extend a distance of at least the section thickness beyond the opening perimeter.	The front wall opening in the top segment of the EOS-HSM-SC only is considered as an opening because the majority of the front wall opening area is in the top segment and the bottom segment has only a slightly concave edge. The design of the front wall opening in the top segment of the EOS-HSM-SC follows the requirements on design and detailing around openings to the maximum practical extent possible to achieve a fully developed edge at the opening perimeter: a sufficiently fine finite element mesh is employed for the front wall and around its opening; a sleeve spanning across the opening from the front faceplate to the back faceplate is provided; and an equivalent flange is provided by thickening the front wall faceplate to provide additional strength in the stress concentration region. For the EOS-HSM-SC front wall, it is impractical to extend a distance of at least the section thickness beyond the opening perimeter because of the proximity of the front wall opening to the side walls.
N9.3.6a	The interaction of out-of-plane shear forces shall be limited by Equation A-N9-24 of N690-18.	The interaction of out-of-plane shear forces for thin walls of the EOS-HSM-SC is considered based on a modified approach described in the discussion on Section N9.1.4b(b) of N690-18.
NM2.4	User Note: Parameters documented and retrievable for each weld include, but are not limited to, the welder, weld wire lot/filler metal used, equipment used, date the weld was performed, date the weld was inspected, identification of weld inspector, and weld WPS used. The fabricator or constructor, as applicable for the work scope, should develop a method whereby each weld and its associated data can be identified.	Welding shall be documented as per the requirements of AISC 360-16. The EOS-HSM-SC is made up of Category B, C, and NITS items and not Safety Related as outlined in N690-18. The requirements of AISC 360-16 are consistent with Category B items as described in Chapter 14 of the UFSAR.
NM2.7.(d).(1)	At tie locations, the perpendicular distance between the opposite faceplates are within plus or minus $t_{sc}/200$, rounded upward to the nearest 1/16 in. (2 mm), where t_{sc} is the SC section thickness. This tolerance check shall be performed for the row of tie-bars located closest to the free edges of SC panels.	For walls less than 24″, the wall thickness tolerance at tie locations shall be plus or minus 1/8″, measured at the row of tie-bars located closest to the free edges of the SC panels. The EOS-HSM-SC does not have segmented walls to apply a tighter tolerance at the free edges. The EOS-HSM-SC design is its own free standing support structure that will not be affected by discontinuities at the wall connections. Any variance will be smoothly transitioned by nature of its construction. The formulas were developed for walls that are a minimum of 24″. The formula when applied to much thinner walls leads to impractical designs. Therefore, the tolerances of this Section should be applied as stated above.

(continued)

4.0 Design Features (continued)

Code alternatives for the steel-plate composite HSM specifications are listed below (continued):

NM2.7.(d).(3)	In between the tie locations, the perpendicular distance between the opposite faceplates are within plus or minus t_{sc}/100, rounded upward to the nearest 1/16 in. (2 mm). This tolerance check shall be performed along the free edges of the SC wall panels.	For less than 24″, the wall thickness tolerance in between tie locations shall be plus or minus 1/4″, measured at the free edge of the SC panels. The EOS-HSM-SC does not have segmented walls to apply a tighter tolerance at the free edges. The EOS-HSM-SC design is its own free standing support structure that will not be affected by discontinuities at the wall connections. Any variance will be smoothly transitioned by nature of its construction. The formulas were developed for walls that are a minimum of 24″. The formula when applied to much thinner walls leads to impractical designs. Therefore, the tolerances of this Section should be applied as stated above.
NM2.7.(2)	Additionally, after concrete curing, the faceplate waviness, f_w, shall be limited to the following: $$f_w \le \left(\frac{t_p}{2}\right)\left(\frac{s_{t,min}}{s}\right) \quad (NM2-1)$$ where, s = spacing of the steel anchors, in. (mm) $s_{t,min}$ = minimum tie spacing, in. (mm) t_p = thickness of faceplate, in. (mm)	The inspection for the faceplate waviness will not be required for the EOS-HSM-SC. Units of HSMs are typically poured in groups, and therefore, the verification of this requirement cannot be performed at all locations. Due to the construction process of the EOS-HSM-SC, many walls are inaccessible after pouring. This exception is for the inspection and verification of these tolerances after curing, not the tolerance values themselves.
NM2.14	If not available from a qualified source, the material shall be dedicated for use as specified in Subpart 2.14 of ASME NQA-1.	Commercial grade dedication is not required for ITS Category B, C and NITS items per the TN QA program. HSMs are not considered basic components; therefore, per 10 CFR Part 21, they are not subject to commercial grade dedication.
NM2.15	The fabricator shall be able to demonstrate, by written procedure and by actual practice, a method of material identification meeting the requirements of the contract documents.	Material traceability is not required for ITS Category B or C items as outlined in Section 14.2 of the UFSAR and therefore, the EOS-HSM-SC components do not require material traceability as described in the code. However, all other aspects of NM2.15, including material identification, are required.
NM3.4	Except for stainless steels, machine-finished surfaces shall be protected against corrosion by a rust-inhibitive coating that is removable prior to erection or that has characteristics that make removal prior to erection unnecessary.	Rust inhibitor shall not be required for threads or cut edges of rolled shapes and plates. Dywidag rods and similar threaded items used in concrete construction are not normally provided with rust inhibitor.
NN	This chapter addresses minimum requirements for quality control, quality assurance and nondestructive evaluation for safety-related structural steel systems and steel elements of composite members for nuclear facilities.	Chapter NN quality control and quality assurance requirements do not apply to the EOS-HSM-SC. The EOS-HSM-SC is an ITS Category B item; therefore, AISC 360-16 shall be applied. The nondestructive examination of welded joints described in Section NN5.5 shall still apply.

(continued)

4.0 Design Features (continued)

Proposed alternatives to the above-specified ASME and ACI codes, other than the aforementioned alternatives, may be used when authorized by the Director of the Office of Nuclear Material Safety and Safeguards, or designee. The applicant should demonstrate that:

1. The proposed alternatives would provide an acceptable level of quality and safety, or
2. Compliance with the specified requirements of above-specified ASME and ACI codes would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

The applicant should also submit information regarding the environmental impact of such a request to support the NRC's NEPA regulations in 10 CFR Part 51. Any proposed alternatives must be submitted and approved prior to implementation.

Requests for exceptions in accordance with this section should be submitted in accordance with 10 CFR 72.4.

(continued)

4.5 Storage Location Design Features

The following storage location design features and parameters shall be verified by the system user to assure technical agreement with the UFSAR.

4.5.1 Storage Configuration

EOS-HSMs and HSM-MXs are placed together in single rows or back to back arrays. A rear shield wall is placed on the rear of any single row loaded EOS-HSM.

4.5.2 Concrete Storage Pad Properties to Limit DSC Gravitational Loadings Due to Postulated Drops

The EOS-37PTH DSC and EOS-89BTH DSC have been evaluated for drops of up to 65 inches onto a reinforced concrete storage pad. The 61BTH Type 2 DSC has been evaluated for drops of up to 80 inches onto a reinforced concrete storage pad.

4.5.3 Site Specific Parameters and Analyses

The following parameters and analyses are applicable to all HSMs unless specifically noted and shall be verified by the system user for applicability at their specific site. Other natural phenomena events, such as lightning, tsunamis, hurricanes, and seiches, are site specific and their effects are generally bounded by other events, but they should be evaluated by the user.

1. Flood levels up to 50 ft and water velocity of 15 fps.
2. One-hundred year roof snow load of 110 psf.
3. Normal ambient temperature is based on the heat load of the DSC as follows:

   For the EOS-HSM:

   a. For the EOS-37PTH DSCs with a heat load less than or equal to 41.8 kW or for the EOS-89BTH DSCs with a heat load less than or equal to 41.6 kW, the minimum temperature is -20 °F. The maximum calculated normal average ambient temperature corresponding to a 24-hour period is 90 °F.
   b. For the EOS-37PTH DSCs with a heat load greater than 41.8 kW or for the EOS-89BTH DSCs with a heat load greater than 41.6 kW, the minimum temperature is -20 °F. The maximum calculated average yearly temperature is 70 °F.

   For the HSM-MX:

   c. The minimum temperature is -20 °F. The maximum calculated normal average ambient temperature corresponding to a 24-hour period is 90 °F.
4. Off-normal ambient temperature range of -40 °F without solar insolation to 117 °F with full solar insolation. The 117 °F off-normal ambient temperature corresponds to a 24-hour calculated average temperature of 103 °F.

(continued)

4.0 Design Features (continued)

5. The response spectra at the base of the HSMs shall be compared against the response spectra defined in UFSAR Section 2.3.4 for the EOS-HSM, and Section A.2.3.4 for the HSM-MX and shown to be enveloped by the UFSAR response spectra. If it is not enveloped, stability can be demonstrated by either static or dynamic analysis.
6. The potential for fires and explosions shall be addressed, based on site-specific considerations.
7. Supplemental Shielding: In cases where engineered features (i.e., berms, shield walls) are used to ensure that the requirements of 10 CFR 72.104(a) are met, such features are to be considered important to safety and must be evaluated to determine the applicable Quality Assurance Category.
8. If an INDEPENDENT SPENT FUEL STORAGE INSTALLATION (ISFSI) site is located in a coastal salt water marine atmosphere, then any load-bearing carbon steel DSC support structure rail components for the EOS-HSM, or front and rear DSC supports for the HSM-MX shall be procured with a minimum 0.20% copper content or stainless steel shall be used for corrosion resistance. For weld filler material used with carbon steel, 1% or more nickel bearing weld material would also be acceptable in lieu of 0.20% copper content.
9. If an ISFSI site is required to evaluate blockage of air vents for durations longer than evaluated in the UFSAR, a new duration can be determined based on site-specific parameters. The evaluation should be performed using the same methodology documented in the UFSAR.

5.0 ADMINISTRATIVE CONTROLS

5.1 Programs

Each user of the NUHOMS® EOS System will implement the following programs to ensure the safe operation and maintenance of the ISFSI:

- Radiological Environmental Monitoring Program (see 5.1.1 below)
- Radiation Protection Program (see 5.1.2 below)
- HSM Thermal Monitoring Program (see 5.1.3 below)

5.1.1 Radiological Environmental Monitoring Program

a. A radiological environmental monitoring program will be implemented to ensure that the annual dose equivalent to an individual located outside the ISFSI controlled area does not exceed the annual dose limits specified in 10 CFR 72.104(a).

b. Operation of the ISFSI will not create any radioactive materials or result in any credible liquid or gaseous effluent release.

5.1.2 Radiation Protection Program

The Radiation Protection Program will establish administrative controls to limit personnel exposure to As Low As Reasonably Achievable (ALARA) levels in accordance with 10 CFR Part 20 and Part 72.

a. As part of its evaluation pursuant to 10 CFR 72.212, the licensee shall perform an analysis to confirm that the limits of 10 CFR Part 20 and 10 CFR 72.104 will be satisfied under the actual site conditions and configurations considering the planned number of DSCs to be used and the planned fuel loading conditions. This analysis is also used to qualify fuel considered for loading, as outlined below:

   1. For the DSCs considered for loading, select HLZC(s) appropriate to store the spent fuel.
   2. Compute the decay heat of the fuel assemblies considered for loading. Methods include, but are not limited to, NRC Regulatory Guide 3.54, or the methodology described in the UFSAR (i.e., ORIGEN-ARP).
   3. Compute the source term for the fuel assemblies considered for loading. The design basis source terms provided in the UFSAR may be used for site-specific shielding analysis if they are shown to bound the site-specific source terms.
   4. Demonstrate computationally that the EOS-HSM or HSM-MX to be loaded meets the dose rate requirements of TS 5.1.2(c). This evaluation may be used as the basis for the dose rate limits established in TS 5.1.2(b).
   5. Demonstrate computationally that direct radiation from the ISFSI meets the requirements of 72.104.

(continued)

5.0 ADMINISTRATIVE CONTROLS (continued)

b. On the basis of the analysis in TS 5.1.2(a), the licensee shall establish a set of HSM dose rate limits which are to be applied to DSCs used at the site. Limits shall establish dose rates for:

   i. HSM front face,

   ii. HSM door centerline, and

   iii. End shield wall exterior for the EOS-HSM or exterior side wall of the HSM-MX monolith.

c. Notwithstanding the limits established in TS 5.1.2(b), the dose rate limits may not exceed the following values as calculated for a content of design basis fuel as follows:

   For EOS-HSM:

   i. 65 mrem/hr average over the front face,

   ii. 15 mrem/hr at the door centerline, and

   iii. 5 mrem/hr average at the end shield wall exterior.

   For HSM-MX:

   i. 165 mrem/hr average over the front face,

   ii. 15 mrem/hr at the door centerline, and

   iii. 5 mrem/hr average at the exterior side wall of the HSM-MX monolith.

   If the measured dose rates do not meet the limits of TS 5.1.2(b) or TS 5.1.2(c), whichever are lower, the licensee shall take the following actions:

   - Notify the U.S. Nuclear Regulatory Commission (Director of the Office of Nuclear Material Safety and Safeguards) within 30 days,
   - Administratively verify that the correct fuel was loaded,
   - Ensure proper installation of the HSM door,
   - Ensure that the DSC is properly positioned on the DSC supports, and
   - Perform an analysis to determine that placement of the as-loaded DSC at the ISFSI will not cause the ISFSI to exceed the radiation exposure limits of 10 CFR Part 20 and 10 CFR Part 72 and/or provide additional shielding to assure exposure limits are not exceeded.

d. A monitoring program to ensure the annual dose equivalent to any real individual located outside the ISFSI controlled area does not exceed regulatory limits is incorporated as part of the environmental monitoring program in the Radiological Environmental Monitoring Program of TS 5.1.1.

(continued)

5.0 ADMINISTRATIVE CONTROLS (continued)

e. When using the EOS-TC108 with a liquid neutron shield (NS), the NS shall be verified to be filled when DSC cavity draining or TC/DSC annulus draining operations are initiated and continually monitored during the first five minutes of the draining evolution to ensure the NS remains filled. The NS shall also be verified to be filled prior to the movement of the loaded TC from the decontamination area. Observation of water level in the expansion tank or some other means can be used to verify compliance with this requirement.

f. Following completion of the DSC shell assembly at the fabricator facility, the inner bottom cover plate, canister shell and all associated welds are leak-tested to demonstrate that these welds and components meet the “leak-tight” criterion ($\leq 1.0 \times 10^{-7}$ reference cm^3/sec) as defined in “American National Standard for Radioactive Materials – Leakage Tests on Packages for Shipment”, ANSI N14.5-1997. If the leakage rate exceeds 1.0×10^{-7} reference cm^3/sec, check and repair these welds or components.

Following completion of the welding of the DSC shell to the inner top cover and drain port cover and vent plug after fuel loading, these welds and components are leak-tested to demonstrate that they meet the “leak-tight” criterion ($\leq 1.0 \times 10^{-7}$ reference cm^3/sec) as defined in “American National Standard for Radioactive Materials - Leakage Tests on Packages for Shipment”, ANSI N14.5-1997. If the leakage rate exceeds 1.0×10^{-7} reference cm^3/sec, check and repair these welds or components.

5.1.3 HSM Thermal Monitoring Program

Two separate programs for the EOS-HSM and MATRIX HSM are described in Technical Specifications 5.1.3.1 and 5.1.3.2, respectively.

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5.0 ADMINISTRATIVE CONTROLS (continued)

5.1.3.1 EOS-HSM Thermal Monitoring Program

This program provides guidance for temperature measurements that are used to monitor the thermal performance of each EOS-HSM. The intent of the program is to prevent conditions that could lead to exceeding the concrete and fuel clad temperature criteria. Each user must implement either TS 5.1.3.1(a) OR 5.1.3.1(b).

a. Daily Visual Inspection of EOS-HSM Inlets and Outlets (Front Wall and Roof Birdscreens) and Wind Deflectors

  i. The user shall develop and implement procedures to perform visual inspection of EOS-HSM inlets and outlets on a daily basis.

  Perform a daily visual inspection of the air vents to ensure that EOS-HSM air vents are not blocked for more than 40 hours. If visual inspection indicates blockage, clear air vents and replace or repair birdscreens if damaged. If the air vents are blocked or could have been blocked for more than 40 hours, evaluate existing conditions in accordance with the site corrective action program to confirm that conditions adversely affecting the concrete or fuel cladding do not exist.

  ii. Daily Visual Inspection of Wind Deflectors

  If wind deflectors are required per TS 5.5, the user shall develop and implement procedures to perform visual inspection of the wind deflectors on a daily basis.

  There is a possibility that the wind deflectors could become damaged or lost by extreme winds, tornados, or other accidents. The condition caused by a damaged or lost wind deflector is bounded by the air vent blockage postulated and analyzed in the UFSAR accident analyses. The procedures shall ensure that the duration of a damaged or lost wind deflector will not exceed periods longer than 40 hours as assumed in the UFSAR analyses for vent blockage. If visual inspection indicates a damaged or lost wind deflector, replace or repair the wind deflector. If the wind deflectors are damaged or could have been damaged for more than 40 hours, evaluate existing conditions in accordance with the site corrective action program to confirm that conditions adversely affecting the concrete or fuel cladding do not exist.

b. Daily EOS-HSM Temperature Measurement Program

  i. The user shall develop a daily temperature measurement program to verify the thermal performance of each NUHOMS® EOS System. The user shall establish administrative temperature limits to (1) detect off-normal and accident blockage conditions before the EOS- HSM components and fuel cladding temperatures would exceed temperature design limits and (2) ensure the EOS-HSM air vents are not blocked for more than 40 hours. The daily temperature measurements shall include one of the following options:

    1. direct measurement of the EOS-HSM concrete temperature

    2. direct measurement of inlet and outlet air temperatures

(continued)

5.0 ADMINISTRATIVE CONTROLS (continued)

If the direct measurement of the inlet and outlet air temperatures (option 2) is performed, the measured temperature differences of the inlet and outlet vents of each individual EOS-HSM must be compared to the predicted temperature differences for each individual EOS-HSM during normal operations. The measured temperature difference between the inlet and outlet vents shall not exceed 138 °F.

ii. The user shall establish in the program, measurement locations in the EOS-HSM that are representative of the EOS-HSM thermal performance and directly correlated to the predicted fuel cladding temperatures, air mass flow rates, and NUHOMS® EOS System temperature distributions that would occur with the off-normal and accident blockage conditions, as analyzed in the UFSAR. The administrative temperature limits shall employ appropriate safety margins that ensure temperatures would not exceed design basis temperature limits in the UFSAR, and be based on the UFSAR methodologies used to predict thermal performance of the NUHOMS® EOS System. If the direct measurement of the inlet and outlet air temperatures (option 2) is performed, the user must develop procedures to measure air temperatures that are representative of inlet and outlet air temperatures, as analyzed in the UFSAR. The user must also consider site-specific environmental conditions, loaded decay heat patterns, and the proximity of adjacent EOS-HSM modules in the daily air temperature measurement program. The user must ensure that measured air temperatures reflect only the thermal performance of each individual module, and not the combined performance of adjacent modules.

iii. The user shall establish in the program the appropriate actions to be taken if administrative temperature criteria are exceeded. If an administrative temperature limit is exceeded during a daily measurement, the user shall inspect the vents, wind deflectors if installed, and implement TS 5.1.3.1(a) for the affected system, until the cause of the excursion is determined and necessary corrective actions are completed under the site corrective action program.

iv. If measurements or other evidence indicate that the EOS-HSM concrete temperatures have exceeded the concrete accident temperature limit of 500 °F for more than 40 hours, the user shall perform an analysis and/or tests of the concrete in accordance with TS 5.3. The user shall demonstrate that the structural strength of the EOS-HSM has an adequate margin of safety and take appropriate actions to return the EOS-HSM to normal operating conditions.

v. If measurements or other evidence indicate that off-normal or accident temperature limits for fuel cladding have been exceeded, verify that canister confinement is maintained and assess analytically the condition of the fuel. Additionally, within 30 days, take appropriate actions to restore the spent fuel to a safe configuration.

(continued)

5.0 ADMINISTRATIVE CONTROLS (continued)

5.1.3.2 HSM-MX Thermal Monitoring Program

This program provides guidance for temperature measurements that are used to monitor the thermal performance of each HSM-MX. There are no credible scenarios that could block both the inlet and outlet vents. Therefore, only blockage of inlet vent is considered in the UFSAR. The intent of the program is to prevent conditions that could lead to exceeding the concrete and fuel clad temperature criteria. Each user must implement either TS 5.1.3.2(a) OR 5.1.3.2(b).

a. Daily Visual Inspection of HSM-MX Inlets and Outlets (Front Wall and Roof Birdscreens)

   The user shall develop and implement procedures to perform visual inspection of HSM-MX inlets and outlets on a daily basis.

   Perform a daily visual inspection of the air vents to ensure that HSM-MX air vents are not blocked for more than 32 hours. If visual inspection indicates blockage, clear air vents and replace or repair birdscreens if damaged. If the air vents are blocked or could have been blocked for more than 32 hours, evaluate existing conditions in accordance with the site corrective action program to confirm that conditions adversely affecting the concrete or fuel cladding do not exist.

b. Daily HSM-MX Temperature Measurement Program

   i. The user shall develop a daily temperature measurement program to verify the thermal performance of each HSM-MX System through direct measure of the HSM-MX concrete temperature. The user shall establish administrative temperature limits to (1) detect off-normal and accident blockage conditions before the HSM-MX components and fuel cladding temperatures would exceed temperature design limits and (2) ensure the HSM-MX air vents are not blocked for more than 32 hours.

   ii. The user shall establish in the program measurement locations in the HSM-MX that are representative of the HSM-MX thermal performance and directly correlated to the predicted fuel cladding temperatures, air mass flow rates, and NUHOMS® MATRIX System temperature distributions that would occur with the off-normal and accident blockage conditions, as analyzed in the UFSAR. The administrative temperature limits shall employ appropriate safety margins that ensure temperatures would not exceed design basis temperature limits in the UFSAR, and be based on the UFSAR methodologies used to predict thermal performance of the NUHOMS® MATRIX System.

   iii. The user shall establish in the program the appropriate actions to be taken if administrative temperature criteria are exceeded. If an administrative temperature limit is exceeded during a daily measurement, the user shall inspect the vents and implement TS 5.1.3.2(a) for the affected system, until the cause of the excursion is determined and necessary corrective actions are completed under the site corrective action program.

(continued)

5.0 ADMINISTRATIVE CONTROLS (continued)

iv. If measurements or other evidence indicate that the HSM-MX concrete temperatures have exceeded the concrete accident temperature limit of 500 °F for more than 32 hours, the user shall perform an analysis and/or tests of the concrete in accordance with TS 5.3. The user shall demonstrate that the structural strength of the HSM-MX has an adequate margin of safety and take appropriate actions to return the HSM-MX to normal operating conditions.

v. If measurements or other evidence indicate that off-normal or accident temperature limits for fuel cladding have been exceeded, verify that canister confinement is maintained and assess analytically the condition of the fuel. Additionally, within 30 days, take appropriate actions to restore the spent fuel to a safe configuration.

5.2 Lifting Controls

5.2.1 TC/DSC Lifting Height and Temperature Limits

The requirements of 10 CFR 72 apply to TC/DSC lifting/handling height limits outside the FUEL BUILDING. The requirements of 10 CFR Part 50 apply to TC/DSC lifting/handling height limits inside the FUEL BUILDING. Confirm the surface temperature of the TC before TRANSFER OPERATIONS of the loaded TC/DSC.

The lifting height of a loaded TC/ DSC is limited as a function of low temperature and the type of lifting/handling device, as follows:

- No lifts or handling of the TC/DSC at any height are permissible at TC surface temperatures below 0 °F
- The maximum lift height of the TC/DSC shall be 65 inches for the EOS-DSCs or 80 inches for the 61BTH Type 2 DSC if the surface temperature of the TC is above 0 °F and a non-single-failure-proof lifting/handling device is used.
- No lift height restriction is imposed on the TC/DSC if the TC surface temperature is higher than 0 °F, and a single-failure-proof lifting/handling system is used.

The requirements of 10 CFR Part 72 apply when the TC/DSC is in a horizontal orientation on the transfer trailer. The requirements of 10 CFR Part 50 apply when the TC/DSC is being lifted/handled using the cask handling crane/hoist. (This distinction is valid only with respect to lifting/handling height limits.)

5.2.2 Cask Drop

<u>Inspection Requirement</u>

The TC will be inspected for damage and the DSC will be evaluated after any TC with a loaded DSC side drop of 15 inches or greater.

(continued)

5.0 ADMINISTRATIVE CONTROLS (continued)

Background

TC/DSC handling and loading activities are controlled under the 10 CFR Part 50 license until a loaded TC/DSC is placed on the transporter, at which time fuel handling activities are controlled under the 10 CFR Part 72 license.

Safety Analysis

The analysis of bounding drop scenarios shows that the TC will maintain the structural integrity of the DSC confinement boundary from an analyzed side drop height of 65 inches for the EOS-DSCs and 80 inches for the 61BTH Type 2 DSC. This 65-inch/80-inch drop height envelopes the maximum height from the bottom of the TC when secured to the transfer trailer while en route to the ISFSI.

Although analyses performed for cask drop accidents at various orientations indicate much greater resistance to damage, requiring the inspection of the DSC after a side drop of 15 inches or greater ensures that:

1. The DSC will continue to provide confinement.
2. The TC can continue to perform its design function regarding DSC transfer and shielding.

5.3 Concrete Testing

HSM concrete shall be tested during the fabrication process for elevated temperatures to verify that there are no significant signs of spalling or cracking and that the concrete compressive strength is greater than that assumed in the structural analysis. Tests shall be performed at or above the calculated peak accident temperature and for a period no less than the permissible duration as specified in Technical Specification 5.1.3.

HSM concrete temperature testing shall be performed whenever:

- There is a change in the supplier of the cement, or
- There is a change in the source of the aggregate, or
- The water-cement ratio changes by more than 0.04.

(continued)

5.0 ADMINISTRATIVE CONTROLS (continued)

5.4 Hydrogen Gas Monitoring

For DSCs, while welding the inner top cover during LOADING OPERATIONS, and while cutting the inner top cover to DSC shell weld when the DSC cavity is wet during UNLOADING OPERATIONS, hydrogen monitoring of the space under the top shield plug in the DSC cavity is required, to ensure that the combustible mixture concentration remains below the flammability limit of 4%. If this limit is exceeded, all welding operations shall be stopped and the DSC cavity purged with helium to reduce hydrogen concentration safely below the limit before welding or cutting operations can be resumed.

5.5 EOS-HSM Wind Deflectors

If the heat load of an EOS-37PTH DSC during STORAGE OPERATIONS is greater than 41.8 kW, wind deflectors shall be installed on the EOS-HSM.

If the heat load of a fuel assembly loaded per HLZC 5 in the EOS-37PTH DSC during STORAGE OPERATIONS is greater than 1.625 kW, wind deflectors shall be installed on the EOS-HSM.

If the heat load of an EOS-89BTH DSC during STORAGE OPERATIONS is greater than 41.6 kW, wind deflectors shall be installed on the EOS-HSM.

Table 1
Fuel Assembly Design Characteristics for the EOS-37PTH DSC

PWR FUEL CLASS	B&W 15X15	WE 17X17	CE 15X15	WE 15X15	CE 14X14	WE 14X14	CE 16X16
Fissile Material	UO_2	UO_2	UO_2	UO_2	UO_2	UO_2	UO_2
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

Table 2
Maximum Uranium Loading per FFC for Failed PWR Fuel

Fuel Assembly Class	Maximum Uranium Loading (MTU)
WE 17x17	0.550
CE 16x16	0.456
BW 15x15	0.492
WE 15x15	0.480
CE 15x15	0.450
CE 14x14	0.400
WE 14x14	0.410

Table 3
Co-60 Equivalent Activity for CCs Stored in the EOS-37PTH DSC

<table>
<tr><th rowspan="2">Fuel Region</th><th colspan="3">Maximum Co-60 Equivalent Activity per DSC (Curies/DSC)(2)</th></tr>
<tr><th>Transfer in the EOS-TC108 AND (storage in the EOS-HSM OR HSM-MX)</th><th>Transfer in the EOS-TC125/135 AND storage in the HSM-MX</th><th>Transfer in the EOS-TC125/135 AND storage in the EOS-HSM</th></tr>
<tr><td>Active Fuel</td><td colspan="2">32,656</td><td>37,259</td></tr>
<tr><td>Plenum/Top Region</td><td colspan="2">6,671</td><td>7,607</td></tr>
</table>

Notes:

1. Not Used.
2. NSAs and Neutron Sources shall only be stored in the inner zone of the basket. Figure 3 defines the compartments categorized as the Inner and Peripheral Zones.

Table 4
Maximum Planar Average Initial Enrichment for EOS-37PTH

(2 Pages)

PWR Fuel Class	Maximum Planar Average Initial Enrichment (wt. % U-235) as a Function of Soluble Boron Concentration and Basket Type (Fixed Poison Loading) With and Without CCs								
	Minimum Soluble Boron (ppm)	Basket Type							
		A1/A2/A3/A4H/A4L/A5				B1/B2/B3/B4H/B4L/B5			
		w/o CCs		w/ CCs		w/o CCs		w/ CCs	
		INTACT FUEL	DAMAGED/ FAILED FUEL(2)	INTACT FUEL	DAMAGED/ FAILED FUEL(2)	INTACT FUEL	DAMAGED/ FAILED FUEL(3)	INTACT FUEL	DAMAGED/ FAILED FUEL(3)
WE 17x17 Class	2000	4.35	4.20	4.35	4.15	4.50	4.15	4.45	4.25
	2100	4.50	4.20	4.45	4.20	4.65	4.25	4.60	4.40
	2200	4.60	4.40	4.55	4.35	4.75	4.45	4.70	4.55
	2300	4.70	4.45	4.65	4.50	4.85	4.65	4.85	4.60
	2400	4.85	4.45	4.80	4.60	5.00	4.65	4.95	4.75
	2500	4.95	4.65	4.90	4.70	5.00	5.00	5.00	4.95
CE 16x16 Class	2000	5.00	4.75	5.00	4.70	5.00	5.00	5.00	5.00
	2100	5.00	5.00	5.00	5.00	-	-	-	-
	2200	-	-	-	-	-	-	-	-
	2300	-	-	-	-	-	-	-	-
	2400	-	-	-	-	-	-	-	-
	2500	-	-	-	-	-	-	-	-
BW 15x15 Class	2000	4.25	4.05	4.20	4.00	4.40	4.10	4.35	4.15
	2100	4.40	4.10	4.30	4.15	4.55	4.20	4.45	4.25
	2200	4.50	4.25	4.45	4.15	4.65	4.35	4.60	4.30
	2300	4.60	4.35	4.55	4.30	4.80	4.40	4.70	4.50
	2400	4.75	4.40	4.65	4.45	4.90	4.55	4.85	4.50
	2500	4.85	4.55	4.75	4.65	5.00	4.75	4.90	4.75
	2600	(1)	(1)	(1)	(1)	5.00	5.00	(1)	(1)
WE 15x15	2000	4.45	4.10	4.40	4.10	4.55	4.30	4.55	4.25
	2100	4.60	4.15	4.55	4.15	4.65	4.50	4.65	4.35
	2200	4.70	4.25	4.65	4.35	4.80	4.55	4.80	4.45
	2300	4.85	4.35	4.75	4.45	5.00	4.50	4.95	4.50
	2400	4.95	4.50	4.90	4.50	5.00	4.90	5.00	4.80
	2500	5.00	4.75	5.00	4.65	5.00	5.00	5.00	5.00
CE 15x15 Assembly Class	2000	4.60	4.25	4.55	4.20	4.75	4.35	4.70	4.30
	2100	4.70	4.45	4.65	4.40	4.85	4.50	4.85	4.35
	2200	4.85	4.50	4.80	4.45	5.00	4.60	4.95	4.60
	2300	5.00	4.55	4.90	4.65	5.00	5.00	5.00	4.80
	2400	5.00	5.00	5.00	4.85	5.00	5.00	5.00	5.00
	2500	-	-	5.00	5.00	-	-	-	-
CE 14x14 Assembly Class	2000	5.00	5.00	5.00	4.50	5.00	5.00	5.00	4.95
	2100	-	-	5.00	4.95	-	-	5.00	5.00
	2200	-	-	5.00	5.00	-	-	-	-
	2300	-	-	-	-	-	-	-	-
	2400	-	-	-	-	-	-	-	-
	2500	-	-	-	-	-	-	-	-

Table 4
Maximum Planar Average Initial Enrichment for EOS-37PTH

(2 Pages)

PWR Fuel Class	Maximum Planar Average Initial Enrichment (wt. % U-235) as a Function of Soluble Boron Concentration and Basket Type (Fixed Poison Loading) With and Without CCs								
	Minimum Soluble Boron (ppm)	Basket Type							
		A1/A2/A3/A4H/A4L/A5				B1/B2/B3/B4H/B4L/B5			
		w/o CCs		w/ CCs		w/o CCs		w/ CCs	
		INTACT FUEL	DAMAGED/ FAILED FUEL(2)	INTACT FUEL	DAMAGED/ FAILED FUEL(2)	INTACT FUEL	DAMAGED/ FAILED FUEL(3)	INTACT FUEL	DAMAGED/ FAILED FUEL(3)
WE 14x14 Class	2000	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
	2100	-	-	-	-	-	-	-	-
	2200	-	-	-	-	-	-	-	-
	2300	-	-	-	-	-	-	-	-
	2400	-	-	-	-	-	-	-	-
	2500	-	-	-	-	-	-	-	-

Notes:

1. Not analyzed.
2. May only be stored in basket types A4H and A4L
3. May only be stored in basket types B4H and B4L

Table 5
Minimum B-10 Content in the Neutron Poison Plates of the EOS-37PTH DSC

Basket Type	Minimum B-10 Content (areal density) for MMC (mg/cm^2)
A1/A2/A3/A4H/A4L/A5	28.0
B1/B2/B3/B4H/B4L/B5	35.0

Table 6
Fuel Assembly Design Characteristics for the EOS-89BTH DSC

BWR FUEL CLASS	BWR Fuel ID	Example Fuel Designs (1)(2)
7 x 7	ENC-7-A	ENC-IIIA
7 x 7	ENC-7-B	ENC-III ENC-IIIE ENC-IIIF
7 x 7	GE-7-A	GE-1, GE-2, GE-3
8 x 8	ENC-8-A	ENC Va and Vb
8 x 8	ABB-8-A	SVEA-64
8 x 8	ABB-8-B	SVEA-64
8 x 8	FANP-8-A	FANP 8x8-2
8 x 8	GE-8-A	GE-4, XXX-RCN
8 x 8	GE-8-B	GE-5, GE-Pres GE-Barrier GE-8 Type 1
8 x 8	GE-8-C	GE-8 Type II
8 x 8	GE-8-D	GE-9, GE-10
9 x 9	FANP-9-A	FANP-9x9-79/2 FANP-9x9-72 FANP-9x9-80 FANP-9x9-81
9 x 9	FANP-9-B	Siemens QFA ATRIUM 9
9 x 9	GE-9-A	GE-11, GE-13
10 x 10	ABB-10-A	SVEA-92 SVEA-96Opt SVEA-100
10 x 10	ABB-10-B	SVEA-92 SVEA-96 SVEA-100
10 x 10	ABB-10-C	SVEA-96Opt2
10 x 10	FANP-10-A	ATRIUM 10 ATRIUM 10XM
10 x 10	GE-10-A	GE-12, GE-14
10 x 10	GE-10-B	GNF2
11 x 11	FANP-11-A	ATRIUM 11

Notes:

1. Any fuel channel average thickness up to 0.120 inch is acceptable on any of the fuel designs.
2. Example BWR fuel designs are listed herein and are not all-inclusive.

Table 7A
PWR Minimum Enrichments as a Function of Burnup

Burnup Range (GWd/MTU)	Minimum Enrichment (wt. % U-235)
1-6	0.7
7-16	1.3
17-30	1.8
31-62	Burnup/16[(1)]

Notes:

(1) Round enrichment down to the nearest 0.1%. Example: for 62 GWd/MTU, 62/16 = 3.875%, round down to 3.8%.

(2) Fuel below the minimum enrichment defined in this table is classified as LOW-ENRICHED OUTLIER FUEL. Number and location are specified in Section 2.1.

Table 7B
EOS-37PTH DSC Fuel Qualification Table for Storage in the HSM-MX, All Fuel

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

Burnup (GWd/FA)	Fuel Assembly Average Initial U-235 Enrichment (wt.%)												
	0.7	1.3	1.8	2.0	2.5	2.8	3.1	3.4	3.7	3.8	4.0	4.5	5.0
2.95	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
4.92		2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
9.84			2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
14.76			2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
19.68					2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
22.14						2.16	2.12	2.09	2.05	2.04	2.02	2.00	2.00
24.60							2.35	2.31	2.28	2.26	2.24	2.18	2.14
27.06								2.55	2.51	2.49	2.47	2.41	2.35
29.52									2.76	2.75	2.71	2.64	2.58
30.50										2.85	2.82	2.74	2.67
34.10										3.22	3.20	3.11	3.03

Notes:

(1) The minimum cooling time is 2.0 years.

(2) The burnup in GWd/FA is the assembly average burnup in GWd/MTU multiplied by the MTU of the fuel assembly.

(3) Linear interpolation is allowed to obtain a cooling time within the specified range of burnup and enrichment values.

(4) Extrapolation is allowed to obtain a cooling time in the gray-shaded region.

Table 7C
EOS-37PTH DSC Fuel Qualification Table for Storage in the EOS-HSM, All Fuel

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

Burnup (GWd/FA)	Fuel Assembly Average Initial U-235 Enrichment (wt.%)												
	0.7	1.3	1.8	2.0	2.5	2.8	3.1	3.4	3.7	3.8	4.0	4.5	5.0
2.95	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
3.44		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7.87		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
8.36			1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
9.84			1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
14.76			1.08	1.07	1.03	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00
19.68					1.35	1.32	1.30	1.27	1.25	1.24	1.23	1.20	1.17
22.14						1.48	1.46	1.43	1.40	1.39	1.38	1.34	1.31
24.60							1.62	1.59	1.56	1.55	1.53	1.49	1.45
27.06								1.75	1.72	1.71	1.69	1.65	1.60
29.52									1.89	1.88	1.85	1.80	1.76
30.50										1.94	1.92	1.87	1.82
34.10										2.19	2.17	2.11	2.06

Notes:

(1) The minimum cooling time is 1 year. For fuel transferred in the EOS-TC108, the minimum cooling time is 2.0 years.

(2) The burnup in GWd/FA is the assembly average burnup in GWd/MTU multiplied by the MTU of the fuel assembly.

(3) Linear interpolation is allowed to obtain a cooling time within the specified range of burnup and enrichment values.

(4) Extrapolation is allowed to obtain a cooling time in the gray-shaded region.

Table 8
Maximum Lattice Average Initial Enrichment and Minimum B-10 Areal Density for the EOS-89BTH DSC

<table>
<tr><th rowspan="2">Basket Type</th><th rowspan="2">Loading Configuration - Number of Fuel Assemblies (1)</th><th colspan="3">Maximum Lattice Average Initial Enrichment (wt. % U-235)</th><th colspan="2">Minimum B-10 Areal Density (mg/cm²)</th></tr>
<tr><th>All fuel Except ABB-10-C and ATRIUM 11</th><th>ABB-10-C Fuel</th><th>ATRIUM 11 Fuel</th><th>MMC</th><th>BORAL®</th></tr>
<tr><td rowspan="4">A1/A2/A3 (2)</td><td>89</td><td>4.20</td><td>4.05</td><td>4.05</td><td rowspan="4">32.7</td><td rowspan="4">39.2</td></tr>
<tr><td>88</td><td>4.45</td><td>4.25</td><td>4.25</td></tr>
<tr><td>87</td><td>4.60</td><td>4.40</td><td>4.35</td></tr>
<tr><td>84</td><td>5.00</td><td>4.90</td><td>4.80</td></tr>
<tr><td rowspan="4">B1/B2/B3 (2)</td><td>89</td><td>4.55</td><td>4.35</td><td>4.30</td><td rowspan="4">41.3</td><td rowspan="4">49.6</td></tr>
<tr><td>88</td><td>4.80</td><td>4.60</td><td>4.50</td></tr>
<tr><td>87</td><td>4.95</td><td>4.70</td><td>4.65</td></tr>
<tr><td>84</td><td>5.00</td><td>5.00</td><td>5.00</td></tr>
<tr><td>C1/C2/C3 (2)</td><td>89</td><td>4.85</td><td>4.60</td><td>(3)</td><td>Not Allowed</td><td>60.0</td></tr>
</table>

Note:

1. See Figure 10 for 88-FA, 87-FA and 84-FA loading configurations.
2. Mixing fuel types in the same DSC is permissible based on the calculated enrichments for each fuel type for a given basket type and loading configuration. For example, when mixing GNF2 and ATRIUM 11 fuels in basket type A1/A2/A3 and 88-fuel-assembly loading configuration, the maximum enrichment for GNF2 fuels is 4.45wt% and the maximum enrichment for ATRIUM 11 fuels is 4.25wt%.
3. ATRIUM 11 fuel is not an allowed content for basket type C1/C2/C3.

Table 9
Maximum Lattice Average Initial Enrichment and Minimum B-10 Areal Density for the 61BTH Type 2 DSC (Intact Fuel)

Basket Type	Maximum Lattice Average Initial Enrichment (wt. % U-235)(1)	Minimum B-10 Areal Density, (mg/cm^2)	
		Borated Aluminum/MMC	Boral®
A	3.7	22	27
B	4.1	32	38
C	4.4	42	50
D	4.6	48	58
E	4.8	55	66
F	5.0(1)	62	75

Note:

1) For ATRIUM 11 fuel assemblies, the U-235 wt. % enrichment is reduced by 0.55%. The ATRIUM 11 fuel assemblies are authorized for storage in the Type F basket only.

Table 10
Maximum Lattice Average Initial Enrichment and Minimum B-10 Areal Density for the 61BTH Type 2 DSC (Damaged Fuel)

Basket Type	Maximum Lattice Average Initial Enrichment (wt. % U-235)		Minimum B-10 Areal Density, (mg/cm^2)	
	Up to 4 Damaged Assemblies(1)	Five or More Damaged Assemblies(1) (16 Maximum)	Borated Aluminum/MMC	Boral®
A	3.7	2.80	22	27
B	4.1	3.10	32	38
C	4.4	3.20	42	50
D	4.6	3.40	48	58
E	4.8	3.50	55	66
F	5.0(2, 3)	3.60	62	75

Notes:

1) See Figure 5 for the location of damaged fuel assemblies within the 61BTH Type 2 DSC.
2) ATRIUM 11 fuel assemblies are authorized for storage only in the Type F basket only with a maximum of 4 damaged fuel assemblies.
3) For ATRIUM 11 fuel assemblies, the U-235 wt. % enrichment is reduced by 0.55%.

Table 11
Maximum Lattice Average Initial Enrichment and Minimum B-10 Areal Density for the 61BTH Type 2 DSC (Failed and Damaged Fuel)

Basket Type	Maximum Lattice Average Initial Enrichment (wt. % U-235)		Minimum B-10 Areal Density (mg/cm^2)	
	Up to 4 Failed Assemblies (Corner Locations)(1, 2)	Up to 4 Failed Assemblies (Corner Locations) and up to 12 Damaged Assemblies (Interior Locations)(1, 2)	Borated Aluminum/MMC	Boral®
A	3.7	2.8	22	27
B	4.0	3.1	32	38
C	4.4	3.2	42	50
D	4.6	3.4	48	58
E	4.8	3.4	55	66
F	5.0	3.5	62	75

Notes:

1) See Figure 5 for the locations of the failed and damaged assemblies within the 61BTH Type 2 DSC.
2) Failed ATRIUM 11 fuel assemblies are not authorized for storage in the 61BTH Type 2 DSC.

Table 12
Maximum Lattice Average Initial Enrichments and Minimum B-10 Areal Density for the 61BTH Type 2 DSC for > 16 Damaged Fuel Assemblies

Basket Type	Up to 57 Damaged Fuel at 3.30 wt. % U-235		Minimum B-10 Areal Density (mg/cm^2)	
	Remaining Four Intact Assemblies (1)	Remaining Four Damaged Assemblies (1)	Borated Aluminum/MMC	Boral®
A	-	-	-	-
B	-	-	-	-
C	-	-	-	-
D	5.00	4.20	48	58
E	5.00	4.20	55	66
F	5.00	4.20	62	75

Note:
1) See Figure 5 for the locations of the damaged assemblies within the 61BTH Type 2 DSC

Table 13
BWR Fuel Assembly Design Characteristics for the 61BTH Type 2 DSC

BWR FUEL CLASS	Initial Design or Reload Fuel Designation(1) (3)
7x7-49/0	GE1 GE2 GE3
8x8-63/1	GE4
8x8-62/2	GE-5 GE-Pres GE-Barrier GE8 Type I
8x8-60/4	GE8 Type II
8x8-60/1	GE9 GE10
9x9-74/2	GE11 GE13
10x10-92/2	GE12 GE14 GNF2
7x7-49/0	ENC-IIIA
7x7-48/1Z	ENC-III(2)
8x8-60/4Z	ENC Va ENC Vb
8x8-62/2	FANP 8x8-2
9x9-79/2	FANP9 9x9-2
Siemens QFA	9x9
10x10-91/1	ATRIUM-10 ATRIUM-10XM
11x11	ATRIUM-11

Notes:

(1) Any fuel channel average thickness up to 0.120 inch is acceptable on any of the fuel designs.

(2) Includes ENC-IIIE and ENC-IIIF.

(3) Initial designs or reload fuel designations belonging to a listed fuel class, but not listed herein may be qualified for storage using the same methodology as documented in the UFSAR.

Table 14
Maximum Uranium Loading per FFC for Failed 61BTH Type 2 Fuel

Fuel Assembly Class	Maximum MTU/Assembly
7x7	0.198
8x8	0.188
9x9	0.180
10x10	0.187

Table 15
Deleted

Table 16
Deleted

Table 17
System Configurations for 61BTH Type 2 HLZCs

HLZC	Storage Module	Transfer Cask
1	HSM-MX	OS197/OS197H/ OS197FC-B/OS197HFC-B
2	HSM-MX	OS197/OS197H/ OS197FC-B/OS197HFC-B
3	HSM-MX	OS197/OS197H/ OS197FC-B/OS197HFC-B
4	HSM-MX	OS197/OS197H/ OS197FC-B/OS197HFC-B
5	HSM-MX	OS197FC-B/OS197HFC-B
6	HSM-MX	OS197FC-B/OS197HFC-B
7	HSM-MX	OS197FC-B/OS197HFC-B
8	HSM-MX	OS197FC-B/OS197HFC-B
9	HSM-MX	OS197/OS197H/ OS197FC-B/OS197HFC-B
10	HSM-MX	OS197FC-B/OS197HFC-B

Table 18
BWR Minimum Enrichments as a Function of Burnup (EOS-89BTH DSC and 61BTH Type 2 DSC)

Burnup Range (GWd/MTU)	Minimum Enrichment (wt. %)
1-6	0.7
7-19	0.9
20-35	Burnup/20(1)
36-62	Burnup/16(1)

Notes:

1) Round down to the nearest 0.1%. Example: for 62 GWd/MTU, 62/16 = 3.875%, round down to 3.8%.
2) Fuel below the minimum enrichment defined in this table is classified as LOW-ENRICHED OUTLIER FUEL. Number and location are specified in Section 2.2 for the EOS-89BTH DSC and in Section 2.3 for the 61BTH Type 2 DSC.

Table 19
61BTH Type 2 DSC Fuel Qualification Table, All Fuel

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

Burnup (GWd/FA)	Fuel Assembly Average Initial U-235 Enrichment (wt.%)														
	0.7	0.9	1.0	1.5	1.7	2.2	2.5	2.8	3.1	3.4	3.7	3.8	4.0	4.5	5.0
1.19	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1.39		2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
2.97		2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
3.76		2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
3.96			2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
5.94				2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
6.93					2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
7.13						2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
7.92							2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
8.91								2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
9.90									2.11	2.06	2.01	2.00	2.00	2.00	2.00
10.89										2.29	2.24	2.22	2.19	2.11	2.05
11.88											2.48	2.46	2.43	2.34	2.27
12.28												2.57	2.53	2.44	2.36

Notes:

1) The minimum cooling time is 2.0 years.
2) The burnup in GWd/FA is the assembly average burnup in GWd/MTU multiplied by the MTU of the fuel assembly.
3) Linear interpolation is allowed to obtain a cooling time within the specified range of burnup and enrichment values.
4) Extrapolation is allowed to obtain a cooling time in the gray-shaded region.

Table 20
61BTH Type 2 DSC Fuel Qualification Table, HLZC 2, 4, 5, 6, 7, and 8, Peripheral Locations

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

Burnup (GWd/FA)	Fuel Assembly Average Initial U-235 Enrichment (wt.%)														
	0.7	0.9	1.0	1.5	1.7	2.2	2.5	2.8	3.1	3.4	3.7	3.8	4.0	4.5	5.0
1.19	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
1.39		2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
2.97		2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
3.76		2.35	2.33	2.23	2.20	2.12	2.09	2.06	2.03	2.01	2.00	2.00	2.00	2.00	2.00
3.96			2.41	2.31	2.28	2.20	2.16	2.13	2.10	2.08	2.06	2.05	2.04	2.02	2.00
5.94				3.13	3.09	2.98	2.93	2.88	2.83	2.79	2.75	2.74	2.72	2.67	2.63
6.93					3.55	3.43	3.36	3.29	3.24	3.18	3.14	3.12	3.10	3.03	2.98
7.13						3.52	3.45	3.39	3.33	3.27	3.22	3.21	3.18	3.11	3.06
7.92							3.87	3.79	3.71	3.64	3.58	3.57	3.53	3.45	3.38
8.91								4.39	4.29	4.20	4.12	4.10	4.05	3.94	3.85
9.90									5.03	4.91	4.80	4.77	4.70	4.56	4.43
10.89										5.86	5.70	5.65	5.56	5.35	5.18
11.88											6.97	6.89	6.75	6.45	6.19
12.28												7.53	7.36	7.00	6.70

Notes:

1) The minimum cooling time is 2.0 years.
2) The burnup in GWd/FA is the assembly average burnup in GWd/MTU multiplied by the MTU of the fuel assembly.
3) Linear interpolation is allowed to obtain a cooling time within the specified range of burnup and enrichment values.
4) Extrapolation is allowed to obtain a cooling time in the gray-shaded region.
5) The peripheral locations are defined in Figure 6.

Table 21
EOS-89BTH DSC Fuel Qualification Table, All Fuel

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

Burnup (GWd/FA)	Fuel Assembly Average Initial U-235 Enrichment (wt.%)														
	0.7	0.9	1.0	1.5	1.7	2.2	2.5	2.8	3.1	3.4	3.7	3.8	4.0	4.5	5.0
1.19	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1.39		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2.97		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
3.76		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
3.96			1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
5.94				1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
6.93					1.11	1.06	1.03	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7.13						1.09	1.06	1.03	1.00	1.00	1.00	1.00	1.00	1.00	1.00
7.92							1.17	1.14	1.11	1.08	1.06	1.05	1.04	1.00	1.00
8.91								1.28	1.25	1.22	1.19	1.18	1.16	1.12	1.09
9.90									1.40	1.36	1.33	1.32	1.30	1.25	1.21
10.89										1.51	1.48	1.46	1.44	1.39	1.34
11.88											1.63	1.62	1.59	1.53	1.48
12.28												1.68	1.66	1.60	1.54

Notes:

1) The minimum cooling time is 1.0 year.
2) The burnup in GWd/FA is the assembly average burnup in GWd/MTU multiplied by the MTU of the fuel assembly.
3) Linear interpolation is allowed to obtain a cooling time within the specified range of burnup and enrichment values.
4) Extrapolation is allowed to obtain a cooling time in the gray-shaded region.
5) For fuel transferred in the EOS-TC108, additional cooling time restrictions are specified in Figure 2.

Table 22
EOS-89BTH DSC Reconstituted Fuel Limits for Transfer in the EOS-TC125

Parameter	Limit
Number of RECONSTITUTED FUEL ASSEMBLIES per DSC	≤ 89
Maximum number of irradiated stainless steel rods per RECONSTITUTED FUEL ASSEMBLY	Per table below
Minimum cooling time	Per table below

Number of Irradiated Stainless Steel Rods per Fuel Assembly										Minimum Cooling Time (years)
7x7 Class		8x8 Class		9x9 Class		10x10 Class		11x11 Class		
Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	
0	5	0	6	0	7	0	9	0	11	Per Table 21
6	15	7	18	8	22	10	26	12	34	2.00
16	20	19	24	23	29	27	34	35	46	2.25
21	25	25	30	30	37	35	43	47	57	2.50
26	30	31	36	38	44	44	51	58	69	2.75
31	35	37	42	45	51	52	60	70	80	3.00
36	49	43	64	52	81	61	100	81	112	3.25

Table 23
EOS-89BTH DSC Reconstituted Fuel Limits for Transfer in the EOS-TC108

Parameter	Limit
Number of RECONSTITUTED FUEL ASSEMBLIES per DSC	• ≤ 89 (all types) • ≤ 49 containing irradiated stainless steel rods
Maximum number of irradiated stainless steel rods per DSC	• 100 for 7x7 Class • 120 for 8x8 Class • 140 for 9x9 Class • 180 for 10x10 Class • 220 for 11x11 Class
Maximum number of irradiated stainless steel rods per RECONSTITUTED FUEL ASSEMBLY	• 5 for 7x7 Class • 6 for 8x8 Class • 7 for 9x9 Class • 9 for 10x10 Class • 11 for 11x11 Class
Loading restrictions for locations within the basket	Per Figure 9
Minimum cooling time	Per Table 21

Table 24
EOS-37PTH DSC Reconstituted Fuel Limits for Transfer in the EOS-TC125/135 AND Storage in the EOS-HSM

Parameter	Limit
Number of RECONSTITUTED FUEL ASSEMBLIES per DSC	≤ 37
Maximum number of irradiated stainless steel rods per RECONSTITUTED FUEL ASSEMBLY	Per table below
Minimum cooling time	Per table below

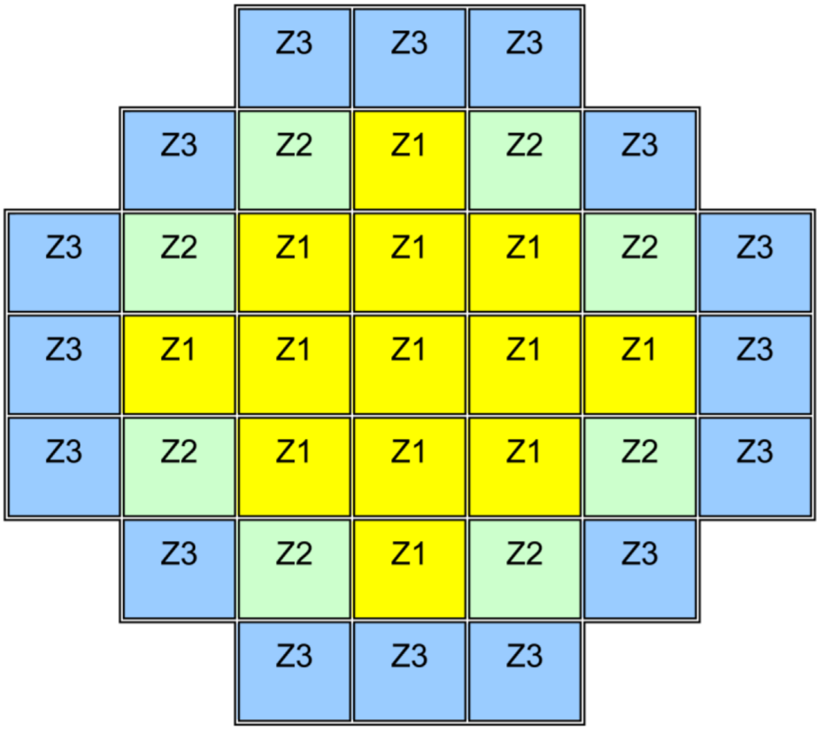
Number of Irradiated Stainless Steel Rods per Fuel Assembly								Minimum Cooling Time (years)
14x14 Class		15x15 Class		16x16 Class		17x17 Class		
Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	
0	8	0	10	0	11	0	13	Per Table 7C
9	17	11	20	12	23	14	25	3.00
18	34	21	40	24	45	26	51	4.00
35	51	41	60	46	68	52	76	4.50
52	68	61	80	69	91	77	102	5.00
69	85	81	100	92	113	103	127	5.25
86	102	101	120	114	136	128	152	5.50
103	118	121	140	137	159	153	178	5.75
119	135	141	160	160	182	179	203	6.00
136	179	161	216	183	236	204	264	6.25

Table 25
EOS-37PTH DSC Reconstituted Fuel Limits for Transfer in the EOS-TC108

Number of RECONSTITUTED FUEL ASSEMBLIES per DSC	• ≤ 37 (all types) • ≤ 21 containing irradiated stainless steel rods
Maximum number of irradiated stainless steel rods per DSC	• 32 for 14x14 Class • 40 for 15x15 Class • 48 for 16x16 and 17x17 Classes
Maximum number of irradiated stainless steel rods per RECONSTITUTED FUEL ASSEMBLY	• 4 for 14x14 Class • 5 for 15x15 Class • 6 for 16x16 and 17x17 Classes
Loading restrictions for locations within the basket	Per Figure 14
Minimum cooling time	2 years

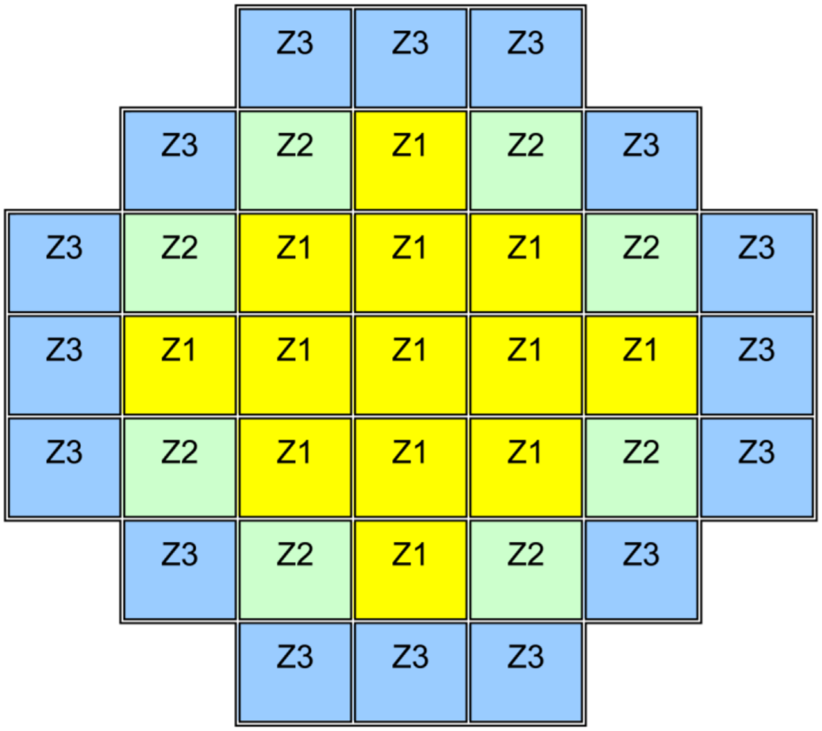
Figure 1A
Heat Load Zone Configuration 1 for the EOS-37PTH DSC

See Figure 2-3a of Chapter 2 of the UFSAR for HLZC 1



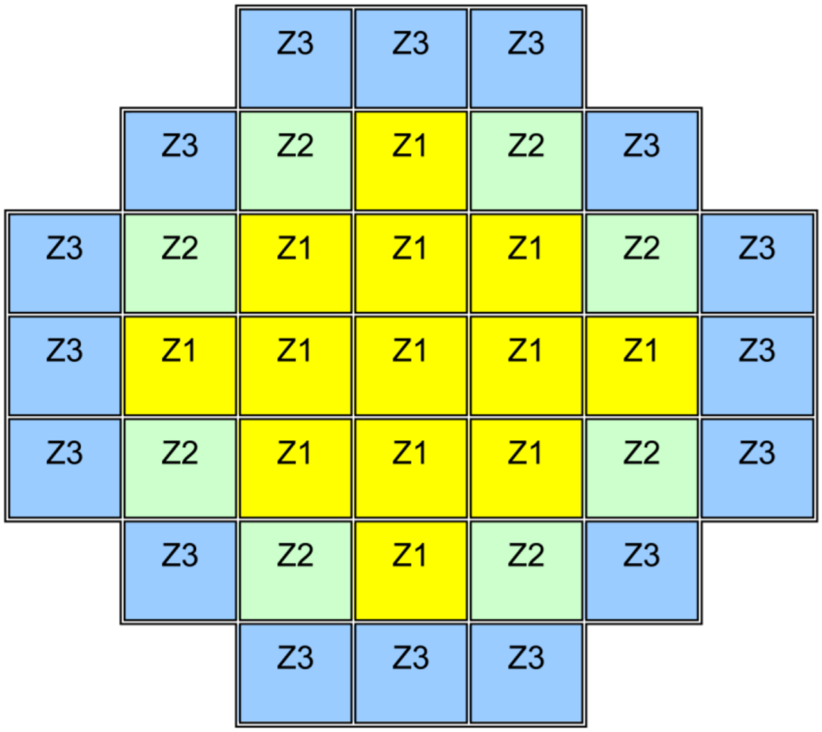
Zone Number	1	2	3
Maximum Decay Heat, (H), (kW/FA plus CCs, if included)	1.0	1.5	1.05
Maximum Number of Fuel Assemblies	13	8	16
Maximum Decay Heat per DSC (kW)	41.8		

Figure 1B
Heat Load Zone Configuration 2 for the EOS-37PTH DSC



Zone Number	1	2	3
Maximum Decay Heat (kW/FA plus CCs, if included)	0.95	1.0	1.0
Maximum Number of Fuel Assemblies	13	8	16
Maximum Decay Heat per DSC (kW)	36.35		

Figure 1C
Heat Load Zone Configuration 3 for the EOS-37PTH DSC

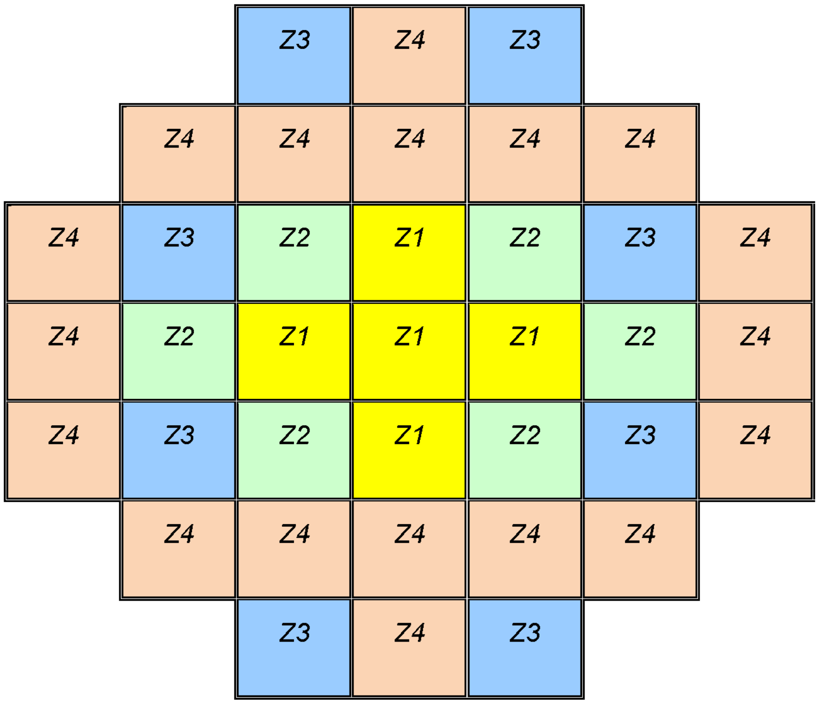


Zone Number	1	2	3
Maximum Decay Heat (kW/FA plus CCs, if included)	1.0	1.625	1.6
Maximum Number of Fuel Assemblies	13	8	16
Maximum Decay Heat per DSC (kW)	50.0(1)		

Notes:

1. Adjust payload to maintain total canister heat load within the specified limit.

Figure 1D
Heat Load Zone Configuration 4 for the EOS-37PTH DSC

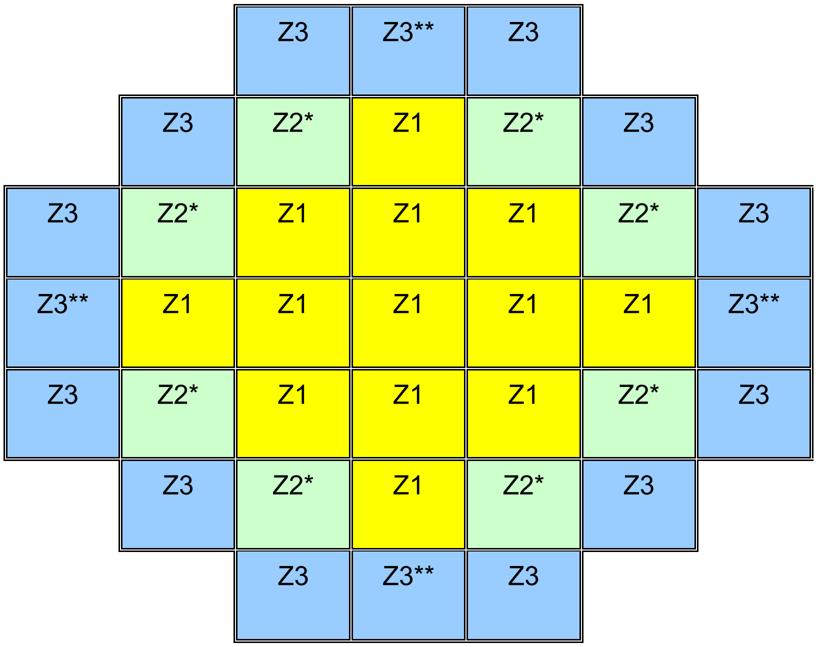


Zone Number	1	2	3	4
Maximum Decay Heat (kW/FA plus CCs, if included)	0.7	0.5	2.4	0.85
Maximum Number of Fuel Assemblies	5	6	8	18
Maximum Decay Heat per DSC (kW)	41.0			

Notes:

1. Adjust payload to maintain total canister heat load within the specified limit.

Figure 1E
Heat Load Zone Configuration 5 for the EOS-37PTH DSC

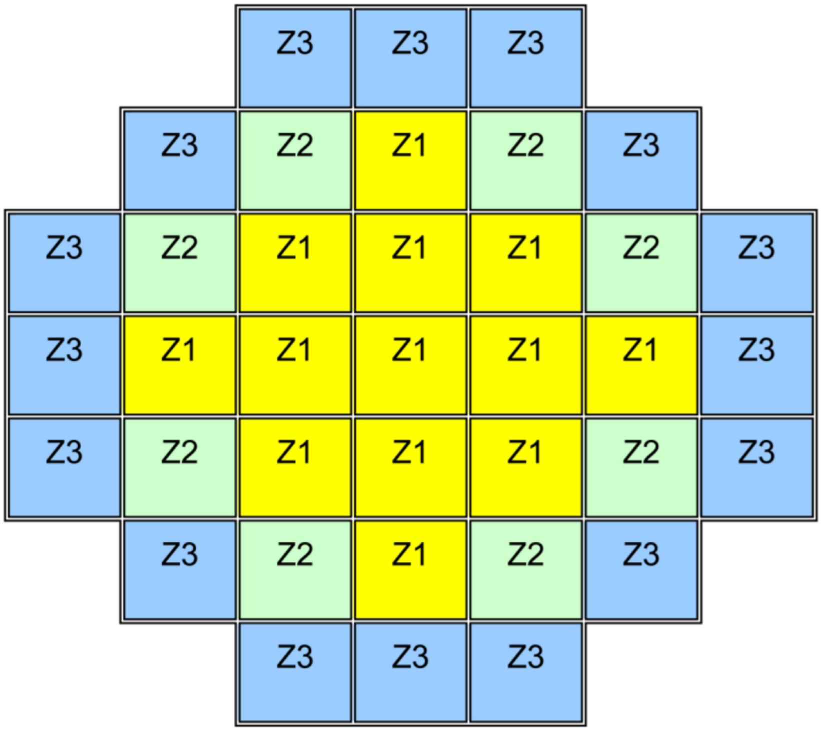


(*) denotes location where INTACT or DAMAGED FUEL can be stored.
(**) denotes location where INTACT or FAILED FUEL can be stored.

Zone Number	1	2(1)	3(1)
Maximum Decay Heat (kW/FA plus CCs, if included)	1.0	1.5	1.3125(2)
Maximum Number of Fuel Assemblies	13	8	16
Maximum Decay Heat per DSC (kW)	46.00		

1. DAMAGED FUEL and FAILED FUEL shall not be loaded in the same DSC.
2. The maximum allowable heat load per FAILED FUEL compartment is 0.8 kW.

Figure 1F
Heat Load Zone Configuration 6 for the EOS-37PTH DSC



Zone Number	1	2	3
Maximum Number of Fuel Assemblies	13	8	16
Upper Compartment			
Maximum Decay Heat (kW/FA plus CCs, if included)	1.0	1.60	1.3125
Maximum Decay Heat per DSC (kW)	41.8[(1)]		
Lower Compartment			
Maximum Decay Heat (kW/FA plus CCs, if included)	0.9	1.60	1.60
Maximum Decay Heat per DSC (kW)	50.0[(1)]		

Notes:

1. Adjust payload to maintain total canister heat load within the specified limit.

Figure 1G
Heat Load Zone Configuration 7 for the EOS-37PTH DSC

		Z3	Z3**	Z3		
	Z3	Z2*	Z1	Z2*	Z3	
Z3	Z2*	Z1	Z1	Z1	Z2*	Z3
Z3**	Z1	Z1	Z1	Z1	Z1	Z3**
Z3	Z2*	Z1	Z1	Z1	Z2*	Z3
	Z3	Z2*	Z1	Z2*	Z3	
		Z3	Z3**	Z3		

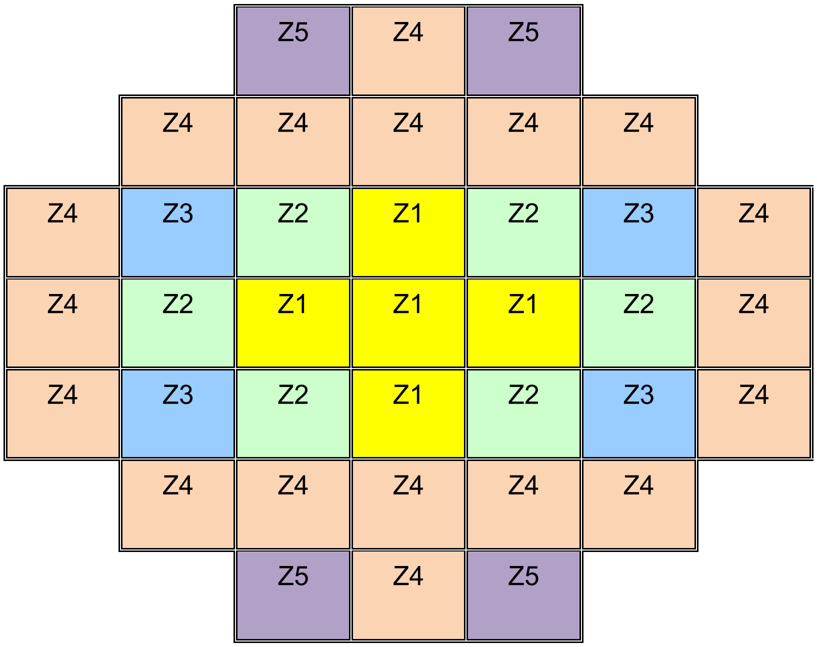
(*) denotes location where INTACT or DAMAGED FUEL can be stored.
(**) denotes location where INTACT or FAILED FUEL can be stored.

Zone Number	1	2[2]	3[2][3]
Maximum Number of Fuel Assemblies	13	8	16
Upper Compartment			
Maximum Decay Heat (kW/FA plus CCs, if included)	0.8	1.50	1.50
Maximum Decay Heat per DSC (kW)	41.8[1][4]		
Lower Compartment			
Maximum Decay Heat (kW/FA plus CCs, if included)	0.8	1.50	1.50
Maximum Decay Heat per DSC (kW)	46.4[1]		

Notes:

1. The maximum decay heat per DSC is limited to 41.8 kW when DAMAGED or FAILED FUEL is loaded.
2. DAMAGED FUEL and FAILED FUEL shall not be loaded in the same DSC.
3. The maximum allowable heat load per FAILED FUEL is 0.8 kW.
4. Adjust payload to maintain total canister heat load within the specified limit.

Figure 1H
Heat Load Zone Configuration 8 for the EOS-37PTH DSC

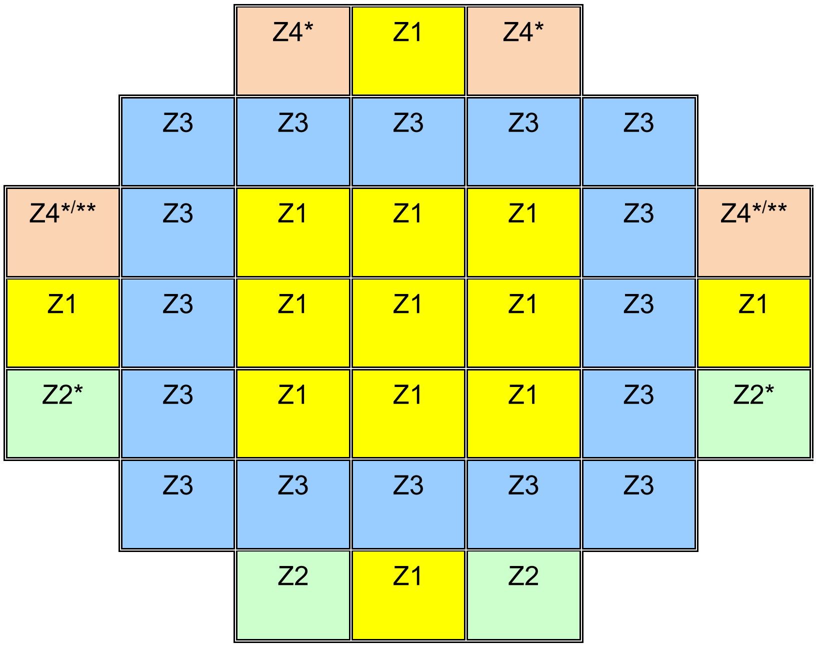


Zone Number	1	2	3	4	5
Maximum Decay Heat (kW/FA plus CCs, if included)	0.50	0.70	2.0	0.75	2.4
Maximum Number of Fuel Assemblies	5	6	4	18	4
Maximum Decay Heat per DSC (kW)	37.80				

Figure 1I
Heat Load Zone Configuration 9 for the EOS-37PTH DSC

Figure 1J
Heat Load Zone Configuration 10 for the EOS-37PTH DSC

See Figure 2-3j of Chapter 2 of the UFSAR for HLZC 10



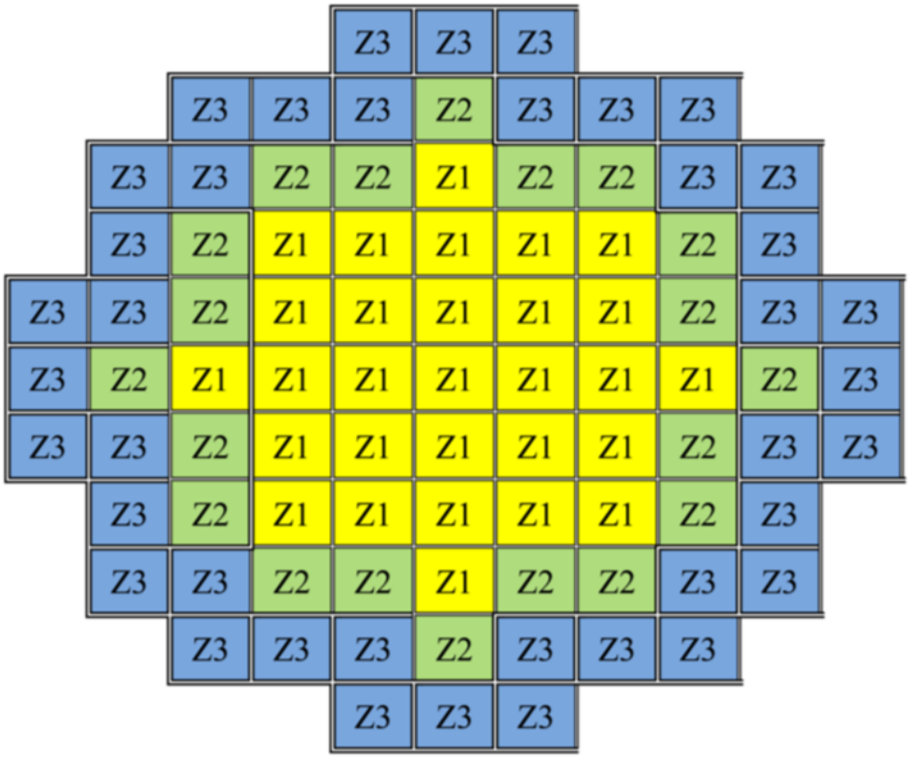
(*) denotes location where INTACT or DAMAGED FUEL ASSEMBLY can be stored.
(**) denotes location where INTACT or FAILED FUEL can be stored.

Zone Number	1	2(1)	3	4(1)
Maximum Number of Fuel Assemblies	13	4	16	4
Upper Compartment				
Maximum Decay Heat (kW/FA plus CCs, if included)	0.5	3.0	0.7	3.0(2)
Maximum Decay Heat per DSC (kW)	41.8			
Lower Compartment				
Maximum Decay Heat (kW/FA plus CCs, if included)	0.5	3.5	0.7	3.2(2)
Maximum Decay Heat per DSC (kW)	44.5			

Notes:

1. DAMAGED FUEL and FAILED FUEL shall not be loaded in the same DSC.
2. The maximum allowable heat load per FAILED FUEL is 0.8 kW.

Figure 1K
Heat Load Zone Configuration 11 for the EOS-37PTH DSC



Heat Load Zone Configuration 2

Zone Number	1	2	3[(1)]
Maximum Decay Heat (kW/FA plus channel, if included)	0.4	0.5	0.5
Maximum Number of Fuel Assemblies	29	20	40
Maximum Decay Heat per DSC (kW)	41.6		

Heat Load Zone Configuration 3

Zone Number	1	2	3[(2)]
Maximum Decay Heat (kW/FA plus channel, if included)	0.36	0.4	0.4
Maximum Number of Fuel Assemblies	29	20	40
Maximum Decay Heat per DSC (kW)	34.44		

Notes:

1. The minimum cooling time for HLZC 2 Zone 3 in the EOS-TC108 is 9.7 years.
2. The minimum cooling time for HLZC 3 Zone 3 in the EOS-TC108 is 9.0 years.

Figure 2
EOS-89BTH DSC Heat Load Zone Configurations for transfer in the EOS-TC108

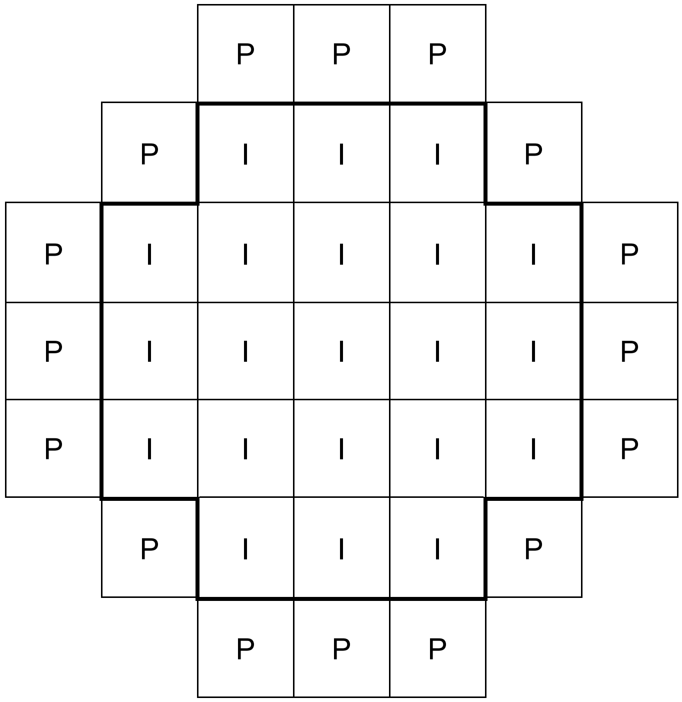
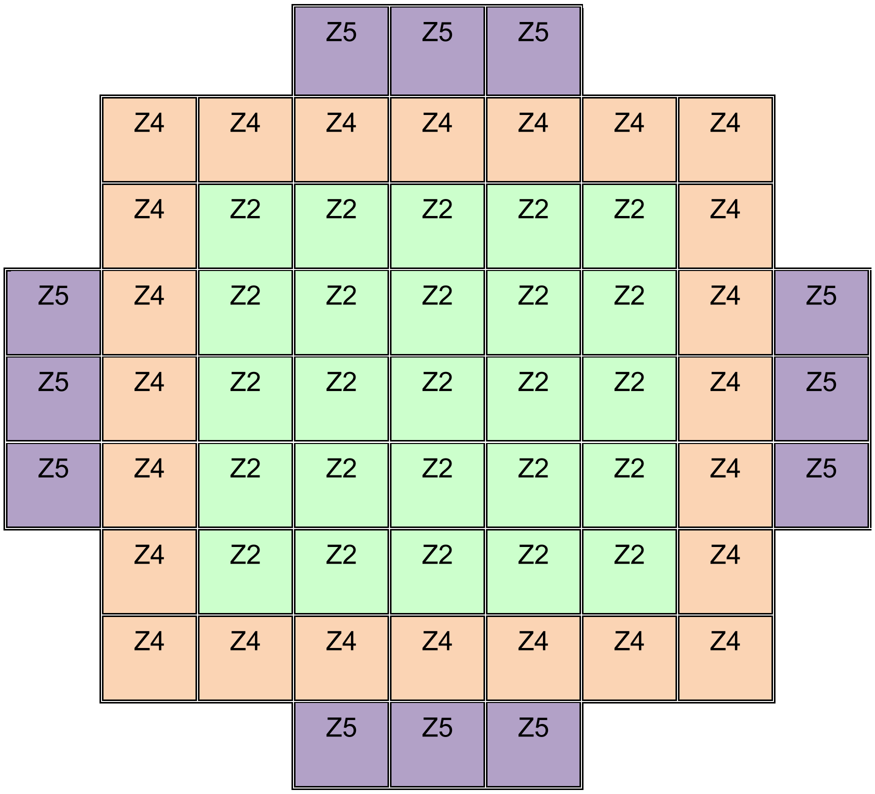


Figure 3
Peripheral (P) and Inner (I) Fuel Locations for the EOS-37PTH DSC

			Z3	Z3	Z3			
	Z3	Z3	Z3	Z3	Z3	Z3	Z3	
	Z3	Z3	Z3	Z3	Z3	Z3	Z3	
Z3	Z3	Z3	Z3	Z3	Z3	Z3	Z3	Z3
Z3	Z3	Z3	Z3	Z3	Z3	Z3	Z3	Z3
Z3	Z3	Z3	Z3	Z3	Z3	Z3	Z3	Z3
	Z3	Z3	Z3	Z3	Z3	Z3	Z3	
	Z3	Z3	Z3	Z3	Z3	Z3	Z3	
			Z3	Z3	Z3			

	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
Maximum Decay Heat (kW/FA)	NA	NA	0.393	NA	NA	NA
Maximum Decay Heat per Zone (kW)	NA	NA	22.0	NA	NA	NA
Maximum Decay Heat per DSC (kW)	22.0					

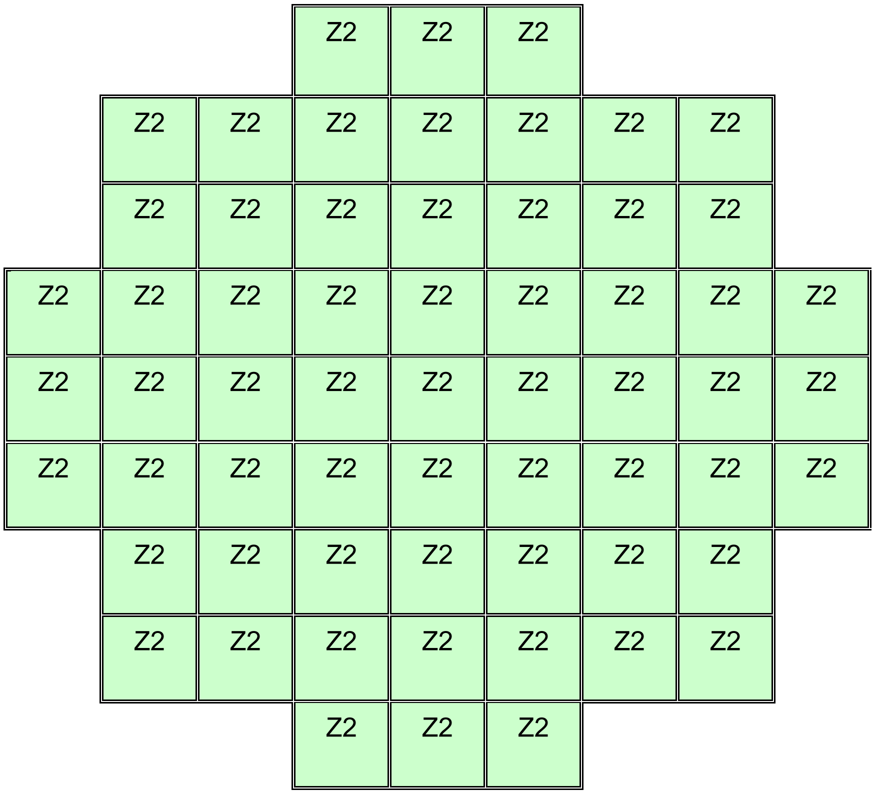
Figure 4A
Heat Load Zone Configuration 1 for the 61BTH Type 2 DSC



	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
Maximum Decay Heat (kW/FA)	NA	0.35	NA	0.48	0.54	NA
Maximum Decay Heat per Zone (kW)	NA	8.75	NA	11.52	6.48	NA
Maximum Decay Heat per DSC (kW)	22.0(1)					

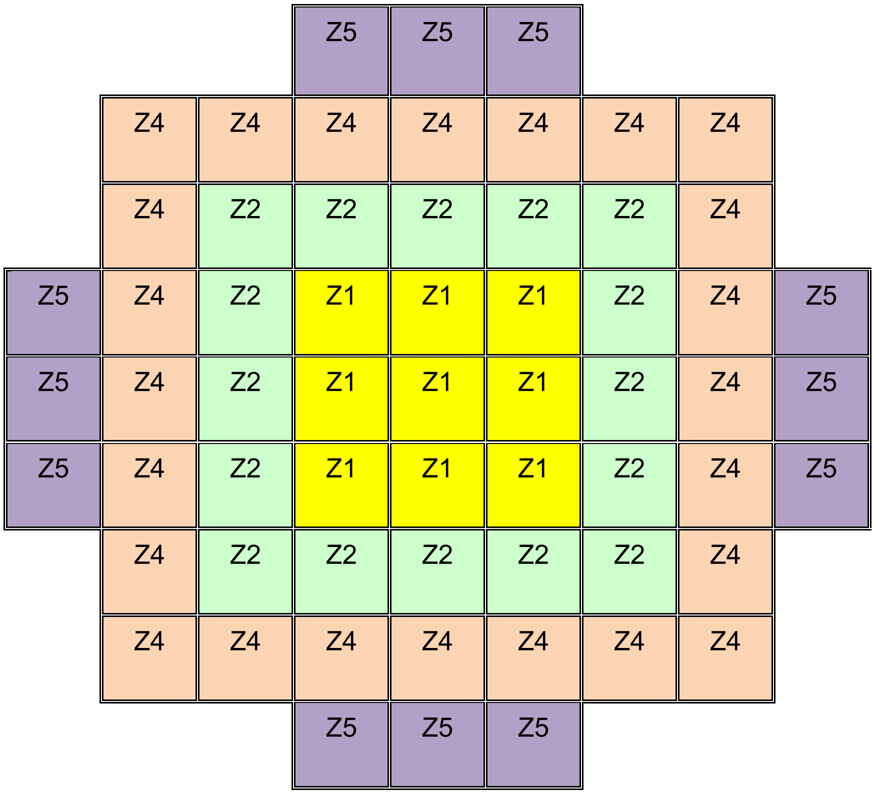
(1) Adjust payload to maintain total DSC heat load within the specified limit

Figure 4B
Heat Load Zone Configuration 2 for the 61BTH Type 2 DSC



	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
Maximum Decay Heat (kW/FA)	NA	0.35	NA	NA	NA	NA
Maximum Decay Heat per Zone (kW)	NA	19.4	NA	NA	NA	NA
Maximum Decay Heat per DSC (kW)	19.4					

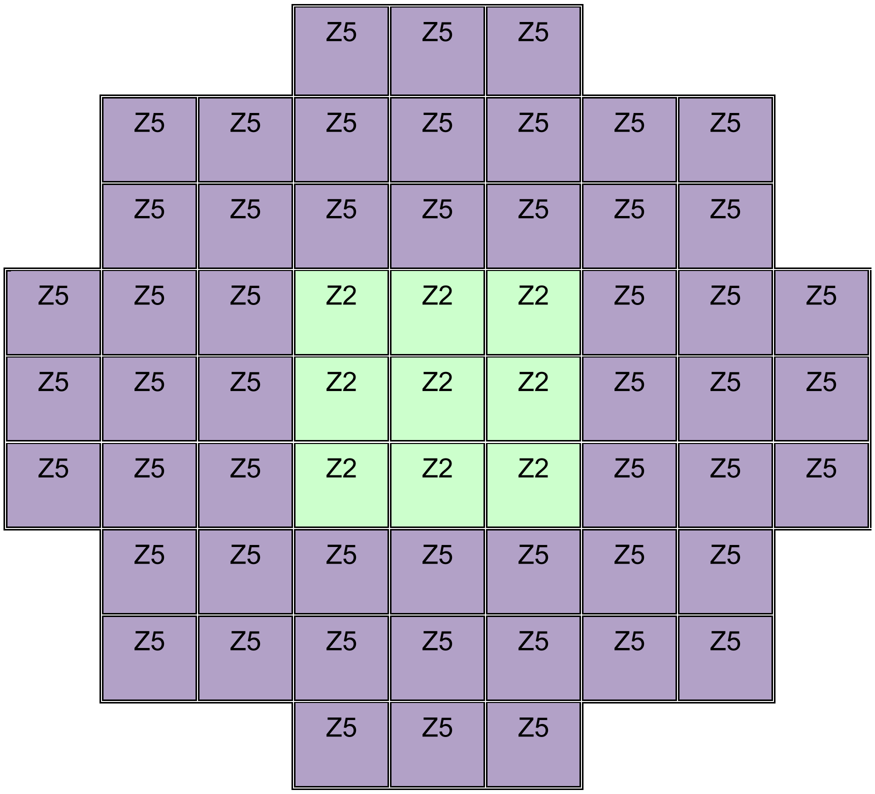
Figure 4C
Heat Load Zone Configuration 3 for the 61BTH Type 2 DSC



	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
Maximum Decay Heat (kW/FA)	0.22	0.35	NA	0.48	0.54	NA
Maximum Decay Heat per Zone (kW)	1.98	5.60	NA	11.52	6.48	NA
Maximum Decay Heat per DSC (kW)	19.4[1]					

[1] Adjust payload to maintain total DSC heat load within the specified limit.

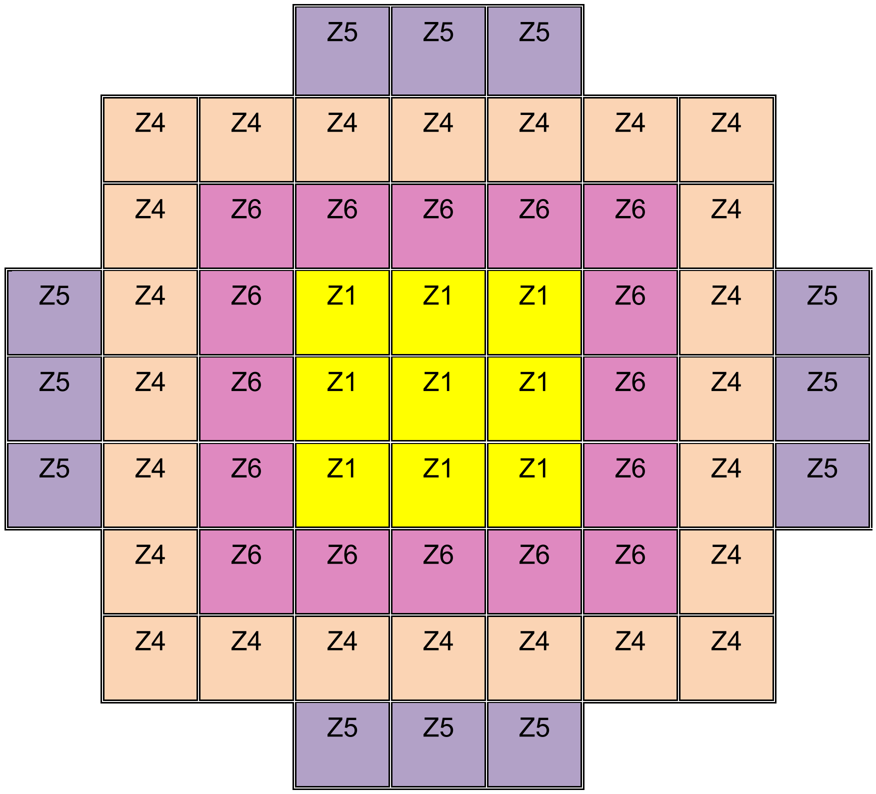
Figure 4D
Heat Load Zone Configuration 4 for the 61BTH Type 2 DSC



	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
Maximum Decay Heat (kW/FA)	NA	0.35	NA	NA	0.54	NA
Maximum Decay Heat per Zone (kW)	NA	3.15	NA	NA	28.08	NA
Maximum Decay Heat per DSC (kW)	31.2[(1)]					

[(1)] Adjust payload to maintain total DSC heat load within the specified limit.

Figure 4E
Heat Load Zone Configuration 5 for the 61BTH Type 2 DSC



	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
Maximum Decay Heat (kW/FA)	0.22	NA	NA	0.48	0.54	0.70
Maximum Decay Heat per Zone (kW)	1.98	NA	NA	11.52	6.48	11.20
Maximum Decay Heat per DSC (kW)	31.2					

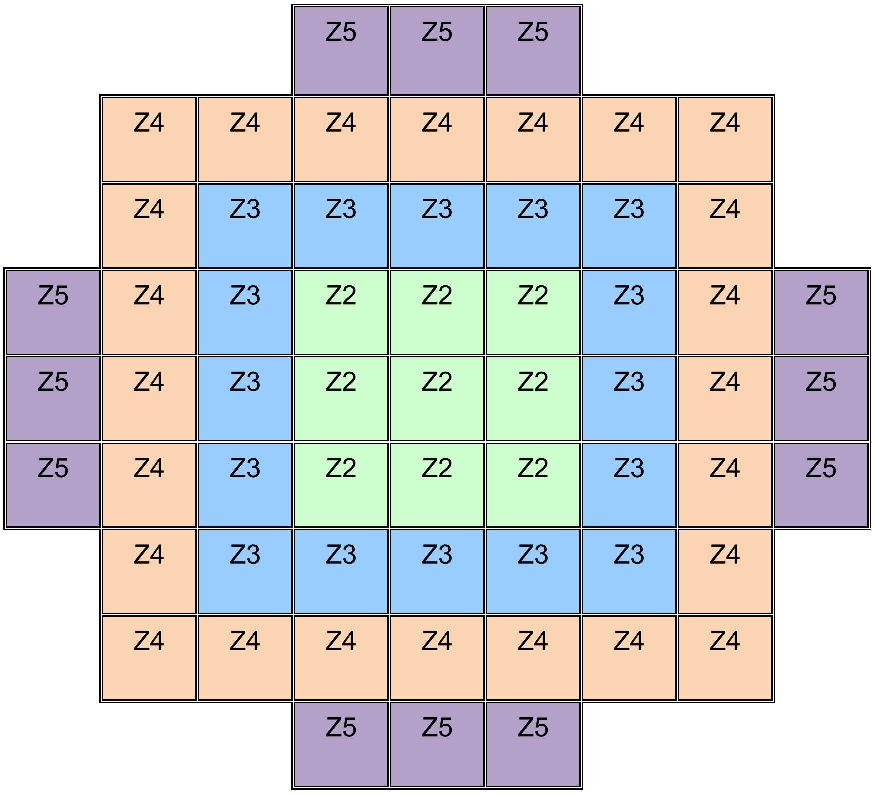
Figure 4F
Heat Load Zone Configuration 6 for the 61BTH Type 2 DSC

			Z5	Z5	Z5			
	Z5	Z5	Z5	Z5	Z5	Z5	Z5	
	Z5	Z4	Z4	Z4	Z4	Z4	Z5	
Z5	Z5	Z4	Z4	Z4	Z4	Z4	Z5	Z5
Z5	Z5	Z4	Z4	Z4	Z4	Z4	Z5	Z5
Z5	Z5	Z4	Z4	Z4	Z4	Z4	Z5	Z5
	Z5	Z4	Z4	Z4	Z4	Z4	Z5	
	Z5	Z5	Z5	Z5	Z5	Z5	Z5	
			Z5	Z5	Z5			

	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
Maximum Decay Heat (kW/FA)	NA	NA	NA	0.48	0.54	NA
Maximum Decay Heat per Zone (kW)	NA	NA	NA	12.00	19.44	NA
Maximum Decay Heat per DSC (kW)	31.2(1)					

(1) Adjust payload to maintain total DSC heat load within the specified limit.

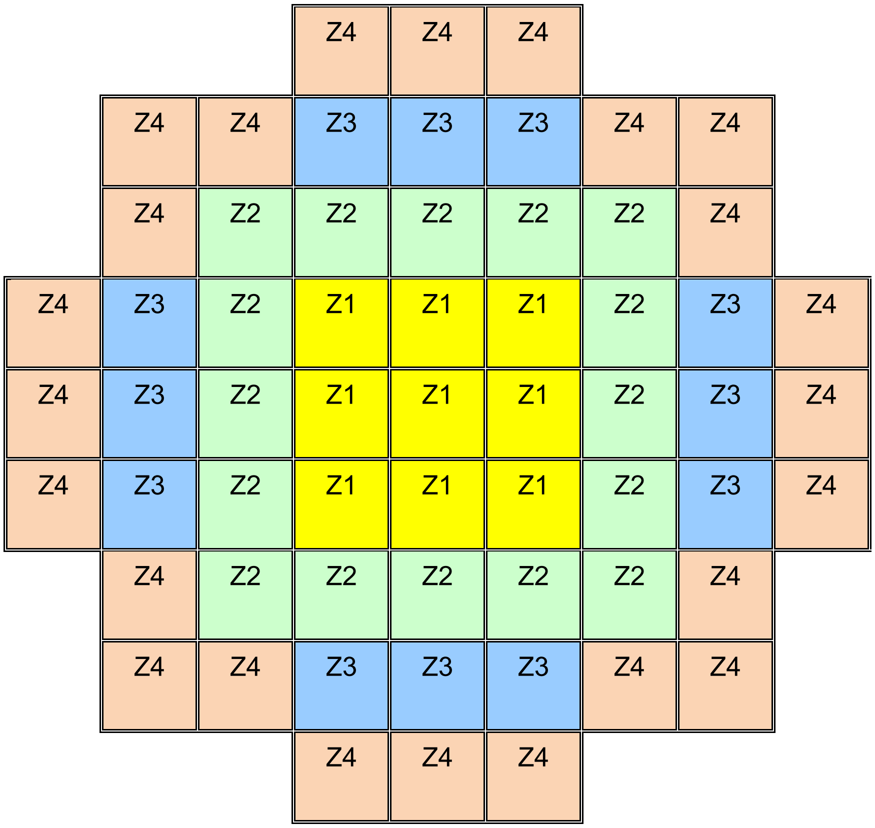
Figure 4G
Heat Load Zone Configuration 7 for the 61BTH Type 2 DSC



	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
Maximum Decay Heat (kW/FA)	NA	0.35	0.393	0.48	0.54	NA
Maximum Decay Heat per Zone (kW)	NA	3.15	6.288	11.52	6.48	NA
Maximum Decay Heat per DSC (kW)	27.4[1]					

[1] Adjust payload to maintain total DSC heat load within the specified limit.

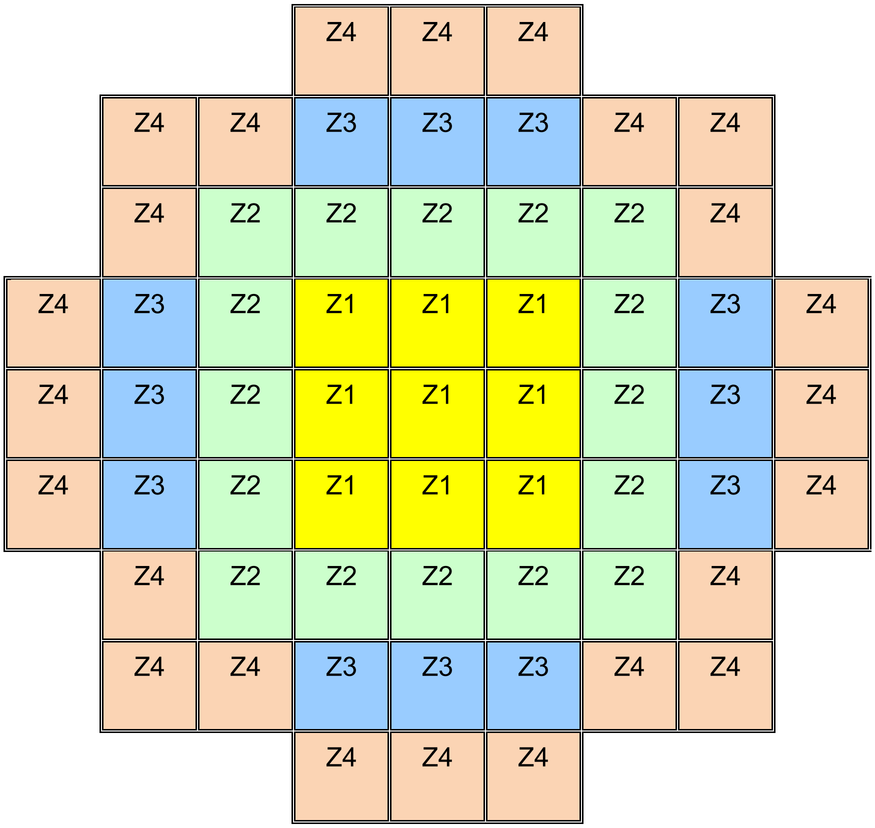
Figure 4H
Heat Load Zone Configuration 8 for the 61BTH Type 2 DSC



	Zone 1	Zone 2	Zone 3	Zone 4
Maximum Decay Heat (kW/FA)	0.393	0.48	0.35	0.35
Maximum Decay Heat per Zone (kW)	3.54	7.68	4.2	8.4
Maximum Decay Heat per DSC (kW)	22.0[1]			

Note 1: Adjust payload to maintain total canister heat load within the specified limit.

Figure 4I
Heat Load Zone Configuration 9 for the 61BTH Type 2 DSC



	Zone 1	Zone 2	Zone 3	Zone 4
Maximum Decay Heat (kW/FA)	0.393	0.48(2)	1.20(2)	0.48(2)
Maximum Decay Heat per Zone (kW)	3.54	7.68	14.4	11.52
Maximum Decay Heat per DSC (kW)	31.2(1)			

Note 1: Adjust payload to maintain total canister heat load within the specified limit.

Note 2: If the maximum decay heat per FA in Zone 3 is greater than 0.9 kW, the maximum decay heat per FA in Zone 2 and Zone 4 shall be less than or equal to 0.393 kW.

Figure 4J
Heat Load Zone Configuration 10 for the 61BTH Type 2 DSC

			C	C	C			
	A	B	C	C	C	B	A	
	B	B	C	C	C	B	B	
C	C	C	C	C	C	C	C	C
C	C	C	C	C	C	C	C	C
C	C	C	C	C	C	C	C	C
	B	B	C	C	C	B	B	
	A	B	C	C	C	B	A	
			C	C	C			

A	Corner Locations See Note 1
C	Interior/Edge Locations See Note 3

B	Interior Locations See Note 2

Note 1: When loading up to 4 damaged or 4 failed assemblies, these must be placed in corner “A” locations, and the remaining locations “B” and “C” shall be loaded with intact fuel. If fewer than 4 damaged or 4 failed assemblies are to be stored, the remaining “A” locations may be loaded with intact fuel provided they meet the respective damaged or failed enrichment limits of Table 10 or Table 11. Damaged and failed fuel shall not be mixed, i.e., up to four damaged assemblies may be stored, or up to four failed assemblies may be stored in “A” locations.

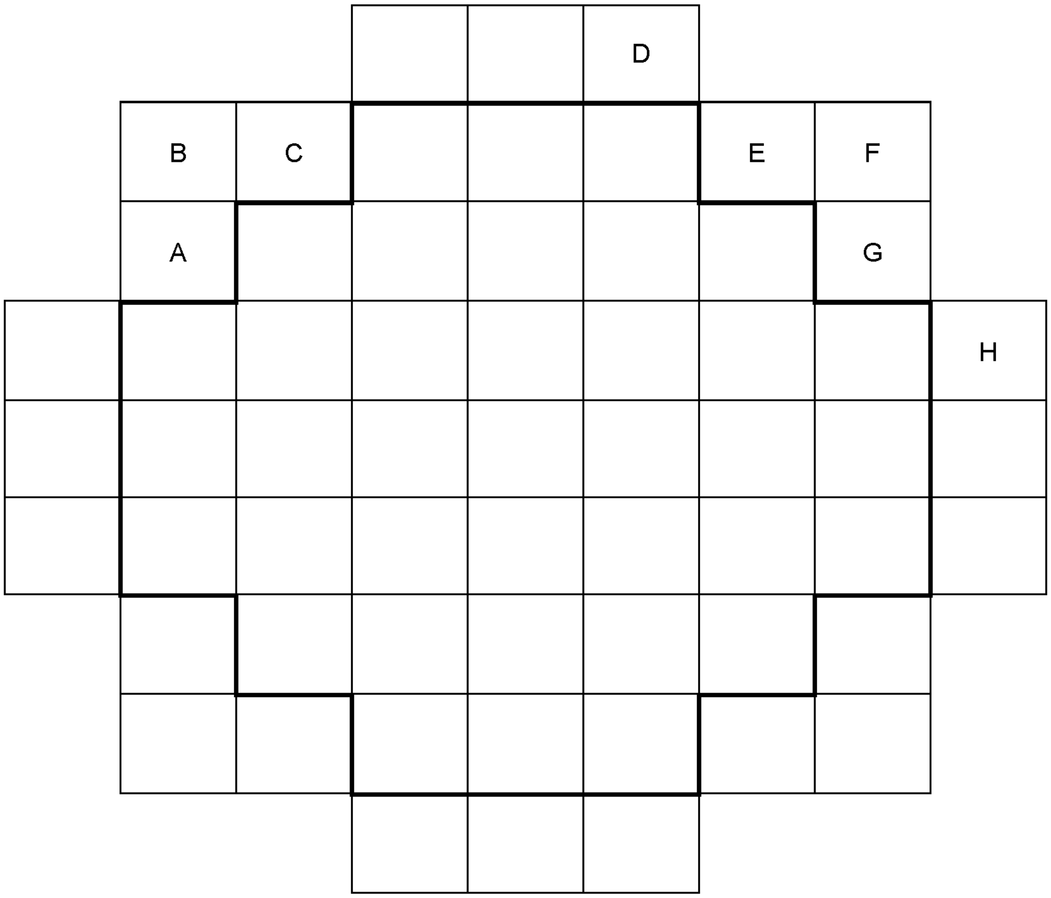
Note 2: If loading more than four damaged assemblies, place first four damaged assemblies in the corner “A” locations per Note 1, and up to 12 additional damaged assemblies in these interior “B” locations, with the remaining intact in a 61BTH Type 2 Basket. The maximum lattice average initial enrichment of assemblies (damaged or intact stored in the 2x2 cells) is limited to the “Five or More Damaged Assemblies” column of Table 10. For the 61BTH Type 2 DSC containing both damaged and failed fuel assemblies, this enrichment is limited to the “and up to 12 Damaged Assemblies” column of Table 11.

Note 3: If loading more than 16 damaged assemblies, place the first 57 damaged assemblies in the interior/edge "C" and the interior “B” locations. Place the remaining four intact or damaged assemblies in the corner "A" locations. The maximum lattice average initial enrichments of assemblies is limited to the “Remaining Four Intact Assemblies” or “Remaining Four Damaged Assemblies” column of Table 12.

Figure 5
Location of Damaged and Failed Fuel Assemblies inside the 61BTH Type 2 DSC

			P	P	P			
	P	P	I	I	I	P	P	
	P	I	I	I	I	I	P	
P	I	I	I	I	I	I	I	P
P	I	I	I	I	I	I	I	P
P	I	I	I	I	I	I	I	P
	P	I	I	I	I	I	P	
	P	P	I	I	I	P	P	
			P	P	P			

Figure 6
Peripheral (P) and Inner (I) Fuel Locations for the 61BTH Type 2 DSC



RECONSTITUTED FUEL ASSEMBLIES with ≤ 5 irradiated stainless steel rods may be loaded into all peripheral locations (i.e., not restricted). See Figure 6 for peripheral locations.

A RECONSTITUTED FUEL ASSEMBLY with > 5 and ≤ 10 irradiated stainless steel rods may be loaded in any peripheral location, with additional restrictions in accordance with Section 2.3. Examples:

- If Location B contains a RECONSTITUTED FUEL ASSEMBLY with > 5 irradiated stainless steel rods, peripherally adjacent Locations A and C shall contain fuel assemblies that do not contain irradiated stainless steel rods.
- If Locations E and G contain RECONSTITUTED FUEL ASSEMBLIES with > 5 irradiated stainless steel rods, peripherally adjacent Locations D, F, and H shall contain fuel assemblies that do not contain irradiated stainless steel rods.

Figure 7
Peripheral Location Restrictions for Reconstituted Fuel with Irradiated Stainless Steel Rods for the 61BTH Type 2 DSC

				P	P	P				
		P	P	I	I	I	P	P		
	P	I	I	I	I	I	I	I	P	
	P	I	I	I	I	I	I	I	P	
P	I	I	I	I	I	I	I	I	I	P
P	I	I	I	I	I	I	I	I	I	P
P	I	I	I	I	I	I	I	I	I	P
	P	I	I	I	I	I	I	I	P	
	P	I	I	I	I	I	I	I	P	
		P	P	I	I	I	P	P		
				P	P	P				

Figure 8
Peripheral (P) and Inner (I) Fuel Locations for the EOS-89BTH DSC

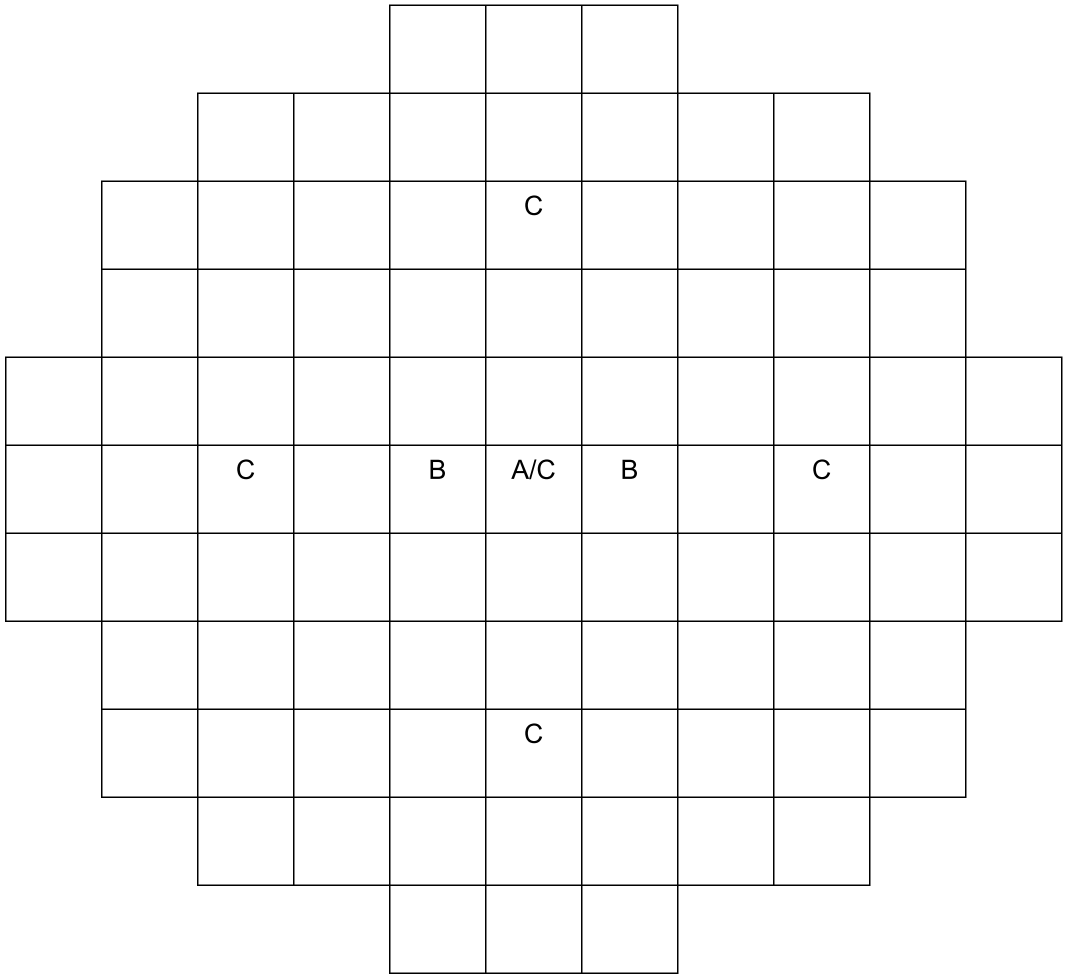
				X	X	X				
		X	X	X	R	X	X	X		
	X	X	R	R	R	R	R	X	X	
	X	R	R	R	R	R	R	R	X	
X	X	R	R	R	R	R	R	R	X	X
X	R	R	R	R	R	R	R	R	R	X
X	X	R	R	R	R	R	R	R	X	X
	X	R	R	R	R	R	R	R	X	
	X	X	R	R	R	R	R	X	X	
		X	X	X	R	X	X	X		
				X	X	X				

R = RECONSTITUTED FUEL ASSEMBLIES with irradiated stainless steel rods allowed at these locations.

X = RECONSTITUTED FUEL ASSEMBLIES with irradiated stainless steel rods not allowed at these locations.

Note: No restrictions on location for RECONSTITUTED FUEL ASSEMBLIES that do not contain irradiated stainless steel rods.

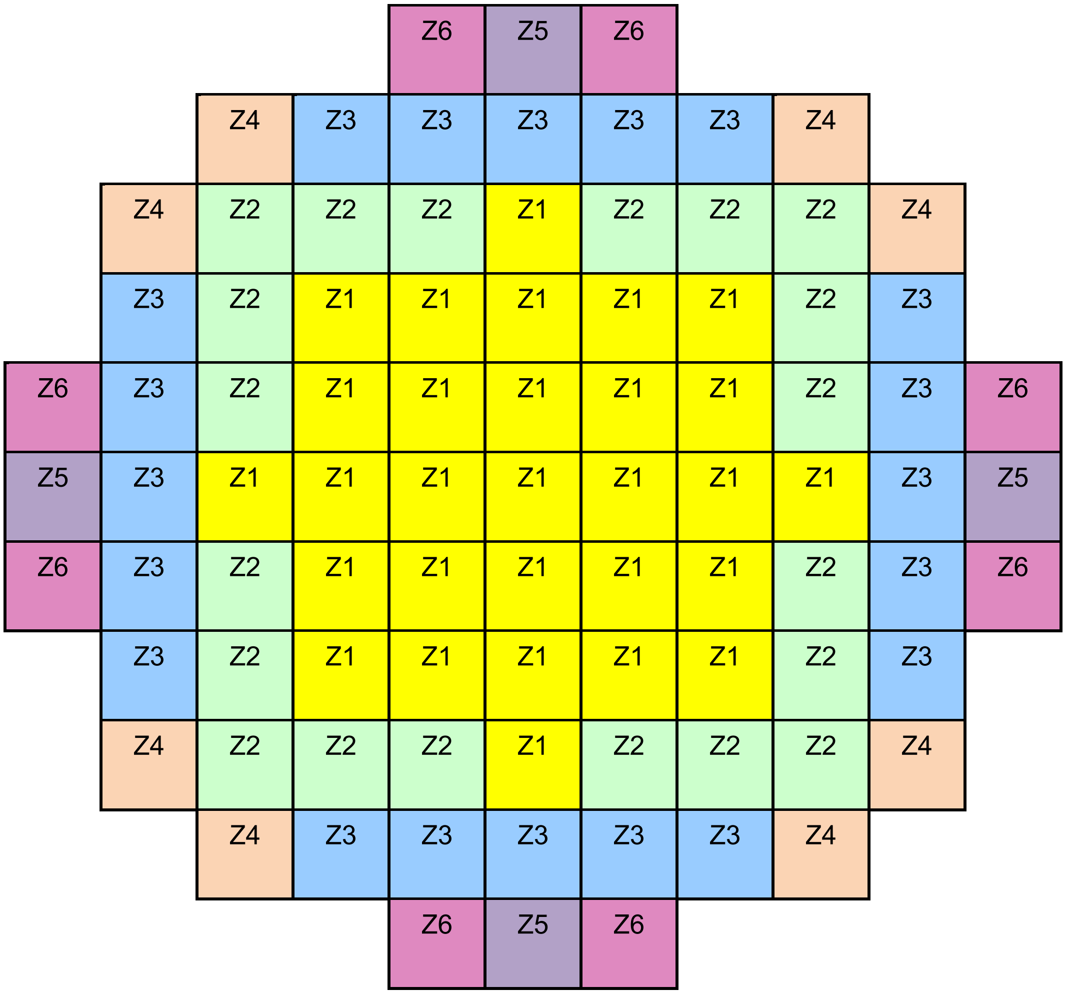
Figure 9
EOS-89BTH DSC Allowed Reconstituted Fuel Locations for Transfer in the EOS-TC108



Note:

1. Location identified as “A” is for empty placement in 88-FA Loading
2. Locations identified as “B” are for empty placements in 87-FA Loading
3. Locations identified as “C” are for empty placements in 84-FA Loading

Figure 10
Empty Locations in Short-Loading Configurations for the EOS-89BTH DSC

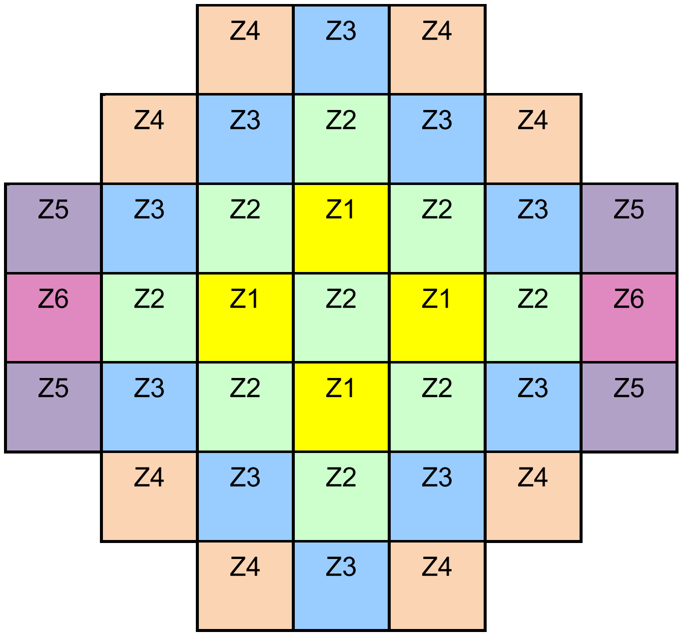


Zone No.	Z1	Z2	Z3	Z4	Z5	Z6
Max. Decay Heat per SFA (kW)	0.40	0.60	1.30	1.70	1.30	1.70
No. of Fuel Assemblies	29	20	20	8	4	8
Heat Load Per Zone	11.6	12.0	26.0	13.6	5.2	13.6
Max. Decay Heat per DSC (kW)	See Note 1 for EOS-HSM and Note 2 for HSM-MX					

Notes:

1. Maximum heat load for EOS-89BTH DSC during Storage is 48.2 kW in EOS-HSM.
2. Maximum heat load for EOS-89BTH DSC during Storage is 48.2 kW in lower compartment of HSM-MX and 41.8 kW in upper compartment of HSM-MX.

Figure 11
Maximum Heat Load Configuration 1 for EOS-89BTH DSC (MHLC-89-1) Transferred in the EOS-TC125



Zone No.	Z1	Z2	Z3	Z4	Z5	Z6
Max. Decay Heat per SFA (kW)	1.5	1.0	2.4	3.5	4.3	1.6
No. of Fuel Assemblies	4	9	10	8	4	2
Heat Load Per Zone	6.0	9.0	24.0	28.0	17.2	3.2
Max. Decay Heat per DSC (kW)	See Note 1					

Notes:

1. Maximum heat load for EOS-37PTH DSC during Storage is *54.0* kW in the EOS-HSM.
2. See Figure 13 for Damaged/failed fuel locations.
3. MHLC-37-1 is only applicable for transfer operations in an EOS-TC125 or EOS-TC135 transfer cask and storage in an EOS-HSM storage module. It is not applicable to the following configurations:
   A. transfer in an EOS-TC108 transfer cask and storage in either an EOS-HSM or HSM-MX storage module or
   B. transfer in an EOS-TC125 or EOS-TC135 transfer cask and storage in an HSM-MX storage module.

Figure 12
Maximum Heat Load Configuration 1 for EOS-37PTH DSC (MHLC-37-1) Transferred in the EOS-TC125/135 AND Stored in the EOS-HSM

		D2	F1	D2		
		D1		D1		
D2/F2	D1				D1	D2/F2
F1						F1
D2	D1				D1	D2
		D1		D1		
			F1			

Notes:

1. The damaged fuel locations are marked with a “D1” for configuration 1, and “D2” for configuration 2. Only one configuration may be loaded in each DSC.
2. The Failed fuel locations are marked with an “F1” for configuration 1, and “F2” for configuration 2. Only one configuration may be loaded in each DSC. Failed fuel in all configurations is limited to 0.8 kW.
3. Damaged and failed fuel shall not be loaded in the same DSC.

Figure 13
Damaged and Failed Fuel Configurations for the EOS-37PTH DSC

		X	X	X		
	X	R	R	R	X	
X	R	R	R	R	R	X
X	R	R	R	R	R	X
X	R	R	R	R	R	X
	X	R	R	R	X	
		X	X	X		

R = RECONSTITUTED FUEL ASSEMBLIES with irradiated stainless steel rods allowed at these locations.

X = RECONSTITUTED FUEL ASSEMBLIES with irradiated stainless steel rods not allowed at these locations.

Note: No restrictions on location for RECONSTITUTED FUEL ASSEMBLIES that do not contain irradiated stainless steel rods.

Figure 14
EOS-37PTH DSC Allowed Reconstituted Fuel Locations for Transfer in the EOS-TC108

Enclosure 5 to E-64033

Proposed Amendment 5, Revision 0

Changes to the NUHOMS® EOS System

Updated Final Safety Analysis Report

(Proprietary and Security-Related Version)

Withheld Pursuant to 10 CFR 2.390

Enclosure 6 to E-64033

Proposed Amendment 5, Revision 0
Changes to the NUHOMS® EOS System
Updated Final Safety Analysis Report
(Public Version)

- Incorporated a method to determine new loading patterns based on the maximum allowable heat load per DSC and per location specified in the TS. All HLZCs and time limits for transfer for the EOS-89BTH DSC transferred in the EOS-TC125 are moved from the TS to the updated final safety analysis report (UFSAR) chapter 2.
- For the single bottom forging EOS-DSCs, waived the fabrication pressure test requirement.
- TS and UFSAR changes for consistency among DSC types and terminology clarifications.
- UFSAR revisions associated with transfer cask lifting heights and consideration of severe weather.
- UFSAR revisions associated with maintaining water in the annulus.
- Design changes to the Matrix Loading Crane (MX-LC).

Amendment 4 adds a maximum heat load configuration (MHLC) for the EOS-37PTH as shown in the Technical Specifications, Figure 12 [1-7], similar to that added for the EOS-89BTH in Amendment 3. Any HLZCs that fall within the bounds of the MHLC that are transferred in the EOS-TC125 and stored in any variation of the EOS-HSM may be qualified for use in the UFSAR. Amendment 4 also adds HLZC 12 and 13 for the EOS-37PTH.

Amendment 4 also adds a new EOS-HSM option to fabricate the components using a steel-plate composite (SC) design, EOS-HSM-SC. A comparison of MCNP to MAVRIC software analyses is performed to demonstrate MAVRIC software capability for use in dose rate analyses. Additionally, measured exposures from past loading campaigns are added to highlight that measured exposures are significantly less than calculated exposures.

Amendment 5 increases the maximum heat load of the EOS-37PTH to 54 kW per DSC. Amendment 5 also adds HLZC 14 for the EOS-37PTH which is applicable for transfer in the EOS-TC125/135 and storage in the EOS-HSM, excluding the EOS-HSM-HS (high seismic) variant.

All Indicated Changes are Enclosure 2, Item 1.

1.1 Introduction

The type of fuel to be stored in the NUHOMS® EOS System is light water reactor (LWR) fuel of the PWR and BWR type. The EOS-37PTH DSC is designed to accommodate up to 37 intact PWR FAs with uranium dioxide (UO_2) fuel, zirconium alloy cladding, and with or without control components (CCs). The EOS-37PTH DSC is also designed to accommodate up to eight damaged FAs or up to four failed fuel canisters (FFCs) with the balance intact FAs. The EOS-89BTH DSC is designed to accommodate up to 89 intact BWR FAs with uranium dioxide (UO_2) fuel, zirconium alloy cladding, and with or without fuel channels. The physical and radiological characteristics of these payloads are provided in Chapter 2.

The NUHOMS® EOS System consists of the following components as shown in Figure 1-1 through Figure 1-7:

- Two dual-purpose (storage and transportation) DSCs that provide confinement in an inert environment, structural support and criticality control for the FAs; the EOS-37PTH DSC and the EOS-89BTH DSC. The DSC shells are welded stainless or duplex steel pressure vessels that includes thick shield plugs at either end to maintain occupational exposures as low as reasonably achievable (ALARA).
- Three EOS-37PTH DSC basket designs, see the table below. Basket Type 1 has non-staggered basket plates as shown in EOS01-1010-SAR for storage of intact fuel only. Basket Types 1 through 3 correlate with the respective HLZCs 1 through 3 (Figures 1A through 1C of the Technical Specifications [1-7]). Basket Type 4 incorporates a plate configuration that offsets the aluminum plates to allow for damaged/failed fuel storage in the EOS-37PTH DSC. The Type 4 basket has two options. The Type 4H basket is fabricated from a coated steel plate for higher emissivity and higher conductivity poison plate, while the Type 4L basket has a low emissivity coated steel plate and a low conductivity poison plate. These requirements are further detailed in the material and design limits discussed in Section 4.2 and Section 10.1. The 4HA basket type is a subset of the 4H basket where the aluminum basket plates are anodized. This anodizing is required when HLZCs with decay heats greater than 3.5 kW *per fuel assembly or 50 kW per DSC* are stored in the basket. When used without distinction, 4H includes both basket types 4H and 4HA. The Type 5 basket is similar to the Type 1 basket in configuration, but also incorporates the low emissivity coated steel plates and low conductivity poison plate. The maximum heat loads and the allowable HLZCs for Basket Types 1, 4 and 5 are listed in Table 1-2. Each of these basket types also allows for two levels of boron loading in the poison plates (A and B). Each basket type is designated as follows:

- The EOS-HSM and EOS-HSMS provides the bulk of the radiation shielding for the DSCs. The EOS-HSM/EOS-HSMS can be arranged in either a single-row or a back-to-back arrangement. Thick concrete supplemental shield walls are used at either end of an EOS-HSM and EOS-HSMS array and along the back wall of single-row arrays to minimize radiation dose rates both onsite and offsite. Two or more empty modules can be substituted for the end walls until the array is fully built.
- A horizontal storage module (HSM), designated as the HSM-MX, is a two-tiered, staggered reinforced monolithic structure, consisting of massive reinforced concrete compartments to accommodate EOS-DSCs. This system is further detailed in Appendix A, where relevant chapters are preceded with an A, i.e., A.1. Where the term "HSM" is used without distinction, this term applies to both the EOS-HSM and HSM-MX.
- An EOS-TC system is provided with a top cover plate that allows air circulation through the TC/DSC annulus during transfer operations at certain heat loads when time limits for transfer operations cannot be satisfied. The EOS-TC system consists of a 135-ton cask (EOS-TC135), a 125-ton cask (EOS-TC125), and the EOS-TC108 Cask.

The EOS-37PTH DSC is designed for a maximum heat load of *54* kW when transferred in the EOS-TC125/135, or *for a maximum heat load of 50 kW when transferred in the* EOS-TC108. The EOS-89BTH DSC is designed for a maximum heat load of 48.2 kW when transferred in the EOS-TC125, and a maximum heat load of 41.6 kW when transferred in the EOS-TC108. The EOS-37PTH DSC can be transferred in any EOS-TC with a maximum heat load of 36.35 kW without air circulation available and, similarly, the EOS-89BTH with a maximum heat load of 34.4 kW.

The NUHOMS® EOS System is designed to be compatible with removal of the stored DSC for transportation and ultimate disposal by the Department of Energy, in accordance with 10 CFR 72.236(m). However, this application only addresses the storage of the spent fuel in the NUHOMS® EOS System.

The cavity length of the DSCs is adjustable to match the length of the fuel to be stored. This eliminates or reduces the need for fuel spacers to address secondary impact of the fuel on the lids during transportation accident scenarios.

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

The EOS-37PTH damaged/failed fuel basket configuration is also used in conjunction with failed fuel canisters to allow for failed fuel to be stored in the EOS-37PTH DSC. Each FFC is constructed of sheet metal and is provided with a welded bottom closure and a removable top closure that allows lifting of the FFC. The FFC is provided with screens at the bottom and top to contain the failed fuel and allow fill/drainage of water from the FFC during loading operations. The FFC is protected by the fuel compartment tubes and its only function is to confine the failed fuel. The FFC geometry and the materials used for its fabrication are shown on Drawing EOS01-1010-SAR.

Basket "transition rails" provide the transition between the rectangular basket structure and the cylindrical DSC shell. The transition rails are made of extruded aluminum open or solid sections, which are reinforced with internal steel, as necessary. These transition rails provide the transition to a cylindrical exterior surface to match the inside surface of the DSC shell. The transition rails support the fuel basket egg-crate structure and transfer mechanical loads to the DSC shell. They also provide the thermal conduction path from the basket assembly to the DSC shell wall, making the basket assembly efficient in rejecting heat from its payload. The nominal dimension of each fuel compartment opening is sized to accommodate the limiting assembly with sufficient clearance around the FA.

The EOS-37PTH DSC is designed for a maximum heat load of *54* kW. The internal basket assembly contains a storage position for each FA. The criticality analysis credits the fixed borated neutron absorbing material placed between the FAs. The analysis also takes credit for soluble boron during loading operations. Sub-criticality during wet loading/unloading, drying, sealing, transfer, and storage operations is maintained through the geometric separation of the FAs by the basket assembly, the boron loading of the pool water, and the neutron absorbing capability of the EOS-37PTH DSC materials, as applicable. Based on coating of basket steel plates, poison material and boron loading, and the HLZC, ten basket configurations are provided, as shown on drawing EOS01-1010-SAR for the intact and damaged/failed fuel basket. Poison material and boron loading requirements as well as basket plate coating requirements are discussed in Chapter 10. The aluminum basket plates may be anodized to allow for storage of fuels with decay heats greater than 3.5 kW. Requirements are discussed in Section 4.9.9.

In general, the dimensions of the EOS-37PTH DSC components described in the text and provided in figures and tables of this UFSAR are nominal dimensions for general system description purposes. Actual design dimensions are contained in the drawings in Section 1.3.1 of this UFSAR. See Sections 1.4.1 and 2.2.1 for a discussion of the contents authorized to be stored in this DSC.

The EOS-HSMs provide an independent, passive system with substantial structural capacity to ensure the safe dry storage of SFAs. To this end, the EOS-HSMs are designed to ensure that normal transfer operations and postulated accidents or natural phenomena do not impair the DSC or pose a hazard to the public or plant personnel.

The EOS-HSM provides a means of removing spent fuel decay heat by a combination of radiation, conduction and convection. Ambient air enters the EOS-HSM through ventilation inlet openings located on both sides of the lower front wall of the EOS-HSM and circulates around the DSC and the heat shields. Air exits through air outlet openings located on each side of the top of the EOS-HSM. The EOS-HSM is designed to remove up to *54* kW of decay heat from the bounding EOS-37PTH DSC.

1.7 References

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

1-2 NUREG-1536, "Standard Review Plan for Spent Fuel Dry Storage Systems at a General License Facility," Revision 1, U.S. Nuclear Regulatory Commission, Office of Nuclear Material Safety and Safeguards, July 2010.

1-3 U.S. Nuclear Regulatory Commission, "Certificate of Compliance 72-1030, NUHOMS® HD Horizontal Modular Storage System for Irradiated Nuclear Fuel," Amendment No. 2, October 14, 2014.

1-4 TN Americas LLC, Updated Final Safety Analysis Report, "NUHOMS® HD Horizontal Modular Storage System for Irradiated Nuclear Fuel," Revision 6, U.S. Nuclear Regulatory Commission Docket No. 72-1030, September 2017.

1-5 Title 10, Code of Federal Regulations, Part 50, "Domestic Licensing of Production and Utilization Facilities."

1-6 TN Americas LLC, "TN Americas LLC Quality Assurance Program Description Manual for 10 CFR Part 71, Subpart H and 10 CFR Part 72, Subpart G," current revision.

1-7 CoC 1042 Appendix A, NUHOMS® EOS System Generic Technical Specifications, Amendment *5*.

All Indicated Changes are Enclosure 2, Item 1.

Table 1-2
System Configurations for the NUHOMS® EOS System and NUHOMS® MATRIX System
(2 Pages)

DSC	System Configuration	Basket Design	Basket Type	Emissivity/ Poison	Storage Module	Wind Deflector	HLZC	Intact	Damaged/ Failed	Transfer Cask
EOS-37PTH	S1	Non-Staggered	1	High	EOS-HSM	Yes(1)	1	Yes	No	EOS-TC125/135
	S2	Non-Staggered	1	High	EOS-HSM	No	2	Yes	No	EOS-TC108/125/135
		Non-Staggered	1	High	EOS-HSM	No	3	Yes	No	EOS-TC108/125/135
	S3	Staggered	4L	Low	EOS-HSM	Yes	4	Yes	No	EOS-TC125/135
		Staggered	4L	Low	EOS-HSM	Yes(2)	5	Yes	No	EOS-TC125/135
		Staggered	4L	Low	EOS-HSM	Yes	6	Yes	Yes	EOS-TC125/135
	S3a	Staggered	4H	High	EOS-HSM	Yes(1)	1	Yes	No	EOS-TC125/135
		Staggered	4H	High	EOS-HSM	Yes(1)	4	Yes	No	EOS-TC108/125/135
		Staggered	4H	High	EOS-HSM	Yes(2)	5	Yes	No	EOS-TC108/125/135
		Staggered	4H	High	EOS-HSM	Yes(1)	6	Yes	Yes	EOS-TC108/125/135
		Staggered	4H	High	EOS-HSM	Yes(1)	10	Yes	Yes	EOS-TC125/135
		Staggered	4H	High	EOS-HSM	Yes(1)	11	Yes	Yes	EOS-TC125/135
	S3b	Staggered	4HA	High	EOS-HSM	Yes(3)	12	Yes	Yes	EOS-TC125/135
		Staggered	4HA	High	EOS-HSM	Yes(3)	13	Yes	Yes	EOS-TC125/135
		Staggered	*4HA*	*High*	*EOS-HSM*	*Yes(3)*	*14*	*Yes*	*No*	*EOS-TC125/135*
	S4	Non-staggered	5	Low	EOS-HSM	Yes	4	Yes	No	EOS-TC125/135
		Non-staggered	5	Low	EOS-HSM	Yes(2)	5	Yes	No	EOS-TC125/135
	S5	Staggered	4H	High	HSM-MX	N/A	7	Yes	No	EOS-TC108/125/135
		Staggered	4H	High	HSM-MX	N/A	8	Yes	Yes	EOS-TC108/125/135
		Staggered	4H	High	HSM-MX	N/A	9	Yes	No	EOS-TC108/125/135
		Staggered	4H	High	HSM-MX	N/A	11	Yes	Yes	EOS-TC125/135
	S6	Staggered	4L	Low	HSM-MX	N/A	8	Yes	Yes	EOS-TC125/135
		Staggered	4L.	Low	HSM-MX	N/A	9	Yes	No	EOS-TC125/135
	S7	Non-staggered	5	Low	HSM-MX	N/A	8	Yes	No	EOS-TC125/135
		Non-staggered	5	Low	HSM-MX	N/A	9	Yes	No	EOS-TC125/135

All Indicated Changes are Enclosure 2, Item 1.

Table 1-2
System Configurations for the NUHOMS® EOS System and NUHOMS® MATRIX System
(2 Pages)

DSC	System Configuration	Basket Design	Basket Type	Emissivity/ Poison	Storage Module	Wind Deflector	HLZC	Intact	Damaged/ Failed	Transfer Cask
EOS-89BTH	S8	Non-Staggered	1	High	EOS-HSM	Yes	1	Yes	No	EOS-TC125
		Non-Staggered	1	High	EOS-HSM	Yes	4	Yes	No	EOS-TC125
		Non-Staggered	1	High	EOS-HSM	Yes	5	Yes	No	EOS-TC125
		Non-Staggered	1	High	EOS-HSM	Yes	6	Yes	No	EOS-TC125
	S9	Non-Staggered	2	High	EOS-HSM	No	2	Yes	No	EOS-TC108/125
		Non-Staggered	3	High	EOS-HSM	No	3	Yes	No	EOS-TC108/125
	S10	Non-Staggered	3	High	HSM-MX	N/A	3	Yes	No	EOS-TC108/125
	S11	Non-Staggered	1	High	HSM-MX	N/A	4	Yes	No	EOS-TC125
		Non-Staggered	1	High	HSM-MX	N/A	5	Yes	No	EOS-TC125
		Non-Staggered	1	High	HSM-MX	N/A	6	Yes	No	EOS-TC125

Notes:

1. Wind deflectors are needed only if the heat load is greater than 41.8 kW.
2. For HLZC 5, wind deflectors are needed only if the heat load of a single fuel assembly is greater than 1.625 kW.
3. Basket Type 4HA with anodized aluminum plates is required for HLZCs storing fuels with decay heats higher than 3.5 kW *per FA or total decay heat loads greater than 50 kW per DSC*. Basket Type 4HA capabilities bound basket types 4L and 4H and may be used in lieu of any 4L and 4H basket.

Proprietary and Security Related Information for Drawing EOS01-1010-SAR, Rev. 6A Withheld Pursuant to 10 CFR 2.390

8 7 6 5 4 3 2 1

H G F E D C B A

Proprietary and Security Related Information for Drawing EOS01-3000-SAR, Rev. 6A Withheld Pursuant to 10 CFR 2.390

H G F E D C B A

8 7 6 5 4 3 2 1

The maximum allowable assembly average burnup is limited to 62 GWd/MTU and the minimum cooling time is 1 year for both the EOS-37PTH DSC and the EOS-89BTH DSC. Dummy FAs and reconstituted FAs are also included in the EOS-37PTH DSC and EOS-89BTH DSC payloads. Low enriched or natural uranium fuel rods or unirradiated non-fuel rods are acceptable for storage in an EOS-37PTH DSC and EOS-89BTH DSC as intact FAs.

Fuel assemblies that contain fixed integral non-fuel rods are also considered as intact FAs. These FAs are different than reconstituted assemblies because fuel rods are not “replaced” by non-fuel rods, rather the non-fuel rods are part of the initial fuel design. The non-fuel rods displace the same amount of moderator, with zirconium-alloy (or aluminum) cladding and typically contain burnable absorber (or other non-fuel) material. The radiation and thermal source terms for the non-fuel rods are significantly lower than those of the fuel rods since there is no significant radioactive decay source. The internal pressure of the non-fuel rods after irradiation is lower than those of the fuel rods since there is no fission gas generation. The reactivity of the fuel rods (from a criticality standpoint) is significantly higher than that of non-fuel rods. In summary, the mechanical, thermal, shielding, and criticality evaluations for these rods are bounded by those of the regular fuel rods. Therefore, no further evaluations are required for the qualification of these FAs.

Reconstituted assemblies containing an unlimited number of low enriched or natural uranium fuel rods or unirradiated non-fuel rods are acceptable for storage. Reconstituted fuel assemblies with irradiated stainless steel rods are allowed, with additional restrictions. These restrictions vary between the EOS-37PTH DSC and EOS-89BTH DSC and are defined in the Technical Specifications, Table 22 through Table 25[2-18].

The EOS-37PTH DSC may contain less than 37 FAs and the EOS-89BTH DSC may contain less than 89 FAs. In both DSCs, the basket slots not loaded with FAs may have empty slots or be loaded with dummy FAs. The dummy FAs approximate the weight and center of gravity of an FA.

The NUHOMS® EOS-37PTH DSC can also accommodate up to eight damaged FAs placed in the DSC. Damaged PWR FAs are defined in Section 1.1 of the Technical Specifications [2-18]. Locations for damaged fuel storage are shown in Figure 13 of the Technical Specifications [2-18].

The NUHOMS® EOS-37PTH DSCs can also accommodate up to a maximum of four FFCs, placed in cells located on the outer edge of the DSC. Failed fuel is defined in Section 1.1 of the Technical Specifications [2-18]. Locations for failed fuel storage are shown in Figure 13 of the Technical Specifications [2-18].

All Indicated Changes are Enclosure 2, Item 1.

Following loading, each DSC is evacuated and then backfilled with an inert gas, helium, to preclude detrimental chemical reaction between the fuel and the DSC interior atmosphere during storage. Multilayer, confinement boundary welds at each end of the DSC and multi-layer circumferential and longitudinal DSC shell welds ensure retention of the helium atmosphere for the full storage period.

2.2.1 EOS-37PTH DSC

The EOS-37PTH DSC stores up to 37 PWR FAs with up to eight damaged FAs or four FFCs with characteristics as described in Table 2-2 and the PWR FAs listed in Table 2-4. One or more PWR fuel designs are grouped under a "PWR class". EOS-37PTH DSC payloads may also contain CCs, such as identified below, with *the* radiological characteristics as listed in Table 3 *of the Technical Specifications [2-18]* and Figure 2-3a through *Figure 2-3n*:

Burnable Poison Rod Assemblies

- Burnable poison rod assemblies (BPRAs),
- Burnable absorber assemblies (BAAs),
- Wet annular burnable absorbers (WABAs),
- Vibration suppression inserts (VSIs),

Thimble Plug Assemblies

- Thimble plug assemblies (TPAs),
- Control spiders,
- Orifice rod assemblies (ORAs),

Control Element Assemblies

- Control rod assemblies (CRAs),
- Rod cluster control assemblies (RCCAs),
- Control element assemblies (CEAs),
- Axial power shaping rod assemblies (APSRAs),
- Peripheral power suppression assemblies (PPSAs),
- Flux suppression inserts (FSIs),

Neutron Sources

- Neutron sources,
- Neutron source assemblies (NSAs).

Furthermore, non-fuel hardware that is positioned within the fuel assembly after the fuel assembly is discharged from the core such as guide tube or instrument tube tie rods or anchors, guide tube inserts, BPRA spacer plates or devices that are positioned and operated within the FA during reactor operation such as those listed above are also considered as CCs.

Damaged fuel containing control components may be stored in the designated damaged fuel compartments. Similarly, failed control component debris may be stored in the FFCs.

Control components not explicitly listed herein are also authorized within the DSC, as long as they meet the following criteria:

1. External materials are limited to zirconium alloys, nickel alloys, and stainless steels,
2. Radiological limits listed in Table 3 *of the Technical Specifications [2-18]* and Figure 2-3a through *Figure 2-3n*, and
3. They fit within the weight limits and dimensional limits of the DSC.

10 CFR 72.236(a) requires the maximum heat designed to be dissipated and the maximum spent fuel loading limit to be specified in the TS. For the EOS-37PTH DSC transferred in the EOS-TC125/135 and stored in the EOS-HSM, Figure 12 of the TS provides this required information, wherein the maximum heat load of the DSC is limited to *54* kW. It also provides limits on the maximum allowable heat loads in each fuel compartment and zone.

The limits on the total decay heat load of the DSC and the maximum heat load in each fuel compartment and zone in Figure 12 of the Technical Specification [2-18] are used to qualify the various HLZCs and to also verify the corresponding radiation source term is consistent with the shielding analysis presented in Chapter 6. The maximum weight of a FA plus CC, if applicable, is 1,900 lbs.

Furthermore, since TS Figure 12 [2-18] presents only the maximum heat loads, there can be a multitude of ways that the heat loads in each fuel compartment and zone can be adjusted to meet the total heat load limit of the DSC. To ensure this adjustment meets all the design criteria, the various HLZCs that are developed based on Figure 12 of TS [2-18] must be evaluated and pre-qualified. It should be noted that the pre-qualification is limited to thermal and structural design functions, since the shielding evaluation in Chapter 6 considers a bounding evaluation that encompasses the maximum heat loads in Figure 12 of TS [2-18].

All Indicated Changes are Enclosure 2, Item 1.

UFSAR Figure 2-3a through Figure 2-3f and Figure 2-3j through *Figure 2-3n* present examples for EOS-37PTH wherein HLZCs 1 to 6 and 10 to *14* are qualified based on the limitations and constraints of TS Figure 12. Chapter 4, Sections 4.4 and 4.5 present the *thermal* evaluations of HLZCs 1 through 3, Appendix 4.9.6 provides the *thermal* evaluations of HLZCs 4 through 6, Appendix 4.9.7 provides the *thermal* evaluations of HLZCs 10 and 11, Appendix 4.9.9 provides the evaluation of HLZCs 12 and 13*, and Appendix 4.9.10 provides the evaluation of HLZC 14* in the EOS-HSM and EOS-TC125/135.

In addition, LCO 3.1.3 of the TS [2-18] notes that a minimum duration of 13 hours shall be allowed for transfer operations (8 hours for the transfer and 5 hours for recovery as allowed by the action statements). Table 2-10 presents the minimum transfer time limits for the various HLZCs. It should be noted that these time limits are the minimum required time limits for transfer operations based on the maximum allowable heat loads for each HLZC and a new time limit may be determined to allow for longer time limits if the DSC is loaded to less than the maximum allowable limit.

The evaluations presented for storage in EOS-HSM and EOS-TC125/135 in Chapter 4 present the methodology to evaluate and pre-qualify additional HLZCs.

Section 2.4.3.1 presents the detailed methodology to evaluate and pre-qualify additional HLZCs based on these evaluations.

For EOS-37PTH DSCs transferred in the EOS-TC108 and stored in EOS-HSM or HSM-MX and for those transferred in EOS-TC125/TC135 and stored in the HSM-MX, Figures 1B through 1I and Figure 1K of the Technical Specifications [2-18] apply. These figures define the maximum decay heat, failed/damaged fuel locations, and other parameters for PWR fuel assemblies, with or without CCs, authorized for storage. These tables are used to ensure that the decay heat load of the FA to be stored is less than that as specified in each table, and that the corresponding radiation source term is consistent with the shielding analysis presented in Chapter 6. The parameters of Section 2.1 of the TS [2-18] apply.

All Indicated Changes are Enclosure 2, Item 1.

The heat loads listed in Figure 2-3a through *Figure 2-3n* and Figures 1B through 1I, and Figure 1K of the TS [2-18] are the maximum allowable heat loads for each FA and the maximum allowable heat load per DSC. These heat loads can be reduced to ensure adequate heat removal capability is maintained to accommodate site-specific conditions. Some examples of the site-specific conditions are a higher ambient temperature, different blocked vent duration, a requirement to use a different neutron absorber plate or a requirement for a specific coating on the basket steel plates or to accommodate longer DSC lengths than those specified in Section 1.1 for the EOS-Short HSM, based on ISFSI layout considerations. Each of these changes could result in a change to the inputs of the thermal evaluation utilized in the UFSAR. To ensure that adequate heat removal is maintained with these modified inputs, the bounding evaluations for storage and transfer operations should be re-evaluated. The maximum fuel cladding temperature based on the modified inputs shall be lower than the maximum fuel cladding temperatures listed in the Chapter 4 and Chapter A.4 for the same bounding evaluations. In addition, new HLZCs may also be developed based on site-specific conditions using the approach presented in Section 2.4.3.1. Any design changes considered to accommodate the site specific conditions shall be evaluated as noted in Section 2.4.3.1. These site-specific configurations shall be listed in Table 1-2 along with a description of the limitations with regards to the heat loads or the new HLZC applicable to these configurations.

As limited by their definition, damaged FAs maintain their geometric configuration for normal and off-normal conditions and are confined to their respective compartments by means of top and bottom end caps. Damaged FAs do not contain missing major sub-components like top and bottom nozzles that impact their ability to maintain their geometric configuration for normal and off-normal conditions during loading.

From the standpoint of NUREG-1536 Revision 1, the damaged FAs for the EOS System are more similar to the undamaged FAs, where their geometry is still in the form of intact bundles. For completeness, failed fuel for the EOS System is more similar to the damaged FAs per NUREG-1536 Revision 1 and will require FFCs.

The fuel compartment and the top and bottom end cap together form the “acceptable alternative,” per NUREG-1536 Revision 1 for confinement of damaged fuel. If fuel particles are released from the damaged assembly, the top and bottom end caps provide for the confinement of gross fuel particles to a known volume. Similarly, the FFC provides confinement of the FFC contents to a known volume, and has lifting features to allow the ability to unload the FFC. Additionally, consistent with ISG-2, Revision 2, ready retrieval of the damaged and failed fuel as well as intact fuel is based on the ability to remove a canister from the HSM.

All Indicated Changes are Enclosure 2, Item 1.

2.4.2 Structural

2.4.2.1 EOS-DSC Design Criteria

The principal design criteria for the DSCs are presented in Table 2-5 and Table 2-6. The EOS-37PTH DSC is designed to store intact PWR FAs with or without CCs, damaged fuel and failed fuel canisters. The EOS-89BTH DSC is designed to store intact BWR FAs with or without fuel channels. The maximum total heat generation rate of the stored fuel is limited to *54* kW per DSC for the EOS-37PTH DSC and 48.2 kW per DSC for the EOS-89BTH DSC, in order to keep the maximum fuel cladding temperature below the limit necessary to ensure cladding integrity. The maximum heat load for any single assembly is *4.3* kW for the EOS-37PTH DSC and 1.7 kW for the EOS-89BTH DSC. The fuel cladding integrity is assured by limiting fuel cladding temperature and maintaining a nonoxidizing environment in the DSC cavity as described in Chapter 4.

Enclosure 2, Item 1

Enclosure 2, Item 2

2.4.2.2 EOS-HSM Design Criteria

The principal design criteria for the EOS-HSM/EOS-HSMS/EOS-HSM-HS, both the module and DSC support structure, are presented in Table 2-7.

The reinforced concrete EOS-HSM (EOS-HSM-RC) is designed to meet the requirements of ACI 349-06 [2-3]. The ultimate strength method of analysis is utilized with the appropriate strength reduction factors as described in Appendix 3.9.4. The steel structure of the steel-plate composite EOS-HSM (EOS-HSM-SC) is designed to meet the requirements of ANSI/AISC N690-18 [2-23] with exceptions as noted in Section 4.4.4 of the TS [2-18]. The load and resistance factor design (LRFD) method of ANSI/AISC N690-18 is used as described in Appendix 3.9.8. The concrete and supplemental reinforcement of the EOS-HSM-SC are designed to meet the requirements of ACI 349-13 [2-24]. The load combinations specified in Section 6.17.3.1 of ANSI 57.9-1984 are used for combining normal operating, off-normal, and accident loads for the EOS-HSM. All seven load combinations specified are considered and the governing combinations are selected for detailed design and analysis. The resulting EOS-HSM load combinations and the appropriate load factors are presented in Appendix 3.9.4. The effects of duty cycle on the EOS-HSM are considered and found to have negligible effect on the design.

2.4.2.3 EOS-TC Design Criteria

The EOS-TCs are designed in accordance with the applicable portions of the ASME Code, Section III, Division 1, Subsection NF for Class 1 vessels, except for the neutron shield tank, which is designed to ASME Code, Section III, Division 1, Subsection ND, since it will see pressure greater than 15 psig. The load combinations considered for the TC normal, off-normal, and postulated accident loadings are shown in Table 2-8. Service Levels A and B allowables are used for all normal operating and off-normal loadings. Service Levels C and D allowables are used for load combinations that include postulated accident loadings. The maximum shear stress theory is used to calculate principal stresses in the cask structural shell. Allowable stress limits for the lifting trunnions conservatively meet the requirements of ANSI N14.6- 1993 [2-14] for critical loads.

2.4.3 Thermal

The NUHOMS® EOS System relies on natural convection through the air space in the EOS-HSM to cool the DSC. This passive convective ventilation system is driven by the pressure difference due to the stack effect (ΔP_s) provided by the height difference between the bottom of the DSC and the EOS-HSM air outlet. This pressure difference is greater than the flow pressure drop (ΔP_f) at the design air inlet and outlet temperatures. The details of the ventilation system design are provided in Chapter 4.

Thermal analysis is based on FAs with decay heat up to *54*.0 kW per DSC for the EOS-37PTH and up to 48.2 kW per DSC for the EOS-89BTH. Zoning is used to accommodate high per assembly heat loads. For the EOS-37PTH DSC stored in the HSM-MX or transferred in the EOS-TC108, the heat load zoning configurations (HLZCs) for the DSCs are shown in Figures 1B through 1I and Figure 1K of the Technical Specifications [2-18]. Based on the discussion in Section 2.2.1, for the EOS-37PTH DSC stored in the EOS-HSM and transferred in the EOS-TC125/135, Figure 12 in the TS [2-18] presents the maximum heat load configuration (MHLC) while the individual HLZCs are presented in UFSAR Section 2.4.3.2. For the EOS-89BTH DSC based on the discussion in Section 2.2.2, Figure 11 presents the maximum allowable heat loads in the Technical Specifications while the individual HLZCs are presented in Section 2.4.3.2. As noted in Section 2.1 of Technical Specification [2-18], the maximum allowable heat loads may be reduced based on the methodology presented in Chapter 4 or Chapter A.4 for each FA type allowed in either the EOS-37PTH DSC or the EOS-89BTH DSC. The thermal properties for the various FA types should be determined based on the methodology presented in Chapter 4, Appendix 4.9.1.

The thermal analyses is performed for the environmental conditions listed in Table 2-9.

5. Based on the thermal evaluation in Step 2 through Step 4 (if applicable), the impact of temperature changes on structural design functions shall be considered based on the methodology in Chapter 3.

2.4.3.2 HLZCs for EOS-37PTH DSC and EOS-89BTH DSC

HLZCs 1 through 6 and 10 through *14* that are qualified for use with the EOS-37PTH DSC based on the methodology presented in Section 2.4.3.1 are presented in Figure 2-3a through Figure 2-3f and Figure 2-3j through *Figure 2-3n*. In addition to these HLZCs, additional HLZCs may be qualified based on the methodology presented in Section 2.4.3.1. Note that HLZCs 1-3, 4-6, 7-11, *and 12-13* were previously approved by the NRC in Amendment 0, 1, 2, *and 4* respectively.

HLZCs 1 through 6 that are qualified for use with the EOS-89BTH DSC based on the methodology presented in Section 2.4.3.1 are presented in Figure 2-2a through Figure 2-2f. In addition to these HLZCs, additional HLZCs may be qualified based on the methodology presented in Section 2.4.3.1. Note that HLZCs 1-3 were previously approved by the NRC in Amendment 0.

Table 2-10
Time Limits for Transfer by HLZC

DSC Model	Applicable HLZC	Time Limits (Hours)
EOS-37PTH	HLZC 1, 2, 4-*14*	8
EOS-37PTH	HLZC 3	No Limit
EOS-89BTH	HLZC 1 or 2	10
EOS-89BTH	HLZC 3	No Limit
EOS-89BTH	HLZC 4-6	8

All Indicated Changes are Enclosure 2, Item 1.

		Z8*	Z5	Z8*		
	Z7	Z3	Z2	Z3	Z7	
Z3*/**	Z3	Z2	Z2	Z2	Z3	Z3*/**
Z2	Z2	Z4	Z1	Z4	Z2	Z2
Z9*	Z2	Z2	Z4	Z2	Z2	Z9*
	Z6	Z3	Z2	Z3	Z6	
		Z8	Z5	Z8		

(*) denotes location where INTACT or DAMAGED FUEL ASSEMBLY can be stored.

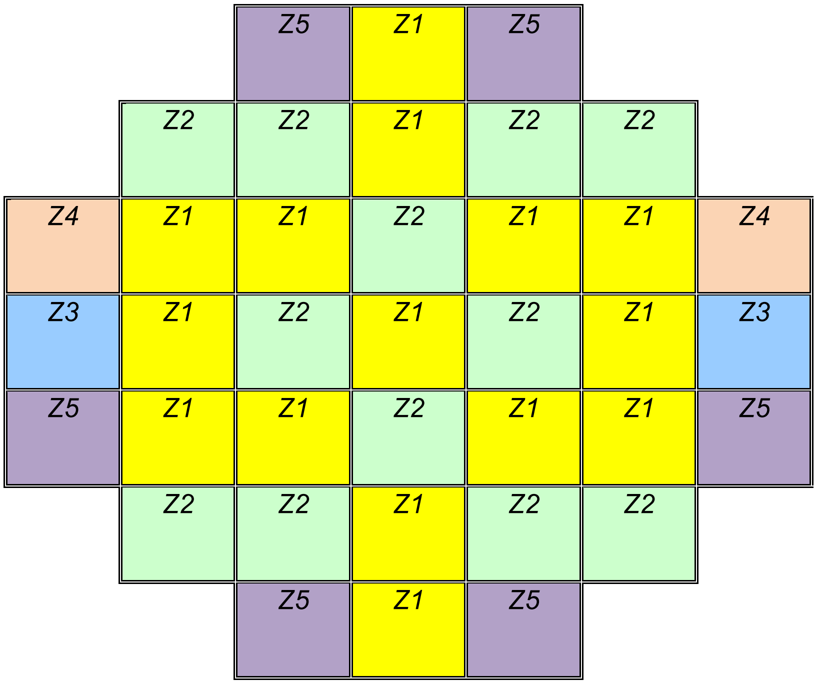
(**) denotes location where INTACT or FAILED FUEL can be stored. Damaged and failed fuels cannot be loaded in the same DSC.

Zone No.	Z1	Z2	Z3	Z4	Z5	Z6	Z7	Z8	Z9
Max. Decay Heat per SFA (kW)	0.5	0.8	1.0	1.25	1.5	2.0	2.2	2.9	4.2
No. of Fuel Assemblies	1	13	8	3	2	2	2	4	2
Heat Load Per Zone	0.5	10.4	8.0	3.75	3.0	4.0	4.4	11.6	8.4
Max Decay Heat per DSC	Note 1 (54.05 kW total)								

Notes:

1. Maximum heat load for EOS-37PTH DSC during Storage is 50.0 kW in the EOS-HSM.
2. This HLZC is not applicable for:
   A. Transfer in EOS-TC108 transfer cask and storage in either EOS-HSM or HSM-MX storage module, or
   B. Transfer in EOS-TC125 or EOS-TC135 transfer cask and storage in HSM-MX storage module.
3. This HLZC *is* not applicable for storage of WE 14x14 class FAs.
4. See UFSAR Table 1-2 or TS Section 2.1 for applicable system configurations.

Figure 2-3m
Heat Load Zone Configuration 13 for the EOS-37PTH DSC



Zone No.	Z1	Z2	Z3	Z4	Z5
Max. Decay Heat per SFA [kW]	1.0	1.2	1.5	2.10	2.9
No. of Fuel Assemblies	15	12	2	2	6
Heat Load Per Zone	15	14.4	3	4.2	17.4
Max Decay Heat per DSC	54 kW				

Notes:

1. *This HLZC is not applicable for storage of damaged or failed fuel assemblies.*
3. *This HLZC is not applicable for:*
   A. Transfer in EOS-TC108 transfer cask and storage in either EOS-HSM or HSM-MX storage module, or
   B. Transfer in EOS-TC125 or EOS-TC135 transfer cask and storage in HSM-MX storage module.
4. *This HLZC is not applicable for storage of WE 14x14 class FAs.*
5. *See UFSAR Table 1-2 or TS Section 2.1 for applicable system configurations.*

Figure 2-3n
Heat Load Zone Configuration 14 for the EOS-37PTH DSC

Component	Weight (kips)	Thermal Heat Load
EOS-37PTH DSC (Loaded Weight)	134	*54* kW
EOS-89BTH DSC (Loaded Weight)	120	48.2 kW
Bounding EOS-HSM-RC	135 (2)	*54* kW (1)

Notes:
1. The thermal loading condition of the EOS-HSM-RC is based on the most conservative thermal loading configuration.
2. For stability evaluation, the design weight of the governing DSC among those corresponding to the length of HSM being evaluated is considered.

Detailed geometry descriptions, material properties, loadings, and structural evaluation for the EOS-HSM-RC is presented in Appendix 3.9.4.

For the structural evaluation of the EOS-HSM-SC, only the medium length model is evaluated using the bounding DSC weight of 135 kips and bounding thermal heat load of *54* kW. Detailed geometry descriptions, material properties, loadings, and structural evaluation for the EOS-HSM-SC are presented in Appendix 3.9.8.

3.6.3 EOS-TC

Details of the structural analysis of the EOS-TC are provided in Appendices 3.9.3 and 3.9.5.

The details of the structural analyses of the EOS-TC body, including the cylindrical shell assembly and bottom assembly, the top cover, and the local stresses at the trunnion/cask body interface are presented in Appendix 3.9.5. The specific methods, models and assumptions used to analyze the cask body for the various individual loading conditions specified in 10 CFR Part 72 [3-13] are described in that appendix.

The EOS-TC body structural analyses use static or quasistatic linear elastic methods. The stresses and deformations due to the applied loads are determined using the ANSYS [3-12] computer program.

Appendix 3.9.5 presents the evaluation of the trunnion stresses in the EOS-TC due to all applied loads during fuel loading and transfer operations.

Based on the loading and transfer scenario, the top trunnions are analyzed per ANSI N14.6 [3-7] for vertical lifting loads.

The evaluations summarized in Appendix 3.9.5 show that all calculated trunnion stresses are less than their corresponding allowable stresses. Therefore, the EOS-TC top and bottom trunnions are structurally adequate to withstand loads during lifting and transfer operations.

3.8 References

3-1 NUREG-1536, Revision 1, "Standard Review Plan for Spent Fuel Dry Cask Storage Systems at a General License Facility," July 2010.

3-2 American Society of Mechanical Engineers, "ASME Boiler and Pressure Vessel Code," Section III, Division 1, Subsections NB, NG, NF, ND and NCA, 2010 Edition through 2011 Addenda.

3-3 American Society of Mechanical Engineers, "ASME Boiler and Pressure Vessel Code," Section II, Materials Specifications, Parts A, B, C and D, 2010 Edition through 2011 Addenda.

3-4 ACI 349-06, "Code Requirements for Nuclear Safety Related Concrete Structures," American Concrete Institute, November 2006.

3-5 American Institute of Steel Construction, "AISC Manual of Steel Construction," 13th Edition or later.

3-6 ANSI/ANS 57.9-1984, "Design Criteria for an Independent Spent Fuel Storage Installation (Dry Storage Type)," American National Standards Institute.

3-7 ANSI N14.6-1993, "American National Standard for Special Lifting Device for Shipping Containers Weighing 10,000 lbs. or More for Nuclear Materials," American National Standards Institute.

3-8 U.S. Nuclear Regulatory Commission, Regulatory Guide 1.124, "Service Limits and Loading Combination for Class 1 Linear-Type Supports," February 2007.

3-9 NUREG/CR-7024, "Material Property Correlations: Comparisons between FRAPCON-3.4, FRAPTRAN 1.4, and MATPRO," U.S. Nuclear Regulatory Commission, August 2010.

3-10 Nuclear Assurance Corporation, "Domestic Light Water Reactor Fuel Design Evolution," Volume III, 1981.

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

3-12 "ANSYS Computer Code and User's Manual", Release 14.0.3*,* 17.1*, and 2022 R2*.

3-13 Title 10, Code of Federal Regulations, Part 72, "Licensing Requirements for the Storage of Spent Fuel in the Independent Spent Fuel Storage Installation," U.S. Nuclear Regulatory Commission, August 3, 1988.

3-14 NUREG/CR–6007, "Stress Analysis of Closure Bolts for Shipping Casks," U.S. Nuclear Regulatory Commission, 1993.

3-15 ANSI/ANSI N690-18, "Specification for Safety-Related Steel Structures for Nuclear Facilities."

All Indicated Changes are Enclosure 2, Item 1.

- Side drop away from the cask rail with internal pressure

Figure 3.9.1-16 shows the stress results for side drop away from cask rails without internal pressure.

3.9.1.2.7.8 Thermal Loads

Per Chapter 4, the thermal storage load cases have lower temperature gradients in the DSC shell compared to thermal transfer load cases. Therefore, only bounding off-normal thermal transfer load cases have been selected for thermal stress analysis of the EOS-37PTH DSC.

For thermal stress analysis, temperature profiles and maximum component temperatures are based on the thermal analyses of the EOS-37PTH DSC in TC125 for transfer conditions, which is discussed in Chapter 4*, excluding the 54 kW heat load HLZC 14*. Only the off-normal load cases with higher temperature gradients in the DSC shell are taken for thermal stress analysis. *Temperature gradients associated with the 54 kW heat load HLZC 14 are shown to be comparable to those for the EOS-37PTH loaded with a 50 kW heat load, such that there is not a substantial effect on the thermal stresses of the DSC shell assembly. As shown in Tables 3.9.1-7 through 3.9.1-12a, 3.9.1-16, and 3.9.1-16a for all components, load combinations that contain thermal loads have adequate margin to accommodate any marginal increase in thermal stress due to HLZC 14 temperatures.*

Since the TC125 is shorter than TC135, there is a higher temperature distribution in TC125. Therefore, the thermal analysis of the EOS-37PTH in TC125 bounds the thermal analysis of EOS-37PTH in TC135. The thermal conditions have been evaluated separately to minimize the number of analyses to be performed. For all DSC components, the thermal stresses have been combined by adding the maximum stress intensities of components from thermal load runs to the primary membrane plus bending stresses of components from mechanical load runs.

Thermal stresses are classified as secondary stresses per the ASME Code, [3.9.1-3]. These secondary stresses are a result of dissimilar material properties, primarily differential thermal growth of a structure due to material thermal expansion coefficient differences between different materials used for construction of the structure, or differential temperature distribution throughout the structure, or a combination of both.

Nodal temperature from thermal analyses is transferred to the structural model described in Section 3.9.1.2.3. The structural model is solved and stresses of thermal load of each load step are post-processed and the largest stresses for all the transfer cases are selected. Only the largest selected stresses are used for further stress evaluation and stress combination.

3.9.1-4	American Society of Mechanical Engineers, ASME Boiler and Pressure Vessel Code, Section XI, Division 1, Appendix C, 2010 Edition Addenda through 2011 Addenda.
3.9.1-5	ANSI N14.5, "Leakage Tests on Packages for Shipment of Radioactive Materials," 1997.
3.9.1-6	ANSI N14.6 – 1993, "American National Standard for Radioactive Materials – Special Lifting Devices for Shipping Containers Weighing 10000 pounds (4500 kg) or More," American National Standards Institute, Inc., New York.
3.9.1-7	NUREG-1536, "Standard Review Plan for Spent Fuel Dry Cask Storage Systems at a General License Facility," Revision 1, U.S. Nuclear Regulatory Commission, July 2010.
3.9.1-8	U.S. Nuclear Regulatory Commission, Regulatory Guide 1.60, "Design Response Spectra for Seismic Design of Nuclear Power Plants," Revision 1, 1973.
3.9.1-9	ANSYS Computer Code and User's Manual, Release 14.0, 14.0.3, 17.1*, and 2022 R2*.
3.9.1-10	American Society of Mechanical Engineers, ASME Boiler and Pressure Vessel Code, 2013, Section III Appendices.
3.9.1-11	NUREG CR/1815, "Recommendations for Protecting Against Failure by Brittle Fracture in Ferritic Steel Shipping Containers Up to Four Inches Thick."
3.9.1-12	"475 °C Embrittlement in a Duplex Stainless Steel UNS S31803," Materials Research, Vol. 4, No. 4, 237-240, 2001.
3.9.1-13	Welding Research Council Bulletin 265, "Interpretive Report on Small Scale Test Correlations with K_{Ic} Data," February 1981.

All Indicated Changes are Enclosure 2, Item 1.

3.9.2.1.6 Methodology

ANSYS [3.9.2-2] is used for the evaluation of side loads and thermal loads. Hand calculations are performed to conservatively calculate the stresses due to the axial handling loads. Axial loads are combined with the corresponding side loads, as applicable. Load conditions for the vertical orientation of the DSC/TC are not controlling. Therefore, only the horizontal orientation is evaluated. However, the temperature gradient applied in the thermal analysis bounds the gradients applicable to both the horizontal and vertical orientations (see Section 3.9.2.1.6.1.4).

3.9.2.1.6.1 Finite Element Model

3.9.2.1.6.1.1 Analysis Model Description for Side Loads

In consideration of continuous support of the basket grid structure by the transition rails along the entire length, a 6-inch slice of the basket assembly is modeled, consisting of one-half the widths (basket axial direction) of the basket plates. One end of the 6-inch long model is at the symmetry plane of the horizontal plates and is at the free edges of the vertical plates. The opposite end of the 6-inch long model is at the symmetry plane of the vertical plates and is at the free edges of the horizontal plates. Symmetry boundary conditions (UY = ROTX = ROTZ = 0) are defined at the symmetry planes of the grid plates and at both cut faces of the transition rails and steel angle plates. Geometry plots of the ANSYS model are shown in Figure 3.9.2-1 through Figure 3.9.2-7.

The top and bottom regions of the basket assembly use grid plates with widths as small as 6 inches. The resulting ligaments at the 3-inch deep slots are only 3 inches wide, which is one-half of 6-inch wide ligaments for grid plates in the middle region. However, the tributary width for loading from fuel is also one-half of the tributary width for plates in the middle region, and the fuel distributed load is smaller at the ends since it is away from the active fuel region. Furthermore, the temperatures are lower at the top and bottom of the basket assembly. Therefore, the top and bottom regions of the basket assembly are bounded by the analyzed middle region.

The steel grid plates and the DSC shell are modeled using ANSYS Shell181 elements. No structural credit is taken for the poison plates or for the aluminum plates. The mass of the poison plates and aluminum plates is accounted for by increasing the density of the adjacent steel grid plates. Reinforcing steel angle plates in the R45 transition rails are also modeled using ANSYS Shell181 elements. The aluminum transition rails are modeled using ANSYS Solid185 elements.

To consider bounding conditions, two sets of analyses are performed. The first set of analyses defines nominal gaps for a basket thermal growth, relative to the DSC shell, approximated to be 0.05 inches. The second set of analyses adjusts the gaps for a basket minimum thermal growth, relative to the DSC shell, of 0.0158 inch, calculated based on average temperatures of the basket and DSC shell at the hottest cross-section per Chapter 4. *A sensitivity study was performed with a relative thermal growth of 0.0119 inch (marginally larger gap) calculated based on the slightly increased temperatures for HLZC 14. The impact was found to be negligible.*

Side loads due to transfer handling bound the loads applicable to storage in the EOS-HSM for which only deadweight is applicable. As discussed earlier, the DSC shell, when fully welded with cover plates, is much stiffer than the basket and therefore, for static analyses of the basket for small load levels such as deadweight and on-site handling loads, the DSC shell is considered to be rigid. Therefore the impact of the rail location is insignificant and one model envelopes the configuration when the DSC is inside the EOS-TC and EOS-HSM.

3.9.2.1.6.1.2 Analysis Model Description for Thermal Loads

The basket assembly thermal stress model is similar to the side-loaded model except that it excludes the DSC cylindrical shell (which does not restrain the thermal growth of the basket). One Belleville spring washer is used at each end of the tie rods to allow for thermal growth of the R90 aluminum rail assemblies. Therefore, nonlinear Combin39 spring elements are used in lieu of contact elements at one end of each tie rod for the thermal analyses. The force-deflection input is determined using data associated with the spring washer.

Boundary conditions for the transition rails and rail angle plates are removed from one end of the model to avoid fictitious thermal stresses that would occur if both ends were restrained. Two thermal cases are considered in consideration of the boundary conditions for the transition rails and rail angle plates: restraint at y = 0 inch (near end restraint), and restraint at y = 6 inches (far end restraint). Although the maximum stress results from these two cases are effectively the same, the results are combined with the deadweight and handling cases using ANSYS load combinations to preclude the conservatism of adding maximum stresses regardless of location. The consideration of two sets of boundary conditions for thermal ensures that the correct maximum stress in combination with deadweight and handling stress is obtained.

3.9.2.1.6.1.3 Material Properties in Analyses

The modeled components of the basket and DSC are based on lower bound material properties. The material properties used for stress analyses (except thermal stress analyses) are based on bounding average temperature values at the hottest section for off-normal transfer in a horizontal EOS-TC. Elastic analyses are used for all normal and off-normal conditions.

3.9.2.1.6.1.4 Loads

Load cases are based on the loads described in Chapter 2.

For side loading, the fuel weight load is modeled conservatively using a pressure load equivalent to the applicable acceleration, or G-load, times the FA weight divided by the basket fuel compartment area associated with the active fuel region length and the fuel compartment width between slots (8.79 inches). A fuel load of 11.0 lbs/in acting on the fuel compartment width between slots is applied to bound the load distribution in the active fuel region for all PWR fuel types identified in Chapter 2. Figure 3.9.2-8 shows the application of fuel weight pressure loads to the model.

For 0° and 180° side load orientations, the equivalent fuel assembly pressure acts only on the horizontal plates. For 90° and 270° side load orientations, the equivalent fuel assembly pressure acts only on the vertical plates. For other orientations, the equivalent FA pressure acts perpendicular to the horizontal and vertical plates, proportioned based on the Cosine and Sine of the orientation angle.

Based on the handling load combination required per Chapter 2, the following bounding normal side load conditions (DSC and basket in horizontal position) are evaluated:

- DW + 1g Vertical = 2.0g Vertical at $\theta = 180°$
- DW + 0.5g Vert. + 0.5g Transverse = 1.58g at $\theta_{198} = 198.43°$ *
- DW + 1.0g Transverse = 1.414g at $\theta_{225} = 225.0°$ *

* $\theta_{198} = 180° + \mathrm{Tan}^{-1}(0.5 / 1.5) = 198.43°$; $\theta_{225} = 180° + \mathrm{Tan}^{-1}(1.0 / 1.0) = 225°$

Thermal stress analyses are based on a bounding temperature profile. The temperature profile used is represented by the following equation, labeled “EOS Basket Analysis” in Figure 3.9.2-9:

$$T(x) = -0.3952\,x^2 + 3.4661\,x + 790.29$$

Where,

$T(x)$ = Basket temperature as a function of radius, x.

Figure 3.9.2-9 shows the raw temperature data (versus radius) for one load case from the thermal analyses, labeled “EOS-37PTH in EOS-TC125, Grid Plates, LC # 6”. A comparison of the curves shows that the curve labeled as “EOS Basket Analysis,” which gives the temperatures versus radius used in the basket thermal stress analysis herein, provides the bounding steeper gradient.

3.9.2.1.6.2 Criteria

The basis for allowable stresses is obtained from Chapter 8 and ASME Section III, Division 1, Subsection NG [3.9.2-1]. The criteria are summarized in Chapter 3, Table 3-2. Allowable stresses for the threaded fasteners, used to connect the transition rails to the basket grid structure, are from Chapter 8 and Section NG-3230 of [3.9.2-1]. The criteria are summarized in Table 3.9.2-1. The component allowable stress values are summarized in Table 3.9.2-2. The allowable stresses are based on material properties at 700 °F for the grid plates and *575* °F for the transition rails, angle plates, bolts and tie rods. These temperatures bound the average temperatures at the hottest section for the grid plates and transition rails, respectively, summarized in Chapter 4 for off-normal transfer in a horizontal EOS-TC.

3.9.2.1.6.3 Creep Evaluation for Long Term Storage

The aluminum R90 rails are designed to resist the bearing loads due to the deadweight of the loaded basket for 80 years while stored in the EOS-HSM. For long-term creep effects, where loading on the aluminum transition rail redistributes over time, an average bearing stress is an appropriate value to consider.

Conservatively, it is assumed that the entire weight of the basket is resisted by the three pieces of a single aluminum R90 rail. The 1g deadweight load from the entire weight of a 6-inch long portion of the basket is approximately 3,416 lb. The area of the corresponding 6-inch long portion of the R90 rail that resists the load is approximately = 156 in^2. However, credit for the outer portion of the width of the rail is excluded by conservatively considering only half of the rail width. The corresponding bearing stress is calculated as follows:

Basket 1g vertical bearing stress = Load / Area = 43.8 psi, or, 0.044 ksi.
(on aluminum R90 transition rail)

The individual compartment load at each SFA location on the supporting aluminum plate gives a much lower bearing stress. Using a conservative width of only 8 inches for a compartment gives:

SFA 1g vert. bearing stress = (Load / length) / Width = 1.375 psi, or, 0.0014 ksi.
(on aluminum plate)

The allowable bearing stresses are provided in Chapter 8, and based on Reference [3.9.2-3]; they represent the stress in Aluminum 1100 to produce a strain of 0.01 in 550,000 hours (approximately 63 years). However, the creep strain curve is so flat that the values at 80 years are approximately the same. The allowable bearing stress for Aluminum 1100 represents a conservative lower bound. The initial temperature values (time = 0) and the corresponding allowable bearing stresses in the basket aluminum components, to limit creep strain to 0.01, are as follows:

- 0.254 ksi in the hottest aluminum plate, with a starting temperature of 680 °F
- 0.758 ksi in the hottest R90 rail, with a starting temperature of 470 °F
- 0.876 ksi in a less than hottest R90 rail, based on a starting temperature of 440 °F

From Chapter 4 for normal conditions (applicable to long-term storage conditions) at the hottest cross-section of the basket, the average R90 transition rail temperature is not more than 469 °F, which is less than the above temperature of 470 °F for the hottest R90 rail. Similarly, from Chapter 4, for normal conditions, the hottest basket plate temperature is not more than *672* °F, which is less than the above temperature of 680 °F for the hottest aluminum plate. Based on this comparison of temperatures, and since the heat dissipation rate for the EOS-37PTH basket is better than that for the basket temperature data (temperature versus time) used in Reference [3.9.2-3], the allowable creep stresses given above are applicable to the aluminum components of the EOS-37PTH basket.

3.9.2.1.7 Results

3.9.2.1.7.1 Results for On-Site DW+Handling and Thermal Stress Analysis

Combined results for basket component stress results for normal condition deadweight + handling loads and thermal stress analysis are shown in Table 3.9.2-3. The tabulated results show that all stresses meet the corresponding Code limits.

ANSYS Force Summation Comparison

An ANSYS force summation for the basket components only, for the 2g deadweight plus handling load combination, is compared to the expected load as shown below:

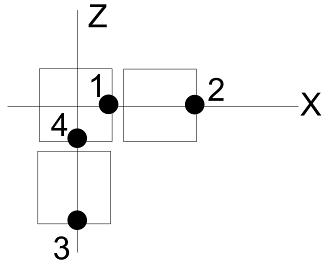
Force Summation: F_Z = -6,831.256 lb
(in vertical direction (z), length of model is 6 inches)
Expected Load:
Basket weight / length w/o spent fuel: = 167.2 lb/in
Basket wt. w/o spent fuel (6" long) = 1,003 lb.
Spent fuel weight (6" long) = (11 lb/in) (6" length of basket) (37 SFAs)
= 2,442 lb.
Total weight of the basket, with spent fuel (6" long) = 3,445 lb (for 1g)
Expected Load at 2g (in vertical direction) = 6,890 lb.

The ANSYS load of 6,831 is within 1% of the hand-calculated weight load and therefore, is acceptable.

Similarly, the ANSYS 1g load is 3,416 lb, or half of the ANSYS 2g load, as expected.

3.9.2.4.7.3 Adjacent Fuel Compartment Relative Displacements

Maximum relative perpendicular displacement from one fuel compartment plate to another is determined from the ANSYS results for the accident side drops. These differences are addressed in the criticality evaluations to ensure that the fuel assembly array pitch does not significantly change due to the accident side drop. The sketch below indicates the sign convention and typical locations where displacements are extracted.



The relative displacements are calculated as follows:

$\Delta_{UX} = UX_2 - UX_1$

$\Delta_{UZ} = UZ_4 - UZ_3$

Maximum relative displacements for those adjacent compartments that have moved closer together are tabulated in Table 3.9.2-13. Relative displacements that indicate fuel compartments have moved away from one another are ignored. The summary table includes results for analyses with bolts and tie rods modeled and for analyses without bolts and tie rods modeled.

3.9.2.4.7.4 Conclusions

Finite element analyses and hand calculations for the EOS-89BTH basket assembly are performed for all accident side and end drop on-site conditions. Controlling strains are reported in Table 3.9.2-11. A comparison of equivalent plastic strains to the corresponding allowable values indicates that all load conditions show acceptable results.

As demonstrated in Section 3.9.2.4.6.3, uncontrolled crack propagation in the grid plates is not an issue for the selected HSLA steel material.

3.9.2.5 References

3.9.2-1 American Society of Mechanical Engineers, "ASME Boiler and Pressure Vessel Code," Section III, Division 1, Subsection NG, 2010 Edition thru 2011 Addenda.

3.9.2-2 ANSYS Computer Code and User's Manual, Release 10.0, 17.1*, and 2022 R2*.

All Indicated Changes are Enclosure 2, Item 1.

Table 3.9.2-2
Component Allowable Stresses (Normal / Off-Normal)

Component	Material	Temp. (°F)	Stress Category	Allowable Stress (ksi)
Steel Grid Plates	HSLA steel such as AISI 4130	700	P_m	24.96
			$P_m + P_b$	37.43
			$P_m + P_b + Q$	74.87
Rail Angle Plates	SA-516 Grade 70	550*(2)*	P_m	20.00
			$P_m + P_b$	30.00
			$P_m + P_b + Q$	60.00
Transition Rails	Aluminum 6061	550*(2)*	$P_m + P_b$	4.85
			$P_m + P_b + Q$	9.70
Bolts (1)	A 564 Type 630 H1100	550*(2)*	Tension, P_m	44.15
			Tension, $P_m + Q_m$	84.56
			Shear, P_m	26.49
Tie Rods	A 564 Type 630 H1100	550*(2)*	Tension, P_m	44.15
			Tension, $P_m + Q_m$	84.56

(1) For basket side loading, only tension loads are transferred through the bolts and tie rods due to oversized/slotted bolts holes that allow for thermal expansion.

(2) Allowable stresses taken at 575 °F for the transition rail components in EOS-37PTH evaluations.

Table 3.9.2-3
EOS-37PTH Basket Stress Summary – Enveloped DW + Handling + Thermal

Load Combination	Component	Stress Category	Maximum Stress (ksi) [1]	Allowable Stress (ksi)	Stress Ratio
Enveloping Results for Normal Conditions in the EOS-TC	Grid Plates [3]	P_m	4.61+0.25= 4.86	24.96	0.195
		$P_m + P_b$	23.95+0.25= 24.20	37.43	0.647
		$P_m + P_b + Q$	31.94	74.87	0.427
	Angle Plates	P_m	3.56	*19.70*	*0.181*
		$P_m + P_b$	4.63	*29.55*	*0.157*
		$P_m + P_b + Q$	12.75	*59.10*	*0.216*
	Transition Rails	$P_m + P_b$	2.72	*4.53*	*0.600*
		$P_m + P_b + Q$	8.57	*9.05*	*0.947*
	Bolts [2][4]	P_m	12.24	*43.98*	*0.278*
		$P_m + Q_m$	44.61	*83.99*	*0.531*
	Tie Rods [2]	P_m	7.32	*43.98*	*0.166*
		$P_m + Q_m$	14.87	*83.99*	*0.177*

(1) $P_m + P_b + Q$ values are determined using ANSYS load combinations.

(2) Bolt and tie rod stresses listed are increased for the reduced area at the threads.

(3) Grid plate stresses include hand calculated stresses for 0.5g axial, where controlled by the DW + (0.5g Vert., 0.5g Trans., 0.5g Ax.) Handling load combination.

(4) Bolt maximum shear stress is 14.84 < *26.39* ksi, with a stress ratio of *0.562* per conservative hand calculation for axial handling.

All Indicated Changes are Enclosure 2, Item 1.

The ultimate strength method of ACI 349-06 [3.9.4-12] is used for the design of the EOS-HSM reinforced concrete structural components. The reinforcement is provided to meet the minimum flexural and shear reinforcement requirement of ACI 349-06 and to ensure that the provided design strength exceeds the required strength. Alternatively, for some cases, the minimum reinforcement area requirement can be waived for components with a flexural stress ratio of less than 0.66 as per Section 10.5.3 of ACI 349-06 [3.9.4-12].

Concrete capacities consider temperatures that bound those reported in Chapter 4. The axial, shear and moment capacities for all the concrete components of the EOS-HSM calculated based on ACI 349-06 are provided in Table 3.9.4-11, Table 3.9.4-12, Table 3.9.4-26, and Table 3.9.4-27 for EOS-HSM and Table 3.9.4-11a, Table 3.9.4-12a,Table 3.9.4-26a, and Table 3.9.4-27a for EOS-HSM-FPS. With additional reinforcement, the axial tension capacities of certain parts of the front wall for the EOS-HSM-HS are greater than those for the EOS-HSM-FPS as shown in Table 3.9.4-29c. The capacities for blocked vent accident condition consider the strength reduction at elevated temperature.

The results considering DSC heat loads of 50kW and 54kW (where applicable) are presented. The comparison of the Highest Combined Shear Force/Moment with the capacities for the EOS HSM is provided in Table 3.9.4-13 *and Table 3.9.4-13d. T*he comparison of the Highest Combined Shear Force/Moment with the capacities for the Alternate Front wall is provided in Table 3.9.4-28 *and Table 3.9.4-29f*.

The comparison of the highest combined shear force/moment with the capacities for the EOS HSM-FPS is provided in Table 3.9.4-13a *and Table 3.9.4-13e. T*he comparison of the highest combined shear force/moment with the capacities for the Alternate Front wall is provided in Table 3.9.4-28a *and Table 3.9.4-28d*. The comparisons of the highest combined shear force/moment with the capacities for the EOS-HSMS-FPS-OVVP, for load combination C4, are provided in *Table 3.9.4-13b and Table 3.9.4-13f. The comparisons of the highest combined shear force/moment with the capacities for the EOS-HSMS-FPS-OVVP alternate front wall, for load combination C4, are provided in Table 3.9.4-28b and Table 3.9.4-28e.* The comparisons of the highest combined shear force/moment with the capacities for the EOS-HSM-HS, for load combination C4, are provided in Table 3.9.2-13c and Table 3.9.4-28c.

Similarly, the comparison of the highest combined axial force/moment with capacities for the EOS HSM is provided in Table 3.9.4-14 *and Table 3.9.4-14e. The* comparison of the highest combined axial force/moments with capacities for the alternate front wall is provided in Table 3.9.4-29 *and Table 3.9.4-29f*.

The comparison of the highest combined axial force/moment with the capacities for the EOS HSM-FPS is provided in Table 3.9.4-14a *and Table 3.9.4-14f. T*he comparison of the highest combined *axial* force/moment with the capacities for the Alternate Front wall is provided in Table 3.9.4-29a *and Table 3.9.4-29d*. The comparisons of the highest combined axial force/moment with the capacities for the EOS-HSMS-FPS-OVVP, for load combination C4, are provided in *Table 3.9.4-14c and Table 3.9.4-14g. The comparisons of the highest combined axial force/moment with the capacities for the EOS-HSMS-FPS-OVVP alternate front wall, for load combination C4, are provided in Table 3.9.4-29b and Table 3.9.4-29e.* The comparisons of the highest combined axial force/moment with the capacities for the EOS-HSM-HS, for load combination C4, are provided in Table 3.9.2-14d and Table 3.9.4-29c.

The required steel strength, S, and required steel shear strength, S_v, for critical section of steel structure are calculated in accordance with the requirements of AISC Steel Construction Manual [3.9.4-14] using the Allowable Strength Design (ASD) method.

3.9.4.4 Load Cases

A summary of the design loads for EOS-HSM concrete component evaluation is provided in Table 3.9.4-4. This table also presents the applicable codes and standards for specific load. A summary of the design loads for DSC support structure is provided in Table 3.9.4-15.

3.9.4.5 Load Combination

The load combinations used in the structural analysis of EOS-HSM and DSC support structure comply with the requirement of 10 CFR 72.122 [3.9.4-1] and ANSI 57.9-84 [3.9.4-10]. Table 3.9.4-5 and Table 3.9.4-16 summarize the load combination requirement of EOS-HSM and DSC support structure, respectively.

The modifications applied to the EOS-HSMS-FPS-OVVP and the EOS-HSM-HS affect evaluations for load combination C4 only. Therefore, only this load combination is considered in the results for the EOS-HSMS-FPS-OVVP and the EOS-HSM-HS.

3.9.4.6 Finite Element Models

EOS-HSM and EOS-HSMS have variable lengths to store DSCs of different lengths. EOS-HSM Long is analyzed and governs the structural design of EOS-HSM Short, Medium and Long. EOS-HSM-FPS, EOS-HSMS-FPS, EOS-HSMS-FPS-OVVP and EOS-HSM-HS are only available and analyzed at a Medium length.

All Indicated Changes are Enclosure 2, Item 1.

The node coupling option of ANSYS is used to represent the appropriate connection between the base and roof of the EOS-HSM and EOS-HSM-FPS models. For EOS-HSMS and EOS-HSMS-FPS, the node to node contact element (ANSYS element type CONTA178) is used across the interface of the upper and lower segment to transfer the load from the roof and upper segment to the lower segment. The counter bore and rail extension baseplate groove at the door opening are not included in the FEM. Conservatively, the nodes at the bottom of EOS-HSM are constrained in all three translational degree of freedom, thus maximizing the EOS-HSM design forces and moments.

3.9.4.6.2 Finite Element Model of the EOS-HSM Concrete Structure for Thermal Stress Analysis

Thermal stress analyses of the EOS-HSM were performed using a 3D FEM, which includes only the concrete components. The connections of the door and the support structure rails to the EOS-HSM concrete structure are designed so that free thermal growth is permitted in these members when the EOS-HSM is subjected to thermal loads. Because of their free thermal growth, the door and the support structure do not induce thermal stresses in the concrete components of the EOS-HSM. Therefore, the analytical model of the EOS-HSM for thermal stress analysis of the concrete components does not include the DSC support structure and the door. The ANSYS models with temperature profile, which is used to perform thermal stress analysis of the concrete components, are shown in *Figure 3.9.4-3, Figure 3.9.4-3a, Figure 3.9.4-3b, Figure 3.9.4-4, Figure 3.9.4-4a, and Figure 3.9.4-4b.*

For the thermal load analysis, the bottom of the EOS-HSM (y=0 in ANSYS model) was restrained at one set of edge nodes (in axial and lateral directions) and friction forces were applied at the bottom of EOS-HSM base in the axial and lateral directions. One node in the front wall and two nodes in the back wall at y=0 are also restrained in vertical direction.

3.9.4.6.3 Finite Element Model for Structural Analysis of DSC Support Structure

A 3D FEM of the DSC main support beam with stiffener plates and rail extension baseplate is developed in the computer program ANSYS [3.9.4-19]. In the finite element model (FEM) for the DSC main support beam (W12x136), the W section of the main support beam is broken down into flange and web components represented individually by BEAM189 elements.

The beam elements (BEAM189) are arranged in a 2D plane aligned with the centerline of the beam, inclined 30 degrees from vertical along the length of the beam. Each element has three nodes with six degrees of freedom (three translational and three rotational) per node.

3.9.4.7 Normal Operation Structural Analysis

The evaluation of the EOS-HSM is performed at normal operating condition. The following table shows the normal operating loads for which the EOS-HSM components are designed. The table also lists the individual EOS-HSM components that are affected by each loading.

Load Type	Components	
	EOS-HSM	**DSC Support Structure**
Dead Load	X	X
Live Load	X	X
Normal Handling	X	X
Normal Thermal	X	X
Wind Load	X	

The reinforced concrete and the steel DSC support structure of the EOS-HSM are analyzed for the normal, off-normal, and postulated accident conditions using FEMs described in Section 3.9.4.6. These models are used to evaluate concrete and support structure forces and moments due to dead load, live load, normal handling loads, normal thermal loads, and wind load. The methodology used to evaluate the effects of these normal loads is addressed in the following paragraphs.

3.9.4.7.1 EOS-HSM Dead Load (DL) Analysis

Dead loads are applied to the analytical model by application of 1g acceleration in the vertical direction where g is the gravitational acceleration (386.4 in/sec2). The 5% variation of dead load as indicated in ANSI/ANS 57.9 is not used because the heaviest design weight is used for analysis.

For the EOS-HSMS-FPS variant, a heavier HSM is also evaluated based upon a maximum fresh concrete density of 160 pcf plus the weight of the rebar, corresponding to a composite weight density of approximately 169 pcf for the HSM, compared to the 160 pcf that is used in the structural models. This weight increase has no impact on the existing seismic load case evaluation performed for the EOS-HSMS-FPS system, as the results are still within the conservative margins available in the seismic analysis. This variation in density only adversely affects the dead weight load case. This results in a maximum increase of 2% in the demand to capacity ratios for the roof component with negligible changes in the demands for the other HSM components. For the EOS-HSMS-FPS, when considering both 50kW and 54kW heat load, there is greater than 2% margin for affected load combinations and therefore, for this considered weight increase, the HSM concrete components remain structurally adequate for the increase in dead load. 72.48 & Amd 5

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3.9.4.7.2 EOS-HSM Live load (LL) Analysis

Live load analysis is performed by applying 200 psf pressure on the roof. The DSC weight is also applied on the DSC support structure as a live load.

3.9.4.7.3 EOS-HSM Normal Operational Handling Load (R_o) Analysis

Normal operation assumes the canister is sliding over the DSC support structure due to a hydraulic ram force of up to 135,000 lbs (insertion) and 80,000 lbs (extraction) applied at the grapple ring. The normal operation handling load of 70,000 lbs is applied to each DSC main support structure in the axial direction resulting in a total applied load of 140,000 lbs on both beams which conservatively envelopes the total insertion/extraction force. The same magnitude of load of 70,000 lbs is also applied at each of the cask restraint embedment in opposite direction. In addition, the DSC weight is applied as a distributed load on both DSC support structure of the EOS-HSM.

3.9.4.7.4 EOS-HSM Normal Operating Thermal (T_o) Stress Analysis

The normal operating thermal (T_o) loads on EOS-HSM include the effect of design basis heat load up to *54kW except for the EOS-HSM-HS, which includes heat loads up to* 50 kW generated by DSC, plus the effect of normal ambient temperature range. To evaluate the effects of normal thermal loads on the EOS-HSM, heat transfer analyses for a range of normal ambient temperatures (-20 °F and 100 °F) are performed with DSC heat load of 50 kW *and 54kW except for the EOS-HSM-HS, which considers a maximum heat load of 50kW.* The normal thermal cold condition (-20 °F) is bounded by off-normal thermal cold condition (-40 °F). Therefore, off-normal thermal cold condition is used in place of normal thermal cold condition. The ambient condition that causes maximum temperature and maximum gradients in the concrete components is used in the analysis. The normal thermal hot condition is the governing case for this load case. The EOS-HSM thermal stress analysis was performed using thermal profiles and maximum temperatures that bounds those reported in Chapter 4.

3.9.4.7.5 EOS-HSM Design Basis Wind Load (W) Analysis

The DSC support structure and DSC inside the EOS-HSM are not affected by wind load. The concrete structure forces and moments due to design basis wind load (W) are bounded by the result of tornado generated wind load discussed in Section 3.9.4.9.1. Therefore, tornado generated wind load is conservatively used in the off-normal wind load combination C2, as seen in Table 3.9.4-5. Therefore, no separate analysis is performed for the design basis wind load case.

3.9.4.9.4 Accident Blocked Vent Thermal (T_a) Stress Analysis

This accident conservatively postulates the complete blockage of the EOS-HSM ventilation air inlet and outlet openings.

Since the EOS-HSMs are located outdoors; there is a remote probability that the ventilation air inlet and outlet vent openings could become blocked by debris from events such as flooding, high wind and tornados. Design features, such as the perimeter security fence and the redundant protected location of the air inlet, and outlet vent openings and the screens reduce the probability of occurrence of such an accident. Nevertheless, for this conservative generic analysis, such an accident is postulated to occur and is analyzed.

The postulated accident thermal event occurs due to blockage of the air inlet and outlet vents under off-normal ambient temperatures range from -40 ºF to 117 ºF.

ANSYS FEM described in Section 3.9.4.6 is used for the structural analysis for accident blocked vent condition.

3.9.4.10 Structural Evaluation

The load categories associated with normal operating conditions, off-normal conditions and postulated accident conditions are described previously. The load combination results and design strengths of EOS-HSM components are presented in this section.

3.9.4.10.1 EOS-HSM Concrete Components

To determine the required strength (internal axial forces, shear forces, and bending moments) for each EOS-HSM concrete component, linear elastic finite element analyses are performed for the normal, off-normal, and accident loads using the analytical models described in Section 3.9.4.6 for mechanical and thermal loads.

The concrete design loads are multiplied by load factors and combined to simulate the most adverse load conditions. The load combinations listed in Table 3.9.4-5 are used to evaluate the concrete components. *The bounding load combination results for each component of the EOS-HSM with up to 50kW thermal load are presented in Table 3.9.4-7 to Table 3.9.4-10. The following table lists the various configurations and associated demand/capacity ratio results tables.*

HSM Configuration	*Heat Load*	*Demand/Capacity Ratio Tables*
EOS-HSM	*up to 50kW*	*Table 3.9.4-13, Table 3.9.4-14, Table 3.9.4-28, Table 3.9.4-29*
	up to 54kW	*Table 3.9.4-13d, Table 3.9.4-14e, Table 3.9.4-29f*
EOS-HSM-FPS	*up to 50kW*	*Table 3.9.4-13a, Table 3.9.4-14a, Table 3.9.4-14b, Table 3.9.4-28a, Table 3.9.4-29a*
	up to 54kW	*Table 3.9.4-13e, Table 3.9.4-14f, Table 3.9.4-28d, Table 3.9.4-29d*
EOS-HSM-OVVP	*up to 50kW*	*Table 3.9.4-13b, Table 3.9.4-14c, Table 3.9.4-28b, Table 3.9.4-29b*
	up to 54kW	*Table 3.9.4-13f, Table 3.9.4-14g, Table 3.9.4-28e, Table 3.9.4-29e*
EOS-HSM-HS	*up to 50kW*	*Table 3.9.4-13c, Table 3.9.4-14d, Table 3.9.4-28c, Table 3.9.4-29c*

The notations for the components of forces and moments and the concrete component planes in which capacities are computed are shown in Figure 3.9.4-5. The thermal stresses of EOS-HSM concrete components used in the load combination results are based on thermal results that bound those reported in Chapter 4. All load combination results are less than computed section capacities.

The required strength, U, for critical sections of concrete is calculated in accordance with the requirements of ANSI 57.9 [3.9.4-10] and ACI 349-06 [3.9.4-12], including the strength reduction factors defined in ACI 349-06, Section 9.3. The design strength of EOS-HSM concrete components exceeds the factored design loads. Thus, the EOS-HSM concrete components are adequate to perform their intended function. EOS-HSM construction details such as construction joints and reinforcement bar splices is detailed on the construction drawings.

3.9.4-16 AREVA Inc., "Updated Final Safety Analysis Report for the Standardized NUHOMS® Horizontal Modular Storage System for Irradiated Nuclear Fuel," Revision 17, USNRC Docket Number 72-1004, March 2018.

3.9.4-17 Bechtel Power Corporation, "Design of Structures for Missile Impact," Topical Report BCTOP-9A, Revision 2, San Francisco, California.

3.9.4-18 Bechtel Corporation, "Design Guide Number C-2.45 for Design of Structures for Tornado Missile Impact," Rev. 0, April 1982.

3.9.4-19 "ANSYS Computer Code and User's Manual," Release 14.0.3, 17.1*, and 2022 R2*.

3.9.4-20 Binder, Raymond C., "Fluid Mechanics," 3rd Edition, Prentice-Hall, Inc, 1973.

3.9.4-21 AREVA Inc., "Updated Final Safety Analysis Report For The Standardized Advanced NUHOMS® Horizontal Modular Storage System For Irradiated Nuclear Fuel," Revision 7, US NRC Docket Number 72-1029, April 2016.

3.9.4-22 U.S. Nuclear Regulatory Commission, Regulatory Guide 1.76, "Design Basis Tornado for Nuclear Power Plants," Revision 1, March 2007.

All Indicated Changes are Enclosure 2, Item 1.

Table 3.9.4-4
Load Cases for EOS-HSM Concrete Components Evaluation

Design Load Type	Load Notation	Design Parameters	Applicable Codes / References
Normal			
Dead	DL	Includes self-weight with 160 pcf density for concrete and 0.28 pci for steel support structure.	ANSI/ANS 57.9-1984 [3.9.4-10]
Live	LL	Design live load of 200 psf on roof which includes snow and ice load and DSC weight of 135 kip applied on DSC support rails.	ANSI/ANS 57.9-1984 [3.9.4-10] & ASCE 7-10 [3.9.4-15]
Normal Handling	R_O	The concrete module is evaluated for 140 kip DSC insertion load as a normal handling load. The DSC weight is also applied at both rail support locations (4 points).	
Normal Thermal	T_O	DSC with spent fuel rejecting up to *54 kW* (2) of decay heat. Extreme ambient air temp. -20 °F and 100 °F. Reference temperature = 70 °F.	
Off-Normal/Accidental			
Off-Normal Handling	R_a	For the steel support structure the magnitude of this load is 135 kip both for DSC insertion and retrieval, applied to one rail. The DSC weight is also applied at one rail support location (two points).	
Accidental Thermal	T_a	Enveloped of Off-Normal and Accidental Thermal (vent blocked) condition. Accidental thermal condition is same as off-normal condition with ambient temperature range of -40 °F to 117 °F. Reference temperature = 70 °F	
Earthquake	E	For all options except EOS-HSM-HS, zero period acceleration of 0.5g in horizontal and 0.333g in vertical direction. For EOS-HSM-HS, zero period acceleration of 0.91g in horizontal and 0.80g in vertical directions All options with enhancement in frequency above 9 Hz and 7% damping. (1)	NRC Reg. Guide 1.60 [3.9.4-2] & Reg. Guide 1.61 [3.9.4-3]
Flood	FL	Maximum flood height of 50 ft and max. velocity of water 15 ft/sec	10 CFR Part 72 [3.9.4-1]
Wind/Tornado Wind	W/W_t	Maximum wind speed of 360 mph, and a pressure drop of 3 psi	ASCE 7-10 [3.9.4-15] & NRC Reg Guide 1.76 [3.9.4-4]
Tornado Generated Missile	W_m	4 types of tornado-generated missiles	NUREG-0800 Section 3.5.1.4 [3.9.4-7]

(1) Seismic loading conservatively exceeds the design basis ZPA values of 0.45g horizontal and 0.30g vertical.

(2) EOS-HSM-HS only accommodates heat loads up to 50kW.

All Indicated Changes are Enclosure 2, Item 1.

Table 3.9.4-7
Demand of EOS-HSM Concrete Components for Shear Forces and Moments *(50kW Heat Load)*

Component	Load Combination	M_1 (in-kip/ft)	M_2 (in-kip/ft)	V_{o1} (kip/ft)	V_{o2} (kip/ft)	V_i (kip/ft)
1. Rear Wall Bottom (32")	C1 through C6	338.7	708.7	6.3	9.8	51.6
	C7	232.8	270.8	1.9	2.7	25.3
2. Rear Wall Top (12")	C1 through C6	36.9	106.6	5.1	6.4	13.7
	C7	24.5	69.3	4.2	2.9	7.6
3. Front Wall Bottom (54")	C1 through C6	1024.0	1877.2	14.2	13.0	57.6
	C7	1049.1	1735.2	3.1	3.1	25.2
4. Front Wall Top (42")	C1 through C6	949.7	1768.7	28.5	25.6	90.4
	C7	1353.1	2485.3	26.1	24.4	48.3
5. Side Wall Bottom (24")	C1 through C6	269.3	182.9	15.4	14.8	23.5
	C7	143.4	396.3	14.3	18.6	11.1
6. Side Wall Bottom (14")	C1 through C6	91.4	38.0	11.4	6.1	14.4
	C7	64.0	117.2	12.1	12.7	11.1
7. Side Wall Top (12")	C1 through C6	285.3	195.0	12.3	11.9	38.5
	C7	341.2	151.8	10.6	10.6	46.5
8. Roof (44")	C1 through C6	622.2	1831.5	46.1	49.5	21.5
	C7	283.6	1004.2	11.6	24.3	22.5

All Indicated Changes are Enclosure 2, Item 1.

Table 3.9.4-8
Demand of EOS-HSM Concrete Components for Axial Forces and Moments *(50kW Heat Load)*

Component	Load Combination	T_1 (kip/ft)	T_2 (kip/ft)	C_1 (kip/ft)	C_2 (kip/ft)	M_{1P} (in-kip/ft)	M_{2P} (in-kip/ft)
1. Rear Wall Bottom (32")	C1 through C6	33.8	32.1	46.4	104.4	299.6	428.3
	C7	13.4	5.5	40.5	44.6	66.4	124.1
2. Rear Wall Top (12")	C1 through C6	9.5	23.6	7.5	29.6	36.9	43.4
	C7	7.1	40.0	15.1	15.8	20.1	45.8
3. Front Wall Bottom (54")	C1 through C6	72.2	65.6	51.3	122.3	1019.5	773.8
	C7	19.8	0.0	32.0	59.8	485.3	0.0
4. Front Wall Top (42")	C1 through C6	97.7	77.5	86.6	256.2	737.5	1137.7
	C7	22.1	32.8	38.7	98.9	1352.7	1796.9
5. Side Wall Bottom (24")	C1 through C6	28.0	37.6	48.2	70.2	267.5	158.6
	C7	22.5	58.7	28.0	38.8	97.1	324.9
6. Side Wall Bottom (14")	C1 through C6	19.4	16.5	47.6	15.9	75.9	37.9
	C7	31.5	62.9	21.9	6.1	64.0	117.2
7. Side Wall Top (12")	C1 through C6	27.5	49.7	157.1	103.7	44.4	49.0
	C7	56.9	11.7	138.0	108.7	64.5	132.3
8. Roof (44")	C1 through C6	24.4	67.5	35.4	107.1	621.8	1817.3
	C7	11.5	59.9	4.8	90.8	239.4	751.2

Table 3.9.4-9
Demand of EOS-HSMS Concrete Components for Shear Forces and Moments *(50kW Heat Load)*

Component	Load Combination	M_1 (in-kip/ft)	M_2 (in-kip/ft)	V_{o1} (kip/ft)	V_{o2} (kip/ft)	V_i (kip/ft)
1. Rear Wall Bottom (32")	C1 through C6	335.6	694.6	6.9	11.3	55.5
	C7	215.2	297.1	2.2	2.5	24.5
2. Rear Wall Top (12")	C1 through C6	69.4	110.3	4.9	7.7	52.9
	C7	25.1	66.2	3.2	3.0	8.5
3. Front Wall Bottom (54")	C1 through C6	970.2	1882.1	13.4	13.0	60.8
	C7	1028.4	1436.7	3.6	3.1	26.2
4. Front Wall Top (42")	C1 through C6	1077.5	1501.8	28.7	28.3	130.5
	C7	1500.8	2424.0	24.8	21.4	46.8
5. Side Wall Bottom (24")	C1 through C6	193.1	161.2	13.3	12.6	20.9
	C7	140.6	409.0	14.6	17.4	13.1
6. Side Wall Bottom (14")	C1 through C6	67.4	38.9	10.9	6.6	15.4
	C7	58.5	115.7	12.0	12.0	9.8
7. Side Wall Top (12")	C1 through C6	265.9	224.6	12.1	12.1	59.3
	C7	307.9	138.6	10.6	10.6	37.7
8. Roof (44")	C1 through C6	623.2	1839.1	39.3	49.8	22.3
	C7	291.1	979.2	10.2	21.8	20.8

Table 3.9.4-10
Demand of EOS-HSMS Concrete Components for Axial Forces and Moments *(50kW Heat Load)*

Component	Load Combination	T_1 (kip/ft)	T_2 (kip/ft)	C_1 (kip/ft)	C_2 (kip/ft)	M_{1P} (in-kip/ft)	M_{2P} (in-kip/ft)
1. Rear Wall Bottom (32")	C1 through C6	25.0	42.4	49.3	108.5	248.3	344.0
	C7	14.6	10.9	39.7	47.3	58.8	295.8
2. Rear Wall Top (12")	C1 through C6	51.4	43.7	306.1	132.2	44.1	29.1
	C7	7.5	34.8	21.9	22.4	21.2	42.4
3. Front Wall Bottom (54")	C1 through C6	54.1	88.6	75.0	117.7	800.5	412.6
	C7	20.5	0.0	35.3	62.5	486.1	0.0
4. Front Wall Top (42")	C1 through C6	111.6	103.8	426.5	336.5	352.2	907.9
	C7	45.6	80.0	65.8	163.9	1500.8	992.9
5. Side Wall Bottom (24")	C1 through C6	34.7	28.2	49.3	60.0	181.8	159.6
	C7	21.0	55.2	26.4	33.8	98.8	342.5
6. Side Wall Bottom (14")	C1 through C6	20.6	15.0	45.9	16.8	64.3	38.9
	C7	29.8	57.3	21.0	10.2	57.2	115.7
7. Side Wall Top (12")	C1 through C6	50.8	62.0	257.1	233.8	40.9	63.2
	C7	51.8	58.5	121.8	240.2	63.3	62.7
8. Roof (44")	C1 through C6	24.9	76.4	38.8	114.5	623.0	1824.9
	C7	10.4	46.9	4.9	94.0	246.1	746.4

All Indicated Changes are Enclosure 2, Item 1.

Table 3.9.4-13
Comparison of Highest Combined Shear Forces/Moments with the Capacities of EOS-HSM *(50kW Heat Load)*
3 Pages

Component	Load Combination	Quantity	V_1 kips/ft	V_{o1} kips/ft	V_{o2} kips/ft	M_1 kip-in/ft	M_2 kip-in/ft
1. Rear Wall Bottom (32")	C1 through C6	Computed	51.62	6.26	9.79	338.75	708.70
		Capacity	90.43	38.26	38.26	886.79	886.79
		Ratio	0.57	0.16	0.26	0.38	0.80
	C7	Computed	25.29	1.86	2.71	232.79	270.83
		Capacity	85.58	36.30	36.30	837.08	837.08
		Ratio	0.30	0.05	0.07	0.28	0.32
2. Rear Wall Top (12")	C1 through C6	Computed	13.70	5.12	6.40	36.93	106.65
		Capacity	64.97	12.81	12.81	290.38	290.38
		Ratio	0.21	0.40	0.50	0.13	0.37
	C7	Computed	7.64	4.22	2.95	24.52	69.33
		Capacity	61.43	12.15	12.15	273.80	273.80
		Ratio	0.12	0.35	0.24	0.09	0.25
3. Front Wall Bottom (54")	C1 through C6	Computed	57.56	14.24	13.02	1023.97	1877.23
		Capacity	195.97	64.28	64.28	3791.72	3791.72
		Ratio	0.29	0.22	0.20	0.27	0.50
	C7	Computed	25.23	3.12	3.11	1049.12	1735.23
		Capacity	185.37	60.98	60.98	3578.11	3578.11
		Ratio	0.14	0.05	0.05	0.29	0.48

All Indicated Changes are Enclosure 2, Item 1.

Table 3.9.4-13
Comparison of Highest Combined Shear Forces/Moments with the Capacities of EOS-HSM *(50kW Heat Load)*
3 Pages

Component	Load Combination	Quantity	V_1 kips/ft	V_{o1} kips/ft	V_{o2} kips/ft	M_1 kip-in/ft	M_2 kip-in/ft
4. Front Wall Top (42")	C1 through C6	Computed	90.42	28.50	25.62	949.69	1768.70
		Capacity	180.69	49.00	49.00	2875.63	2875.63
		Ratio	0.50	0.58	0.52	0.33	0.62
	C7	Computed	48.32	26.12	24.35	1353.14	2485.27
		Capacity	170.88	46.49	46.49	2712.91	2712.91
		Ratio	0.28	0.56	0.52	0.50	0.92
5. Side Wall Bottom (24")	C1 through C6	Computed	23.50	15.39	14.78	269.28	182.86
		Capacity	102.12	27.84	27.84	919.26	919.26
		Ratio	0.23	0.55	0.53	0.29	0.20
	C7	Computed	11.06	14.31	18.56	143.44	396.28
		Capacity	96.57	26.41	26.41	867.25	867.25
		Ratio	0.11	0.54	0.70	0.17	0.46
6. Side Wall Bottom (14")	C1 through C6	Computed	14.39	11.42	6.10	91.36	38.03
		Capacity	89.39	15.11	15.11	489.85	489.85
		Ratio	0.16	0.76	0.40	0.19	0.08
	C7	Computed	11.13	12.14	12.65	63.98	117.21
		Capacity	84.50	14.34	14.34	461.69	461.69
		Ratio	0.13	0.85	0.88	0.14	0.25

All Indicated Changes are Enclosure 2, Item 1.

Table 3.9.4-13
Comparison of Highest Combined Shear Forces/Moments with the Capacities of EOS-HSM *(50kW Heat Load)*
3 Pages

Component	Load Combination	Quantity	V_1 kips/ft	V_{o1} kips/ft	V_{o2} kips/ft	M_1 kip-in/ft	M_2 kip-in/ft
7. Side Wall Top (12")	C1 through C6	Computed	38.48	12.32	11.88	285.32	195.00
		Capacity	86.84	12.57	12.57	403.96	403.96
		Ratio	0.44	0.98	0.95	0.71	0.48
	C7	Computed	46.54	10.56	10.64	341.15	151.85
		Capacity	82.08	11.92	11.92	380.58	380.58
		Ratio	0.57	0.89	0.89	0.90	0.40
8. Roof (44")	C1 through C6	Computed	21.46	46.12	49.54	622.18	1831.53
		Capacity	151.43	51.55	51.55	2283.14	2283.14
		Ratio	0.14	0.89	0.96	0.27	0.80
	C7	Computed	22.51	11.56	24.29	283.58	1004.18
		Capacity	143.25	48.90	48.90	2154.63	2154.63
		Ratio	0.16	0.24	0.50	0.13	0.47

Notes:

Load Combinations C1 through C6 include normal thermal condition and C7 includes accidental thermal condition.

Comparison of highest combined shear forces/moments with capacities for alternate front wall rebar layout reported in Table 3.9.4-28.

All Indicated Changes are Enclosure 2, Item 1.

Table 3.9.4-13a
Comparison of Highest Combined Shear Forces/Moments with the Capacities of EOS FPS HSM (Bounding) *(50kW Heat Load)*
3 Pages

72.48

Component	Load Comb.(1) (2)	Quantity	V_I kips/ft	V_{o1} kips/ft	V_{o2} kips/ft	M_1 kip-in/ft	M_2 kip-in/ft
1. Rear Wall Side (24")	C1 through C6	Demand	36.4	15.8	24.0	192.7	353.7
		Capacity	80.2	28.1	28.1	648.2	648.2
		Ratio	0.45	0.56	0.85	0.30	0.55
	C7	Demand	8.3	4.6	8.4	160.1	217.4
		Capacity	75.9	26.6	26.6	611.8	611.8
		Ratio	0.11	0.17	0.31	0.26	0.36
2. Rear Wall Center and Top (12")	C1 through C6	Demand	53.0	11.3	10.7	68.9	140.9
		Capacity	65.0	12.8	12.8	290.4	290.4
		Ratio	0.81	0.88	0.84	0.24	0.49
	C7	Demand	12.2	9.2	5.2	69.9	105.4
		Capacity	61.4	12.2	12.2	273.8	273.8
		Ratio	0.20	0.76	0.43	0.26	0.38
3. Interior Pedestal (12")	C1 through C6	Demand	49.6	12.4	11.5	41.3	41.3
		Capacity	65.0	12.8	12.8	290.4	290.4
		Ratio	0.76	0.97	0.90	0.14	0.14
	C7	Demand	23.9	2.5	10.2	30.1	31.4
		Capacity	61.4	12.2	12.2	273.8	273.8
		Ratio	0.39	0.20	0.84	0.11	0.11

All Indicated Changes are Enclosure 2, Item 1.

Table 3.9.4-13a
Comparison of Highest Combined Shear Forces/Moments with the Capacities of EOS FPS HSM (Bounding) *(50kW Heat Load)*
3 Pages

72.48

Component	Load Comb.[(1) (2)]	Quantity	V_I kips/ft	V_{o1} kips/ft	V_{o2} kips/ft	M_1 kip-in/ft	M_2 kip-in/ft
4. Front Wall Top (42")	C1 through C6	Demand	128.4	29.3	44.1	1446.2	2379.2
		Capacity	180.7	49.0	49.0	2875.6	2875.6
		Ratio	0.71	0.60	0.90	0.50	0.83
	C7	Demand	58.3	23.6	41.7	1499.3	2436.3
		Capacity	170.9	46.5	46.5	2712.9	2712.9
		Ratio	0.34	0.51	0.90	0.55	0.90
5. Side Wall Bottom (24")	C1 through C6	Demand	29.7	17.2	16.2	215.3	235.5
		Capacity	102.1	27.8	27.8	919.3	919.3
		Ratio	0.29	0.62	0.58	0.23	0.26
	C7	Demand	17.4	16.9	15.8	145.2	408.5
		Capacity	96.6	26.4	26.4	867.3	867.3
		Ratio	0.18	0.64	0.60	0.17	0.47
6. Side Wall Bottom (14")	C1 through C6	Demand	22.0	13.6	9.0	75.8	68.3
		Capacity	89.4	15.1	15.1	489.8	489.8
		Ratio	0.25	0.90	0.59	0.15	0.14
	C7	Demand	14.3	12.1	12.3	65.8	134.1
		Capacity	84.5	14.3	14.3	461.7	461.7
		Ratio	0.17	0.84	0.85	0.14	0.29

All Indicated Changes are Enclosure 2, Item 1.

Table 3.9.4-13a
Comparison of Highest Combined Shear Forces/Moments with the Capacities of EOS FPS HSM (Bounding) *(50kW Heat Load)*
3 Pages

72.48

Component	Load Comb.(1) (2)	Quantity	V_I kips/ft	V_{o1} kips/ft	V_{o2} kips/ft	M_1 kip-in/ft	M_2 kip-in/ft
7. Side Wall Top (12")	C1 through C6	Demand	76.6	11.8	11.3	334.2	192.0
		Capacity	86.8	12.6	12.6	404.0	404.0
		Ratio	0.88	0.94	0.90	0.83	0.48
	C7	Demand	44.1	10.2	10.4	335.4	145.4
		Capacity	82.1	11.9	11.9	380.6	380.6
		Ratio	0.54	0.85	0.87	0.88	0.38
8. Roof (44")	C1 through C6	Demand	26.5	45.7	48.4	596.6	1859.3
		Capacity	151.4	51.5	51.5	2283.1	2283.1
		Ratio	0.18	0.89	0.94	0.26	0.81
	C7	Demand	21.8	16.1	8.6	309.2	990.6
		Capacity	143.3	48.9	48.9	2154.6	2154.6
		Ratio	0.15	0.33	0.18	0.14	0.46

Notes:

(1) Comb C1 through C6 include normal thermal, Comb C7 include accident thermal

(2) See Section 3.9.4.7.1 for impact of 160 pcf fresh concrete density on the increased demand due to higher weight of the storage module 72.48

All Indicated Changes are Enclosure 2, Item 1.

Table 3.9.4-13b
Comparison of Highest Combined Shear Forces/Moments with the Capacities of EOS-HSMS-FPS-OVVP
(Load Combination C4) *(50kW Heat Load)*
2 Pages

72.48

Component	Load Combination[1]	Quantity	V_I	V_{O1}	V_{O2}	M_1	M_2
			kips/ft	kips/ft	kips/ft	kip-in/ft	kip-in/ft
1. Rear Wall Side (24")	C4	Demand	40.15	17.16	20.50	214.57	377.68
		Capacity	80.2	28.1	28.1	648.2	648.2
		Ratio	0.50	0.61	0.73	0.33	0.58
2. Rear Wall Center and Top (12")		Demand	58.55	12.38	11.90	71.69	143.61
		Capacity	65.0	12.8	12.8	290.4	290.4
		Ratio	0.90	0.97	0.93	0.25	0.49
3. Interior Pedestal (12")		Demand	48.18	11.08	12.26	39.28	42.53
		Capacity	65.0	12.8	12.8	290.4	290.4
		Ratio	0.74	0.87	0.96	0.14	0.15
4. Front Wall Top (42")		Demand	140.33	29.67	47.93	1490.37	2317.36
		Capacity	180.7	49.0	49.0	2875.6	2875.6
		Ratio	0.78	0.61	0.98	0.52	0.81
5. Side Wall Bottom (24")		Demand	28.95	16.35	16.79	211.87	239.09
		Capacity	102.1	27.8	27.8	919.3	919.3
		Ratio	0.28	0.59	0.60	0.23	0.26
6. Side Wall Bottom (14")		Demand	22.56	14.68	9.34	78.90	68.30
		Capacity	89.4	15.1	15.1	489.8	489.8
		Ratio	0.25	0.97	0.62	0.16	0.14

All Indicated Changes are Enclosure 2, Item 1.

Table 3.9.4-13b
Comparison of Highest Combined Shear Forces/Moments with the Capacities of EOS-HSMS-FPS-OVVP
(Load Combination C4) *(50kW Heat Load)*
2 Pages

72.48

Component	Load Combination[(1)]	Quantity	V_I kips/ft	V_{O1} kips/ft	V_{O2} kips/ft	M_1 kip-in/ft	M_2 kip-in/ft
7. Side Wall Top (12")	C4	Demand	78.87	8.79	11.52	347.53	198.46
		Capacity	86.8	12.6	12.6	404.0	404.0
		Ratio	0.91	0.70	0.91	0.86	0.49
8. Roof (44")		Demand	27.46	48.39	49.42	618.15	1923.36
		Capacity	151.4	51.5	51.5	2283.1	2283.1
		Ratio	0.18	0.94	0.96	0.27	0.84

Notes:

(1) See Section 3.9.4.7.1 for impact of 160 pcf fresh concrete density on the increased demand due to higher weight of the storage module

72.48

All Indicated Changes are Enclosure 2, Item 1.

Table 3.9.4-13c
Comparison of Highest Combined Shear Forces/Moments with the Capacities of EOS-HSM-HS
(Load Combination C4) *(50kW Heat Load)*
2 Pages

Component	Load Combination	Quantity	V_I kips/ft	V_{O1} kips/ft	V_{O2} kips/ft	M_1 kip-in/ft	M_2 kip-in/ft
1. Rear Wall Side (24")	C4	Demand	71.1	19.0	25.7	342.8	388.1
		Capacity	80.2	28.1	28.1	648.2	648.2
		Ratio	0.89	0.68	0.92	0.53	0.60
2. Rear Wall Center and Top (12")		Demand	62.6	12.1	12.3	79.2	62.3
		Capacity	65.0	12.8	12.8	290.4	290.4
		Ratio	0.96	0.94	0.96	0.27	0.21
3. Interior Pedestal (12")		Demand	62.5	12.2	9.1	64.3	51.2
		Capacity	65.0	12.8	12.8	290.4	290.4
		Ratio	0.96	0.95	0.71	0.22	0.18
4. Front Wall Top (42")		Demand	-	-	-	-	-
		Capacity	-	-	-	-	-
		Ratio	-	-	-	-	-
5. Side Wall Bottom (24")		Demand	28.0	23.4	16.3	360.0	232.0
		Capacity	102.1	27.8	27.8	919.3	919.3
		Ratio	0.27	0.84	0.59	0.39	0.25

All Indicated Changes are Enclosure 2, Item 1.

Table 3.9.4-13c
Comparison of Highest Combined Shear Forces/Moments with the Capacities of EOS-HSM-HS
(Load Combination C4) *(50kW Heat Load)*
2 Pages

Component	Load Combination	Quantity	V_I	V_{O1}	V_{O2}	M_1	M_2
			kips/ft	kips/ft	kips/ft	kip-in/ft	kip-in/ft
6. Side Wall Bottom (14")	C4	Demand	19.1	12.1	8.2	114.9	54.4
		Capacity	89.4	15.1	15.1	489.8	489.8
		Ratio	0.21	0.80	0.54	0.23	0.11
7. Side Wall Top (12")		Demand	45.0	12.1	12.3	263.2	110.5
		Capacity	86.8	12.6	12.6	404.0	404.0
		Ratio	0.52	0.96	0.98	0.65	0.27
8. Roof (44")		Demand	15.7	23.9	19.0	192.3	631.5
		Capacity	151.4	51.5	51.5	2283.1	2283.1
		Ratio	0.10	0.46	0.37	0.08	0.28

Notes:

1 Front Wall is analyzed separately.

All Indicated Changes are Enclosure 2, Item 1.

Table 3.9.4-13d
Highest Demand/Capacity Ratios for Shear Forces/Moments of EOS-HSM (54kW Heat Load)

Component	Load Comb.	M_1	M_2	V_{O1}	V_{O2}	V_1
1. Rear Wall Side (24")	*C1 through C6*	*0.383*	*0.802*	*0.188*	*0.307*	*0.614*
	C7	*0.283*	*0.354*	*0.061*	*0.065*	*0.300*
2. Rear Wall Center and Top (12")	*C1 through C6*	*0.248*	*0.399*	*0.407*	*0.600*	*0.814*
	C7	*0.095*	*0.262*	*0.352*	*0.247*	*0.143*
3. Front Wall Bottom (54")	*C1 through C6*	*0.393*	*0.599*	*0.247*	*0.225*	*0.371*
	C7	*0.338*	*0.476*	*0.065*	*0.071*	*0.155*
4. Front Wall Top (42")[(1)]	*C1 through C6*	*0.368*	*0.628*	*0.593*	*0.597*	*0.721*
	C7	*0.549*	*0.914*	*0.565*	*0.510*	*0.282*
5. Side Wall Bottom (24")	*C1 through C6*	*0.290*	*0.205*	*0.552*	*0.526*	*0.237*
	C7	*0.173*	*0.474*	*0.549*	*0.701*	*0.141*
6. Side Wall Bottom (14")	*C1 through C6*	*0.192*	*0.086*	*0.792*	*0.454*	*0.178*
	C7	*0.145*	*0.258*	*0.868*	*0.884*	*0.130*
7. Side Wall Top (12")	*C1 through C6*	*0.719*	*0.572*	*0.989*	*0.975*	*0.688*
	C7	*0.902*	*0.409*	*0.904*	*0.915*	*0.568*
8. Roof (44")	*C1 through C6*	*0.275*	*0.819*	*0.891*	*0.972*	*0.151*
	C7	*0.138*	*0.462*	*0.241*	*0.497*	*0.159*

Notes:

1. Alternate Front Wall is analyzed separately.

All Indicated Changes are Enclosure 2, Item 1.

Table 3.9.4-13e
Highest Demand/Capacity Ratios for Shear Forces/Moments of EOS-HSM-FPS (54kW Heat Load)
3 Pages

Component	*Load Comb.*	*Quantity*	M_1 kip-in/ft	M_2 kip-in/ft	V_{O1} kips/ft	V_{O2} kips/ft	V_1 kips/ft
1. Rear Wall Side (24")	*C1 through C6*	*Demand*	*190*	*311.7*	*15.7*	*21.9*	*36.1*
		Capacity	*648.2*	*648.2*	*28.1*	*28.1*	*80.2*
		Ratio	*0.29*	*0.48*	*0.56*	*0.78*	*0.45*
	C7	*Demand*	*161.4*	*207.5*	*4.6*	*8.5*	*8.3*
		Capacity	*611.8*	*611.8*	*26.6*	*26.6*	*75.9*
		Ratio	*0.26*	*0.34*	*0.17*	*0.32*	*0.11*
2. Rear Wall Center and Top (12")	*C1 through C6*	*Demand*	*68.4*	*142*	*11.2*	*10.5*	*47.5*
		Capacity	*290.4*	*290.4*	*12.8*	*12.8*	*65*
		Ratio	*0.24*	*0.49*	*0.87*	*0.82*	*0.73*
	C7	*Demand*	*70.1*	*108.9*	*7.4*	*5.5*	*12.4*
		Capacity	*273.8*	*273.8*	*12.2*	*12.2*	*61.4*
		Ratio	*0.26*	*0.4*	*0.61*	*0.45*	*0.2*
3. Interior Pedestal (12")	*C1 through C6*	*Demand*	*53.6*	*46.4*	*10.9*	*11.2*	*42.6*
		Capacity	*290.4*	*290.4*	*12.8*	*12.8*	*65*
		Ratio	*0.18*	*0.16*	*0.85*	*0.88*	*0.66*
	C7	*Demand*	*38.5*	*32.7*	*2.3*	*10.5*	*24.6*
		Capacity	*273.8*	*273.8*	*12.2*	*12.2*	*61.4*
		Ratio	*0.14*	*0.12*	*0.19*	*0.86*	*0.40*

All Indicated Changes are Enclosure 2, Item 1.

Table 3.9.4-13e
Highest Demand/Capacity Ratios for Shear Forces/Moments of EOS-HSM-FPS (54kW Heat Load)
3 Pages

Component	Load Comb.	Quantity	M_1	M_2	V_{O1}	V_{O2}	V_1
			kip-in/ft	kip-in/ft	kips/ft	kips/ft	kips/ft
4. Front Wall (42")[(1)]	C1 through C6	Demand	1439.9	2374.2	27.4	44.0	128.3
		Capacity	2875.6	2875.6	49.0	49.0	180.7
		Ratio	0.50	0.83	0.56	0.90	0.71
	C7	Demand	1383.1	2429.1	23.0	40.2	58.7
		Capacity	2712.9	2712.9	46.5	46.5	170.9
		Ratio	0.51	0.90	0.50	0.86	0.34
5. Side Wall Bottom (24")[(2)]	C1 through C6	Demand	203.6	242.2	14.3	14.6	29
		Capacity	919.3	2219.9	27.8	26	102.1
		Ratio	0.22	0.11	0.51	0.56	0.28
	C7	Demand	146.5	436.7	16	15.7	16
		Capacity	867.3	2089.8	26.4	24.6	96.6
		Ratio	0.17	0.21	0.61	0.64	0.17
6. Side Wall Bottom (14")	C1 through C6	Demand	73.3	67.8	13.6	9.1	23
		Capacity	489.8	489.8	15.1	15.1	89.4
		Ratio	0.15	0.14	0.9	0.6	0.26
	C7	Demand	67.6	109.6	12.6	12.3	14
		Capacity	461.7	461.7	14.3	14.3	84.5
		Ratio	0.15	0.24	0.88	0.86	0.17

All Indicated Changes are Enclosure 2, Item 1.

Table 3.9.4-13e
Highest Demand/Capacity Ratios for Shear Forces/Moments of EOS-HSM-FPS (54kW Heat Load)
3 Pages

Component	Load Comb.	Quantity	M_1	M_2	V_{O1}	V_{O2}	V_1
			kip-in/ft	kip-in/ft	kips/ft	kips/ft	kips/ft
7. Side Wall Top (12")	C1 through C6	Demand	335.9	161	11.9	11.9	65
		Capacity	404	404	12.6	12.6	86.8
		Ratio	0.83	0.4	0.95	0.95	0.75
	C7	Demand	336.6	148.3	10.5	10.7	44
		Capacity	380.6	380.6	11.9	11.9	82.1
		Ratio	0.88	0.39	0.88	0.89	0.54
8. Roof (44")	C1 through C6	Demand	597.4	1838.4	44.8	48.5	24.6
		Capacity	2283.1	2283.1	51.5	51.5	151.4
		Ratio	0.26	0.81	0.87	0.94	0.16
	C7	Demand	298.2	975.5	16.3	8.5	21.6
		Capacity	2154.6	2154.6	48.9	48.9	143.3
		Ratio	0.14	0.45	0.33	0.17	0.15

Notes:
1. *Detailed Front Wall is analyzed separately*
2 *DCR for M2 shown considers additional reinforcement in the sidewall above the air vent. The maximum DCR away from the air vent is 0.89.*

All Indicated Changes are Enclosure 2, Item 1.

Table 3.9.4-13f
Highest Demand/Capacity Ratios for Shear Forces/Moments of EOS-HSM-OVVP (54kW Heat Load)

Component	*Load Comb.*	M_1	M_2	V_{O1}	V_{O2}	V_I
1. Rear Wall Side (24")	*C1 through C6*	*0.330*	*0.580*	*0.610*	*0.735*	*0.500*
	C7	*0.262*	*0.273*	*0.157*	*0.327*	*0.111*
2. Rear Wall Center and Top (12")	*C1 through C6*	*0.256*	*0.505*	*0.970*	*0.930*	*0.900*
	C7	*0.251*	*0.389*	*0.619*	*0.406*	*0.204*
3. Front Wall Bottom (54")	*C1 through C6*	*0.177*	*0.161*	*0.893*	*0.960*	*0.746*
	C7	*0.131*	*0.089*	*0.212*	*0.802*	*0.398*
4. Front Wall Top (42")(1)	*C1 through C6*	*0.520*	*0.810*	*0.613*	*0.982*	*0.781*
	C7	*0.552*	*0.896*	*0.447*	*0.919*	*0.344*
5. Side Wall Bottom (24")	*C1 through C6*	*0.230*	*0.268*	*0.592*	*0.628*	*0.284*
	C7	*0.170*	*0.410*	*0.642*	*0.623*	*0.181*
6. Side Wall Bottom (14")	*C1 through C6*	*0.160*	*0.144*	*0.970*	*0.625*	*0.255*
	C7	*0.136*	*0.298*	*0.857*	*0.808*	*0.149*
7. Side Wall Top (12")	*C1 through C6*	*0.864*	*0.492*	*0.993*	*0.922*	*0.918*
	C7	*0.867*	*0.357*	*0.919*	*0.914*	*0.464*
8. Roof (44")	*C1 through C6*	*0.300*	*0.877*	*0.940*	*0.977*	*0.211*
	C7	*0.173*	*0.476*	*0.368*	*0.210*	*0.173*

Notes:

1. *Detailed Front Wall is analyzed separately.*

Table 3.9.4-14
Comparison of Highest Combined Axial Forces/Moments with the Capacities of EOS-HSM *(50kW Heat Load)*
3 Pages

Component	Load Combination	Quantity	P (Comp) kips/ft	P_1 (Tens) kips/ft	P_2 (Tens.) kips/ft	M_{1p}(1) kip-in/ft	M_{2p}(1) kip-in/ft
1. Rear Wall Bottom (32")	C1 through C6	Computed	104.39	33.78	32.11	299.64	428.28
		Capacity	880.39	59.64	59.64	427.42	738.10
		Ratio	0.12	0.57	0.54	0.70	0.58
	C7	Computed	44.56	13.37	5.46	66.43	124.05
		Capacity	793.88	56.33	56.33	826.20	806.31
		Ratio	0.06	0.24	0.10	0.08	0.15
2. Rear Wall Top (12")	C1 through C6	Computed	29.63	9.50	23.56	36.93	43.42
		Capacity	349.99	59.64	59.64	279.91	238.59
		Ratio	0.08	0.16	0.40	0.13	0.18
	C7	Computed	15.84	7.09	40.00	20.08	45.85
		Capacity	316.52	56.33	56.33	249.52	79.84
		Ratio	0.05	0.13	0.71	0.08	0.57
3. Front Wall Bottom (54")	C1 through C6	Computed	122.27	72.22	65.59	1019.49	773.80
		Capacity	1513.35	152.68	152.68	1998.10	3368.23
		Ratio	0.08	0.47	0.43	0.51	0.23
	C7	Computed	59.82	19.82	0.00	485.33	0.00
		Capacity	1365.94	144.20	144.20	3244.10	3578.11
		Ratio	0.04	0.14	0.00	0.15	0.00

All Indicated Changes are Enclosure 2, Item 1.

Table 3.9.4-14
Comparison of Highest Combined Axial Forces/Moments with the Capacities of EOS-HSM *(50kW Heat Load)*
3 Pages

Component	Load Combination	Quantity	P (Comp) kips/ft	P_1 (Tens) kips/ft	P_2 (Tens.) kips/ft	M_{1p} (1) kip-in/ft	M_{2p} (1) kip-in/ft
4. Front Wall Top (42")	C1 through C6	Computed	256.17	97.70	77.54	737.46	1137.66
		Capacity	1195.11	152.68	152.68	2524.84	1880.68
		Ratio	0.21	0.64	0.51	0.29	0.60
	C7	Computed	98.93	22.08	32.83	1352.68	1796.91
		Capacity	1079.52	144.20	144.20	2297.59	2299.51
		Ratio	0.09	0.15	0.23	0.59	0.78
5. Side Wall Bottom (24")	C1 through C6	Computed	70.20	27.97	37.58	267.46	158.64
		Capacity	682.20	85.88	85.88	664.87	738.53
		Ratio	0.10	0.33	0.44	0.40	0.21
	C7	Computed	38.81	22.46	58.73	97.14	324.92
		Capacity	616.18	81.11	81.11	627.12	331.04
		Ratio	0.06	0.28	0.72	0.15	0.98
6. Side Wall Bottom (14")	C1 through C6	Computed	47.63	19.43	16.50	75.91	37.93
		Capacity	417.00	85.88	85.88	450.17	484.24
		Ratio	0.11	0.23	0.19	0.17	0.08
	C7	Computed	21.85	31.53	62.90	63.98	117.21
		Capacity	377.50	81.11	81.11	337.69	236.42
		Ratio	0.06	0.39	0.78	0.19	0.50

All Indicated Changes are Enclosure 2, Item 1.

Table 3.9.4-14
Comparison of Highest Combined Axial Forces/Moments with the Capacities of EOS-HSM *(50kW Heat Load)*
3 Pages

Component	Load Combination	Quantity	P (Comp) kips/ft	P_1 (Tens) kips/ft	P_2 (Tens.) kips/ft	M_{1p}(1) kip-in/ft	M_{2p}(1) kip-in/ft
7. Side Wall Top (12")	C1 through C6	Computed	157.07	27.52	49.71	44.42	49.00
		Capacity	363.96	85.88	85.88	386.56	170.14
		Ratio	0.43	0.32	0.58	0.11	0.29
	C7	Computed	138.02	56.91	11.68	64.54	132.35
		Capacity	329.77	81.11	81.11	114.93	358.64
		Ratio	0.42	0.70	0.14	0.56	0.37
8. Roof (44")	C1 through C6	Computed	107.11	24.43	67.55	621.82	1817.34
		Capacity	1227.83	114.51	114.51	2237.29	2106.43
		Ratio	0.09	0.21	0.59	0.28	0.86
	C7	Computed	90.83	11.47	59.85	239.44	751.16
		Capacity	1107.99	108.15	108.15	2085.65	1488.26
		Ratio	0.08	0.11	0.55	0.11	0.50

Notes:

1. M_{1p} and M_{2p} are moments at the same location and for the same load combination as P_1 and P_2. M_{1p} and M_{2p} occur at the same location simultaneously with P_1 and P_2, i.e., $M_1 = [(P_{tu} – P_1)/P_{tu}]*M_{u1}$.
2. Load Combinations C1 to C6 include normal thermal, C7 include accident thermal.
3. Comparison of highest combined axial forces/moments with capacities for alternate front wall rebar layout reported in Table 3.9.4-29.

All Indicated Changes are Enclosure 2, Item 1.

Table 3.9.4-14a
Comparison of Highest Combined Axial Forces/Moments with the Capacities of EOS-HSM-FPS Option (Bounding) *(50kW Heat Load)*
3 Pages

72.48

Component	Load Comb.(1) (5)	Quantity	P (Comp) kips/ft	P_1 (Tens) kips/ft	P_2 (Tens.) kips/ft	M_{1p}(2) kip-in/ft	M_{2p}(2) kip-in/ft
1. Rear Wall Side (24")	C1 through C6	Demand	70.3	25.3	49.3	190.8	202.7
		Capacity	668.2	59.6	59.6	430.1	569.0
		Ratio	0.11	0.42	0.83	0.49	0.89
	C7	Demand	44.1	28.0	17.6	160.1	180.6
		Capacity	602.9	56.3	56.3	324.9	608.7
		Ratio	0.07	0.50	0.31	0.52	0.36
2. Rear Wall Center and Top (12")	C1 through C6	Demand	284.2	53.3	41.9	47.5	48.0
		Capacity	350.0	59.6	59.6	243.5	276.6
		Ratio	0.81	0.89	0.70	0.82	0.30
	C7	Demand	34.7	48.6	36.5	11.3	75.7
		Capacity	316.5	56.3	56.3	47.0	112.0
		Ratio	0.11	0.86	0.65	0.29	0.78
3. Interior Pedestal (12")	C1 through C6	Demand	168.7	49.6	35.1	41.3	40.4
		Capacity	350.0	59.6	59.6	181.6	255.4
		Ratio	0.48	0.83	0.59	0.48	0.18
	C7	Demand	84.1	13.2	14.5	30.1	4.3
		Capacity	316.5	56.3	56.3	243.5	271.8
		Ratio	0.27	0.23	0.26	0.12	0.02

All Indicated Changes are Enclosure 2, Item 1.

Table 3.9.4-14a
Comparison of Highest Combined Axial Forces/Moments with the Capacities of EOS-HSM-FPS Option (Bounding) ***(50kW Heat Load)***
3 Pages

72.48

Component	Load Comb.(1) (5)	Quantity	P (Comp) kips/ft	P_1 (Tens) kips/ft	P_2 (Tens.) kips/ft	M_{1p}(2) kip-in/ft	M_{2p}(2) kip-in/ft
4. Front Wall Top (42")	C1 through C6	Demand	386.6	135.5	127.5	619.9	1205.3
		Capacity	1195.1	152.7	152.7	1117.0	1381.3
		Ratio	0.32	0.89	0.84	0.89	0.89
	C7	Demand	142.3	41.9	31.4	1486.8	1733.0
		Capacity	1079.5	144.2	144.2	2360.9	2367.6
		Ratio	0.13	0.29	0.22	0.68	0.76
5. Side Wall Bottom (24") (3)	C1 through C6	Demand	55.4	56.0	68.9	204.0	171.0
		Capacity	682.2	85.9	85.9	677.9	283.5
		Ratio	0.08	0.65	0.80	0.32	0.88
	C7	Demand	37.6	22.1	74.8	69.8	381.7
		Capacity	616.2	81.1	81.1	667.6	138.0
		Ratio	0.06	0.27	0.92	0.11	5.38(3)
6. Side Wall Bottom (14")	C1 through C6	Demand	62.0	32.0	55.8	41.3	66.6
		Capacity	417.0	85.9	85.9	424.1	319.6
		Ratio	0.15	0.37	0.65	0.10	0.28
	C7	Demand	21.3	31.0	65.8	65.8	134.1
		Capacity	377.5	81.1	81.1	368.3	192.2
		Ratio	0.06	0.38	0.81	0.19	0.89

All Indicated Changes are Enclosure 2, Item 1.

Table 3.9.4-14a
Comparison of Highest Combined Axial Forces/Moments with the Capacities of EOS-HSM-FPS Option (Bounding) *(50kW Heat Load)*
3 Pages

72.48

Component	Load Comb.(1) (5)	Quantity	P (Comp)	P_1 (Tens)	P_2 (Tens.)	M_{1p}(2)	M_{2p}(2)
			kips/ft	kips/ft	kips/ft	kip-in/ft	kip-in/ft
7. Side Wall Top (12")	C1 through C6	Demand	222.5	72.8	86.3	53.7	53.9
		Capacity	364.0	85.9	85.9	402.0	148.2
		Ratio	0.61	0.85	1.01(4)	0.30	0.73
	C7	Demand	176.4	44.8	60.4	90.0	113.7
		Capacity	329.8	81.1	81.1	185.0	379.1
		Ratio	0.53	0.55	0.74	0.52	0.59
8. Roof (44")	C1 through C6	Demand	154.2	42.0	74.8	475.0	1732.7
		Capacity	1227.8	114.5	114.5	1459.0	1974.0
		Ratio	0.13	0.37	0.65	0.33	0.88
	C7	Demand	93.5	31.9	54.9	233.4	938.5
		Capacity	1108.0	108.1	108.1	2148.0	2075.4
		Ratio	0.08	0.29	0.51	0.11	0.46

Notes:

1. Comb C1 through C6 include normal thermal, Comb C7 include accident thermal
2. M1p and M2p are moments at the same location and for the same load combination as P1 and P2. M1p and M2p occur at the same location simultaneously with P1 and P2, i.e., M1 = [(Ptu – P1)/Ptu]*Mu1
3. See Table 3.9.4-14b for the results of detailed analysis of side wall local demand to capacity ratio for overstressed region above/adjacent to air vent.
4. The maximum load ratio of the side wall is 1.01, based on the lower tension capacity. Detailed analysis of the side wall local demand to capacity ratio, with actual rebar spacing for the overstressed region, gives maximum load ratio 0.85.
5. *See Section 3.9.4.7.1 for impact of 160 pcf fresh concrete density on the increased demand due to higher weight of the storage module* 72.48

All Indicated Changes are Enclosure 2, Item 1.

Table 3.9.4-14b
Comparison of Highest Combined Axial Forces/Moments of All EOS-HSM-FPS Configuration Options with the Applicable Capacities - Near Air Vent (Bounding) ***(50kW Heat Load)***

72.48

Component	Load Comb.(1) (3)	Quantity	P_1 (Tens.)	P_2 (Tens.)	P_1 (Comp)	P_2 (Comp)	M_{1p}(2)	M_{2p}(2)
			kips/ft	kips/ft	kips/ft	kips/ft	kip-in/ft	kip-in/ft
5B. Side Wall Above/Adjacent Air Vent (24")	C1 through C6	Demand	56.0	68.9	55.4	38.9	204.0	235.5
		Capacity	85.9	232.0	682.2	760.0	677.9	1842.4
		Ratio	0.65	0.30	0.08	0.05	0.32	0.13
	C7	Demand	22.1	74.8	37.6	22.3	69.8	408.5
		Capacity	81.1	219.1	616.2	689.9	667.6	1458.1
		Ratio	0.27	0.34	0.06	0.03	0.11	0.28

Notes:

1 Comb C1 through C6 include normal thermal, Comb C7 include accident thermal

2 M_{1p} and M_{2p} are moments at the same location and for the same load combination as P_1 and P_2. M_{1p} and M_{2p} occur at the same location simultaneously with P_1 and P_2, i.e., $M_1 = [(P_{tu} - P_1)/P_{tu}]*M_{u1}$

3 See Section 3.9.4.7.1 for impact of 160 pcf fresh concrete density on the increased demand due to higher weight of the storage module 72.48

All Indicated Changes are Enclosure 2, Item 1.

Table 3.9.4-14c
Comparison of Highest Combined Axial Forces/Moments with the Capacities of EOS-HSMS-FPS-OVVP (Load Combination C4) ***(50kW Heat Load)***
2 Pages

72.48

Component	Load Combination(2)	Quantity	P (Comp) kip/ft	P_1 (Tens) kip/ft	P_2 (Tens.) kip/ft	M_{1p} kip-in/ft	M_{2p} kip-in/ft
1. Rear Wall Side (24")	C4	Demand	75.70	27.49	54.79	192.66	141.2
		Capacity	668.2	59.6	59.6	372.66	261.5
		Ratio	0.11	0.46	0.92	0.52	0.54
2. Rear Wall Center and Top (12")		Demand	306.87	59.15	48.12	23.28	26.38
		Capacity	350.0	59.6	59.6	34.67	82.12
		Ratio	0.88	0.99	0.81	0.67	0.32
3. Interior Pedestal (12")		Demand	170.75	34.75	38.07	39.16	21.83
		Capacity	350.0	59.6	59.6	170.57	124.11
		Ratio	0.49	0.58	0.64	0.23	0.18
4. Front Wall Top (42")		Demand	417.78	139.12	141.31	475.8	637.5
		Capacity	1195.1	152.7	152.7	1139.6	1208.3
		Ratio	0.35	0.91	0.93	0.42	0.53
5. Side Wall Bottom (24")		Demand	55.34	39.62	64.57	211.41	193.31
		Capacity	682.2	85.9	85.9	638.06	462.45
		Ratio	0.08	0.46	0.75	0.33	0.42
6. Side Wall Bottom (14")		Demand	61.21	34.14	43.42	41.47	53.48
		Capacity	417.0	85.9	85.9	399.13	307.77
		Ratio	0.15	0.40	0.51	0.10	0.17

All Indicated Changes are Enclosure 2, Item 1.

Table 3.9.4-14c
Comparison of Highest Combined Axial Forces/Moments with the Capacities of EOS-HSMS-FPS-OVVP
(Load Combination C4) ***(50kW Heat Load)***
2 Pages

Component	Load Combination(2)	Quantity	P (Comp) kip/ft	P_1 (Tens) kip/ft	P_2 (Tens.) kip/ft	M_{1p} kip-in/ft	M_{2p} kip-in/ft
7. Side Wall Top (12")	C4	Demand	233.26	79.46	A(1)	32.50	66.73
		Capacity	364.0	85.9	A(1)	51.18	171.11
		Ratio	0.64	0.93	0.90	0.63	0.39
8. Roof (44")		Demand	157.57	45.09	79.76	133.51	267.24
		Capacity	1227.8	114.5	114.5	1736.35	699.00
		Ratio	0.13	0.39	0.70	0.08	0.38

72.48

Note*s:*

(1) The ratio of 0.85 from Table 3.9.4-14a is used.

(2) See Section 3.9.4.7.1 for impact of 160 pcf fresh concrete density on the increased demand due to higher weight of the storage module

72.48

All Indicated Changes are Enclosure 2, Item 1.

Table 3.9.4-14d
Comparison of Highest Combined Axial Forces/Moments with the Capacities of EOS-HSM-HS
(Load Combination C4) ***(50kW Heat Load)***
2 Pages

Component[1]	Load Comb.	Quantity	P (Comp) kips/ft	P_1 (Tens) kips/ft	P_2 (Tens.) kips/ft	M_{1p} kip-in/ft	M_{2p} kip-in/ft
1. Rear Wall Side (24")	C4	Demand	97.8	20.8	51.9	231.5	187.4
		Capacity	668.2	59.6	59.6	486.6	193.9
		Ratio	0.15	0.35	0.87	0.48	0.97
2. Rear Wall Center and Top (12")		Demand	273.1	54.3	57.9	31.8	7.0
		Capacity	350.0	59.6	59.6	47.3	8.4
		Ratio	0.78	0.91	0.97	0.67	0.84
3. Interior Pedestal (12")		Demand	195.7	41.0	50.9	52.8	37.2
		Capacity	350.0	59.6	59.6	90.6	42.7
		Ratio	0.56	0.69	0.85	0.58	0.87
4. Front Wall Top (42")		Demand	-	-	-	-	-
		Capacity	-	-	-	-	-
		Ratio	-	-	-	-	-
5. Side Wall Bottom (24")		Demand	84.8	65.6	64.0	213.2	208.5
		Capacity	682.2	85.9	85.9	217.1	395.8
		Ratio	0.12	0.76	0.75	0.98	0.53
6. Side Wall Bottom (14")		Demand	67.5	42.5	39.0	79.4	53.2
		Capacity	417.0	85.9	85.9	265.3	267.4
		Ratio	0.16	0.49	0.45	0.30	0.20

All Indicated Changes are Enclosure 2, Item 1.

Table 3.9.4-14d
Comparison of Highest Combined Axial Forces/Moments with the Capacities of EOS-HSM-HS
(Load Combination C4) *(50kW Heat Load)*
2 Pages

Component[(1)]	Load Comb.	Quantity	P (Comp) kips/ft	P_1 (Tens) kips/ft	P_2 (Tens.) kips/ft	M_{1p} kip-in/ft	M_{2p} kip-in/ft
7. Side Wall Top (12")	C4	Demand	225.6	78.7	77.3	31.1	110.5
		Capacity	364.0	85.9	85.9	38.6	198.6
		Ratio	0.62	0.92	0.90	0.81	0.56
8. Roof (44")		Demand	61.3	33.2	106.8	192.3	627.2
		Capacity	1227.8	114.5	114.5	1620.5	1781.3
		Ratio	0.05	0.29	0.93	0.12	0.35

Notes:

1 Front Wall is analyzed separately.

All Indicated Changes are Enclosure 2, Item 1.

Table 3.9.4-14e
Highest Demand/Capacity Ratios for Axial Forces/Moments of EOS-HSM (54kW Heat Load)

Component	Load Comb.	P_1 (Tens.)	P_2 (Tens.)	P_1 (Comp)	P_2 (Comp)	M_{1p}	M_{2p}
1. Rear Wall Side (24")	C1 through C6	0.581	0.731	0.120	0.120	0.704	0.949
	C7	0.269	0.199	0.060	0.061	0.089	0.367
2. Rear Wall Center and Top (12")	C1 through C6	0.866	0.748	0.871	0.870	0.888	0.386
	C7	0.150	0.714	0.070	0.071	0.073	0.588
3. Front Wall Bottom (54")	C1 through C6	0.646	0.637	0.111	0.102	0.597	0.262
	C7	0.213	0.038	0.064	0.062	0.194	0.001
4. Front Wall Top (42")(1)	C1 through C6	0.737	0.685	0.360	0.360	0.473	0.632
	C7	0.314	0.548	0.150	0.151	0.685	0.809
5. Side Wall Bottom (24")	C1 through C6	0.403	0.469	0.100	0.100	0.406	0.217
	C7	0.280	0.728	0.060	0.060	0.152	0.989
6. Side Wall Bottom (14")	C1 through C6	0.251	0.210	0.110	0.110	0.171	0.089
	C7	0.383	0.765	0.060	0.058	0.193	0.506
7. Side Wall Top (12")	C1 through C6	0.623	0.731	0.713	0.723	0.158	0.471
	C7	0.713	0.709	0.730	0.731	0.577	0.477
8. Roof (44")	C1 through C6	0.222	0.675	0.090	0.090	0.285	0.879
	C7	0.110	0.555	0.080	0.080	0.119	0.495

Notes:

1. *Alternate Front Wall is analyzed separately.*

All Indicated Changes are Enclosure 2, Item 1.

Table 3.9.4-14f
Highest Demand/Capacity Ratios for Axial Forces/Moments of EOS-HSM-FPS (54kW Heat Load)
3 Pages

Component	Load Comb.	Quantity	P_1 (Tens)	P_2 (Tens.)	P_1 (Comp.)	P_2 (Comp.)	M_{1p}	M_{2p}
			kips/ft	kips/ft	kips/ft	kips/ft	kip-in/ft	kip-in/ft
1. Rear Wall Side (24")	C1 through C6	Demand	25.6	49.1	48.5	70	170.3	153.9
		Capacity	59.6	59.6	668.2	668.2	391.9	205.1
		Ratio	0.43	0.82	0.07	0.1	0.43	0.75
	C7	Demand	27	14.9	19.5	42.3	161.4	152.9
		Capacity	56.3	56.3	602.9	602.9	318.3	484.9
		Ratio	0.48	0.26	0.03	0.07	0.51	0.32
2. Rear Wall Center and Top (12")	C1 through C6	Demand	47.7	33.2	87	63.3	22.1	49.3
		Capacity	59.6	59.6	350	350	58.1	246.2
		Ratio	0.8	0.56	0.25	0.18	0.38	0.2
	C7	Demand	47.7	37.5	23.3	18.8	11.2	77.6
		Capacity	56.3	56.3	316.5	316.5	41.9	92.2
		Ratio	0.85	0.66	0.07	0.06	0.27	0.84
3. Interior Pedestal (12")	C1 through C6	Demand	42.8	36.7	100.7	160.2	29.1	39.2
		Capacity	59.6	59.6	350	350	106.7	224
		Ratio	0.72	0.62	0.29	0.46	0.27	0.17
	C7	Demand	13.2	14.6	32.7	86	38.5	13.2
		Capacity	56.3	56.3	316.5	316.5	265.8	261.9
		Ratio	0.24	0.26	0.1	0.27	0.14	0.05

Table 3.9.4-14f
Highest Demand/Capacity Ratios for Axial Forces/Moments of EOS-HSM-FPS (54kW Heat Load)
3 Pages

Component	Load Comb.	Quantity	P_1 (Tens)	P_2 (Tens.)	P_1 (Comp.)	P_2 (Comp.)	M_{1p}	M_{2p}
			kips/ft	kips/ft	kips/ft	kips/ft	kip-in/ft	kip-in/ft
4. Front Wall Top (42")[(1)]	C1 through C6	Demand	120.8	112.4	207.0	250.1	633.2	775.6
		Capacity	152.7	152.7	1195.1	1195.1	989.1	875.3
		Ratio	0.79	0.74	0.17	0.21	0.64	0.89
	C7	Demand	34.1	31.1	77.1	106.2	1354.1	1703.6
		Capacity	144.2	144.2	1079.5	1079.5	2344.4	2296.1
		Ratio	0.24	0.22	0.07	0.10	0.58	0.74
5. Side Wall Bottom (24")	C1 through C6	Demand	55.5	98.6	53.2	39.4	203.6	242.2
		Capacity	85.9	232	682.2	760	638.7	1787.4
		Ratio	0.65	0.42	0.08	0.05	0.32	0.14
	C7	Demand	21.5	106.6	36.2	21.6	66	420.1
		Capacity	81.1	219.1	616.2	689.9	637.4	1215.5
		Ratio	0.27	0.49	0.06	0.03	0.1	0.35
6. Side Wall Bottom (14")	C1 through C6	Demand	34.7	62.4	62.1	11.3	42.1	47.9
		Capacity	85.9	85.9	417	417	417.2	134.1
		Ratio	0.4	0.73	0.15	0.03	0.1	0.36
	C7	Demand	30.3	63.1	21.1	8	67.6	86.8
		Capacity	81.1	81.1	377.5	377.5	350	160.1
		Ratio	0.37	0.78	0.06	0.02	0.19	0.54

All Indicated Changes are Enclosure 2, Item 1.

Table 3.9.4-14f
Highest Demand/Capacity Ratios for Axial Forces/Moments of EOS-HSM-FPS (54kW Heat Load)
3 Pages

Component	Load Comb.	Quantity	P_1 (Tens)	P_2 (Tens.)	P_1 (Comp.)	P_2 (Comp.)	M_{1p}	M_{2p}
			kips/ft	kips/ft	kips/ft	kips/ft	kip-in/ft	kip-in/ft
7. Side Wall Top (12")	C1 through C6	Demand	52.7	69.1	164.1	217	41.5	72.1
		Capacity	85.9	85.9	364	364	297	121.6
		Ratio	0.61	0.8	0.45	0.6	0.14	0.59
	C7	Demand	46.4	27.6	138	116.4	92.7	123.5
		Capacity	81.1	81.1	329.8	329.8	164.9	354.2
		Ratio	0.57	0.34	0.42	0.35	0.56	0.35
8. Roof (44")	C1 through C6	Demand	42.4	65.2	43.7	142.4	412.7	1666.1
		Capacity	114.5	114.5	1227.8	1227.8	1437.4	1915.3
		Ratio	0.37	0.57	0.04	0.12	0.29	0.87
	C7	Demand	30.4	51.1	0	95.9	230.4	921.5
		Capacity	108.1	108.1	1108	1108	2114.5	2029.9
		Ratio	0.28	0.47	0	0.09	0.11	0.45

Notes:

1. *Detailed Front Wall is analyzed separately.*
2. *DCRs for P2 and M2P shown consider additional reinforcement in the sidewall above the air vent. The maximum DCR away from the air vent is 0.89.*

Table 3.9.4-14g
Highest Demand/Capacity Ratios for Axial Forces/Moments of EOS-HSM-OVVP (54kW Heat Load)

Component	*Load Comb.*	P_1 (Tens.)	P_2 (Tens.)	P_1 (Comp)	P_2 (Comp)	M_{1p}	M_{2p}
1. Rear Wall Side (24")	*C1 through C6*	*0.465*	*0.925*	*0.110*	*0.110*	*0.522*	*0.548*
	C7	*0.492*	*0.323*	*0.034*	*0.077*	*0.510*	*0.367*
2. Rear Wall Center and Top (12")	*C1 through C6*	*0.996*	*0.815*	*0.881*	*0.880*	*0.828*	*0.332*
	C7	*0.874*	*0.602*	*0.091*	*0.117*	*0.268*	*0.671*
3. Interior Pedestal (12")	*C1 through C6*	*0.721*	*0.640*	*0.510*	*0.507*	*0.230*	*0.180*
	C7	*0.239*	*0.263*	*0.107*	*0.274*	*0.143*	*0.018*
4. Front Wall Top (42")(1)	*C1 through C6*	*0.910*	*0.931*	*0.350*	*0.350*	*0.663*	*0.901*
	C7	*0.288*	*0.201*	*0.072*	*0.135*	*0.682*	*0.602*
5. Side Wall Bottom (24")	*C1 through C6*	*0.460*	*0.806*	*0.080*	*0.080*	*0.330*	*0.670*
	C7	*0.240*	*0.736*	*0.057*	*0.033*	*0.101*	*0.928*
6. Side Wall Bottom (14")	*C1 through C6*	*0.400*	*0.530*	*0.150*	*0.150*	*0.101*	*0.220*
	C7	*0.343*	*0.739*	*0.053*	*0.034*	*0.169*	*0.715*
7. Side Wall Top (12")	*C1 through C6*	*0.956*	*0.909*	*0.642*	*0.650*	*0.630*	*0.737*
	C7	*0.538*	*0.746*	*0.389*	*0.538*	*0.518*	*0.598*
8. Roof (44")	*C1 through C6*	*0.421*	*0.732*	*0.160*	*0.160*	*0.362*	*0.914*
	C7	*0.292*	*0.477*	*0.032*	*0.117*	*0.141*	*0.471*

Notes:

1. Detailed Front Wall is analyzed separately.

All Indicated Changes are Enclosure 2, Item 1.

Table 3.9.4-28
Comparison of Highest Combined Shear Forces/Moments with the Capacities of the Alternate Front Wall
(50kW Heat Load)
2 Pages

Component	Load Comb.	Quantity	V_I	V_{o1}	V_{o2}	M_1	M_2
			kips/ft	kips/ft	kips/ft	kip-in/ft	kip-in/ft
3. Front Wall Bottom (54")	C1 through C6	Computed	57.6	14.2	13.0	1024.0	1877.2
		Capacity	148.3	42.5	65.6	3041.4	2599.7
		Ratio	0.39	0.34	0.20	0.34	0.72
	C7	Computed	25.2	3.1	3.1	1049.1	1735.2
		Capacity	140.3	40.3	62.2	2869.5	2453.9
		Ratio	0.18	0.08	0.05	0.37	0.71
4. Front Wall Top (42")	C1 through C6	Computed	28.8	28.5	14.0	949.7	1453.5
		Capacity	157.1	35.6	46.7	2566.6	2238.7
		Ratio	0.18	0.80	0.30	0.37	0.65
	C7	Computed	9.8	26.1	13.0	1353.1	1584.6
		Capacity	148.6	33.8	44.3	2420.8	2112.7
		Ratio	0.07	0.77	0.29	0.56	0.75
4. Front Wall Middle (42")	C1 through C6	Computed	90.4	6.4	25.6	938.6	1768.7
		Capacity	181.4	43.6	47.6	2565.8	2806.1
		Ratio	0.50	0.15	0.54	0.37	0.63
	C7	Computed	48.3	6.3	24.4	1326.9	2485.3
		Capacity	171.6	41.4	45.1	2420.2	2647.2
		Ratio	0.28	0.15	0.54	0.55	0.94

All Indicated Changes are Enclosure 2, Item 1.

Table 3.9.4-28
Comparison of Highest Combined Shear Forces/Moments with the Capacities of the Alternate Front Wall
(50kW Heat Load)
2 Pages

Component	Load Comb.	Quantity	V_I kips/ft	V_{o1} kips/ft	V_{o2} kips/ft	M_1 kip-in/ft	M_2 kip-in/ft
4. Front Wall Bottom (42")	C1 through C6	Computed	48.0	8.8	13.1	463.1	399.4
		Capacity	135.5	49.3	47.7	2767.0	1819.5
		Ratio	0.35	0.18	0.27	0.17	0.22
	C7	Computed	12.1	3.9	6.0	1058.0	509.5
		Capacity	128.2	46.8	45.3	2610.6	1717.3
		Ratio	0.09	0.08	0.13	0.41	0.30

Notes:

1. Load Combinations C1 through C6 include normal thermal condition, C7 includes accidental thermal condition.

Table 3.9.4-28a
Comparison of Highest Combined Shear Forces/Moments with Capacities of the EOS-HSM-FPS Alternate Front Wall (Bounding) ***(50kW Heat Load)***
3 Pages

72.48

Component	Load Comb.(1) (3)	Quantity	V_I	V_{o1}	V_{o2}	M_1	M_2
			kips/ft	kips/ft	kips/ft	kip-in/ft	kip-in/ft
4A. Front Wall Top (42")	C1 through C6	Demand	46.0	16.9	31.2	1102.1	1471.7
		Capacity	130.2	35.5	45.2	2566.6	1612.5
		Ratio	0.35	0.47	0.69	0.43	0.91
	C7	Demand	11.2	12.4	29.6	1442.3	1215.0
		Capacity	123.2	33.7	42.9	2420.8	1521.8
		Ratio	0.09	0.37	0.69	0.60	0.80
4B. Front Wall Mid Upper Side (42")	C1 through C6	Demand	118.8	0.0	39.8	1077.7	1336.6
		Capacity	154.8	43.6	44.8	2565.8	2153.9
		Ratio	0.77	0.00	0.89	0.42	0.62
	C7	Demand	45.3	0.0	36.8	1103.5	1827.7
		Capacity	146.5	41.4	42.5	2420.2	2032.2
		Ratio	0.31	0.00	0.87	0.46	0.90
4C. Front Wall Mid Upper Center (42")	C1 through C6	Demand	70.9	29.3	27.7	1104.6	547.8
		Capacity	106.7	43.6	44.8	2565.8	1218.0
		Ratio	0.66	0.67	0.62	0.43	0.45
	C7	Demand	17.7	23.6	29.3	1420.5	545.4
		Capacity	101.0	41.4	42.5	2420.2	1149.7
		Ratio	0.18	0.57	0.69	0.59	0.47

72.48

Table 3.9.4-28a
Comparison of Highest Combined Shear Forces/Moments with Capacities of the EOS-HSM-FPS Alternate Front Wall (Bounding) *(50kW Heat Load)*
3 Pages

Component	Load Comb.[(1)] [(3)]	Quantity	V_I kips/ft	V_{o1} kips/ft	V_{o2} kips/ft	M_1 kip-in/ft	M_2 kip-in/ft
4D. Front Wall Mid Lower Side (42")	C1 through C6	Demand	101.8	0.0	38.1	965.6	1283.7
		Capacity	140.3	43.6	44.8	2565.8	1909.7
		Ratio	0.73	0.00	0.85	0.38	0.67
	C7	Demand	29.8	0.0	29.4	766.6	1212.7
		Capacity	132.7	41.4	42.5	2420.2	1802.1
		Ratio	0.22	0.00	0.69	0.32	0.67
4E. Front Wall Mid Lower Center (42")	C1 through C6	Demand	73.6	18.6	17.8	1446.2	901.2
		Capacity	91.1	43.6	44.7	2565.8	894.3
		Ratio	0.81	0.43	0.40	0.56	1.01[(2)]
	C7	Demand	58.3	9.3	7.8	1190.5	736.2
		Capacity	86.3	41.4	42.4	2420.2	844.3
		Ratio	0.68	0.23	0.18	0.49	0.87
4F. Front Wall Mid Center (42")	C1 through C6	Demand	116.0	0.0	40.2	600.3	1832.5
		Capacity	176.3	43.6	44.9	2565.8	2642.5
		Ratio	0.66	0.00	0.90	0.23	0.69
	C7	Demand	47.5	0.0	30.2	653.7	2350.1
		Capacity	166.8	41.4	42.6	2420.2	2492.7
		Ratio	0.28	0.00	0.71	0.27	0.94

All Indicated Changes are Enclosure 2, Item 1.

Table 3.9.4-28a
Comparison of Highest Combined Shear Forces/Moments with Capacities of the EOS-HSM-FPS Alternate Front Wall (Bounding) ***(50kW Heat Load)***
3 Pages

Component	Load Comb.[(1) (3)]	Quantity	V_I	V_{o1}	V_{o2}	M_1	M_2
			kips/ft	kips/ft	kips/ft	kip-in/ft	kip-in/ft
4G. Front Wall Bottom (42")	C1 through C6	Demand	52.7	11.7	43.6	391.5	687.8
		Capacity	130.2	49.0	50.3	2892.1	1796.8
		Ratio	0.40	0.24	0.87	0.14	0.38
	C7	Demand	16.3	3.1	20.5	445.3	489.5
		Capacity	123.2	46.5	47.7	2728.4	1695.9
		Ratio	0.13	0.07	0.43	0.16	0.29

72.48

Notes:

1. Load Combinations C1 through C6 include normal thermal, Comb C7 includes accident thermal
2. The maximum load ratio from front wall mid lower center is 1.01 based on lower moment capacity. The maximum load ratio (M_2) excluding the critical section is 0.87. The load ratio M_2 for the critical section using weighted average for a section across both mid lower center and mid lower side is 0.67.
3. *See Section 3.9.4.7.1 for impact of 160 pcf fresh concrete density on the increased demand due to higher weight of the storage module* 72.48

All Indicated Changes are Enclosure 2, Item 1.

Table 3.9.4-28b
Comparison of Highest Combined Shear Forces/Moments with Capacities of the EOS-HSMS-FPS-OVVP Alternate Front Wall (Load Combination C4) ***(50kW Heat Load)***

72.48

Component	Load Combination(1)	Quantity	V_I kip/ft	V_{O1} kip/ft	V_{O2} kip/ft	M_1 kip-in/ft	M_2 kip-in/ft
4A. Front Wall Top (42")	C4	Demand	58.23	17.27	34.93	1145.27	1473.16
		Capacity	130.20	35.50	45.20	2566.60	1612.50
		Ratio	0.45	0.49	0.77	0.45	0.91
4B. Front Wall Mid Upper Side (42")		Demand	131.03	0.37	43.63	1121.87	1357.86
		Capacity	154.80	43.60	44.80	2565.80	2153.90
		Ratio	0.85	0.01	0.97	0.44	0.63
4C. Front Wall Mid Upper Center (42")		Demand	83.03	29.67	31.53	1148.27	569.06
		Capacity	106.70	43.60	44.80	2565.80	1218.00
		Ratio	0.78	0.68	0.70	0.45	0.47
4D. Front Wall Mid Lower Side (42")		Demand	114.03	0.37	41.93	792.77	1289.26
		Capacity	140.30	43.60	44.80	2565.80	1909.70
		Ratio	0.81	0.01	0.94	0.31	0.68
4E. Front Wall Mid Lower Center (42")		Demand	77.73	18.97	21.63	1490.37	677.16
		Capacity	91.10	43.60	44.70	2565.80	894.30
		Ratio	0.85	0.44	0.48	0.58	0.76
4F. Front Wall Mid Center (42")		Demand	128.23	0.37	44.03	644.47	1664.76
		Capacity	176.30	43.60	44.90	2565.80	2642.50
		Ratio	0.73	0.01	0.98	0.25	0.63
4G. Front Wall Bottom (42")		Demand	64.93	12.07	45.83	435.67	706.86
		Capacity	130.20	49.00	50.30	2892.10	1796.80
		Ratio	0.50	0.25	0.91	0.15	0.39

Notes:

(1) See Section 3.9.4.7.1 for impact of 160 pcf fresh concrete density on the increased demand due to higher weight of the storage module

72.48

All Indicated Changes are Enclosure 2, Item 1.

Table 3.9.4-28c
Comparison of Highest Combined Shear Forces/Moments with Capacities of the EOS-HSM-HS Front Wall (Load Combination C4) ***(50kW Heat Load)***

Component	Load Combination	Quantity	V_I	V_{O1}	V_{O2}	M_1	M_2
			kip/ft	kip/ft	kip/ft	kip-in/ft	kip-in/ft
4A. Front Wall Top (42")	C4	Demand	84.2	4.9	20.2	396.3	828.4
		Capacity	130.2	35.5	45.2	2566.6	1612.5
		Ratio	0.65	0.14	0.45	0.15	0.51
4B. Front Wall Mid Upper Side (42")		Demand	151.8	0.0	33.8	261.4	650.3
		Capacity	154.8	0.0	44.8	2565.8	2153.9
		Ratio	0.98	0.00	0.75	0.10	0.30
4C. Front Wall Mid Upper Center (42")		Demand	95.6	0.4	19.3	368.9	373.3
		Capacity	106.7	43.6	44.8	2565.8	1218.0
		Ratio	0.90	0.01	0.43	0.14	0.31
4D. Front Wall Mid Lower Side (42")		Demand	136.0	0.0	40.2	1277.8	962.4
		Capacity	140.3	0.0	44.8	2565.8	1909.7
		Ratio	0.97	0.00	0.90	0.50	0.50
4E. Front Wall Mid Lower Center (42")		Demand	89.6	14.6	20.2	340.8	640.3
		Capacity	91.1	43.6	44.7	2565.8	894.3
		Ratio	0.98	0.33	0.45	0.13	0.72
4F. Front Wall Mid Center (42")		Demand	148.3	0.0	37.1	329.6	950.2
		Capacity	176.3	0.0	44.9	2565.8	2642.5
		Ratio	0.84	0.00	0.83	0.13	0.36
4G. Front Wall Bottom (42")		Demand	91.0	5.5	21.9	203.3	605.6
		Capacity	130.2	49.0	50.3	2892.1	1796.8
		Ratio	0.70	0.11	0.43	0.07	0.34

All Indicated Changes are Enclosure 2, Item 1.

Table 3.9.4-28d
Highest Demand/Capacity Ratios for Shear Forces/Moments of the EOS-HSM-FPS Front Wall
(54kW Heat Load)
3 Pages

Component	Load Comb.	Quantity	M_1 kip-in/ft	M_2 kip-in/ft	V_{o1} kips/ft	V_{o2} kips/ft	V_1 kips/ft
4A. Front Wall Top (42")	C1 through C6	Demand	1091.5	1495.8	14.8	31.4	46.6
		Capacity	2566.6	1612.5	35.5	45.2	130.2
		Ratio	0.43	0.93	0.42	0.7	0.36
	C7	Demand	1383.1	1195.1	12.1	29.1	11.5
		Capacity	2420.8	1521.8	33.7	42.9	123.2
		Ratio	0.57	0.79	0.36	0.68	0.09
4B. Front Wall Mid Upper Side (42")	C1 through C6	Demand	1025.3	1314.1	0	40.5	118.6
		Capacity	2565.8	2153.9	43.6	44.8	154.8
		Ratio	0.4	0.61	0	0.9	0.77
	C7	Demand	984.6	1806.1	0	36.2	46.6
		Capacity	2420.2	2032.2	41.4	42.5	146.5
		Ratio	0.41	0.89	0	0.85	0.32
4C. Front Wall Mid Upper Center (42")	C1 through C6	Demand	1079.4	1014.6	27.4	28.7	45.8
		Capacity	2565.8	1218	43.6	44.8	106.7
		Ratio	0.42	0.83	0.63	0.64	0.43
	C7	Demand	1289.9	1118.6	23	24.9	18
		Capacity	2420.2	1149.7	41.4	42.5	101
		Ratio	0.53	0.97	0.56	0.59	0.18

All Indicated Changes are Enclosure 2, Item 1.

Table 3.9.4-28d
Highest Demand/Capacity Ratios for Shear Forces/Moments of the EOS-HSM-FPS Front Wall
(54kW Heat Load)
3 Pages

Component	Load Comb.	Quantity	M_1 kip-in/ft	M_2 kip-in/ft	V_{o1} kips/ft	V_{o2} kips/ft	V_I kips/ft
4D. Front Wall Mid Lower Side (42")	C1 through C6	Demand	956.5	1283	0	38.2	101.9
		Capacity	2565.8	1909.7	43.6	44.8	140.3
		Ratio	0.37	0.67	0	0.85	0.73
	C7	Demand	783.7	1222.8	0	28.1	21.5
		Capacity	2420.2	1802.1	41.4	42.5	132.7
		Ratio	0.32	0.68	0	0.66	0.16
4E. Front Wall Mid Lower Center (42")	C1 through C6	Demand	1364.3	762.6	18.8	36.1	72.6
		Capacity	2565.8	894.3	43.6	44.7	91.1
		Ratio	0.53	0.85	0.43	0.81	0.8
	C7	Demand	1197.8	723.3	9.5	4.9	51.6
		Capacity	2420.2	844.3	41.4	42.4	86.3
		Ratio	0.49	0.86	0.23	0.11	0.6
4F. Front Wall Mid Center (42")	C1 through C6	Demand	613.2	1815.2	0	37.5	115.8
		Capacity	2565.8	2642.5	43.6	44.9	176.3
		Ratio	0.24	0.69	0	0.84	0.66
	C7	Demand	655.8	2324.6	0	29.8	48.8
		Capacity	2420.2	2492.7	41.4	42.6	166.8
		Ratio	0.27	0.93	0	0.7	0.29

All Indicated Changes are Enclosure 2, Item 1.

Table 3.9.4-28d
Highest Demand/Capacity Ratios for Shear Forces/Moments of the EOS-HSM-FPS Front Wall (54kW Heat Load)
3 Pages

Component	***Load Comb.***	***Quantity***	***M_1***	***M_2***	***V_{o1}***	***V_{o2}***	***V_1***
			kip-in/ft	***kip-in/ft***	***kips/ft***	***kips/ft***	***kips/ft***
4G. Front Wall Bottom (42")	*C1 through C6*	*Demand*	*387.8*	*672.7*	*11.7*	*43.8*	*68.1*
		Capacity	*2892.1*	*1796.8*	*49*	*50.3*	*130.2*
		Ratio	*0.13*	*0.37*	*0.24*	*0.87*	*0.52*
	C7	*Demand*	*449.4*	*483.3*	*3*	*20.4*	*17.5*
		Capacity	*2728.4*	*1695.9*	*46.5*	*47.7*	*123.2*
		Ratio	*0.16*	*0.29*	*0.07*	*0.43*	*0.14*

All Indicated Changes are Enclosure 2, Item 1.

Table 3.9.4-28e
Highest Demand/Capacity Ratios for Shear Forces/Moments of the EOS-HSM-OVVP Front Wall (54kW Heat Load)

Component	*Load Comb.*	M_1	M_2	V_{O1}	V_{O2}	V_I
4A. Front Wall Top (42")	*C1 through C6*	*0.464*	*0.925*	*0.494*	*0.777*	*0.450*
	C7	*0.596*	*0.744*	*0.324*	*0.664*	*0.072*
4B. Front Wall Mid Upper Side (42")	*C1 through C6*	*0.446*	*0.645*	*0.010*	*0.985*	*0.850*
	C7	*0.456*	*0.832*	*0.002*	*0.731*	*0.269*
4C. Front Wall Mid Upper Center (42")	*C1 through C6*	*0.464*	*0.489*	*0.681*	*0.707*	*0.780*
	C7	*0.587*	*0.475*	*0.497*	*0.712*	*0.118*
4D. Front Wall Mid Lower Side (42")	*C1 through C6*	*0.310*	*0.680*	*0.010*	*0.940*	*0.811*
	C7	*0.260*	*0.609*	*0.002*	*0.714*	*0.227*
4E. Front Wall Mid Lower Center (42")	*C1 through C6*	*0.580*	*0.760*	*0.443*	*0.480*	*0.850*
	C7	*0.426*	*0.658*	*0.228*	*0.138*	*0.678*
4F. Front Wall Mid Center (42")	*C1 through C6*	*0.255*	*0.642*	*0.010*	*0.993*	*0.730*
	C7	*0.271*	*0.784*	*0.002*	*0.698*	*0.257*
4G. Front Wall Bottom (42")	*C1 through C6*	*0.150*	*0.390*	*0.251*	*0.910*	*0.500*
	C7	*0.152*	*0.205*	*0.068*	*0.363*	*0.115*

All Indicated Changes are Enclosure 2, Item 1.

Table 3.9.4-29
Comparison of Highest Combined Axial Forces/Moments with the Capacities of the Alternate Front Wall
(50kW Heat Load)
2 Pages

Component	Load Comb.	Quantity	P (Comp) kips/ft	P_1 (Tens) kips/ft	P_2 (Tens.) kips/ft	M_{1p} (1) kip-in/ft	M_{2p} (1) kip-in/ft
3. Front Wall Bottom (54")	C1 through C6	Computed	122.3	72.2	65.6	1019.5	773.8
		Capacity	1014.5	123.3	102.1	1260.1	2165.3
		Ratio	0.12	0.59	0.64	0.81	0.36
	C7	Computed	59.8	19.8	0.0	485.3	0.0
		Capacity	916.3	116.5	96.4	2537.9	2453.9
		Ratio	0.07	0.17	0.00	0.19	0.00
4. Front Wall Top (42")	C1 through C6	Computed	58.5	97.7	33.5	737.5	788.5
		Capacity	968.4	150.8	124.4	2249.7	1982.4
		Ratio	0.06	0.65	0.27	0.33	0.40
	C7	Computed	18.7	22.1	31.7	1352.7	1439.2
		Capacity	875.4	142.5	117.5	2045.7	1543.4
		Ratio	0.02	0.15	0.27	0.66	0.93
4. Front Wall Middle (42")	C1 through C6	Computed	256.2	94.0	77.5	721.7	1137.7
		Capacity	1195.6	153.6	153.6	2337.3	1840.9
		Ratio	0.21	0.61	0.50	0.31	0.62
	C7	Computed	98.9	13.8	32.8	1326.9	1796.9
		Capacity	1080.0	145.0	145.0	2209.2	2246.2
		Ratio	0.09	0.09	0.23	0.60	0.80

All Indicated Changes are Enclosure 2, Item 1.

Table 3.9.4-29
Comparison of Highest Combined Axial Forces/Moments with the Capacities of the Alternate Front Wall
(50kW Heat Load)
2 Pages

Component	Load Comb.	Quantity	P (Comp) kips/ft	P_1 (Tens) kips/ft	P_2 (Tens.) kips/ft	M_{1p} (1) kip-in/ft	M_{2p} (1) kip-in/ft
4. Front Wall Bottom (42")	C1 through C6	Computed	66.4	77.3	33.8	450.5	177.3
		Capacity	1166.2	145.8	98.4	1612.9	1422.3
		Ratio	0.06	0.53	0.34	0.28	0.12
	C7	Computed	31.9	18.8	1.0	453.5	405.9
		Capacity	1052.1	137.7	93.0	2566.1	1700.6
		Ratio	0.03	0.14	0.01	0.18	0.24

Notes:

1 M_{1p} and M_{2p} are moments at the same location and for the same load combination as P_1 and P_2. M_{1p} and M_{2p} occur at the same location simultaneously with P_1 and P_2.

2 C1 through C6 include normal thermal, C7 includes accident thermal

All Indicated Changes are Enclosure 2, Item 1.

Table 3.9.4-29a
Comparison of Highest Combined Axial Forces/Moments with Capacities of the EOS-HSM-FPS Alternate Front Wall (Bounding) *(50kW Heat Load)*
3 Pages

72.48

Component	Load Comb.[(1) (3)]	Quantity	P_1 (Tens.) kips/ft	P_2 (Tens.) kips/ft	P_1 (Comp) kips/ft	P_2 (Comp) kips/ft	M_{1p}[(2)] kip-in/ft	M_{2p}[(2)] kip-in/ft
4A. Front Wall Top (42")	C1 through C6	Demand	120.0	58.2	38.6	53.3	790.6	662.5
		Capacity	151.2	92.1	968.5	1162.9	2077.5	1010.5
		Ratio	0.79	0.63	0.04	0.05	0.64	0.70
	C7	Demand	20.9	20.5	15.3	20.2	1442.3	814.6
		Capacity	142.8	87.0	875.6	1049.0	2103.7	1521.8
		Ratio	0.15	0.24	0.02	0.02	0.70	0.70
4B. Front Wall Mid Upper Side (42")	C1 through C6	Demand	115.5	87.2	73.5	122.3	419.6	737.8
		Capacity	153.6	124.7	1089.5	1127.2	1860.7	1323.2
		Ratio	0.75	0.70	0.07	0.11	0.55	0.89
	C7	Demand	10.6	0.0	39.1	54.6	881.1	0.0
		Capacity	145.0	117.8	984.5	1017.7	2378.6	2032.2
		Ratio	0.07	0.00	0.04	0.05	0.37	0.00
4C. Front Wall Mid Upper Center (42")	C1 through C6	Demand	114.2	45.4	56.4	29.0	764.9	253.3
		Capacity	153.6	70.0	1089.5	1045.0	2185.2	1000.5
		Ratio	0.74	0.65	0.05	0.03	0.46	0.56
	C7	Demand	22.7	0.8	24.1	14.2	1414.7	142.6
		Capacity	145.0	66.1	984.5	942.3	2209.5	1148.3
		Ratio	0.16	0.01	0.02	0.02	0.69	0.12

All Indicated Changes are Enclosure 2, Item 1.

Table 3.9.4-29a
Comparison of Highest Combined Axial Forces/Moments with Capacities of the EOS-HSM-FPS Alternate Front Wall (Bounding) ***(50kW Heat Load)***
3 Pages

72.48

Component	Load Comb.(1) (3)	Quantity	P_1 (Tens.) kips/ft	P_2 (Tens.) kips/ft	P_1 (Comp) kips/ft	P_2 (Comp) kips/ft	M_{1p}(2) kip-in/ft	M_{2p}(2) kip-in/ft
4D. Front Wall Mid Lower Side (42")	C1 through C6	Demand	98.0	76.7	185.5	175.6	619.9	455.8
		Capacity	153.6	110.4	1089.5	1066.5	1722.1	1908.9
		Ratio	0.64	0.70	0.17	0.16	0.67	0.62
	C7	Demand	20.4	19.6	47.7	86.8	275.2	895.0
		Capacity	145.0	104.2	984.5	962.7	2407.9	1591.1
		Ratio	0.14	0.19	0.05	0.09	0.12	0.59
4E. Front Wall Mid Lower Center (42")	C1 through C6	Demand	100.0	30.2	207.0	76.9	1372.2	321.8
		Capacity	153.6	51.3	1089.5	1035.1	2262.5	682.6
		Ratio	0.65	0.59	0.19	0.07	0.61	0.79
	C7	Demand	2.0	0.0	77.1	39.3	325.7	0.0
		Capacity	145.0	48.5	984.5	932.9	2420.2	844.3
		Ratio	0.01	0.00	0.08	0.04	0.14	0.00
4F. Front Wall Mid Center (42")	C1 through C6	Demand	118.7	104.5	386.6	296.9	271.7	1143.2
		Capacity	153.6	153.6	1089.5	1089.5	2223.3	1386.5
		Ratio	0.77	0.68	0.35	0.27	0.46	0.83
	C7	Demand	41.9	28.5	56.3	139.3	446.2	1635.4
		Capacity	145.0	145.0	984.5	984.5	2413.5	2365.6
		Ratio	0.29	0.20	0.06	0.14	0.23	0.69

All Indicated Changes are Enclosure 2, Item 1.

Table 3.9.4-29a
Comparison of Highest Combined Axial Forces/Moments with Capacities of the EOS-HSM-FPS Alternate Front Wall (Bounding) *(50kW Heat Load)*
3 Pages

72.48

Component	Load Comb.(1) (3)	Quantity	P_1 (Tens.)	P_2 (Tens.)	P_1 (Comp)	P_2 (Comp)	M_{1p}(2)	M_{2p}(2)
			kips/ft	kips/ft	kips/ft	kips/ft	kip-in/ft	kip-in/ft
4G. Front Wall Bottom (42")	C1 through C6	Demand	44.4	64.6	88.3	87.5	391.5	278.9
		Capacity	153.6	92.1	1195.6	1162.9	2719.9	952.4
		Ratio	0.29	0.70	0.07	0.08	0.14	0.38
	C7	Demand	31.6	10.3	17.2	21.6	326.5	449.9
		Capacity	145.0	87.0	1080.0	1049.0	2145.7	1654.9
		Ratio	0.22	0.12	0.02	0.02	0.15	0.27

Notes:

1 Load Combinations C1 through C6 include normal thermal, Combination C7 includes accident thermal

2 M_{1p} and M_{2p} are moments at the same location and for the same load combination as P_1 and P_2. M_{1p} and M_{2p} occur at the same location simultaneously with P_1 and P_2, i.e. $M_1 = [(P_{tu} - P_1)/P_{tu}]*M_{u1}$

3 See Section 3.9.4.7.1 for impact of 160 pcf fresh concrete density on the increased demand due to higher weight of the storage module 72.48

All Indicated Changes are Enclosure 2, Item 1.

Table 3.9.4-29b
Comparison of Highest Combined Axial Forces/Moments with Capacities of the EOS-HSMS-FPS-OVVP Alternate Front Wall (Load Combination C4) *(50kW Heat Load)*

72.48

Component	Load Combination(1)	Quantity	P_1 (Comp)	P_2 (Comp)	P_1 (Tens)	P_2 (Tens.)	M_{1p}	M_{2p}
			kip/ft	kip/ft	kip/ft	kip/ft	kip-in/ft	kip-in/ft
4A. Front Wall Top (42")	C4	Demand	49.58	60.39	144.17	83.08	503.53	497.75
		Capacity	968.50	1162.90	151.20	92.10	670.12	597.56
		Ratio	0.05	0.05	0.95	0.90	0.75	0.83
4B. Front Wall Mid Upper Side (42")		Demand	45.58	95.09	139.67	112.08	351.83	637.50
		Capacity	1089.50	1127.20	153.60	124.70	451.14	705.50
		Ratio	0.04	0.08	0.91	0.90	0.78	0.90
4C. Front Wall Mid Upper Center (42")		Demand	33.68	25.29	138.37	59.21	503.75	240.89
		Capacity	1089.50	1045.00	153.60	70.00	610.08	353.60
		Ratio	0.03	0.02	0.90	0.85	0.83	0.68
4D. Front Wall Mid Lower Side (42")		Demand	216.78	195.99	78.77	101.58	203.91	262.67
		Capacity	1089.50	1066.50	153.60	110.40	2012.69	609.04
		Ratio	0.20	0.18	0.51	0.92	0.10	0.43
4E. Front Wall Mid Lower Center (42")		Demand	238.98	97.99	88.37	38.58	194.57	186.59
		Capacity	1089.50	1035.10	153.60	51.30	1793.43	229.49
		Ratio	0.22	0.09	0.58	0.75	0.11	0.81
4F. Front Wall Mid Center (42")		Demand	417.48	316.69	142.17	129.38	354.29	829.20
		Capacity	1089.50	1089.50	153.60	153.60	782.96	889.00
		Ratio	0.38	0.29	0.93	0.84	0.45	0.93
4G. Front Wall Bottom (42")		Demand	120.28	104.09	68.37	89.18	189.31	294.26
		Capacity	1195.60	1162.90	153.60	92.10	1667.53	616.10
		Ratio	0.10	0.09	0.45	0.97	0.11	0.48

Notes:

(1) See Section 3.9.4.7.1 for impact of 160 pcf fresh concrete density on the increased demand due to higher weight of the storage module

72.48

All Indicated Changes are Enclosure 2, Item 1.

Table 3.9.4-29c
Comparison of Highest Combined Axial Forces/Moments with Capacities of the EOS-HSM-HS Front Wall (Load Combination C4) *(50kW Heat Load)*

Component	Load Combination	Quantity	P_1 (Tens.) kips/ft	P_2 (Tens.) kips/ft	P_1 (Comp) kips/ft	P_2 (Comp) kips/ft	M_{1p} kip-in/ft	M_{2p} kip-in/ft
4A. Front Wall Top (42")	C4	Demand	129.8	98.2	14.7	47.9	351.7	515.9
		Capacity	151.2	275.3	968.5	1162.9	363.4	1264.9
		Ratio	0.86	0.36	0.02	0.04	0.97	0.41
4B. Front Wall Mid Upper Side (42")		Demand	127.7	187.3	0.0	51.7	194.9	615.9
		Capacity	153.6	307.9	0.0	1127.2	433.1	843.7
		Ratio	0.83	0.61	0.00	0.05	0.45	0.73
4C. Front Wall Mid Upper Center (42")		Demand	121.8	98.1	0.0	0.0	368.9	373.3
		Capacity	153.6	253.2	0.0	0.0	572.0	745.9
		Ratio	0.79	0.39	0.00	0.00	0.64	0.50
4D. Front Wall Mid Lower Side (42")		Demand	15.1	86.2	323.9	256.8	279.7	321.3
		Capacity	153.6	110.4	1089.5	1066.5	2314.5	417.5
		Ratio	0.10	0.78	0.30	0.24	0.12	0.77
4E. Front Wall Mid Lower Center (42")		Demand	48.3	9.0	242.3	103.5	238.6	135.9
		Capacity	153.6	51.3	1089.5	1035.1	1759.6	873.0
		Ratio	0.31	0.17	0.22	0.10	0.14	0.16
4F. Front Wall Mid Center (42")		Demand	130.5	217.8	691.1	340.0	177.1	761.8
		Capacity	153.6	336.8	1089.5	1089.5	956.0	933.9
		Ratio	0.85	0.65	0.63	0.31	0.19	0.82
4G. Front Wall Bottom (42")		Demand	55.4	75.2	114.5	135.0	203.3	319.9
		Capacity	153.6	92.1	1195.6	1162.9	1849.6	330.7
		Ratio	0.36	0.82	0.10	0.12	0.11	0.97

Table 3.9.4-29d
Highest Demand/Capacity Ratios for Axial Forces/Moments of the EOS-HSM-FPS Front Wall (54kW Heat Load)
3 Pages

Component	Load Comb.	Quantity	P_1 (Tens)	P_2 (Tens.)	P_1 (Comp.)	P_2 (Comp.)	M_{1p}	M_{2p}
			kips/ft	kips/ft	kips/ft	kips/ft	kip-in/ft	kip-in/ft
4A. Front Wall Top (42")	C1 through C6	Demand	120.8	38.2	39.4	52.3	437.3	690.4
		Capacity	151.2	92.1	968.5	1162.9	929.2	1003.6
		Ratio	0.8	0.41	0.04	0.04	0.47	0.69
	C7	Demand	19.6	0.9	15.9	20.9	1354.1	215.1
		Capacity	142.8	87	875.6	1049	2088.8	1509.1
		Ratio	0.14	0.01	0.02	0.02	0.65	0.14
4B. Front Wall Mid Upper Side (42")	C1 through C6	Demand	115.4	85.6	74.6	124.1	366.1	627.1
		Capacity	153.6	124.7	1089.5	1127.2	637	674.9
		Ratio	0.75	0.69	0.07	0.11	0.57	0.93
	C7	Demand	10.6	0	40.5	56.4	811.8	0
		Capacity	145	117.8	984.5	1017.7	2360.4	2032.2
		Ratio	0.07	0	0.04	0.06	0.34	0
4C. Front Wall Mid Upper Center (42")	C1 through C6	Demand	114.9	47	57	37.9	437.3	456.7
		Capacity	153.6	70	1089.5	1045	954.1	541.7
		Ratio	0.75	0.67	0.05	0.04	0.46	0.84
	C7	Demand	16.9	0.7	24.2	14.3	1290	142
		Capacity	145	66.1	984.5	942.3	2137.9	1145
		Ratio	0.12	0.01	0.02	0.02	0.6	0.12

All Indicated Changes are Enclosure 2, Item 1.

Table 3.9.4-29d
Highest Demand/Capacity Ratios for Axial Forces/Moments of the EOS-HSM-FPS Front Wall (54kW Heat Load)
3 Pages

Component	*Load Comb.*	*Quantity*	P_1 (Tens) kips/ft	P_2 (Tens.) kips/ft	P_1 (Comp.) kips/ft	P_2 (Comp.) kips/ft	M_{1p} kip-in/ft	M_{2p} kip-in/ft
4D. Front Wall Mid Lower Side (42")	*C1 through C6*	*Demand*	*85.3*	*76.7*	*172.5*	*154.2*	*632.9*	*404.9*
		Capacity	*153.6*	*110.4*	*1089.5*	*1066.5*	*1188.9*	*629.4*
		Ratio	*0.56*	*0.7*	*0.16*	*0.14*	*0.53*	*0.64*
	C7	*Demand*	*18.5*	*17.4*	*35.3*	*69.8*	*273.6*	*874.5*
		Capacity	*145*	*104.2*	*984.5*	*962.7*	*2374.9*	*1502.5*
		Ratio	*0.13*	*0.17*	*0.04*	*0.07*	*0.12*	*0.58*
4E. Front Wall Mid Lower Center (42")	*C1 through C6*	*Demand*	*101.5*	*30.6*	*172.8*	*87.2*	*1364.3*	*326.2*
		Capacity	*153.6*	*51.3*	*1089.5*	*1035.1*	*2234*	*394.9*
		Ratio	*0.66*	*0.6*	*0.16*	*0.08*	*0.61*	*0.83*
	C7	*Demand*	*2.3*	*0*	*61.6*	*52*	*322.6*	*0*
		Capacity	*145*	*48.5*	*984.5*	*932.9*	*2381.4*	*844.3*
		Ratio	*0.02*	*0*	*0.06*	*0.06*	*0.14*	*0*
4F. Front Wall Mid Center (42")	*C1 through C6*	*Demand*	*82.4*	*99.8*	*172.5*	*231.7*	*324.2*	*1030.7*
		Capacity	*153.6*	*153.6*	*1089.5*	*1089.5*	*1189.1*	*1202.8*
		Ratio	*0.54*	*0.65*	*0.16*	*0.21*	*0.27*	*0.86*
	C7	*Demand*	*10.4*	*17.8*	*31.8*	*69.9*	*161.4*	*1615.1*
		Capacity	*145*	*145*	*984.5*	*984.5*	*2412.5*	*2338.7*
		Ratio	*0.07*	*0.12*	*0.03*	*0.07*	*0.07*	*0.69*

All Indicated Changes are Enclosure 2, Item 1.

Table 3.9.4-29d
Highest Demand/Capacity Ratios for Axial Forces/Moments of the EOS-HSM-FPS Front Wall
(54kW Heat Load)
3 Pages

Component	***Load Comb.***	***Quantity***	***P_1 (Tens)***	***P_2 (Tens.)***	***P_1 (Comp.)***	***P_2 (Comp.)***	***M_{1p}***	***M_{2p}***
			kips/ft	***kips/ft***	***kips/ft***	***kips/ft***	***kip-in/ft***	***kip-in/ft***
4G. Front Wall Bottom (42")	*C1 through C6*	*Demand*	*41.4*	*60.5*	*94.9*	*87.5*	*387.8*	*237.2*
		Capacity	*153.6*	*92.1*	*1195.6*	*1162.9*	*2716.1*	*883*
		Ratio	*0.27*	*0.66*	*0.08*	*0.08*	*0.14*	*0.27*
	C7	*Demand*	*34.1*	*6.6*	*21.5*	*19.5*	*308.4*	*443.5*
		Capacity	*145*	*87*	*1080*	*1049*	*2087.9*	*1689.5*
		Ratio	*0.23*	*0.08*	*0.02*	*0.02*	*0.15*	*0.26*

All Indicated Changes are Enclosure 2, Item 1.

Table 3.9.4-29e
Highest Demand/Capacity Ratios for Axial Forces/Moments of the EOS-HSM-OVVP Front Wall (54kW Heat Load)

Component	*Load Comb.*	P_1 (Tens.)	P_2 (Tens.)	P_1 (Comp)	P_2 (Comp)	M_{1p}	M_{2p}
4A. Front Wall Top (42")	*C1 through C6*	*0.952*	*0.900*	*0.050*	*0.050*	*0.785*	*0.855*
	C7	*0.146*	*0.240*	*0.016*	*0.020*	*0.697*	*0.703*
4B. Front Wall Mid Upper Side (42")	*C1 through C6*	*0.910*	*0.900*	*0.040*	*0.080*	*0.803*	*0.944*
	C7	*0.073*	*0.003*	*0.034*	*0.049*	*0.371*	*0.003*
4C. Front Wall Mid Upper Center (42")	*C1 through C6*	*0.902*	*0.850*	*0.030*	*0.020*	*0.864*	*0.705*
	C7	*0.155*	*0.015*	*0.015*	*0.014*	*0.692*	*0.128*
4D. Front Wall Mid Lower Side (42")	*C1 through C6*	*0.510*	*0.920*	*0.200*	*0.180*	*0.340*	*0.430*
	C7	*0.057*	*0.190*	*0.049*	*0.093*	*0.075*	*0.291*
4E. Front Wall Mid Lower Center (42")	*C1 through C6*	*0.580*	*0.750*	*0.220*	*0.090*	*0.157*	*0.810*
	C7	*0.001*	*0.003*	*0.080*	*0.046*	*0.001*	*0.003*
4F. Front Wall Mid Center (42")	*C1 through C6*	*0.930*	*0.841*	*0.380*	*0.290*	*0.463*	*0.965*
	C7	*0.287*	*0.199*	*0.057*	*0.144*	*0.234*	*0.655*
4G. Front Wall Bottom (42")	*C1 through C6*	*0.450*	*0.971*	*0.100*	*0.090*	*0.145*	*0.480*
	C7	*0.217*	*0.121*	*0.017*	*0.024*	*0.154*	*0.130*

All Indicated Changes are Enclosure 2, Item 1.

Table 3.9.4-29f
Comparison of Highest Demand/Capacity Ratios for EOS-HSM Alternate Front Wall (54kW Heat Load)

Component	Load Comb.	M_1	M_2	V_{o1}	V_{o2}	V_1	P_1 (Tens.)	P_2 (Tens.)	P_1 (Comp)	P_2 (Comp)	M_{1p}	M_{2p}
3. Front Wall Bottom	C1 through C6	0.337	0.733	0.337	0.211	0.411	0.594	0.875	0.121	0.121	0.850	0.599
	C7	0.366	0.707	0.095	0.050	0.189	0.176	0.000	0.068	0.070	0.192	0.000
4. Front Wall Top	C1 through C6	0.409	0.659	0.810	0.378	0.319	0.739	0.542	0.060	0.060	0.547	0.446
	C7	0.620	0.750	0.779	0.293	0.068	0.201	0.270	0.021	0.023	0.776	0.932
4. Front Wall Middle	C1 through C6	0.420	0.638	0.155	0.612	0.720	0.734	0.680	0.357	0.357	0.461	0.651
	C7	0.607	0.939	0.158	0.541	0.284	0.314	0.552	0.152	0.153	0.702	0.837
4. Front Wall Bottom	C1 through C6	0.196	0.232	0.192	0.292	0.464	0.538	0.351	0.119	0.119	0.322	0.176
	C7	0.405	0.297	0.097	0.132	0.124	0.137	0.011	0.042	0.043	0.177	0.239

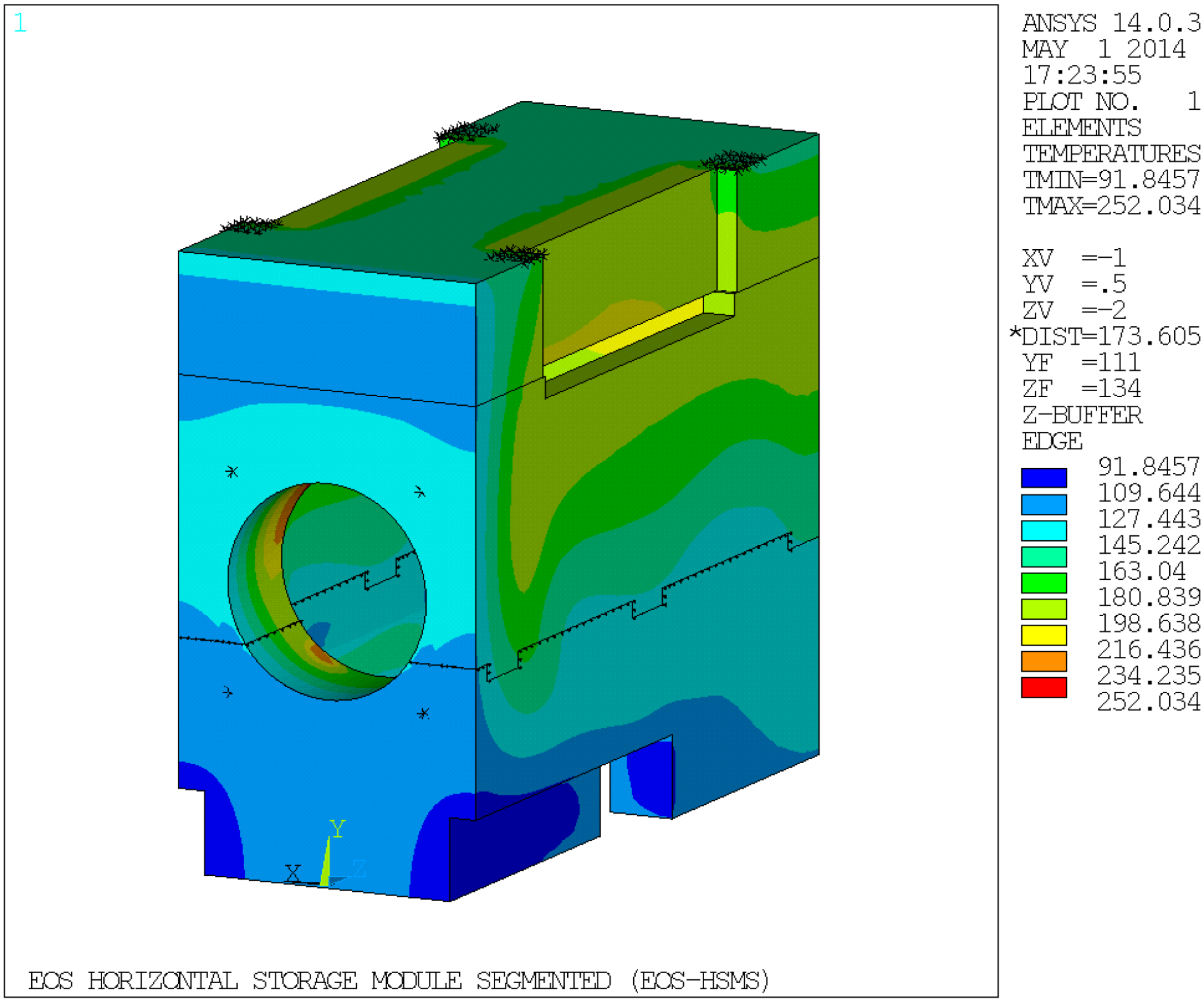

Figure 3.9.4-3
Temperature distribution of EOS-HSMS for Normal Thermal Hot Condition
(50kW Heat Load)

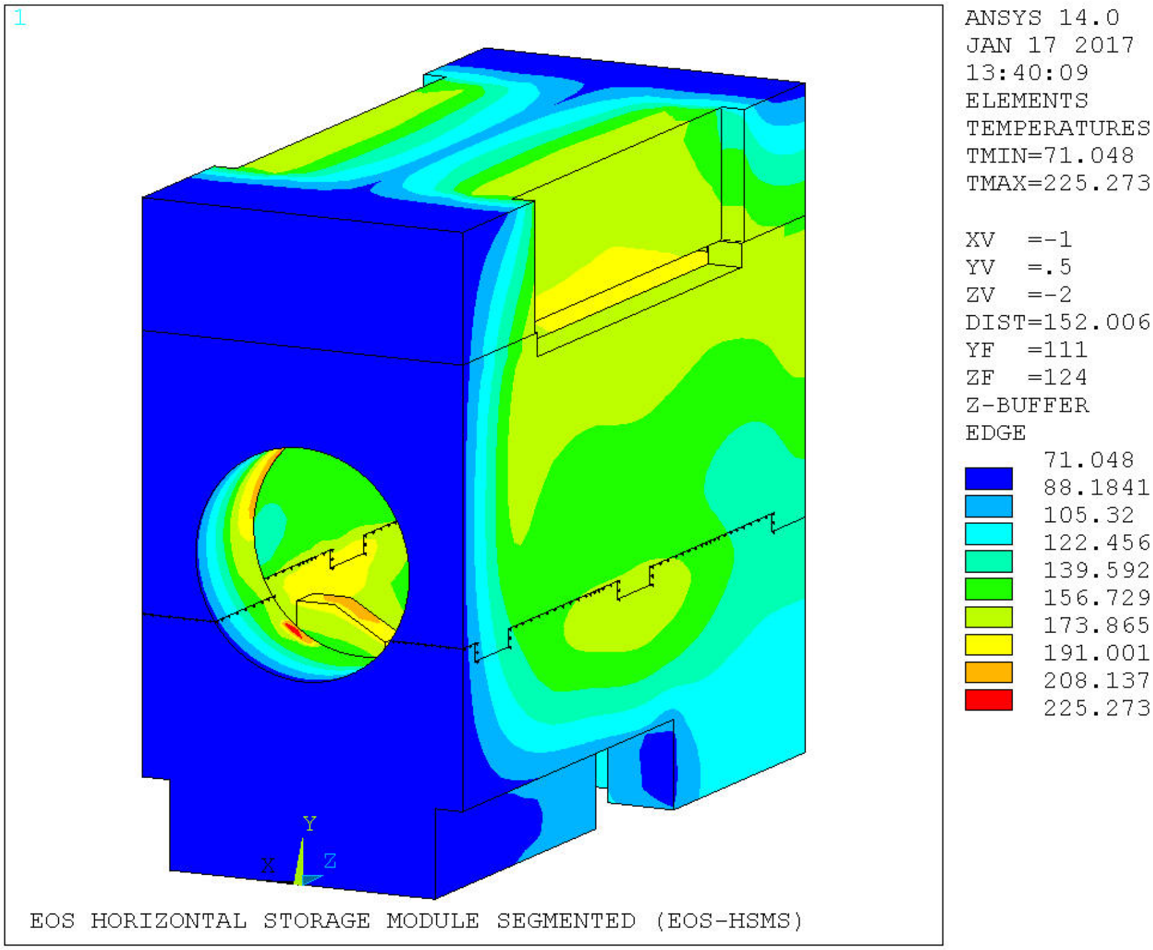

Figure 3.9.4-3a
Temperature distribution of EOS-HSMS-FPS for Normal Thermal Hot Condition *(50kW Heat Load)*

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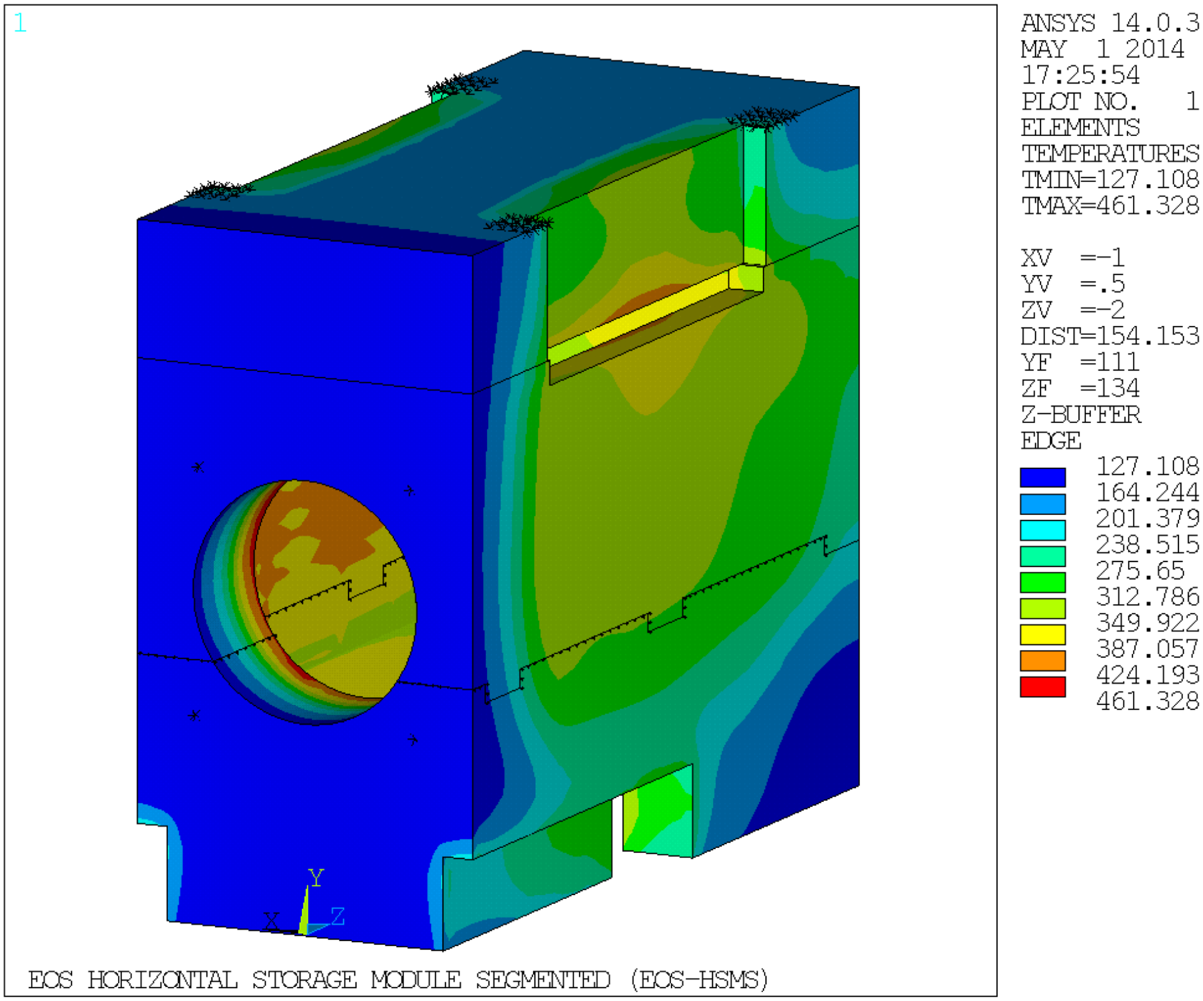
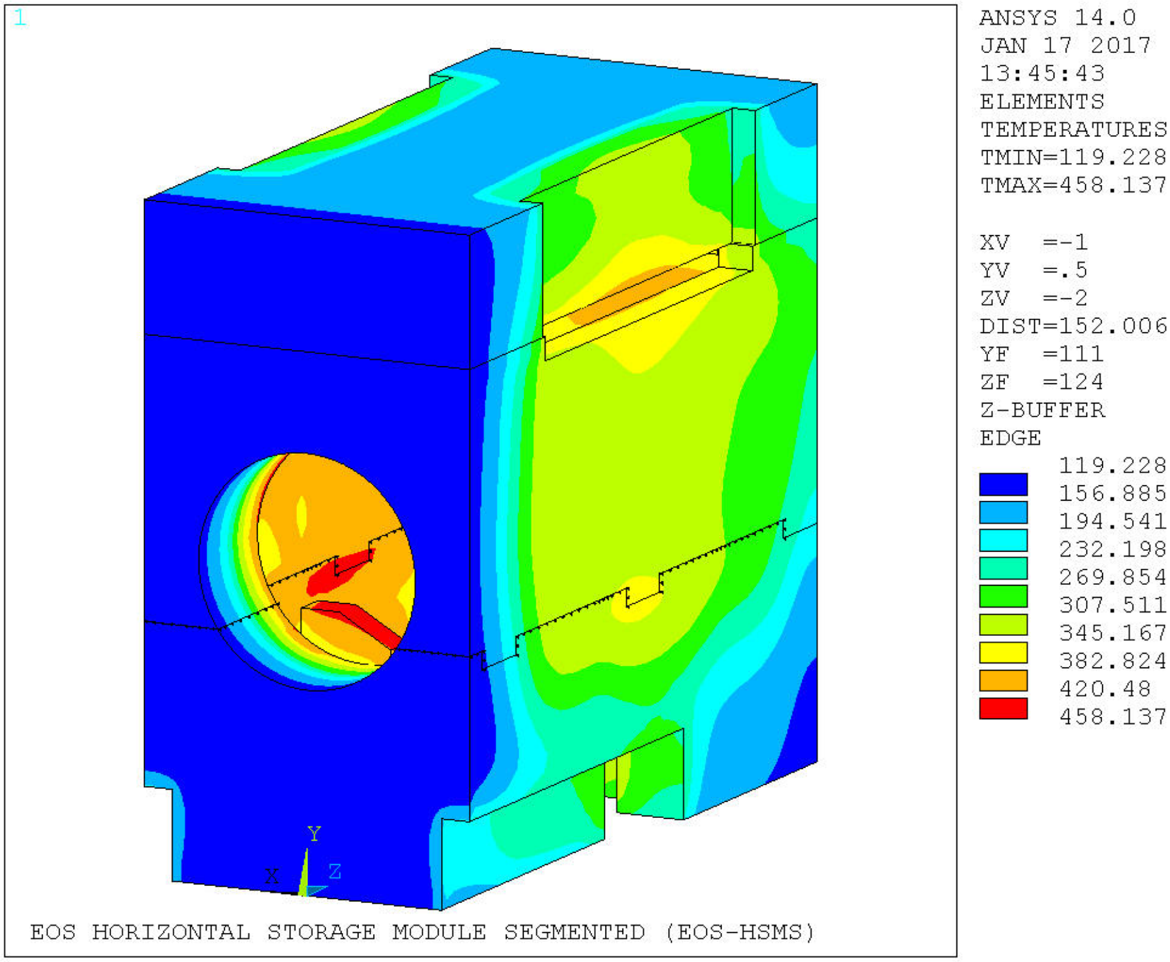


Figure 3.9.4-4
Temperature distribution of EOS-HSMS for Blocked Vent Accident Thermal Condition *(50kW Heat Load)*



Note: The bounding temperature distribution of the EOS-HSMS-FPS is used for the design basis accident blocked for the vent thermal stress analysis, which is conservative compared to the temperature profile provided in Figure 4.9.5-8(e)

Figure 3.9.4-4a
Temperature Distribution of EOS-HSMS-FPS for Blocked Vent Accident Thermal Condition *(50kW Heat Load)*

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3.9.5.4.1 Methodology and Acceptance Criteria

The conservatively bounding weights of the EOS-TC and DSC components employed for the analysis are as follows:

- Unloaded EOS-TC135 136,000 lb
- Loaded EOS-37PTH DSC 134,000 lb
- Total 270,000 lb

The upper trunnions and trunnion welds to the cask top ring are designed in accordance with the allowable stresses defined by ANSI N14.6 [3.9.5-2] for a non-redundant lifting device.

For the vertical configuration, the dead weight load includes the self-weight of the loaded EOS-TC with the bounding EOS-37PTH DSC payload full of water. This load considers the EOS-TC hanging vertically by the two upper trunnions. The weight of the DSC is applied as a uniform pressure on the bottom end plate of the EOS-TCMAX. A dynamic load factor (DLF) of 1.15 is used to include the effects of dynamic interactions.

During transfer of the EOS-TC on the trailer, the EOS-37PTH DSC will rest on the EOS-TC inner shell. The EOS-37PTH DSC weight is therefore applied as a pressure to the inner shell using a cosine shaped load amplitude variation. The EOS-TC will be in contact with the saddle, latch and the lower trunnion pockets; the lower trunnion pocket was modeled in ANSYS as vertically constrained nodes. Similarly, the semicircular half section of the upper trunnion is constrained in radial direction. See Figure 3.9.5-10 for a diagram showing the boundary conditions for various loading conditions.

During down-ending operations on the transfer trailer, the EOS-TC will rotate about the lower trunnion pockets, at which time, the contact between the lifting yoke and the upper trunnion will separate and the total load will be supported by the lower trunnion pockets.

For thermal stress analysis, temperature profiles and maximum component temperatures are based on the thermal analyses described in Chapter 4. Only two load cases are evaluated for thermal stress analysis, depending on the bounding cases, based on the maximum reported temperatures for normal and off-normal conditions. Displacement constraints are applied simply to prevent rigid body motion.

For all analyses, except thermal analysis, material properties are taken at a conservative temperature of 400 °F for the entire cask, except for the trunnions, which are taken at a conservative 367 °F. The allowable stresses for the EOS-TC components are obtained from Chapter 3, Table 3-3 and is reproduced for the pertaining load cases in Table 3.9.5-4.

All Indicated Changes are Enclosure 2, Item 1.

Thermal Loads

For thermal stress analysis, two temperature distributions from the thermal evaluations documented in Chapter 4 are used. The first load case corresponds to the EOS-TC125 loaded with EOS-37PTH DSC, heat load of 50 kW, off-normal hot conditions, outdoor and horizontal position of the TC. The second load case corresponds to the EOS-TC125 loaded with the EOS-37PTH DSC, heat load of 36.35 kW, normal hot conditions, indoor and vertical position of the TC. The temperature distributions are shown in Figure 3.9.5-19. *Temperatures for the EOS-TC125 loaded with the EOS-37PTH, and a heat load of 54 kW are shown to be comparable to those evaluated such that there is not a meaningful impact on thermal stresses.*

3.9.5.5.3 Results

The stress results for the neutron shield shells are summarized in Table 3.9.5-6 and Table 3.9.5-7. The stress contour plots of the EOS-TC108 neutron shield shell for the horizontal transfer/seismic load case are shown in Figure 3.9.5-15 and Figure 3.9.5-16. Also the stress contour plots of the EOS-TC135 neutron shield shell for the horizontal transfer / seismic load case are shown in Figure 3.9.5-17 and Figure 3.9.5-18.

3.9.5.6 EOS Transfer Cask, Trunnion, and Neutron Shield Shell Fatigue Requirements

The transfer cask (TC) and trunnion are designed in accordance with the applicable guidelines of the ASME Code, Section III, Division 1, and Subsection NF for Class 1 vessels, except for the neutron shield tank, which is designed to ASME Code, Section III, Division 1, and Subsection ND. Neither one of these subsections require a fatigue evaluation for low cycle loads. Therefore, the fatigue evaluation is not required for the EOS-TC per ASME code criteria.

3.9.8.9 Accident Condition Structural Analysis

The same accident condition loads described in Section 3.9.4.9 for the EOS-HSM-RC, except for the seismic load, are used to evaluate the EOS-HSM-SC.

The design basis seismic load used for analysis of the EOS-HSM-SC components is as discussed in Section 2.3.4. Based on N690-18 [3.9.8-3], a damping value of five percent is used for seismic analysis of SC components of the EOS-HSM-SC. An evaluation of the frequency content of the loaded EOS-HSM-SC is performed to determine the amplified accelerations associated with the design basis seismic response spectra for the EOS-HSM-SC. Modal frequencies and mass participation factors of the EOS-HSM-SC are shown in Table 3.9.8-1. The results of the frequency analysis yield a lowest frequency of *17.44* Hz in the transverse direction and *28.79* Hz in the longitudinal direction. Because the lowest vertical frequency exceeds 45 Hz, the spectral acceleration is not amplified in the vertical direction. Therefore, based on the Regulatory Guide 1.60 response spectra amplifications, and conservatively using zero period acceleration (ZPA) accelerations of 0.50g and 0.33g in the horizontal and vertical directions, respectively, the corresponding seismic accelerations used for the design of the EOS-HSM-SC are *1.117*g and *0.730*g in the transverse and longitudinal directions, respectively, and 0.333g in the vertical direction. The resulting amplified accelerations are given in Table 3.9.8-2. [

]

Like the EOS-HSM-RC, for sites where the response spectra at the base of the HSM are larger than analyzed, more than one module may need to tie together to prevent significant sliding or to prevent the modules from banging into each other causing unacceptable damage. The requirements on the faceplate, stud, and tie may also need to be reviewed, and the faceplate thickness and tie size may be increased for such sites. The tie and stud spacing may be adjusted as well.

The stability evaluation of the EOS-HSM-SC due to a 0.45g Horizontal/0.30g Vertical seismic load is discussed in Section 3.9.8.11. The stability evaluation by dynamic analysis shall be performed using the analysis methodology described in CoC 1029 [3.9.8-10].

The load combination results for each of these EOS-HSM-SC FPS DSC support structure components are provided in Table 3.9.8-11, Table 3.9.8-12, and Table 3.9.8-13. The maximum demand to capacity ratio for the EOS-HSM-SC DSC support structure is less than 1.0. Thus, the FPS DSC support structure is adequately strong to resist the reasonably foreseeable loads applied to it.

Note that a uniform 1/16-inch is conservatively applied to all exposed steel surfaces in the FPS DSC support structure design calculations as described in Section 3.9.4.10.2.

3.9.8.10.3 EOS-HSM-SC Shield Door

The shield door is free to grow in the radial direction when subjected to thermal loads. Therefore, there are no stresses in the door due to thermal growth. The dead weight, tornado wind, differential pressure, and flood loads cause insignificant stresses in the door compared to stresses due to missile impact load. The evaluation of the door for the missile impact load is presented in Section 3.9.8.10.6.2. For the door anchorage, the controlling load due to tornado-generated differential pressure drop load, calculated for the EOS-HSM-RC in Section 3.9.4.10.3, is applicable.

Additionally, the door is checked for punching shear through the plane of the weld at the corner of the plates at the [ ] portion of the door to ensure that the center section of the door is sufficiently supported and will not enter the HSM cavity due to a missile impact. The maximum peak force from the tornado missile spectrum is 944 kips due to the alternate approach for evaluating the steel pipe described in Section 3.9.8.10.6.2. This is less than the shear capacity of the weld and connecting members, which is 1138 kips, so the center section of the door is sufficiently supported.

3.9.8.10.4 Heat Shield

The heat shield design of the EOS-HSM-SC is identical with the heat shield design for the EOS-HSM-FPS-RC described in Section 3.9.4.10.4.

For the roof heat shield, the maximum interaction ratio for combined axial and bending stress in the connection bolts is 0.428, which is less than 1.0. The maximum bending moment in the roof heat shield panel is 23.79 in-lb/in, which is also less than the panel moment capacity of 59.59 in-lb/in.

For the side heat shield, the maximum interaction ratio for combined axial and bending stress in connection bolts is *0.275*, which is less than 1.0. The maximum bending moment in side heat shield panel is 27.6 in-lb/in, which is also less than the panel moment capacity of 59.59 in-lb/in.

The thermal expansion evaluation of the heat shields for the EOS-HSM-RC is also applicable to the EOS-HSM-SC and, therefore, neither the roof heat shield panel and side wall heat shield panel is subjected to thermal stress.

3.9.8.10.5 DSC Axial Restraint

The geometry and function of the DSC axial retainer of the EOS-HSM-SC is identical with the axial retainer for the EOS-HSM-RC described in Section 3.9.4.10.5. The maximum seismically induced shear load in the retainer is *146.9* kips, and the allowable shear strength of the axial retainer is 181.1 kips. The maximum seismically induced moment in the retainer is *293.8* in-kips, taking a moment arm of 2 inches, conservatively. The allowable flexural strength of axial retainer is 344.9 in-kips. Hence, the DSC axial retainer design is adequate to perform its intended function.

3.9.8.10.6 Evaluation of SC Components for Missile Loading

Missile impact effects are assessed in terms of local damage and overall structural response. As per [3.9.8-11], the local failure modes of SC components subjected to missile impact differ from those for reinforced concrete components in that SC components may experience penetration, bulging, splitting and perforation sequentially. Generally, scabbing is prevented by steel plates and perforation is considered to be the governing local failure mode for SC components. Evaluation of local effects is essential to ensure that protected items (the DSC and fuel) would not be damaged by a missile perforating a protective barrier. Evaluation of overall structural response is essential to ensure that protected items are not damaged or functionally impaired by deformation or collapse of the impacted structure.

The tornado-generated missiles are conservatively assumed to strike normal to the surface with the long axis of the missile parallel to the line of flight to maximize the local effects. Plastic deformation to absorb the energy input by the tornado-generated missile load is desirable and acceptable, provided that the overall integrity of the structure is not impaired. Due to complex physical processes associated with missile impact effects, the EOS-HSM-SC structure is primarily evaluated conservatively by application of empirical formulae.

The end shield wall, rear shield wall, base front wall, roof, and door of the EOS-HSM-SC are evaluated since these components may interface with missile loading. The end and rear shield walls, respectively, serve as missile barriers for the side and rear walls, which are therefore not evaluated for local damage. Additionally, the use of an empty EOS-HSM-SC module as a missile barrier is evaluated. No credit is taken for the contiguous walls behind the shield walls in the evaluations of the end and rear shield walls other than as simple supports.

All Indicated Changes are Enclosure 2, Item 1.

Table 3.9.8-1
Modal Frequencies and Mass Participation of EOS-HSM-SC

Mode	*Frequency (Hz)*	*X-Direction*		*Y-Direction*		*Z-Direction*	
		Mass (kip-s^2/in)	*%*	*Mass (kip-s^2/in)*	*%*	*Mass (kip-s^2/in)*	*%*
1	*17.44*	*0.705*	*55.0*	*0.000*	*0.0*	*0.000*	*0.0*
2	*28.79*	*0.000*	*0.0*	*0.000*	*0.0*	*0.563*	*43.9*
3	*29.01*	*0.000*	*0.0*	*0.000*	*0.0*	*0.263*	*20.5*
4	*31.18*	*0.001*	*0.1*	*0.000*	*0.0*	*0.000*	*0.0*
5	*33.76*	*0.001*	*0.1*	*0.000*	*0.0*	*0.000*	*0.0*
6	*43.35*	*0.000*	*0.0*	*0.002*	*0.1*	*0.206*	*16.0*
7	*47.87*	*0.300*	*23.4*	*0.000*	*0.0*	*0.000*	*0.0*
8	*48.53*	*0.000*	*0.0*	*0.002*	*0.1*	*0.000*	*0.0*
9	*48.72*	*0.053*	*4.2*	*0.000*	*0.0*	*0.000*	*0.0*
10	*54.06*	*0.000*	*0.0*	*0.383*	*29.9*	*0.000*	*0.0*
11	*66.23*	*0.000*	*0.0*	*0.000*	*0.0*	*0.000*	*0.0*
12	*67.32*	*0.001*	*0.1*	*0.000*	*0.0*	*0.000*	*0.0*
13	*73.98*	*0.000*	*0.0*	*0.000*	*0.0*	*0.002*	*0.2*
14	*77.10*	*0.000*	*0.0*	*0.000*	*0.0*	*0.000*	*0.0*
15	*84.30*	*0.000*	*0.0*	*0.257*	*20.0*	*0.011*	*0.8*
16	*90.27*	*0.000*	*0.0*	*0.054*	*4.2*	*0.005*	*0.4*
17	*94.53*	*0.003*	*0.2*	*0.000*	*0.0*	*0.000*	*0.0*
18	*98.13*	*0.000*	*0.0*	*0.018*	*1.4*	*0.030*	*2.4*

All Indicated Changes are Enclosure 2, Item 1.

Table 3.9.8-2
Spectral Acceleration Applicable to Different Components of EOS-HSM-SC for Seismic Analysis

Direction	***Frequency (Hz)***	***Spectral Acceleration (g) Corresponding to Design ZPA***		
		At 3% Damping (for DSC)	***At 4% Damping (Steel Structures)***	***At 5% Damping (for SC Components)***
X (Transverse)	*17.44*	*1.320*	*1.206*	*1.117*
Y (Vertical)	*54.06*	*0.333*	*0.333*	*0.333*
Z (Longitudinal)	*28.79*	*0.790*	*0.757*	*0.730*

All Indicated Changes are Enclosure 2, Item 1.

Proprietary Information on Pages 3.9.8-34 and 3.9.8-35 and Pages 3.9.8-37 through 3.9.8-42
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Table 3.9.8-12
Summary of Demand to Capacity Ratio for the EOS-HSM-SC FPS DSC Support Structure Accessories

Item	Demand/Capacity Ratio
12″ x 1″ Steel Plate	0.77
Tubesteel Spacer	N/A(1)
Stop Plate	*0.39*
Rail Extension Baseplate	0.70

Notes:

1. No change as compared to the EOS-HSM-FPS-RC. Results From Table 3.9.4-21a are applicable.

Table 3.9.8-13
Summary of Demand to Capacity Ratio for the EOS-HSM-SC FPS DSC Support Structure Welds

Weld Between	Demand/Capacity Ratio
4″ x 1″ Plate and 12″ x 1″ Plate	N/A(1)
Stiffener and 12″ x 1″ Plate	0.94
Stop Plate and Support	*0.39*(2)
Tubesteel Spacer and 12″ x 1″ Plate	N/A(1)
Extension Baseplate and 12″ x 1″ Plate	N/A(1)
Nitronic and 4″ x 1″ Plate	N/A(1)

Notes:

1. No change as compared to the EOS-HSM-FPS-RC. Results From Table 3.9.4-22 are applicable.
2. Full penetration weld. Qualification of base metal qualifies the welds. See Table 3.9.8-12.

Proprietary Information on Pages 3.9.8-47 through 3.9.8-54
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Appendix 4.9.8 presents the thermal evaluation of the EOS-89BTH DSC with HLZCs 4 though 6 for storage operations in the EOS-HSM and transfer operations in the EOS-TC125.

Appendix 4.9.9 presents the thermal evaluation of the EOS-37PTH DSC with HLZCs 12 and 13 for storage operations in the EOS-HSM and transfer operations in the EOS-TC125/TC135.

Appendix 4.9.10 presents the thermal evaluation of the EOS-37PTH DSC with HLZC 14 and a maximum heat load of 54 kW for storage operations in the EOS-HSM and transfer operations in the EOS-TC125/TC135.

As discussed in Appendix 4.9.6.1.1, EOS-37PTH Type 4H basket has the same emissivity of steel plates and conductivity of poison material as those of the EOS-37PTH Type 1 basket. Therefore, all the thermal evaluations for EOS-37PTH Type 1 baskets for storage conditions in Section 4.4 and transfer conditions in Section 4.5 are also applicable for EOS-37PTH Type 4H basket.

In addition, since Type 4H basket assembly has higher emissivity steel plates and higher conductivity poison plates, they are more efficient in terms of thermal performance compared to Type 4L/5 baskets. Therefore, all the thermal evaluations for EOS-37PTH Type 4L/5 baskets for storage and transfer conditions in Appendix 4.9.6, Sections A.4.4.4 and A.4.5.5 in Appendix A.4 are also applicable for EOS-37PTH Type 4H basket.

4.1 Discussion of Decay Heat Removal System

The EOS-37PTH and EOS-89BTH DSCs are designed to passively reject decay heat during storage and transfer for normal, off-normal, and hypothetical accident conditions while maintaining temperatures and pressures within specified limits. Objectives of the thermal analyses performed for this evaluation include:

- Determination of maximum and minimum temperatures with respect to material limits to ensure components perform their intended safety functions,
- Determination of temperature distributions to support the calculation of thermal stresses,
- Determination of maximum DSC internal pressures for normal, off-normal, and hypothetical accident conditions, and
- Determination of the maximum fuel cladding temperature, and to confirm that this temperature will remain sufficiently low to prevent unacceptable degradation of the fuel during storage.

The EOS-37PTH DSC is analyzed based on a maximum heat load of *54.0* kW from 37 pressurized water reactor (PWR) fuel assemblies (FAs) with a maximum heat load of 4.3 kW per assembly. The EOS-89BTH DSC is analyzed based on a maximum heat load of 48.2 kW from 89 boiling water reactor (BWR) fuel assemblies (FAs) with a maximum heat load of 1.7 kW per assembly. The authorized HLZCs for the EOS-37PTH DSC are provided in Figure 1 of the Technical Specification [4-24]. Figure 1 of the Technical Specification [4-24] if transferred using an EOS-TC108 transfer cask and stored in either EOS-HSM or HSM-MX, or transferred using EOS-TC125 or EOS-TC135 transfer cask and stored in HSM-MX. For EOS-37PTH DSCs transferred in EOS-TC125 or EOS-TC135 and stored in EOS-HSM, the authorized HLZCs are shown in Figure 2-3a through Figure 2-3*n* of Chapter 2. The authorized HLZCs for the EOS-89BTH DSC are provided in Figure 2-2a through Figure 2-2f in Chapter 2 for transfer in the EOS-TC125 and Figure 2 of the TS [4-24] for the EOS-89BTH when transferred in the EOS-TC108.

Fuel assemblies are considered as homogenized materials in the fuel compartments. The effective thermal conductivity of the FAs used in the thermal analysis is based on the conservative assumption that heat transfer within the fuel region occurs only by conduction and radiation where any convection heat transfer is neglected. The lowest effective properties among the applicable FAs are selected to perform the thermal analysis. Evaluations of heat transfer from the FAs to the basket assembly credits conduction through the basket assembly materials (steel/metal matrix composite/aluminum) and helium fill gas within the DSC. Convection and radiation heat transfer within the basket assembly are conservatively ignored.

13. Surface Properties

Material	Emissivity (ε)	Solar Absorptivity (α)	References
Zircaloy based Fuel Cladding	0.8	--	Figure 3.4-1 from [4-16]
Aluminum	0.09	--	[4-17]
Stainless steel	0.46 (1)	--	[4-19], Appendix U, Section U.4.2
	0.587 (2)	--	[4-18]
Carbon steel	0.55	--	[4-19], Appendix U, Section U.4.2
Concrete	0.9 (3)	1.0	[4-17]

Notes:
1. For machined or flat stainless steel surfaces
2. For rolled surfaces of the DSC cylindrical shell
3. Emissivity of 0.8 is conservatively used in the analyses

For the EOS-37PTH Basket Types 4L and 5, an emissivity of 0.07 is considered based on emissivity of electroless nickel coating [4-28].

Emissivity of rolled stainless steel plates is 0.587 as considered in [4-18]. The emissivity for rolled steel sheets is 0.657 as reported in Table 10-17 of [4-2]. An emissivity of 0.587 is assumed for the exterior surfaces of the DSC.

All exposed internal and external surfaces of the transfer cask are painted. Based on the emissivities listed in Table B-1 of [4-17], it is observed that all paints have an emissivity between 0.92-0.96. Therefore, an emissivity of 0.9 is used for all painted surfaces of the TC.

APPENDIX 4.9.10
THERMAL EVALUATION OF EOS-37PTH DSC FOR HLZC 14

Table of Contents

All Indicated Changes are Enclosure 2, Item 1.

List of Tables

All Indicated Changes are Enclosure 2, Item 1.

List of Figures

All Indicated Changes are Enclosure 2, Item 1.

4.9.10 THERMAL EVALUATION OF EOS-37PTH DSC FOR HLZC 14

This appendix evaluates the thermal performance of the EOS-37PTH Dry Shielded Canister (DSC) for normal, off-normal, and accident conditions with Heat Load Zone Configurations (HLZC) 14 for both storage and transfer operations.

The various basket assembly types within the EOS-37PTH DSC are described in Section 1.1, and the various system configurations allowed for these basket assembly types are listed in Table 1-2. HLZC 14 evaluated in this appendix can be loaded in an EOS-37PTH DSC.

A summary of the EOS-37PTH DSC configurations analyzed in this appendix is shown below.

DSC Type	Basket Assembly Type	Heat Load Zone Configuration (HLZC)	Max. Heat Load (kW)	Transfer Cask	Storage Module[(1)]
EOS-37PTH	4HA	14	54	EOS-TC125/ EOS-TC135	EOS-HSM/EOS-HSMS EOS-HSM-FPS/ EOS-HSMS-FPS

Note:

1. EOS-HSM and EOS-HSMS are identical in thermal performance, and EOS-HSM-FPS and EOS-HSMS-FPS are identical in thermal performance, as discussed in Chapter 4.

Section 4.9.10.1 presents descriptions of HLZC 14. Section 4.9.10.2 presents the storage evaluation of the EOS-37PTH DSC with HLZC 14 in EOS-HSM. Section 4.9.10.3 presents the transfer evaluation of the EOS-37PTH DSC with HLZC 14 in EOS-TC125.

4.9.10.1 Description of HLZC 14

HLZC 14 is shown in Chapter 2, Figure 2-3n. As seen from the figure, the maximum heat load for HLZC 14 is 54 kW. The decay heat load of each fuel assembly (FA) and its location is qualified per Figure 12 of Technical Specifications (TS) [4.9.10-4].

Only intact fuel assemblies can be stored in the DSC with HLZC 14. Damaged or failed fuel assemblies cannot be stored in the DSC with HLZC 14 configuration.

4.9.10.2 Storage Evaluation in HLZC 14

This section evaluates the thermal performance of the EOS-HSM loaded with the EOS-37PTH DSC and Basket Assembly Type 4HA for HLZC 14 with intact FAs during normal, off-normal, and accident conditions.

All Indicated Changes are Enclosure 2, Item 1.

As discussed in Section 1.2.1.3, the EOS-HSM may be constructed of reinforced concrete and steel, or alternatively, the components may be constructed from a steel-plate composite. Based on the discussion in Section 4.4.12, the steel-plate composite option (EOS-HSM-SC) has better thermal performance compared to the reinforced concrete option. Therefore, the reinforced concrete option is considered in this evaluation to bound both designs. Within the reinforced concrete and steel HSM variants, the HSM option with the flap plate support structure with solid bars for rail spacer results in higher temperatures based on the results presented in Section 4.9.5.8b and is considered for this evaluation.

4.9.10.2.1 Description of Load Cases

To determine the thermal performance of the EOS-HSM (FPS) loaded with the EOS-37PTH DSC, the load cases (LCs) listed in Table 4.9.10-1 are evaluated for normal, off-normal, and accident conditions using the CFD model described in Section 4.9.10.2.3. The LCs listed in Table 4.9.10-1 are similar to the design basis LCs evaluated in Section 4.9.4 and Section 4.9.5 for the EOS-HSM with EOS-37PTH DSC loaded per HLZC 1 with 50 kW.

The LCs analyzed for the storage conditions are described as below:

- LC 1 is evaluated for bounding storage under normal conditions using HLZC 14 (54 kW) with wind deflectors [ ], similar to LC 1 described in Section 4.9.5.1.6, and with maximum yearly average ambient temperature of 70 °F for normal storage conditions with heat load greater than 41.8 kW as described in Section 4.9.5.1.3.
- LC 2 is evaluated for storage under off-normal conditions using HLZC 14 (54 kW) with wind deflectors [ ]
- LC 3 is evaluated for storage under accident conditions with blocked inlet and outlet vents for 40 hours using HLZC 14 (54 kW), [ ]

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4.9.10.2.4 EOS-37PTH DSC with HLZC 14 – Storage Evaluation

Temperature Calculations

The maximum temperatures of fuel cladding and concrete of EOS-HSM loaded with EOS-37PTH DSC for LCs 1, 2, and 3 are summarized in Table 4.9.10-3. The maximum temperatures of the fuel cladding and concrete for the normal (LC 1), off-normal (LC 2), and accident (LC 3) storage conditions of the high seismic FPS option of EOS-HSM loaded with EOS-37PTH DSC with HLZC 14 remain within the design temperature limits.

The maximum temperatures of various components of the EOS-HSM loaded with the EOS-37PTH DSC for LCs 1, 2, and 3 are summarized in Table 4.9.10-4. The average temperatures of key components of the EOS-HSM loaded with the EOS-37PTH DSC for LCs 1, 2, and 3 are summarized in Table 4.9.10-5.

Typical temperature plots for the key components in the EOS-HSM loaded with the EOS-37PTH DSC for LCs 1, 2, and 3 are shown in Figure 4.9.10-1 through Figure 4.9.10-3.

Airflow Calculation

Velocity profiles on the transverse middle plane of the EOS-HSM model with 37 PTH DSC and HLZC 14 under normal hot storage condition (LC 1) is shown in Figure 4.9.10-4 , while the streamlines for the airflow inside the EOS-HSM of the same storage condition is shown in Figure 4.9.10-5. Cool ambient air enters into the EOS-HSM from the inlet, absorbs the heat from the EOS-37PTH DSC, and leaves the EOS-HSM through the outlet with higher temperatures. Table 4.9.10-6 summarizes the air temperatures and mass flow rates at the inlet and outlet for LCs 1 and 2.

[ ]

Internal Pressure Calculation

Section 4.7.1 calculates the maximum internal pressures of the EOS-37PTH DSC during normal, off-normal, and accident storage and transfer operations as listed in Table 4-45. Since the same type of EOS-37PTH DSC is used in this evaluation for HLZC 14, the internal pressure calculation for HLZC 14 in this section follows the same methodology and computation as in Section 4.7.1. Table 4.9.10-7 presents a comparison of the average temperature of helium with the DSC cavity based on a short EOS-37PTH DSC. As shown in Table 4.9.10-7, the average helium temperatures determined for the EOS-37PTH DSC in the EOS-HSM with HLZC 14 are lower than the temperatures determined for the design basis values in Table 4-45. Therefore, the maximum internal pressures in Table 4-45 remain bounding for the EOS-37PTH DSC in the EOS-HSM with HLZC 14 under normal, off-normal, and accident storage conditions.

4.9.10.3 Transfer Evaluation for HLZC 14

This section evaluates the thermal performance of the EOS-37PTH DSC with Basket Type 4HA in the EOS-TC125/TC135 during transfer operations for normal, off-normal, and accident conditions, based on HLZC 14.

4.9.10.3.1 Description of Load Cases

As discussed in Section 4.5.1, the load cases considered for transfer of the EOS-37PTH DSC include the vertical loading condition inside of the fuel handling facility, normal and off-normal horizontal transfer conditions with and without air circulation, and the bounding hypothetical accident scenario of loss of both the air circulation system and the water in the neutron shield.

[

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4.9.10.3.2 Thermal Model for Transfer of EOS-37PTH DSC in EOS-TC125

[

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4.9.10.3.3 Normal and Off-Normal Conditions of Transfer - EOS-37PTH DSC

Due to the high decay heat loads considered for the EOS-37PTH DSC, certain time limits are applicable to the transfer operations under normal and off-normal conditions. The time limits are established to maintain the fuel cladding and the EOS-TC125 components temperatures below the allowable limits based on various LCs discussed in Section 4.9.10.3.1.

Normal/Off-Normal Transfer Conditions without Air Circulation

Table 4.9.10-9 and Table 4.9.10-10 summarizes the maximum temperatures for the EOS-TC125 components for LCs 1 and 3 respectively, at 13 hours as well as the comparison of the maximum key component temperatures with the corresponding design basis load cases. As seen from Table 4.9.10-9, the maximum fuel cladding temperature is 702 °F and remains below the design basis temperature with sufficient margin to the temperature limit. [

] Further the maximum temperatures for the DSC shell and TC components increase slightly compared to the design basis temperatures but remain within the allowable limits.

All Indicated Changes are Enclosure 2, Item 1.

Figure 4.9.10-6 and Figure 4.9.10-7 show the temperature distributions of the key components in the EOS-TC125 with EOS-37PTH DSC for, respectively, LC 1 (54 kW, normal hot, vertical transient transfer operations) and LC 3 (54 kW, off-normal hot, horizontal transient transfer operations) at 13 hours after initiation of water drainage in the TC/DSC annulus.

Off-Normal Transfer Conditions with Air Circulation and Air Circulation Turned-Off to Complete Transfer Operations

Transient (LC 6a) thermal analysis is performed for the EOS-TC125 with EOS-37PTH DSC and HLZC 14 with air circulation for off-normal, hot, horizontal transfer conditions. This evaluation demonstrates that the maximum fuel cladding and TC component temperatures remain below the allowable limits once the air circulation is activated. Table 4.9.10-11 summarizes the maximum temperatures for the LC 6a. The temperature profiles are presented in Figure 4.9.10-8. Based on the transient analysis of LC 6a, the maximum fuel cladding temperature after 8 hour of air circulation is 707 °F. Similar to other HLZCs with air circulation, if air circulation is initiated as a recovery option, it must be operated for a minimum duration of 8 hours to allow sufficient time for the TC/DSC components to cool down.

Transient thermal analysis is performed for the EOS-TC125 with EOS-37PTH DSC and HLZC 14 without air circulation when the air circulation is turned off or lost (LC 7). This analysis is assumed to begin with TC and DSC temperatures at the end of LC 6a. During transient run, the air circulation is turned off or lost and the system starts to heat up.

Based on the transient thermal analysis, a maximum duration of 4 hours is available to complete the transfer of the EOS-37PTH DSC to the EOS-HSM after the air circulation is turned off or to re-establish the air circulation. Table 4.9.10-12 summarizes the maximum temperatures for this LC 7. The temperature profiles for LC 7 are presented in Figure 4.9.10-9. Based on the transient analysis of LC 7, the maximum fuel cladding temperature 4 hours after the air circulation is turned off or lost is 708 °F.

4.9.10.3.4 Time Limits for Normal/Off-Normal Transfer Operations - EOS-37PTH DSC with HLZC 14

For HLZC 14, based on the results for LC 1 and 3 in Section 4.9.10.3.3, steady-state transfer operations are not permitted, and a time limit of 13 hours is determined to complete both vertical and horizontal transfer operations. To provide an additional margin and to ensure sufficient time for the initiation of recovery actions consistent with the other HLZCs, a time limit of 8 hours is chosen for the transfer operation with HLZC 14. In addition to the initial time limit, if air circulation is considered as a recovery option, based on the discussion Section 4.5.4 and the evaluation for LC 6a and 7 for HLZC 14, the air circulation needs to be operated for a minimum of 8 hours and 4 hours is available after the air circulation is turned off or lost to complete the transfer operations.

The time limits for the transfer operations of an EOS-37PTH DSC with HLZC 14, consistent with other HLZCs with time limits are listed in Table 4.9.10-16.

4.9.10.3.5 Hypothetical Accident Conditions of Transfer - EOS-37PTH DSC

As noted in Section 4.5.1, the loss of neutron shield and loss of air circulation is bounding for the fire accident case. The maximum temperatures for the bounding loss of neutron shield and loss of air circulation steady-state accident condition (LC 5) are presented in Table 4.9.10-13 for the EOS-37PTH DSC in EOS-TC125. As shown in Table 4.9.10-13, the maximum fuel cladding and gamma shield temperatures are 941 °F and 611 °F and are below the allowable limits of 1058 °F and 620 °F described in Section 4.2.

Figure 4.9.10-10 presents the temperature profiles for the loss of neutron shield and loss of air circulation accident condition for the EOS-TC125 TC loaded with the EOS-37PTH DSC (HLZC 14).

Table 4.9.10-14 lists the average temperatures for the key components of the EOS-37PTH DSC for all LCs listed in Table 4.9.10-8, while the average component temperatures at the hottest section are summarized in Table 4.9.10-15.

4.9.10.3.6 Internal Pressures - EOS-37PTH DSC

Section 4.7.1 calculates the maximum internal pressures of the EOS-37PTH DSCduring normal, off-normal, and accident storage and transfer operations as listed in Table 4-45. Since the same type of EOS-37PTH DSC is used in this evaluation for HLZC 14, the internal pressure calculation for HLZC 14 in this section follows the same methodology and computation as in Section 4.7.1. Table 4.9.10-17 presents a comparison of the average temperature of helium with the DSC cavity based on a short EOS-37PTH DSC.

As shown in Table 4.9.10-17, the calculated bounding average helium temperatures under normal and off-normal transfer conditions remain bounding and no further evaluation is presented for these operating conditions.

Since the quantity of gases, and the total free volume in the DSC cavity are the same between the accident case of HLZC 14 and the design basis accident condition listed in Table 4-45, the DSC internal pressure is then proportional to the average temperature of the DSC cavity gas. Based on this, the calculated bounding internal pressure for HLZC 14 under accident condition is 124.6 psig and remains below the design pressure limit of 130 psig specified in Table 4-45.

Table 4.9.10-18 lists the maximum internal pressures for the EOS-37PTH DSC with HLZC 14 under normal, off-normal, and accident transfer operations, which remain below the design pressure limits specified in Table 4-45.

4.9.10.4 References

4.9.10-1 ANSYS ICEM CFD, Version 2022R2, ANSYS, Inc.

4.9.10-2 ANSYS FLUENT, Version 2022R2, ANSYS, Inc.

4.9.10-3 Title 10, Code of Federal Regulations, Part 71, “Packaging and Transportation of Radioactive Material,” 2003.

4.9.10-4 CoC 1042 Appendix A, NUHOMS® EOS System Generic Technical Specifications, Amendment 5.

All Indicated Changes are Enclosure 2, Item 1.

Table 4.9.10-1
Design Load Cases for EOS-HSM Loaded with EOS-37PTH DSC Basket

LC No.	Operation Condition	Description	Daily Average Ambient Temperature (°F)	HLZC (Heat Load)
1	Normal		70 (1)	14 (54 kW)
2	Off-Normal		103 (2)	14 (54 kW)
3 (3)	Accident		103 (2)	14 (54 kW)

Notes:

1. For storage operations with heat load greater than 41.8 kW for the EOS-37PTH DSC, the maximum yearly average temperature is 70 °F for normal storage conditions based on the discussion in Section 4.9.5.1.3.
2. A daily average ambient temperature of 103 °F is used in the evaluations, corresponding to a daily maximum temperature of 117 °F for the off-normal and accident hot storage conditions, based on the discussion in Section 4.9.5.1.3.
3. Initial temperatures are taken from steady-state results of LC 2.

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Table 4.9.10-3
Maximum Fuel Cladding and Concrete Temperatures of EOS-HSM Loaded with EOS-37PTH DSC, HLZC 14

LC (1)	Description	Fuel Cladding Temperature (°F)		Concrete Temperature (°F)	
		Maximum	Limit (2)	Maximum	Limit (2)
1		710	752	240	300
2		719	1058	262	
3		843		456	500

Notes:

(1) See Table 4.9.10-1 for the description of the LCs.

(2) The temperature limits are specified in Section 4.2.

Table 4.9.10-4
Maximum Temperatures of Key Components of EOS-HSM Loaded with EOS-37PTH DSC, HLZC 14

LC (1)	Temperature (°F)				
	Basket Plate	Transition Rails	DSC Shell	Heat Shield	Support Structure
1	672	519	435	221	339
2	681	534	442	241	351
3	814	685	604	480	523

Notes:

(1) See Table 4.9.10-1 for the description of the LCs.

All Indicated Changes are Enclosure 2, Item 1.

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Table 4.9.10-7
Average Temperatures of Helium Gas in EOS-37PTH DSC Cavity with HLZC 14 During Storage in EOS-HSM

LC (1)	Average Temperature of Helium in DSC (K)		Temperature Difference (K)
	Bounding Design Basis [See Table 4-45]	HLZC 14 in EOS-HSM-HS	
	Short / Medium DSC		
1	565 / 561	550 / 547	-15 / -14
2	565 / 561	554 / 551	-11 / -10
3	653 / 649	634 / 631	-19 / -18

Notes:

(1) See Table 4.9.10-1 for the description of the LCs.

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Table 4.9.10-9
Maximum Temperatures of EOS-TC125 Loaded with EOS-37PTH DSC with HLZC 14, 54 kW, for the Bounding Vertical Normal Hot Transfer Condition

	Normal, Hot, Indoor, Vertical, No Air Condition (LC 1)		
HLZC	**HLZC 1 Design Basis (Table 4-24/4-29, 50 kW)**	**HLZC 14 (3) (54 kW)**	**Temperature Limit (°F)**
Component Name	**Temperatures (°F)**		
Fuel Cladding	742 (2)	702	752
Basket Plates	680	667	
DSC Shell	484	491	-
Transition Rail	553	560	
Inner Shell	316	319	-
Gamma Shield	315	317	620
Structural Shell	228	229	-
Neutron Shield (1) Average	212	212	259
Neutron Shield Outer Skin	222	223	-
Solid Neutron Shield Avg	223	223	262
Closure Lid	179	180	-
Top Forging	200	201	-
Bottom Forging	220	220	-

Notes:

1. Bulk average temperature of water in the neutron shield is limited by the 20 psig pressure relief valves on the shield. The equivalent steam saturation temperature at this pressure is approximately 259 °F.
2. Maximum fuel cladding temperature is reported at 15 hours based on the discussion in Section 4.5.4.
3. Temperature reported in transient case at 13 hours.

Table 4.9.10-10
Maximum Temperatures of EOS-TC125 Loaded with EOS-37PTH DSC with HLZC 14, 54 kW, for the Bounding Horizontal Off-Normal Hot Transfer Condition

	Off-normal, Hot, Outdoor, No Air Circulation (LC 3)		
HLZC	**HLZC 1 Design Basis (Table 4-24/4-29, 50 kW)**	**HLZC 14 (3) (54kW)**	**Temperature Limit (°F)**
Component Name	**Temperatures (°F)**		
Fuel Cladding	740 (2)	692	752
Basket Plates	670	651	
DSC Shell	483	484	-
Transition Rail	552	549	
Inner Shell	347	355	-
Gamma Shield	344	350	620
Structural Shell	236	238	-
Neutron Shield (1) Average	203	202	259
Neutron Shield Outer skin	224	226	-
Solid Neutron Shield Avg	172	171	262
Closure Lid	185	185	-
Top Forging	217	218	-
Bottom Forging	194	194	-

Notes:

1. Bulk average temperature of water in the neutron shield is limited by the 20 psig pressure relief valves on the shield. The equivalent steam saturation temperature at this pressure is approximately 259 °F.
2. Maximum fuel cladding temperature is reported at 15 hours based on the discussion in Section 4.5.4.
3. Temperature reported in transient case at 13 hours.

Table 4.9.10-11
Maximum Temperatures of EOS-TC125 Loaded with EOS-37PTH DSC with HLZC 14, 54 kW, for the Horizontal Off-Normal Hot Transfer Condition with Air Circulation

	Off-normal, Hot, Outdoor, with Air Circulation (LC 6a)		
HLZC	**HLZC 1 Design Basis (Table T.4-26/4-29, 50 kW)**	**HLZC 14 (2) (54 kW)**	**Temperature Limit (°F)**
Component Name	**Temperatures (°F)**		
Fuel Cladding	732	707	752
Basket Plates	673	666	
DSC Shell	452	461	-
Transition Rail	532	541	
Inner Shell	368	380	-
Gamma Shield	364	376	620
Structural Shell	255	260	-
Neutron Shield (1) Average	194	194	259
Neutron Shield Outer Skin	243	247	-
Solid Neutron Shield Avg	121	121	262
Closure Lid	246	249	-
Top Forging	259	263	-
Bottom Forging	147	148	-

Notes:

1. Bulk average temperature of water in the neutron shield is limited by the 20 psig pressure relief valves on the shield. The equivalent steam saturation temperature at this pressure is approximately 259 °F.
2. Temperature reported in transient case at 8 hours.

Table 4.9.10-12
Maximum Temperatures of EOS-TC125 Loaded with EOS-37PTH DSC with HLZC 14, 54 kW, for the Horizontal Off-Normal Hot Transfer Condition After Turning Off Air Circulation

	Off-normal, Hot, Outdoor, After Turning Off Air Circulation (LC 7)		
HLZC	**HLZC 1 Design Basis (2) (Table 4-27/4-29, 50 kW)**	**HLZC 14 (3) (54 kW)**	**Temperature Limit (°F)**
Component Name	**Maximum Component Temperatures (°F)**		
Fuel Cladding	737	708	752
Basket Plates	679	669	
DSC Shell	474	478	-
Transition Rail	548	553	
Inner Shell	375	388	-
Gamma Shield	371	383	620
Structural Shell	260	265	-
Neutron Shield (1) Average	201	198	259
Neutron Shield Outer Skin	248	252	-
Solid Neutron Shield Avg	148	138	262
Closure Lid	211	216	-
Top Forging	247	253	-
Bottom Forging	177	171	-

Notes:

1. Bulk average temperature of water in the neutron shield is limited by the 20 psig pressure relief valves on the shield. The equivalent steam saturation temperature at this pressure is approximately 259 °F.
2. Design basis temperatures reported in transient case at 6 hours.
3. Temperature reported in transient case at 4 hours.

All Indicated Changes are Enclosure 2, Item 1.

Table 4.9.10-13
Maximum Temperatures of EOS-TC125 Loaded with EOS-37PTH DSC with HLZC 14, 54 kW, for the Accident Loss of Neutron Shield with Loss of Air Circulation Accident Condition

	Accident, Hot, Outdoor, Loss of Liquid in Neutron Shield, No Air Circulation (LC 5)		
HLZC	**HLZC 1 Design Basis (Table 4-28/4-29, 50 kW)**	**HLZC 14 (54 kW)**	**Temperature Limit (°F)**
Component Name	**Temperatures (°F)**		
Fuel Cladding	935	941	1058
Basket Plates	902	916	
DSC Shell	674	699	-
Transition Rail	750	776	
Inner Shell	583	616	-
Gamma Shield	579	611	620
Structural Shell	478	502	-
Neutron Shield Outer Skin	296	310	-
Closure Lid	255	263	-
Top Forging	316	328	-
Bottom Forging	304	314	-

Notes:

1. For accident conditions, it is assumed that all neutron shielding materials including the bottom neutron shield are lost as discussed in Section 6.3.2. Therefore, temperatures for these components are not reported for accident conditions.

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Table 4.9.10-16
Time Limits for Transfer Operations of EOS-37PTH DSC with HLZC 14
During Transfer Conditions in EOS-TC125

Operating Conditions [(2)]	Heat Load Zoning Configuration	Heat Load (kW)	Time Limit (hours)
Normal/ Off-Normal Transfer	HLZC 14 (LC 1) Indoor, vertical	54	8
	HLZC 14 (LC 3) Outdoor, horizontal, no air flow	54	8
	HLZC 14 (LC 6a) Outdoor, horizontal, with air circulation	54	No Time Limit [(1)]
Insertion of EOS-37PTH DSC into the EOS-HSM or restart of air circulation after its inactivation	HLZC 14 (LC 7) Outdoor, horizontal, turned-off air circulation	54	4
Loss of Neutron Shield with Loss of Air Circulation, Accident Condition	HLZC 14 (LC 5)	54	No Time Limit

Notes:

1. If air circulation is initiated as a recovery option, it must be maintained for a minimum duration of 8 hours per LC 6a, before it is turned off as explained in Section 4.5.4.
2. Description of design LCs is listed in Table 4.9.10-8.

All Indicated Changes are Enclosure 2, Item 1.

Table 4.9.10-17
Average Helium Temperatures of EOS-37PTH DSC with HLZC 14 During Transfer Conditions in EOS-TC125

Operating Conditions	Average Temperature of Helium in DSC Cavity (K)		Temperature Difference (K)
	Bounding Design Basis See Table 4-45 (Short/Medium)	HLZC 14 in EOS-TC125 (Short/Medium)	
Normal	565 / 561	563 / 561	-2 / 0
Off-Normal	565 / 561	555 / 552	-10 / -9
Accident	653 / 649	674 / 671	21 / 22

Table 4.9.10-18
Maximum Internal Pressures in the EOS-37PTH DSC with HLZC 14 (54 kW) Under Normal, Off-Normal and Accident Transfer Conditions

Operating Conditions	Design Pressure (1) (psig)	Calculated Pressure (psig)
		Short / Medium DSC
Normal	20	< 10.5 / 10.3 (2)
Off-Normal	20	< 18.9 / 18.8 (2)
Accident	130	123.75 / 124.60

Notes:

1. Design pressures obtained from Table 4-45.
2. DSC internal pressure is bounded by the maximum calculated pressure from Table 4-45 and Table 4-46.

Proprietary Information on Pages 4.9.10-24 through 4.9.10-41
Withheld Pursuant to 10 CFR 2.390

5.3 References

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

5-2 NUREG-1536, "Standard Review Plan for Spent Fuel Dry Cask Storage Systems at a General License Facility," Revision 1, U.S. Nuclear Regulatory Commission, July 2010.

5-3 CoC 1042 Appendix A, NUHOMS® EOS System Generic Technical Specifications, Amendment *5*.

6.1 Discussions and Results

The following is a summary of the methodology and results of the shielding analysis of the EOS system. More detailed information is presented in the body of the chapter.

The EOS-37PTH DSC stores up to 37 PWR FAs, while the EOS-89BTH stores up to 89 BWR FAs. Each EOS-DSC is configured into heat load zones in order to optimize the system performance for both thermal and shielding considerations. *Fourteen* heat load zone configurations (HLZCs) are available for the EOS-37PTH DSC, and six HLZCs are available for the EOS-89BTH DSC. The HLZCs are defined in either the Technical Specifications (TS) [6-11] or Chapter 2. Fuel to be stored is limited by the decay heat and minimum cooling times defined in the Technical Specifications.

The EOS-37PTH DSC is authorized to store up to eight damaged FAs or four FFCs using HLZC 6, 8, 12, or 13. The EOS-37PTH DSC is also authorized to store up to six damaged FAs or two FFCs using HLZC 10 or 11. Damaged and failed fuel shall not be present in the same DSC. *The EOS-37PTH DSC using HLZC 14 is authorized to store only intact FAs.*

Source Terms

The ORIGEN-ARP module of the Oak Ridge National Laboratory (ORNL) SCALE6.0 code package [6-1] is used to develop reasonably bounding gamma and neutron source terms. [

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Control components (CCs) are allowed to be stored within a PWR FA. Examples of CCs include burnable poison rod assemblies (BPRAs) and thimble plug assemblies. Control components typically have a Co-60 source because of its light element activation, which contributes substantially to the dose rates. The CC source term used in the analysis is provided in Table 6-37. Co-60 equivalent activity limits per zone are provided in TS Table 3 [6-11].

BWR fuel does not include CCs other than the fuel channel, which is conservatively included in the source term. The BWR fuel channel is fabricated from zirconium alloy and does not require a Co-60 limit because the contribution to the source term from the fuel channel is negligible.

Sources are developed for a variety of different enrichments. For a particular U-235 enrichment, the uranium fuel loading is distributed according to the following relationship from the SCALE 6.0 manual:

- wt. % U-234 = 0.0089 * wt. % U-235
- wt. % U-236 = 0.0046 * wt. % U-235
- wt. % U-238 = 100 – wt. % U-234 – wt. % U-235 – wt. % U-236

6.2.2.1 Bounding HLZCs

The EOS-DSC baskets are zoned by heat load. Heat load zoning allows hotter FAs, which generally have larger neutron and gamma source terms, to be placed in the inner zones and be shielded by FAs in the outer zone. The EOS-TC108 and EOS-TC125/135 have different heat load zone configurations because the EOS-TC125/135 is more heavily shielded than the EOS-TC108 and can therefore be loaded with stronger sources.

Fourteen HLZCs are available for the EOS-37PTH DSC and six HLZCs are available for the EOS-89BTH DSC. The EOS-37PTH DSC and EOS-89BTH DSC also have maximum heat load configurations (MHLC) that bound the HLZCs. The MHLCs are provided in the TS [6-11], although the individual HLZCs may be provided in either the TS or Chapter 2. When source terms are developed based on an MHLC rather than individual HLZCs, all HLZCs bounded by the MHLC are also bounded by the shielding analysis. Systems for which the MHLC concept has been employed in source term development are summarized in Table 6-1.

All PWR HLZCs may be transferred in the EOS-TC125/135, while the EOS-TC108 is limited to HLZCs 2 through 9. All BWR HLZCs may be transferred in the EOS-TC125/135, while the EOS-TC108 is limited to BWR HLZC 2 and 3. The EOS-HSM may store PWR HLZCs 1 through 6, 10, 11, 12, 13*, 14* and all BWR HLZCs.

The bounding HLZCs are used for dose rate analysis. For each zone within a DSC, higher heat loads result in stronger source terms and larger dose rates if the minimum cooling time is the same.

EOS-89BTH DSC

The bounding HLZCs used in the EOS-89BTH DSC analyses are:

- EOS-89BTH DSC transferred in the EOS-TC125 and stored in the EOS-HSM: “Shielding HLZC” that bounds HLZC 1 through 6, as described below.
- EOS-89BTH DSC transferred in the EOS-TC108: HLZC 2

Rather than justify which HLZC is bounding, an EOS-89BTH DSC "shielding HLZC" is developed to bound HLZC 1 through 6 when transferred in the EOS-TC125 and stored in the EOS-HSM. Each basket location in the shielding HLZC bounds the corresponding heat load at that location allowed in HLZC 1 through 6. The shielding HLZC is provided in Figure 6-18 and is identical to the MHLC, Figure 11 of the TS [6-11]. The shielding HLZC is highly conservative for dose rate analysis, as the shielding HLZC features 42.8 kW on the periphery and 82.8 kW within the entire DSC. The peripheral fuel assemblies are defined in TS Figure 8 [6-11]. The minimum cooling time associated with the shielding HLZC is 1.0 year.

Only the EOS-89BTH DSC HLZC 2 and 3 may be transferred in the EOS-TC108. The minimum cooling time of 3 years is applicable to zones 1 and 2. HLZC 2 has larger heat loads in each zone compared to HLZC 3. When HLZC 2 or 3 is used with the EOS-TC108, the minimum cooling time in zone 3 is 9.7 years and 9.0 years, respectively. While the EOS-89BTH DSC HLZC 2 zone 3 has a slightly longer minimum cooling time than HLZC 3 zone 3, the minimum cooling time difference (0.7 years) is small compared to the large difference in decay heat (0.1 kW/FA). Therefore, EOS-89BTH DSC HLZC 2 is bounding for EOS-TC108 analysis.

EOS-37PTH DSC

The HLZCs used in the EOS-37PTH DSC analyses are:

- EOS-37PTH DSC transferred in the EOS-TC125/135 and stored in the EOS-HSM: HLZCs 4 and 10
- EOS-37PTH DSC transferred in the EOS-TC125/135 and stored in the EOS-HSM: "Shielding HLZC" that bounds the MHLC, as described below.
- EOS-37PTH DSC transferred in the EOS-TC108: HLZCs 4 and 5

Rather than justify which HLZC is bounding, an EOS-37PTH DSC "shielding HLZC" is developed when transferred in the EOS-TC125/135 and stored in the EOS-HSM. The shielding HLZC is provided in Figure 6-19 and bounds the MHLC, Figure 12 of the TS [6-11]. Therefore, the shielding HLZC also bounds HLZC 1 through *14*.

In the shielding HLZC, the hottest fuel is distributed evenly around the periphery to ensure EOS-HSM inlet and outlet vent dose rates are maximized. The heat load of the bounding fuel assembly is also increased to 5.0 kW/FA rather than the MHLC maximum of 4.3 kW/FA. The shielding HLZC is highly conservative for dose rate analysis, as the shielding HLZC features 63.6 kW on the periphery and 98.3 kW within the entire DSC. The peripheral fuel assembly locations are defined in TS Figure 3 [6-11]. The minimum cooling time associated with the shielding HLZC is 1.0 year.

8.2.8 Protective Coatings and Surface Treatments

No coatings are applied to the DSC surface. The top shield plug of the DSCs is coated with an electroless nickel, [

] The HSLA steel plates of other 37PTH basket types have a coating or surface treatment to provide corrosion resistance for short-term pool immersion.

Anodizing is required for aluminum plates for baskets utilizing HLZCs with maximum decay heat greater than 3.5 kW per fuel assembly *or total decay heat loads greater than 50 kW per DSC*. Anodizing requirements for the aluminum basket plates are specified in Section [10.1.6].

The exposed carbon steel surfaces of the EOS-TCs are coated with a painting system suitable for spent fuel pool immersion, and withstanding long-term exposure to the elevated temperatures of the TC. Stainless steel surfaces, that is, trunnions, sliding rails, and the stainless steel overlay for the ram access port sealing surfaces are not coated. The removable aluminum neutron shield shell for the EOS-TC108 is painted only on the outer diameter. The following finish enamels are used on the transfer cask:

- PPG Amerishield™ enamel or Carboline Carboguard® 890, color white, is used for the EOS-TC exterior surfaces.
- PPG Amerishield™, color white, is used for coating the exterior of the removable EOS-TC108 neutron shield. This neutron shield is not immersed.
- Carboline Thermaline® 450-EP PPG or Amercoat® 91 is used for coating the EOS-TC interior surfaces, which are exposed to higher service temperatures up to 373 °F (Tables 4-26 and 4-27).

Manufacturer's recommendations are followed for surface preparation, primer coat selection, and coating application.

Alternate coatings that are accepted by licensees for spent fuel pool immersion, and whose short-term service temperature is above the normal condition TC surface temperatures may be used. For solar absorptivity, white color must be maintained where specified.

The DSC support structure in the EOS-HSM, or front and rear DSC supports on the HSM-MX, are coated with an inorganic zinc-rich primer and a high build epoxy enamel finish, for example, Carboline Carbozinc® 11 primer with Carboguard® 890 enamel. Similarly, EOS-HSM-SC exterior faceplates are coated with either an inorganic or organic zinc-rich primer and epoxy finish coating. Embedments and fasteners are coated, plated, or galvanized.

Note: If applicable to the planned DSC heat load zone configuration per Figure 2-2a, 2b, and 2d through 2f or Figure 2-3a, 3b, and 3d through *3n* of Chapter 2, the air circulation system shall be assembled and verified operational within 7 days prior to initiating transfer operations per Technical Specification LCO 3.1.3 [9-5].

Note: The operating procedures for the NUHOMS 61BTH Type 2 DSC and the OS197 TC are provided in Chapter B.9.

9. Open the TC drain port valve and drain the water from the TC/DSC annulus.

CAUTION: For the EOS-TC108, verify the neutron shield is filled with water and continuously monitor water in the neutron shield during the first five minutes of TC/DSC annulus draining as specified in Section 5.1.2.e of the Technical Specifications [9-5].

Note: The time limit for Transfer Operations, if any, starts from initiation of this step. This step may be performed at any time from this point until lifting the TC to the transfer trailer.

CAUTION: Monitor the applicable time limits of Section 3.1.3 of the Technical Specifications [9-5] until the completion of DSC transfer Step 16 of Section 9.1.6, or Step 17 of Section A.9.1.6.
Section 3.1.3 of the Technical Specifications [9-5] allows a new time limit for transfer operations to be determined if the maximum heat load is less than *54* kW. Based on this provision, Table 9-1 provides the new time limits that can be used in lieu of the time limits in LCO 3.1.3.

10. Rig the TC top cover plate and lower the cover plate onto the TC.

Note: To meet weight limits the aluminum TC top cover plate may be used during the lift to the trailer.

11. Bolt the TC cover plate into place, tightening the bolts in a star pattern. 72.48

12. Check the exterior of the TC to verify that it meets the limits specified in Section 3.3.1 of the Technical Specifications [9-5] for surface contamination.

13. Check the surface temperature of the TC to verify the temperature limits and any resulting lifting or handling restrictions specified in Section 5.2.1 of the Technical Specifications [9-5].

9.1.5 TC Downending and Transfer to ISFSI

The following weather-related administrative controls are based on NEI 22-02 Revision 2, "Guidelines for Weather-Related Administrative Controls for Short Duration Outdoor Dry Cask Storage Operations," and NRC Regulatory Guide 3.77 Revision 0, "Weather-Related Administrative Controls at Independent Spent Fuel Storage Installations." 72.48

Note: Although the administrative controls covered here are in this section on transfer cask downending and transfer, as discussed herein they apply to any short-term operations where weather conditions must be considered.

All Indicated Changes are Enclosure 2, Item 1.

13. Verify operation of the ram and grapple.

14. Position the ram behind the TC in approximate horizontal alignment with the TC and level the ram. Remove the bottom ram access cover plate. Extend the ram through the bottom TC opening into the DSC grapple ring. 72.48

15. Recheck all alignment marks and ready all systems for DSC transfer.

16. Activate the ram to initiate insertion of the DSC into the EOS-HSM. Stop the ram when the DSC reaches the support rail stops at the back of the module.

    Note: The time limit for transfer operations, if any, starts with the initiation of the TC/DSC annulus water draining described in Step 9 of Section 9.1.4 and ends when the DSC is fully inserted into the EOS-HSM.

CAUTION: Verify that the applicable time limits for transfer operations of Section 3.1.3 of the Technical Specifications [9-5] are met.
Section 3.1.3 of the Technical Specifications [9-5] allows a new time limit for transfer operations to be determined if the maximum heat load is less than *54* kW. Based on this provision, Table 9-1 provides the new time limits that can be used in lieu of the time limits in LCO 3.1.3.

17. NOT USED.

18. Retract and disengage the ram system from the TC and move it clear of the TC. Remove the TC restraints from the EOS-HSM.

19. Using the skid positioning system, disengage the TC from the EOS-HSM access opening.

20. Install the DSC axial retainer through the EOS-HSM door opening. For the EOS-HSM-HS, either one or two axial retainers are required depending on the hardware option selected; tension the set screws to the specified torque value.

21. Raise the transfer trailer jacks, disconnect the skid positioning system, and move the trailer away from the EOS-HSM sufficiently to install the HSM door.

22. Install the EOS-HSM door and secure it in place. Door may be welded for security. Verify that the EOS-HSM dose rates are compliant with the limits specified in Section 5.1.2 of the Technical Specifications [9-5].

23. Install the TC top cover plate and secure the skid to the trailer. Move the trailer and TC to the designated equipment storage area. Return the remaining transfer equipment to the storage area.

24. Close and lock the ISFSI access gate and activate the ISFSI security measures.

All Indicated Changes are Enclosure 2, Item 1.

9.3 References

9-1 U.S. Nuclear Regulatory Commission, Office of the Nuclear Material Safety and Safeguards, "Safety Evaluation of VECTRA Technologies' Response to Nuclear Regulatory Commission Bulletin 96-04 For the NUHOMS®-24P and NUHOMS®-7P.

9-2 U.S. Nuclear Regulatory Commission Bulletin 96-04, "Chemical, Galvanic or Other Reactions in Spent Fuel Storage and Transportation Casks," July 5, 1996.

9-3 SNT-TC-1A, "American Society for Nondestructive Testing, Personnel Qualification and Certification in Nondestructive Testing," 2006.

9-4 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 Container," February 1989.

9-5 CoC 1042 Appendix A, NUHOMS® EOS System Generic Technical Specifications, Amendment *5*.

9-6 U.S. Nuclear Regulatory Commission, Interim Staff Guidance (ISG-22), "Potential Rod Splitting due to Exposures to an Oxidizing Atmosphere during Short-term Cask Loading Operations in LWR of Other Uranium Oxide Based Fuel."

All Indicated Changes are Enclosure 2, Item 1.

Potential change effect	Example
Reduction of the yield or ultimate strength or the elongation	Increase in nominal boron carbide content over that previously qualified
Adverse effect on the uniformity of boron carbide distribution at the microscopic scale	Increase in the boron carbide particle size
Adverse effect on the uniformity of boron carbide distribution at the macroscopic level	Change in the blending process
Reduced density of the final product	Change in the method of billet production or thermo-mechanical processing to plate
Adverse reaction between the boron carbide and the matrix alloy under normal and off-normal service temperatures	Change in the matrix alloy
Lower corrosion resistance or higher rate of hydrogen generation	Change in the matrix alloy

Identification and Control of Key Process Changes

The manufacturer provides the Certificate Holder with a description of materials and process controls used in producing the MMC. The Certificate Holder and manufacturer prepare a written list of key process changes that cannot be made without prior approval of the Certificate Holder.

10.1.6 Thermal Acceptance

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10.1.7 High-Strength Low-Alloy Steel for Basket Structure

The basket structural material shall be a High-Strength Low-Alloy (HSLA) steel meeting one of the following requirements A, B, or C:

A. ASTM A829 Gr 4130 or AMS 6345 SAE 4130, quenched and tempered at not less than 1050 °F, 103.6 ksi minimum yield strength, and 123.1 ksi minimum ultimate strength. This material is qualified as described in [10-31].

B. ASME Code edition 2010 with 2011 addenda, SA-517 Gr A, B, E, F, or P. This material is qualified by the material properties at elevated temperature in ASME Section II, Part D, which exceed the values of yield and ultimate strength in UFSAR Table 8-10.

All Indicated Changes are Enclosure 2, Item 1.

C. Other HSLA steel, with the specified heat treatment, meeting these qualification and acceptance criteria:

   i. If quenched and tempered, the tempering temperature shall be at no less than 1000 °F,

   ii. Qualified prior to first use by testing at least two lots and demonstrating that the fracture toughness value $K_{JIc} \geq 150$ ksi $\sqrt{in}$ at -40 °F with 95% confidence based on the methodology in Reference [10-31] for HSLA steel.

   iii. Qualified prior to first use by testing at least two lots and demonstrating that the 95% lower tolerance limit of yield and ultimate strengths ≥ the values in UFSAR Table 8-10 based on the methodology in Reference [10-31] for HSLA steel.

   iv. Meet production acceptance criteria based on the 95% lower tolerance limit of yield strength and ultimate strength at room temperature as determined by qualification testing described in Section 10.1.7.iii.

The basket HSLA material shall also meet the following production acceptance criteria:

- Weld repair shall not be permitted.
- Impact testing shall be performed at -40 °F
  - Charpy testing per ASTM A370, minimum absorbed energy 25 ft-lb average, 20 ft-lb lowest of three (modify these acceptance criteria for sub-size specimens per A370-17 Table 9), or
  - Dynamic tear testing per ASTM E604 with acceptance criterion of a minimum 80% shear fracture appearance.
- Test specimen location, orientation, and sampling rate per ASTM A6 or ASTM A20 for production acceptance testing.
- *Scratches and other surface imperfections up to 1/16-inch depth are acceptable. These scratches and imperfections must be at least three times the plate thickness away from other scratches and imperfections.*

All Indicated Changes are Enclosure 2, Item 3.

10-17 ASTM E1461, "Standard Test Method for Thermal Diffusivity by the Flash Method," ASTM International, West Conshohocken, PA, 2014.

10-18 USNRC SFST-ISG-23, Application of ASTM Standard Practice C1671-07 when performing technical reviews of spent fuel storage and transportation packaging licensing actions

10-19 ASTM B557, "Standard Test Methods for Tension Testing Wrought and Cast Aluminum- and Magnesium-Alloy Products," ASTM International, West Conshohocken, PA, 2014.

10-20 ASTM E290-14, "Standard Test Methods for Bend Testing of Material for Ductility," ASTM International, West Conshohocken, PA, 2014.

10-21 NUREG-0933, "Resolution of Generic Safety Issues: Issue 196: Boral Degradation, (Main Report with Supplements 1–34), U.S. Nuclear Regulatory Commission, December 2011.

10-22 ASTM A829, "Standard Specification for Alloy Structural Steel Plates," ASTM International, West Conshohocken, PA, 2014.

10-23 [ ]

10-24 ASTM A370, "Standard Test Methods and Definitions for Mechanical Testing of Steel Products," ASTM International, West Conshohocken, PA, 2014.

10-25 ASTM E604, "Standard Test Method for Dynamic Tear Testing of Metallic Materials," ASTM International, West Conshohocken, PA, 2014.

10-26 Not used.

10-27 ACI 201.1R, "Guide for Conducting a Visual Inspection of Concrete in Service," American Concrete Institute, 2008.

10-28 U.S. Nuclear Regulatory Commission, Regulatory Guide 7.11, "Fracture Toughness Criteria of Base Metal for Ferritic Steel Shipping Cask Containment Vessels with a Maximum Wall Thickness of 4 Inches (0.1 m)," June 1991.

10-29 ASTM B311, "Standard Test Method for Density of Powder Metallurgy (PM) Materials Containing Less Than Two Percent Porosity," ASTM International, West Conshohocken, PA, 2014.

10-30 ASTM B963, "Standard Test Methods for Oil Content, Oil-Impregnation Efficiency, and Surface-Connected Porosity of Sintered Powder Metallurgy (PM) Products Using Archimedes' Principle," ASTM International, West Conshohocken, PA, 2014.

10-31 [

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10-32 CoC 1042 Appendix A, "NUHOMS® EOS System Generic Technical Specifications," Amendment 5.

10-33 American National Standard, Specification for Safety-Related Steel Structures for Nuclear Facilities, ANSI/AISC-N690-18, June 28, 2018.

All Indicated Changes are Enclosure 2, Item 1.

12.3.2 Earthquake

Cause of Accident

For the EOS-HSM except for the EOS-HSM-HS, the explicitly evaluated seismic response spectra for the NUHOMS® EOS System consist of the U.S. Nuclear Regulatory Commission (NRC) Regulatory Guide 1.60 (Reg. Guide 1.60) [12-6] response spectra, anchored to a maximum ground acceleration of 0.45g horizontal and 0.30g for the vertical peak accelerations. The results of the frequency analysis of the EOS-HSM structure (which includes a simplified model of the DSC) *are reported in Table 3.9.4-3 for the lowest frequencies in each of the transverse, longitudinal, and vertical directions.* Thus, based on the Reg. Guide 1.60 response spectra amplifications, and conservatively using ZPA values of 0.50g horizontal and 0.333g vertical, the corresponding seismic accelerations used for the structural design of the EOS-HSM are *determined for each direction (transverse, longitudinal, and vertical) and are reported in Table 3.9.4-3. This table also includes the corresponding accelerations applicable to the DSC.* Stability analyses are based on accelerations of 0.45g horizontal and 0.30g vertical.

For the EOS-HSM-FPS, the lowest frequencies are *shown in Table 3.9.4-3a for* the transverse, longitudinal, and vertical direction*s*. The corresponding seismic accelerations, based on the Reg. Guide 1.60 response spectra with ZPAs of 0.50g horizontal and 0.333g vertical, for the structural design of the EOS-HSM-FPS*, along with the corresponding accelerations applicable to the DSC, are also shown in Table 3.9.4-3a for each direction.*

For the EOS-HSM-SC, the lowest frequencies are *reported in Table 3.9.8-2 for* the transverse, longitudinal, and vertical direction*s*. The corresponding seismic accelerations, based on the Reg. Guide 1.60 response spectra with ZPAs of 0.50g horizontal and 0.33g vertical, for the structural design of the EOS-HSM-SC*, along with the corresponding accelerations applicable to the DSC, are also shown in Table 3.9.8-2 for each direction.*

The lowest frequencies for the EOS-HSM-HS are the same as those for the EOS-HSM-FPS, but the seismic design criteria are based on the Reg. Guide 1.60 response spectra with ZPAs of 0.91g in the horizontal and 0.80g in the vertical directions. The corresponding amplified seismic accelerations for the structural design of the EOS-HSM-HS *and the associated DSC for the transverse, longitudinal, and vertical directions are shown in Table 3.9.4-3b.*

All Indicated Changes are Enclosure 2, Item 1.

B.3.1 DSC FUEL INTEGRITY

B.3.1.3 Time Limit for Completion of DSC Transfer

BASES

BACKGROUND	After a DSC has been loaded with fuel assemblies, vacuum dried and sealed, it is ready for transfer to the ISFSI. The design of a loaded TC/DSC system provides sufficient passive heat rejection capacity to ensure that the integrity of the fuel cladding is maintained provided the specified time limits for completion of the transfer are met.
APPLICABLE SAFETY ANALYSIS	Long-term integrity of the fuel cladding depends on storage in an inert atmosphere and maintaining fuel cladding temperature below an acceptable limit. The TC/DSC transient thermal analysis provided in Chapters 4 and B.4 of the UFSAR evaluates the fuel cladding temperatures under normal, off-normal, and accident conditions during the transfer of a loaded TC/DSC. The time limits for transfer operations for EOS-DSCs are based on the EOS-37PTH DSC in the TC125 with the maximum allowable heat load of *54* kW. The use of these time limits during the transfer operation is bounding for all DSC/EOS-TC configurations. Longer time limits can be calculated based on the as loaded heat load of the DSC.
LCO	The time to complete the transfer of a loaded TC/DSC is monitored to ensure that the fuel cladding does not exceed the NUREG-1536, Revision 1, limit of 752 °F during transfer.
APPLICABILITY	This specification is applicable to a loaded NUHOMS® EOS-37PTH or EOS-89BTH DSC when transferred in an EOS-TC or a 61BTH Type 2 DSC transferred in an OS197TC. Those DSCs with lower heat loads as identified in LCO 3.1.3 have no time limit for completion of DSC transfer. The thermal analysis performed at those lower heat load as documented in UFSAR Chapter 4 or B.4 demonstrate that the steady state cladding temperatures during TRANSFER OPERATIONS are below the cladding temperature limit. Those DSCs with higher heat loads identified in LCO 3.1.3 have associated time limits for the DSC transfer based on the associated thermal analyses.

Listing of Computer Files Contained in Enclosure 8

Disk ID No. (size)	Discipline	System/Component	File Series (topics)	Number of Files
Enclosure 8 One Computer Hard Drive Thermal (39.9 GB)	**Thermal**	**EOS-37PTH DSC in EOS-HSM**	**Section 4.9.10.2.4 (LC 1 in Table 4.9.10-1) Folder: \Thermal\EOS-37PTH-EOS-HSM\LC1-Normal** Case and data files for the bounding normal storage condition of EOS-37PTH DSC Basket Type 4HA in EOS-HSM with Intact FAs (ANSYS FLUENT Evaluation)	13
			Section 4.9.10.2.4 (LC 2 in Table 4.9.10-1) Folder: \Thermal\EOS-37PTH-EOS-HSM\LC2-Off-normal Case and data files for the bounding off-normal storage condition of EOS-37PTH DSC Basket Type 4HA in EOS-HSM with Intact FAs (ANSYS FLUENT Evaluation)	16
			Section 4.9.10.2.4 (LC 3 in Table 4.9.10-1) Folder: \Thermal\EOS-37PTH-EOS-HSM\LC3-Accident Case and data files for the bounding accident storage condition of EOS-37PTH DSC Basket Type 4HA in EOS-HSM with Intact FAs (ANSYS FLUENT Evaluation)	17
		EOS-37PTH DSC in EOS-TC125	**Section 4.9.10.3.3 (LC 1 in Table 4.9.10-8) Folder: \Thermal\EOS-37PTH-EOS-TC125\LC1-Normal** Case and data files for the bounding normal transfer condition of EOS-37PTH DSC Basket Type 4HA in EOS-TC125 with Intact FAs (ANSYS FLUENT Evaluation)	19

Listing of Computer Files Contained in Enclosure 8

Disk ID No. (size)	Discipline	System/Component	File Series (topics)	Number of Files
	Thermal (cont.)	**EOS-37PTH DSC in EOS-TC125 (cont.)**	**Section 4.9.10.3.3 (LC 3 in Table 4.9.10-8) Folder: \Thermal\EOS-37PTH-EOS-TC125\LC3-Off-normal** Case and data files for the bounding off-normal transfer condition without air flow for EOS-37PTH DSC Basket Type 4HA in EOS-TC125 with Intact FAs (ANSYS FLUENT Evaluation)	20
			Section 4.9.10.3.3 (LC 6a in Table 4.9.10-8) Folder: \Thermal\EOS-37PTH-EOS-TC125\LC6a-Off-normal-with-air Case and data files for the bounding off-normal transfer condition with air circulation for EOS-37PTH DSC Basket Type 4HA in EOS-TC125 with Intact FAs (ANSYS FLUENT Evaluation)	13
			Section 4.9.10.3.3 (LC 7 in Table 4.9.10-8) Folder: \Thermal\EOS-37PTH-EOS-TC125\LC7-Off-normal-air-turned-off Case and data files for the bounding off-normal transfer condition with turned-off air circulation for EOS-37PTH DSC Basket Type 4HA in EOS-TC125 with Intact FAs (ANSYS FLUENT Evaluation)	15
			Section 4.9.10.3.5 (LC 5 in Table 4.9.10-8) Folder: \Thermal\EOS-37PTH-EOS-TC125\LC5-Accident Case and data files for the bounding accident transfer condition of EOS-37PTH DSC Basket Type 4HA in EOS-TC125 with Intact FAs (ANSYS FLUENT Evaluation)	18