APPENDIX B.1
INTRODUCTION AND GENERAL DESCRIPTION OF INSTALLATION
Standardized Advanced NUHOMS® System

Table of Contents

B.1. INTRODUCTION AND GENERAL DESCRIPTION OF INSTALLATION B.1-1

B.1. INTRODUCTION AND GENERAL DESCRIPTION OF INSTALLATION

No change or additional information required for the Advanced NUHOMS® System containing the NUHOMS® 24PT1-DSCs for Chapter 1.

APPENDIX B.2
SITE CHARACTERISTICS
Standardized Advanced NUHOMS® System

Table of Contents

B.2. SITE CHARACTERISTICS...B.2-1

B.2. SITE CHARACTERISTICS

No change or additional information required for the Advanced NUHOMS® System containing the NUHOMS® 24PT1-DSCs for Chapter 2.

APPENDIX B.3
PRINCIPAL DESIGN CRITERIA
Standardized Advanced NUHOMS® System

Table of Contents

B.3. PRINCIPAL DESIGN CRITERIA B.3-1

B.3.1 SSCs Important to Safety B.3-2

B.3.1.1 24PT1 DSC B.3-2

B.3.1.2 Horizontal Storage Module B.3-2

B.3.1.3 NUHOMS® Basemat and Approach Slab B.3-2

B.3.1.4 NUHOMS® Transfer Equipment B.3-3

B.3.2 Spent Fuel to Be Stored B.3-4

B.3.3 Design Criteria for Environmental Conditions and Natural Phenomena B.3-5

B.3.3.1 Tornado Wind and Tornado Missiles B.3-5

B.3.3.2 Water Level (Flood) Design B.3-5

B.3.3.3 Seismic Design B.3-5

B.3.3.4 Snow and Ice Loading B.3-6

B.3.3.5 Lightning B.3-6

B.3.4 Safety Protection Systems B.3-7

B.3.4.1 General B.3-7

B.3.4.2 Structural B.3-7

B.3.4.3 Thermal B.3-8

B.3.4.4 Shielding/Confinement/Radiation Protection B.3-8

B.3.4.5 Criticality B.3-8

B.3.4.6 Material Selection B.3-9

B.3.4.7 Operating Procedures B.3-9

B.3.5 References B.3-10

List of Tables

Table B.3-1 Summary of WCS CISF Principal Design Criteria..B.3-11

Table B.3-2 Standardized Advanced NUHOMS® Horizontal Modular Storage System Major Components and Safety Classifications..B.3-16

B.3. PRINCIPAL DESIGN CRITERIA

The Standardized Advanced NUHOMS® System principal design criteria is documented in Chapter 2 of the "Advanced NUHOMS® Horizontal Modular Storage System Safety Analysis Report" [B.3-1]. Table B.3-1 provides a comparison of the Standardized Advanced NUHOMS® System principal design criteria and the WCS Consolidated Interim Storage Facility (WCS CISF) design criteria provided in Table 1-2 which demonstrates that the Standardized Advanced NUHOMS® System bounds the WCS CISF criteria.

B.3.1 SSCs Important to Safety

The classifications of the Standardized Advanced NUHOMS® System systems, structures and components, are discussed in Section 2.5 of the of the "Advanced NUHOMS® Horizontal Modular Storage System Safety Analysis Report" [B.3-1] for the canister and AHSM and Section 3.4 of the "Rancho Seco Independent Spent Fuel Storage Installation Safety Analysis Report" [B.3-2] for the MP187 cask in the transfer configuration. These classifications are summarized in Table B.3-2 for convenience.

B.3.1.1 24PT1 DSC

The 24PT1-DSC provides fuel assembly support required to maintain the fuel geometry for criticality control. Accidental criticality inside a 24PT1-DSC could lead to off-site doses comparable with the limits in 10 CFR Part 100, which must be prevented. The 24PT1-DSC also provides the confinement boundary for radioactive materials. The DSCs are designed to maintain structural integrity under all accident conditions identified in Chapter 12 without losing their function to provide confinement of the spent fuel assemblies. The DSCs are important-to-safety (ITS).

B.3.1.2 Horizontal Storage Module

For the Standardized Advanced NUHOMS® System, the horizontal storage modules (HSM) used is the advance horizontal storage module, herein referred to as AHSM. The AHSM is considered ITS since it provides physical protection and shielding for the spent fuel container (24PT1-DSC) during storage. The reinforced concrete AHSM is designed in accordance with ACI 349-97 [B.3-5] and built to ACI-318 [B.3-6]. The level of testing, inspection, and documentation provided during construction and maintenance is in accordance with the quality assurance requirements as defined in 10 CFR 72, Subpart G. Thermal instrumentation for monitoring AHSM concrete temperatures is considered "not-important-to-safety" (NITS).

B.3.1.3 NUHOMS® Basemat and Approach Slab

The basemat and approach slabs for the AHSMs are considered NITS and are designed, constructed, maintained, and tested to ACI-318 [B.3-5] as commercial-grade items.

B.3.1.4 NUHOMS® Transfer Equipment

The MP187 transportation cask is qualified for transfer operations for the Standardized Advanced NUHOMS® System in this application and herein is referred to as a transfer cask. The MP187 cask is ITS since it protects the DSC during handling and is part of the primary load path used while handling the DSCs in the Transfer Facility. An accidental drop of a loaded transfer cask has the potential for creating conditions adverse to the public health and safety. These possible drop conditions are evaluated with respect to the impact on the DSC in Chapter 12. Therefore, the MP187 is designed, constructed, and tested in accordance with a QA program incorporating a graded quality approach for ITS requirements as defined by 10 CFR Part 72, Subpart G, paragraph 72.140(b).

The remaining transfer equipment (i.e., ram, skid, transfer vehicle) is necessary for the successful loading of the DSCs into the AHSMs. However, these items are not required to provide reasonable assurance that the canister can be received, handled, packaged, stored, and retrieved without undue risk to the health and safety of the public. Therefore, these components are considered NITS and need not comply with the requirements of 10 CFR Part 72. These components are designed, constructed, and tested in accordance with good industry practices.

B.3.2 Spent Fuel to Be Stored

The authorized contents for the 24PT1-DSCs are described in Certificate of Compliance 72-1029 [B.3-7] and the "Advanced NUHOMS® Horizontal Modular Storage System Safety Analysis Report" [B.3-1].

Certificate of Compliance 72-1029 Technical Specifications Section 2.1 [B.3-7] provides a description of the fuels stored in the 24PT1 DSCs as referenced in Section 2.1 "Spent Fuel to be Stored" of the "Advanced NUHOMS® Horizontal Modular Storage System Safety Analysis Report" [B.3-1].

B.3.3 Design Criteria for Environmental Conditions and Natural Phenomena

B.3.3.1 Tornado Wind and Tornado Missiles

The design basis tornado wind and tornado missiles for the Standardized Advanced NUHOMS® Horizontal Modular Storage System AHSM are provided in Section 2.2.1 of reference [B.3-1] and for the NUHOMS®-MP187 cask in Section 3.2.1 of Volume 1 of reference [B.3-2]. The Standardized Advanced NUHOMS® Horizontal Modular Storage System components are designed and conservatively evaluated for the most severe tornado and missiles anywhere within the United States (Region I as defined in NRC Regulatory Guide 1.76 [B.3-9]) while the WCS CISF is in Region II, a less severe location with respect to tornado and tornado missiles.

The AHSM protects the DSC from adverse environmental effects and is the principal structure exposed to tornado wind and missile loads. Furthermore, all components of the AHSM (regardless of their safety classification) are designed to withstand tornadoes and tornado-based missiles. The MP187 cask protects the DSC during transit to the Storage Pad from adverse environmental effects such as tornado winds and missiles.

B.3.3.2 Water Level (Flood) Design

The 24PT1 DSCs and AHSMs are designed for an enveloping design basis flood, postulated to result from natural phenomena as specified by 10 CFR 72.122(b). The system is evaluated for a flood height of 50 feet with a water velocity of 15 fps.

The DSCs are subjected to an external hydrostatic pressure equivalent to the 50 feet head of water. The AHSM is evaluated for the effects of a water current of 15 fps impinging on the sides of a submerged AHSM. For the flood case that submerges the AHSM, the inside of the AHSM will rapidly fill with water through the AHSM vents.

As documented in Sections 2.4.2.2 and 3.2.2, the WCS CISF is not in a floodplain and is above the Probable Maximum Flood elevation and, therefore, will remain dry in the event of a flood.

B.3.3.3 Seismic Design

The seismic criteria for the Standardized Advanced NUHOMS® Horizontal Modular Storage System AHSM are provided in Section 2.2.3 of reference [B.3-1]. This system was designed for very high seismic regions, such as the west coast, and as such the design basis earthquake shown in Figures 2.2-1 and 2.2-2 of reference [B.3-1] for the AHSM easily envelops the enveloping acceleration response spectra at the concrete pad base and HSM center of gravity obtained by the WCS CISF soil-structure interaction (SSI) analysis at all frequencies as demonstrated in Sections B.7.5 and B.7.8. *As Section 11.2.1 of reference [B.3-1] indicates, tipping/rocking and module-to-module separation is negligible when the AHSM row assembly consists of a minimum of three modules side-by-side with shield walls; configurations with additional modules back-to-back with this row remain bounded by this analysis.*

B.3.3.4 Snow and Ice Loading

The design basis snow and ice loading for the Standardized Advanced NUHOMS® Horizontal Modular Storage System are provided in Section 2.2.4 of reference [B.3-1]. Snow and ice loads for the AHSM are conservatively derived from ASCE 7 [B.3-10]. The maximum 100-year roof snow load, specified for most areas of the continental United States for an unheated structure, of 110 psf is assumed. Snow and ice loads for the on-site transfer cask with a loaded DSC are negligible due to the smooth curved surface of the cask, the heat rejection of the SFAs, and the infrequent short term use of the cask.

The snow and ice loads used in the evaluation of the Standardized Advanced NUHOMS® Horizontal Modular Storage System components envelope the maximum WCS CISF snow and ice loads of 10 psf.

B.3.3.5 Lightning

The likelihood of lightning striking the AHSM and causing an off-normal or accident condition is not considered a credible event. Simple lightning protection equipment and grounding for the AHSM structures is considered a miscellaneous attachment acceptable per the AHSM design.

B.3.4 Safety Protection Systems

The safety protection systems of the Standardized Advanced NUHOMS® Horizontal Modular Storage System are discussed in Section 2.3 of the "Advanced NUHOMS® Horizontal Modular Storage System Safety Analysis Report" [B.3-1].

B.3.4.1 General

The Standardized Advanced NUHOMS® Horizontal Modular Storage System is designed for safe confinement during dry storage of SFAs. The components, structures, and equipment that are designed to assure that this safety objective is met are summarized in Table B.3-2. The key elements of the Standardized Advanced NUHOMS® Horizontal Modular Storage System and its operation at the WCS CISF that require special design consideration are:

1. Minimizing the contamination of the DSC exterior.
2. The double closure seal welds on the DSC shell to form a pressure retaining confinement boundary and to maintain a helium atmosphere.
3. Minimizing personnel radiation exposure during DSC transfer operations.
4. Design of the cask and DSC for postulated accidents.
5. Design of the AHSM passive ventilation system for effective decay heat removal to ensure the integrity of the fuel cladding.
6. Design of the DSC basket assembly to ensure subcriticality.

B.3.4.2 Structural

The principal design criteria for the 24PT1 DSCs are presented in Section 2.3.2 of the "Advanced NUHOMS® Horizontal Modular Storage System Safety Analysis Report" [B.3-1]. The DSCs are designed to store intact, damaged and failed PWR FAs with or without Control Components. The fuel cladding integrity is assured by limiting fuel cladding temperature and maintaining a nonoxidizing environment in the DSC cavity.

The principal design criteria for the MP187 cask when used as a transfer cask are presented in Section 3.2.5.3 of the "Rancho Seco Independent Spent Fuel Storage Installation Safety Analysis Report" [B.3-2]. In this mode, the MP187 cask is designed for the on-site transfer of a loaded DSC from the Cask Handling Building to the AHSM.

B.3.4.3 Thermal

The thermal performance requirements for the Standardized Advanced NUHOMS® Horizontal Modular Storage System are described in Section 2.3.2 of the "Advanced NUHOMS® Horizontal Modular Storage System Safety Analysis Report" [B.3-1]. The AHSM relies on natural convection through the air space in the AHSM 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 AHSM air outlet. This pressure difference is greater than the flow pressure drop (ΔP_f) at the design air inlet and outlet temperatures.

B.3.4.4 Shielding/Confinement/Radiation Protection

The shielding performance and radiation protection requirements for the Standardized Advanced NUHOMS® Horizontal Modular Storage System are described in Sections 2.3.2.5 and 2.3.5 of the "Advanced NUHOMS® Horizontal Modular Storage System Safety Analysis Report" [B.3-1]. The confinement performance requirements for the Standardized NUHOMS® Horizontal Modular Storage System are described in Section 2.3.2 of the "Advanced NUHOMS® Horizontal Modular Storage System Safety Analysis Report" [B.3-1] for storage conditions. In addition, a bounding evaluation in WCS CISF SAR Section A.7.7 (also referenced in Section B.7.9) is performed to demonstrate that the confinement boundary for the 24PT1-DSC does not exceed ASME B&PV Subsection NB Article NB-3200 (Level A allowables) during normal conditions of transport to provide reasonable assurance that the confinement boundary is not adversely impacted by transport to the WCS CISF.

The AHSM provides the bulk of the radiation shielding for the DSCs. The AHSM design is arranged in a back-to-back arrangement. Thick concrete supplemental shield walls are used at either end of an AHSM array to minimize radiation dose rates both on-site and off-site. The AHSMs provide sufficient biological shielding to protect workers and the public.

The MP187 cask is designed to provide sufficient shielding to ensure dose rates are ALARA during transfer operations and off-normal and accident conditions.

There are no radioactive releases of effluents during normal and off-normal storage operations. In addition, there are no credible accidents that cause significant releases of radioactive effluents from the DSC. Therefore, there are no off-gas or monitoring systems required for the system at the WCS CISF.

B.3.4.5 Criticality

The criticality performance requirements for the Standardized Advanced NUHOMS® Horizontal Modular Storage System are described in Section 2.3.4 of the "Advanced NUHOMS® Horizontal Modular Storage System Safety Analysis Report" [B.3-1].

For the DSCs, a combination of fixed poison in the basket and geometry are relied on to maintain criticality control. The structural analysis shows that there is no deformation of the basket under accident conditions that would increase reactivity.

B.3.4.6 Material Selection

Materials are selected based on their corrosion resistance, susceptibility to stress corrosion cracking, embrittlement properties, and the environment in which they operate during normal, off normal and accident conditions. The confinement boundary for the DSC materials meet the requirements of ASME Boiler and Pressure Vessel Code, Section III, Article NB-2000 and the specification requirements of Section II, Part D [B.3-8] *with the listing of ASME Code Alternatives for the DSCs provided in Table 3.1-14 of the "Advanced NUHOMS® Horizontal Modular Storage System Safety Analysis Report" [B.3-1]*. The DSC and cask materials are resistant to corrosion and are not susceptible to other galvanic reactions. Studies under severe marine environments have demonstrated that the shell materials used in the DSC shells are expected to demonstrate minimal corrosion during an 80-year exposure. The DSC internals are enveloped in a dry, helium-inerted environment and are designed *to withstand the loads from all normal, off-normal and accident conditions*. The AHSM is a reinforced concrete component with an internal DSC support structure that is fabricated to ACI and AISC Code requirements. Both have durability well beyond a design life of 80 years.

B.3.4.7 Operating Procedures

The sequence of operations are outlined for the Standardized Advanced NUHOMS® System in Chapter 5 and B.5 for receipt and transfer of the DSCs to the storage pad, insertion into the AHSM, monitoring operations, and retrieval and shipping. Throughout Chapter 5, CAUTION statements are provided at the steps where special notice is needed to maintain ALARA, protect the contents of the DSC, or protect the public and/or ITS components of the Standardized Advanced NUHOMS® System.

B.3.5 References

B.3-1 TN Document, ANUH-01.0150, Revision 6, "Updated Final Safety Analysis Report for the Standardized Advanced NUHOMS® Horizontal Modular Storage System for Irradiated Nuclear Fuel, NRC Docket No. 72-1029.

B.3-2 "Rancho Seco Independent Spent Fuel Storage Installation Safety Analysis Report," NRC Docket No. 72-11, Revision 4.

B.3-3 TN Document NUH-05-151 Rev. 17, "NUHOMS®-MP187 Multi-Purpose Transportation Package Safety Analysis Report." (Basis for NRC CoC 71-9255).

B.3-4 Proposed SNM-1050, WCS Consolidated Interim Storage Facility Technical Specifications, Amendment 0.

B.3-5 American Concrete Institute, American Concrete Institute, Code Requirements for Nuclear Safety Related Concrete Structures, ACI 349-97, American Concrete Institute, Detroit Michigan.

B.3-6 American Concrete Institute, "Building Code Requirements for Reinforced Concrete," ACI-318, 1989 (92).

B.3-7 U.S. Nuclear Regulatory Commission, Certificate of Compliance for the Standardized Advanced NUHOMS® Horizontal Modular Storage System for Irradiated Nuclear Fuel, Certificate No. 1029, Amendment all.

B.3-8 American Society of Mechanical Engineers, ASME Boiler and Pressure Vessel Code, Section III, Division 1, Subsection NB, 1992 Edition with Addenda through 1994 with Code Case N-595-1.

B.3-9 Reg Guide 1.76, "Design-Basis Tornado and Tornado Missiles for Nuclear Power Plants," Revision 1, March 2007.

B.3-10 American Society of Civil Engineers Standard ASCE 7-95, "Minimum Design Loads for Buildings and Other Structures," (Formerly ANSI A58.1).

Table B.3-1
Summary of WCS CISF Principal Design Criteria
(5 pages)

Design Parameter	WCS CISF Design Criteria	Condition	Standardized Advanced NUHOMS® System Design Criteria
Type of fuel	Commercial, light water reactor spent fuel	Normal (Bounded)	Advanced NUHOMS® FSAR Section 2.1
Storage Systems	Transportable canisters and storage overpacks docketed by the NRC	Normal (Bounded)	71-9255 72-1029
Fuel Characteristics	Criteria as specified in previously approved licenses for included systems	Normal (Bounded)	Advanced NUHOMS® FSAR Section 2.1
Tornado (Wind Load) (AHSM)	Max translational speed: 40 mph Max rotational speed: 160 mph Max tornado wind speed: 200 mph Radius of max rotational speed: 150 ft Tornado pressure drop: 0.9 psi Rate of pressure drop: 0.4 psi/sec	Accident (Bounded)	Advanced NUHOMS® FSAR Section 2.2.1 and Table 3.6-10 Max translational speed: 70 mph Max rotational speed: 290 mph Max tornado wind speed: 360 mph Radius of max rotational speed: 150 ft Tornado pressure drop: 3.0 psi Rate of pressure drop: 2.0 psi/sec
Tornado (Wind Load) (MP187 Cask)	Max translational speed: 40 mph Max rotational speed: 160 mph Max tornado wind speed: 200 mph Radius of max rotational speed: 150 ft Tornado pressure drop: 0.9 psi Rate of pressure drop: 0.4 psi/sec	Accident (Bounded)	Rancho Seco FSAR Section 3.2.1 of Volume 1 Max translational speed: NA Max rotational speed: NA Max tornado wind speed: 360 mph Radius of max rotational speed: NA Tornado pressure drop: NA Rate of pressure drop: NA

Table B.3-1
Summary of WCS CISF Principal Design Criteria
(5 pages)

Design Parameter	WCS CISF Design Criteria	Condition	Standardized Advanced NUHOMS® System Design Criteria
Tornado (Missile)	Automobile 4000 lb, 112 ft/s Schedule 40 Pipe 287 lb, 112 ft/s Solid Steel Sphere 0.147 lb, 23 ft/s	Accident (Bounded)	Advanced NUHOMS® FSAR Section 2.2.1 Automobile 4000 lb, 195 ft/s 8" diameter artillery shell 276 lb, 185 ft/s Solid Steel Sphere NA 12" OD Steel Pipe 1500 lb, 205 fps Wood pole 1500 lb, 294 ft/s
Floods	The WCS CISF is not in a floodplain and is above the Probable Maximum Flood elevation and will remain dry in the event of a flood.	Accident (Bounded)	Advanced NUHOMS® FSAR Section 2.2.2 and Table 3.6-10 Flood height 50 ft Water velocity 15 ft/s
Seismic (Ground Motion)	Site-specific ground-surface uniform hazard response spectra (UHRS) with 1E-4 annual frequency of exceedance (AFE) having peak ground acceleration (PGA) of 0.250 g horizontal and 0.175 g vertical. (Table 1-5 and Figure 1-5)	Accident (Bounded)	Advanced NUHOMS® FSAR Section 2.2.3 Reg Guide 1.60 Response Spectra anchored at 1.5 g horizontal and 1.0 g vertical peak accelerations
Vent Blockage	For NUHOMS® Systems: Inlet and outlet vents blocked 40 hrs	Accident (Same)	Advanced NUHOMS® FSAR Section 4.6.2 and Table 3.6-10 Inlet and outlet vents blocked 40 hrs
Fire/Explosion	For NUHOMS® Systems: Equivalent fire 300 gallons of diesel fuel	Accident (Same)	Advanced NUHOMS® FSAR Section 4.6.4 Equivalent fire 300 gallons of diesel fuel
Cask Drop	For NUHOMS® Systems: Transfer Cask Horizontal side drop or slap down 80 inches(3)	Accident (Same)	Section B.7.3 (New Evaluation) Transfer Cask Horizontal side drop or slap down 80 inches(3)

Table B.3-1
Summary of WCS CISF Principal Design Criteria
(5 pages)

Design Parameter	WCS CISF Design Criteria	Condition	Standardized Advanced NUHOMS® System Design Criteria
Transfer Load	For NUHOMS® Systems only: Normal insertion load 60 kips Normal extraction load 60 kips	Normal (Same)	Section B.7.3 (New Evaluation) and Advanced NUHOMS® FSAR Section 3.6.2.2.5 and Table 3.6-10 Normal insertion load 60 kips Normal extraction load 60 kips
Transfer Load	For NUHOMS® Systems only: Maximum insertion load 80 kips Maximum extraction load 80 kips	Off-Normal/ Accident (Same)	Section B.7.3 (New Evaluation) and Advanced NUHOMS® FSAR Section 3.6.2.2.7 Maximum insertion load 80 kips Maximum extraction load 80 kips
Ambient Temperatures	Normal temperature 44.1 – 81.5°F	Normal (Bounded)	Advanced NUHOMS® FSAR Table 4.1-1 Normal temperature 0 - 104°F(1)
Off-Normal Temperature	Minimum temperature 30.1°F Maximum temperature 113°F	Off-Normal (Bounded)	Advanced NUHOMS® FSAR Table 4.1-1 Minimum temperature -40.0°F Maximum temperature 117°F(2)
Extreme Temperature	Maximum temperature 113°F	Accident (Bounded)	Advanced NUHOMS® FSAR Table 4.1-1 Maximum temperature 120°F
Solar Load (Insolation)	Horizontal flat surface insolation 2949.4 BTU/day-ft^2 Curved surface solar insolation 1474.7 BTU/day-ft^2	Normal (Same)	Advanced NUHOMS® FSAR Section 4.4.2.2 Horizontal flat surface insolation 2952 BTU/day-ft^2 Curved surface solar insolation Not Specified
Snow and Ice	Snow Load 10 psf	Normal (Bounded)	Advanced NUHOMS® FSAR Section 2.2.4 Snow Load 110 psf
Dead Weight	Per design basis for systems listed in Table 1-1	Normal (Same)	Advanced NUHOMS® FSAR Sections 3.1.2.1.3.1, 3.6.1.1.3, and 3.6.2.2.1 and Table 3.6-10

Table B.3-1
Summary of WCS CISF Principal Design Criteria
(5 pages)

Design Parameter	WCS CISF Design Criteria	Condition	Standardized Advanced NUHOMS® System Design Criteria
Internal and External Pressure Loads	Per design basis for systems listed in Table 1-1	Normal (Same)	Advanced NUHOMS® FSAR Section 3.1.2.1.3.2
Design Basis Thermal Loads	Per design basis for systems listed in Table 1-1	Normal (Same)	Advanced NUHOMS® FSAR Section 3.1.2.1.3.3
Operating Loads	Per design basis for systems listed in Table 1-1	Normal (Same)	Advanced NUHOMS® FSAR Section 3.1.2.2.2 and Table 3.6-10
Live Loads	Per design basis for systems listed in Table 1-1	Normal (Same)	Advanced NUHOMS® FSAR Table 3.6-10 Design Load (including snow and ice) 200psf
Radiological Protection	Public wholebody ≤ 5 Rem Public deep dose plus individual organ or tissue ≤ 50 Rem Public shallow dose to skin or extremities ≤ 50 Rem Public lens of eye ≤ 15 Rem	Accident (Same)	Chapter 9 demonstrates these limits are met Public wholebody ≤ 5 Rem Public deep dose plus individual organ or tissue ≤ 50 Rem Public shallow dose to skin or extremities ≤ 50 Rem Public lens of eye ≤ 15 Rem
Radiological Protection	Public wholebody ≤ 25 mrem/yr(4) Public thyroid ≤ 75 mrem/yr(4) Public critical organ ≤ 25 mrem/yr(4)	Normal (Same)	Chapter 9 demonstrates these limits are met Public wholebody ≤ 25 mrem/yr(4) Public thyroid ≤ 75 mrem/yr(4) Public critical organ ≤ 25 mrem/yr(4)
Confinement	Per design basis for systems listed in Table 1-1	N/A	Advanced NUHOMS® FSAR Section 7 [B.3-1] (leaktight)
Nuclear Criticality	Per design basis for systems listed in Table 1-1	N/A	Advanced NUHOMS® FSAR Section 6
Decommissioning	Minimize potential contamination	Normal (Same)	Advanced NUHOMS® FSAR Section 14 Minimize potential contamination

Table B.3-1
Summary of WCS CISF Principal Design Criteria
(5 pages)

Design Parameter	WCS CISF Design Criteria	Condition	Standardized Advanced NUHOMS® System Design Criteria
Materials Handling and Retrieval Capability	Cask/canister handling system prevent breach of confinement boundary under all conditions Storage system allows ready retrieval of canister for shipment off-site	Normal (Same)	Advanced NUHOMS® FSAR Section 2.5.1 Cask/canister handling system prevent breach of confinement boundary under all conditions Storage system allows ready retrieval of canister for shipment off-site

Notes

1. Not Used
2. Not Used
3. 75g Side drop and 25g corner is equivalent to 80 inch drop.
4. In accordance with 10 CFR 72.104(a)(3) limits include any other radiation from uranium fuel cycle operations within the region.

Table B.3-2
Standardized Advanced NUHOMS® Horizontal Modular Storage System
Major Components and Safety Classifications

Component	10CFR72 Classification
Dry Shielded Canister (DSC)	Important to Safety[(1)]
Advanced Horizontal Storage Module (AHSM)	Important to Safety[(1)]
Basemat and Approach Slabs	Not Important to Safety
Transfer Equipment	
Cask	Important to Safety
Transport Trailer/Skid	Not Important to Safety
Ram Assembly	Not Important to Safety
Lubricant	Not Important to Safety
Auxiliary Equipment	
AHSM Temperature Monitoring	Not Important to Safety

Notes

1. Graded Quality

APPENDIX B.4
OPERATING SYSTEMS
Standardized Advanced NUHOMS® System

Table of Contents

B.4. OPERATING SYSTEMS B.4-1
B.4.1 Concrete Pad Structures B.4-2
B.4.1.1 Operating Functions B.4-2
B.4.1.2 Design Description B.4-2
B.4.1.3 Safety Considerations B.4-4
B.4.2 Cask Storage System B.4-5
B.4.2.1 Operating Function B.4-5
B.4.2.2 Design Description B.4-5
B.4.2.3 Safety Considerations B.4-6
B.4.3 Cask Transporter System B.4-7
B.4.3.1 Operating Function B.4-7
B.4.3.2 Design Description B.4-7
B.4.3.3 Safety Considerations B.4-7
B.4.4 Storage Module Thermal Monitoring System B.4-8
B.4.5 References B.4-9
B.4.6 Supplemental Data Drawings B.4-10

List of Tables

Table B.4-1 Weight of AHSM B.4-11
Table B.4-2 AHSM Overall Dimensions B.4-12

B.4. OPERATING SYSTEMS

This Appendix provides information on the operating systems applicable to the Standardized Advanced NUHOMS® System Cask System identified in Chapter 4 of the SAR. Those systems include the concrete pad structures, cask storage system, cask transporter system and the optional AHSM thermal monitoring system.

B.4.1 Concrete Pad Structures

This section is applicable to the basemat and approach slabs for the NUHOMS® AHSM. The following discussion provides guidance for these structures; but as noted in Section B.4.1.3, the basemat and approach slabs are not-important-to-safety (NITS).

B.4.1.1 Operating Functions

The NUHOMS® System basemat and approach slabs are cast-in-place reinforced concrete foundation structures that support the AHSMs (the basemat) and provide for access and support of the transfer system (the approach slabs). The thickness of the basemat and the approach slab will be determined by Storage Area foundation analysis.

B.4.1.2 Design Description

The following provides a description of the design considerations that will be taken into account when designing the basemat and approach slabs.

The basemat and approach slab loads consist of both dead and live loads, seismic loads, and tornado wind loads imposed on the AHSM array and transferred to the basemat.

The dead load consists of the weight of the basemat or approach slab.

Live loads for the basemat include the weight of the loaded DSC, the weight of the modules and shield walls plus an additional 200 psf applied over the area of the AHSM base to account for snow and ice loads, safety railings on the roofs of the AHSM, etc. These loads are provided in Table B.4-1. The values shown in Table B.4-1 are based on nominal material density; however, the as-built weight can vary ±5%, therefore; the storage pad is designed to accommodate 105% of the nominal weight shown in the table.

Live loads for the approach slab include the MP187 cask and transfer vehicle design payload which is 300,000 lb. Additional live loads of 200 psf are applied over the surface area of the approach slabs.

Localized front (furthest from AHSM) jack loads of 85,000 lb and rear jack loads of 109,000 lb are considered in designing the approach slab (this conservatively assumes the load of the DSC is carried only by the two rear jacks as the DSC is inserted into the AHSM). These loads are spread as necessary by use of spreading plates or other suitable means.

The site-specific soil conditions at the WCS Consolidated Interim Storage Facility (WCS CISF) are considered in the basemat design based on basemat and AHSM acceleration resulting from seismic activity.

Tornado wind loads acting on the AHSM array are transferred to the basemat as friction and pressure loads. Generic design pressure loads acting on the NUHOMS® system due to tornado wind loading are described in the Standardized Advanced NUHOMS® UFSAR, Section 3.6.2.2.4 [B.4-1]. These may be replaced by the site-specific tornado loads which are significantly lower.

The basemat for the NUHOMS® AHSMs will be level and constructed with a "Class B" surface flatness finish as specified in ACI 301-89 [B.4-2], or FF 25 per ASTM E 1155. Specifically, finishes with Class B tolerances shall be true planes within 1/4" in 10 feet, as determined by a ten foot straightedge placed anywhere on the slab in any direction. Although Class B surface finish is required, for modules with mating surfaces Class A surface flatness or FF 50 per ASTM E 1155 is recommended in order to provide better fit up and minimize gaps.

The surface finish for the basemat may be broomed, troweled or ground surface. Laser guided finishers and certified personnel may be utilized for construction of the basemat to assure proper finish, levelness and flatness. Alternatively, when grouted installation of AHSMs is used, a reduced flatness may be targeted. The grouted installation consists of setting the modules on approximately one-inch thick stainless steel shims and grouting between the module and the pad using cement-based grouts.

The slope of the approach slabs shall not exceed 7% which is the adjustable limit of brake of the transfer vehicle.

The overall dimensions of the AHSM modules are listed in Table B.4-2. When determining the length of the basemat, 1/2" should be added to the width of each module to account for as-built conditions in the modules and basemat. The basemat typically extends one foot beyond the front face of the module and matches the elevation of the approach slab. Thus, the width of a basemat for the double array is typically two feet wider than the modules. Similarly, the basemat typically extends one foot beyond the end walls.

To maintain levelness and stability of the module array, the joints intersecting the basemat should be minimized. Joints with expansion and sealant material must be compatible with expected basemat temperatures.

Two methods of AHSM array expansion are permitted. One involves the temporary removal of end walls, installation of new modules, and then re-installation of the end walls. This method requires that the existing modules adjacent to the end walls be empty (unloaded) during array expansion. The other method of array expansion effectively buries the existing end walls by placing new modules directly adjacent to the end walls with new end walls placed at the end of the expanded array. The length of the basemat should be designed to accommodate the planned method of array expansion, as applicable. The basemat shall be designed to a maximum differential settlement of 1/4 inch, front to back and side-to-side (AHSM array).

Finally, approach roads and aprons should be designed or repaired to eliminate features such as speed bumps, drains or potholes that would result in a difference of more than 5 inches in surface flatness over any 10-foot wide by 20-foot long area.

B.4.1.3 Safety Considerations

The foundation is not relied upon to provide safety functions. There are no structural connections or means to transfer shear between the AHSM base unit module and the foundation slab. Therefore, the basemat and approach slabs for the AHSMs are considered NITS and are designed, constructed, maintained, and tested as commercial-grade items.

B.4.2 Cask Storage System

This section is applicable to the NUHOMS®-24PT1 canisters; NUHOMS® AHSM; and MP187 cask configured for transfer operations.

B.4.2.1 Operating Function

The overall function of the AHSM used at the WCS CISF is to safely provide interim storage of spent nuclear fuel (SNF) canisters. These canisters provide a convenient means to place set quantities of SNF into dry storage in a way that allows easy retrieval of the canisters for off-site shipment.

The NUHOMS®-24PT1 canisters containing SNF assemblies are designed for storage in accordance with 10 CFR 72, and for transportation in accordance with 10 CFR 71. The main function of sealed canisters is to accommodate SNF assemblies, and provide confinement and criticality control during normal operation and postulated design-basis accident conditions for on-site storage. The NUHOMS®-24PT1 canister is shown in drawing NUH-05-4010 Revision 5, included in Section B.4.6.

The AHSM is designed in accordance with 10 CFR 72, and provides horizontal on-site storage of the sealed SNF canisters. The main function of the AHSM is to provide safe, long-term storage of NUHOMS®-24PT1 canisters containing SNF assemblies.

The AHSM design function is to passively cool the canisters by air convection. The AHSM also provides the capability for canister transfer from their associated transportation/transfer casks. The AHSM is shown in drawing NUH-03-4011 Revision 7, included in Section B.4.6.

The MP187 cask, in the transfer configuration, design function is to protect the canisters and provide shielding from the radiation sources inside the canisters during transfer operations. The MP187 cask in the transfer configuration is shown in drawings NUH-05-4001 Revision 15 and NUH-05-4003 Revision 10, included in Section A.4.6.

B.4.2.2 Design Description

The NUHOMS®-24PT1 canister is a stainless steel flat head pressure vessel that provides confinement and is designed to withstand all normal condition loads as well as the off-normal and accident condition loads created by earthquakes, tornadoes, flooding, and other natural phenomena.

The AHSM is a low profile, reinforced concrete structure designed to withstand all normal condition loads as well as the off-normal and accident condition loads created by earthquakes, tornadoes, flooding, and other natural phenomena. The AHSM is also designed to withstand off-normal and accident condition loadings postulated to occur during design basis accident conditions such as a complete loss of ventilation.

The MP187 cask, in the transfer configuration, is used to transfer the canisters from the CHB to the storage pad where the cask is mated to the AHSM. The cask is designed to withstand all normal condition loads as well as the off-normal and accident condition loads created by earthquakes, tornadoes, flooding, and other natural phenomena.

B.4.2.3 Safety Considerations

The NUHOMS®-24PT1 canisters are Important- to-Safety (ITS), Quality Category A components.

The AHSM is an important-to-safety (ITS), Quality Category B component. The MP187 cask is an ITS, Quality Category *A* component.

B.4.3 Cask Transporter System

This section is applicable to the cask transporter system for the MP187 cask. This following provides a general description of the cask transporter system, however as noted Section B.4.3.3, this equipment is NITS.

B.4.3.1 Operating Function

The cask transporter system for the MP187 cask is designed to move the loaded MP187 cask in the on-site transfer configuration between the Cask Handling Building and the Storage Area and transfer the canister from the MP187 cask to the AHSM.

B.4.3.2 Design Description

The transfer vehicle includes a transfer skid which cradles the top and bottom lifting trunnions of the cask, and is designed to be moved with the skid and cask. The transfer vehicle is also used in the Storage Area to transfer the canister from an MP187 cask to an AHSM. It features a transfer skid, a skid positioner, a hydraulic ram system and hydraulic jacks for stabilization. The system utilizes a self-contained hydraulic ram to hydraulically push the canister out of the MP187 cask and into the AHSM. The alignment of the MP187 cask and the AHSM is verified by an alignment system.

B.4.3.3 Safety Considerations

All transfer equipment is designed to limit the height of the MP187 cask to less than 80” above the surrounding surface; therefore, it is NITS and is designed, constructed, maintained, and tested as commercial-grade items.

B.4.4 Storage Module Thermal Monitoring System

As described in Section 5.1.3*,* AHSM Thermal Monitoring Program of the Technical Specifications [B.4-3]*, daily visual inspection of the inlet and outlet vents of the HSM and removing any identified debris* prevent*s* conditions that could lead to exceeding the concrete and fuel clad temperature criteria. *In addition, instrumentation that can be used for monitoring HSM roof concrete temperatures is also provided for each HSM.*

B.4.5 References

B.4-1 TN Document, ANUH-01.0150, Revision 6, "Updated Final Safety Analysis Report for the Standardized Advanced NUHOMS® Horizontal Modular Storage System for Irradiated Nuclear Fuel, NRC Docket No. 72-1029.

B.4-2 American Concrete Institute, "Specifications for Structural Concrete for Buildings," ACI 301, 1989.

B.4-3 Proposed SNM-1050, WCS Consolidated Interim Storage Facility Technical Specifications, Amendment 0.

B.4.6 Supplemental Data Drawings

The following drawings are located as noted below:

1. "General License NUHOMS® 24PT1-DSC Main Assembly (six sheets)," NUH-05-4010, Revision 5 (See Section 1.5.2 of the Standardized Advanced NUHOMS® UFSAR [B.4-1]).

2. "General License NUHOMS® Advanced Horizontal Storage Module Main Assembly (nine sheets)," NUH-003-4011, Revision 7 (See Section 1.5.2 of the Standardized Advanced NUHOMS® UFSAR [B.4-1]).

Table B.4-1
Weight of AHSM

Component	Nominal Weight kips[1]	105% weight kips
AHSM	318.3	334.3
End Walls	188	197.4

Notes

1. Values reported in this table are for the purposes of designing the basemat and may differ from other SAR values.

Table B.4-2
AHSM Overall Dimensions

Width	Depth	Height w/o vent covers	Height w/ vent covers
101”	235”	222”	247”

APPENDIX B.5
OPERATING PROCEDURES
Standardized Advanced NUHOMS® System

Table of Contents

B.5. OPERATING PROCEDURES B.5-1

B.5.1 Procedures for Loading the DSC and Transfer to the AHSM B.5-2

B.5.1.1 Receipt of the Loaded NUHOMS®-MP187 Cask B.5-2

B.5.1.2 Transfer to the AHSM B.5-3

B.5.1.3 Monitoring Operations B.5-5

B.5.2 Procedures for Retrieval and Off-Site Shipment B.5-6

B.5.2.1 DSC Retrieval from the AHSM B.5-6

B.5.3 References B.5-8

List of Figures

Figure B.5-1 Standardized Advanced NUHOMS® System Loading Operations B.5-9

B.5. OPERATING PROCEDURES

This chapter presents the operating procedures for the Standardized Advanced NUHOMS® System containing the NUHOMS® 24PT1-DSCs originally loaded and stored under Certificate of Compliance (CoC) 1029 with the addition of the NUHOMS®-MP187 transport/transfer cask (TC) qualified for transfer operations with the 24PT1 DSC. The procedures include receipt of the NUHOMS®-MP187 Cask; placing the TC onto the transfer skid on the transfer vehicle, transfer to the Storage Area, DSC transfer into the Standardized Advanced Horizontal Storage Module (AHSM), monitoring operations, and DSC retrieval from the AHSM. The NUHOMS®-MP187 cask transfer equipment, and the Cask Handling Building systems and equipment are used to accomplish these operations. Procedures are delineated here to describe how these operations may be performed and are not intended to be limiting. Temporary shielding may be used throughout as appropriate to maintain doses as low as reasonably achievable (ALARA).

The following sections outline the typical operating procedures for the Standardized Advanced NUHOMS® System. These procedures have been developed to minimize the amount of time required to complete the subject operations, to minimize personnel exposure, and to assure that all operations required for transfer, and storage are performed safely. Operations may be performed in a different order if desired to better utilize personnel and minimize dose as conditions dictate.

Pictograms of the Standardized Advanced NUHOMS® System operations are presented in Figure B.5-1.

The generic terms used throughout this section are as follows.

- TC, or transfer cask is used for the NUHOMS®-MP187 transportation/transfer cask.
- DSC is used for the NUHOMS® 24PT1-DSC.
- AHSM is used for the Standardized Advanced Horizontal Storage Module.

B.5.1 Procedures for Loading the DSC and Transfer to the AHSM

A pictorial representation of key phases of this process is provided in Figure B.5-1.

B.5.1.1 Receipt of the Loaded NUHOMS®-MP187 Cask

Procedures for receiving the loaded TC after shipment are described in this section. These procedures are taken from reference [B.5-1], and must remain consistent with [B.5-1].

1. Verify that the tamperproof seals are intact.

2. Remove the tamperproof seals.

3. Remove the impact limiter attachment bolts from each impact limiter and remove the impact limiters from the TC.

4. Remove the transportation skid personnel barrier and skid support structure (closure assembly).

5. Take contamination smears on the outside surfaces of the TC. If necessary, decontaminate the TC until smearable contamination is at an acceptable level.

6. Attach the WCS Lift Beam Assembly to TC top and bottom ends.

7. Using the overhead crane, lift the TC from the railcar.

CAUTION: Verify that the TC is not lifted more than 80" above the adjacent surface in accordance with the limits specified in Section 5.2.1 of the Technical Specifications [A.5-2].

   a. Remove upper and lower trunnion plugs.

   b. Inspect the trunnion sockets for excessive wear, galling, or distortion in accordance with the transport license requirements [B.5-1].

   c. Install the upper and lower trunnions. Torque trunnion attachment bolts to at least 200 ft-lbs in accordance with the transport license requirements [B.5-1].

8. Place the TC onto the transfer cask skid trunnion towers.

9. Inspect the trunnions to ensure that they are properly seated onto the skid.

10. Remove the WCS Lift Beam Assembly.

11. Install the cask shear key plug assembly.

12. Install the on-site support skid pillow block covers.

13. Any time prior to removing the TC top cover plate or the bottom ram access cover plate, sample the TC cavity atmosphere through the vent port. Flush the TC interior gases to the radwaste system if necessary.

14. Draw a vacuum on the TC cavity and helium leak test the DSC in accordance with reference [B.5-3] requirements.

B.5.1.2 Transfer to the AHSM

CAUTION: Verify that the requirements of Section 5.2.1 of the Technical Specifications [B.5-2] are met prior to the next step. The maximum lifting height and ambient temperature requirements must be met during transfer from the Cask Handling Building to the AHSM.

1. Move the TC from the Cask Handling Building to the storage pad along the designated transfer route.

2. Prior to the TC arrival at the AHSM, remove the AHSM door, inspect the cavity of the AHSM, removing any debris and ready the AHSM to receive a DSC. The doors on adjacent AHSMs must remain in place.

CAUTION: The inside of empty modules have the potential for high dose rates due to adjacent loaded modules. Proper ALARA practices should be followed for operations inside these modules and in the areas outside these modules whenever the door from an empty AHSM has been removed.

3. Inspect the AHSM air inlet and outlet to ensure that they are clear of debris. Inspect the screens on the air inlet and outlet for damage.

4. Verify specified lubrication of the DSC support structure rails.

5. Once at the storage pad, position the transfer vehicle to within a few feet of the AHSM.

   Note: If performing inspection of the DSC surface per reference [B.5-3] requirement, install inspection apparatus between the TC and the AHSM.

6. Check the position of the transfer vehicle to ensure the centerline of the AHSM and TC approximately coincide. If the transfer vehicle is not properly oriented, reposition the transfer vehicle, as necessary.

7. Unbolt and remove the TC top cover plate.

8. Verify the DSC serial number against appropriate records.

CAUTION: High dose rates are expected after removal of the TC top cover plate. Proper ALARA practices should be followed.

9. Back the transfer vehicle to within a few inches of the AHSM/inspection apparatus, set the transfer vehicle brakes and disengage the tractor, if applicable. Extend the transfer vehicle vertical jacks.

10. Use the skid positioning system to bring the TC into approximate vertical and horizontal alignment with the AHSM. Using alignment equipment and the alignment marks on the TC and the AHSM, adjust the position of the TC until it is properly aligned with the AHSM.

11. Using the skid positioning system, fully insert the TC into the AHSM/inspection apparatus access opening docking collar.

12. Secure the TC to the front wall embedments of the AHSM using the cask restraints.

13. After the TC is docked with the AHSM/inspection apparatus, verify the alignment of the TC using the alignment equipment.

14. Remove the bottom ram access cover plate. Position the ram behind the TC in approximate horizontal alignment with the TC and level the ram. Extend the ram through the bottom TC opening into the DSC grapple ring.

15. Operate the ram grapple and engage the grapple arms with the DSC grapple ring.

16. Recheck all alignment marks and ready all systems for DSC transfer.

17. Activate the ram to initiate insertion of the DSC into the AHSM. Stop the ram when the DSC reaches the support rail stops at the back of the module.

    Note: Performing inspection of the DSC surface, as required, by the aging management program while the DSC is being transferred from the TC to the AHSM.

18. Disengage the ram grapple mechanism so that the grapple is retracted away from the DSC grapple ring.

19. Retract and disengage the ram system from the TC and move it clear of the TC. Remove the cask restraints from the AHSM.

20. Using the skid positioning system, disengage the TC from the AHSM/inspection apparatus access opening.

21. Remove the inspection apparatus if used.

22. Install the DSC seismic restraints through the AHSM door opening.

CAUTION: High dose rates are expected in the AHSM cavity after removal of the AHSM door. Proper ALARA practices should be followed.

23. The transfer vehicle can be moved, as necessary, to install the AHSM door. Install the AHSM door and secure it in place.

24. Replace the TC top cover plate and ram access cover plate. Secure the skid to the transfer vehicle.

25. Move the transfer vehicle and TC to the designated area. Return the remaining transfer equipment to the Storage Area.

26. Remove the AHSM Door and adjust the seismic restraints on the DSC one week following initial placement.

B.5.1.3 Monitoring Operations

27. Perform routine security surveillance in accordance with the security plan.

28. Perform a daily visual surveillance of the AHSM air inlet and outlet (bird screens) to verify that no debris is obstructing the AHSM vents in accordance with Section 5.1.3(a) of the Technical Specification [B.5-2] requirements.

B.5.2 Procedures for Retrieval and Off-Site Shipment

The following section outlines the procedures for retrieving the DSC from the AHSM for shipment off-site.

B.5.2.1 DSC Retrieval from the AHSM

CAUTION: Verify that the requirements of Section 5.2.1 of the Technical Specifications [B.5-2] are met prior to the next step. The maximum lifting height and ambient temperature requirements must be met during transfer from the AHSM to the Cask Handling Building.

1. Ready the TC, transfer vehicle, and support skid for service. Remove the top cover and ram access plates from the TC. Move the transfer vehicle to the AHSM.

2. Remove the AHSM door and the DSC seismic restraints. Position the transfer vehicle to within a few feet of the AHSM.

3. Check the position of the transfer vehicle to ensure the centerline of the AHSM and TC approximately coincide. If the transfer vehicle is not properly oriented, reposition the transfer vehicle as necessary.

CAUTION: High dose rates are expected in the AHSM cavity after removal of the AHSM door. Proper ALARA practices should be followed.

4. Back the TC to within a few inches of the AHSM, set the transfer vehicle brakes and disengage the tractor, if applicable. Extend the transfer vehicle vertical jacks.

5. Use the skid positioning system to bring the TC into approximate vertical and horizontal alignment with the AHSM. Using alignment equipment and the alignment marks on the TC and the AHSM, adjust the position of the TC until it is properly aligned with the AHSM.

6. Using the skid positioning system, fully insert the TC into the AHSM access opening docking collar.

7. Secure the TC to the front wall embedments of the AHSM using the cask restraints.

8. After the TC is docked with the AHSM, verify the alignment of the TC using the alignment equipment.

9. Position the ram behind the TC in approximate horizontal alignment with the TC and level the ram. Extend the ram through the TC into the AHSM until it is inserted in the DSC grapple ring.

10. Operate the ram grapple and engage the grapple arms with the DSC grapple ring.

11. Recheck all alignment marks and ready all systems for DSC transfer.

12. Activate the ram to pull the DSC into the TC.

13. Once the DSC is seated in the TC, disengage the ram grapple mechanism so that the grapple is retracted away from the DSC grapple ring.

14. Retract and disengage the ram system from the TC and move it clear of the TC. Remove the cask restraints from the AHSM.

15. Using the skid positioning system, disengage the TC from the AHSM access opening.

CAUTION: The inside of empty modules have the potential for high dose rates due to adjacent loaded modules. Proper ALARA practices should be followed for operations inside these modules and in the areas outside these modules whenever the door from the empty AHSM has been removed.

16. Bolt the TC top cover plate and the ram access cover plate into place, tightening the bolts to the required torque in a star pattern.

17. Retract the vertical jacks and disconnect the skid positioning system.

18. Ready the transfer vehicle for transfer.

19. Replace the AHSM door and DSC seismic restraints on the AHSM.

20. Move the TC from the storage pad to the Cask Handling Building along the designated transfer route.

21. Prepare the transportation cask for transport in accordance with Certificate of Compliance No. 9255.

B.5.3 References

B.5-1 U.S. Nuclear Regulatory Commission, "Certificate of Compliance No. 9255, Revision 12 for the Model No. NUHOMS®-MP187 Multi-Purpose Cask (Docket 71-9255).

B.5-2 Proposed SNM-1050, WCS Consolidated Interim Storage Facility Technical Specifications, Amendment 0.

B.5-3 "Post Transport Package Evaluation," QP-10.02, Revision 1.

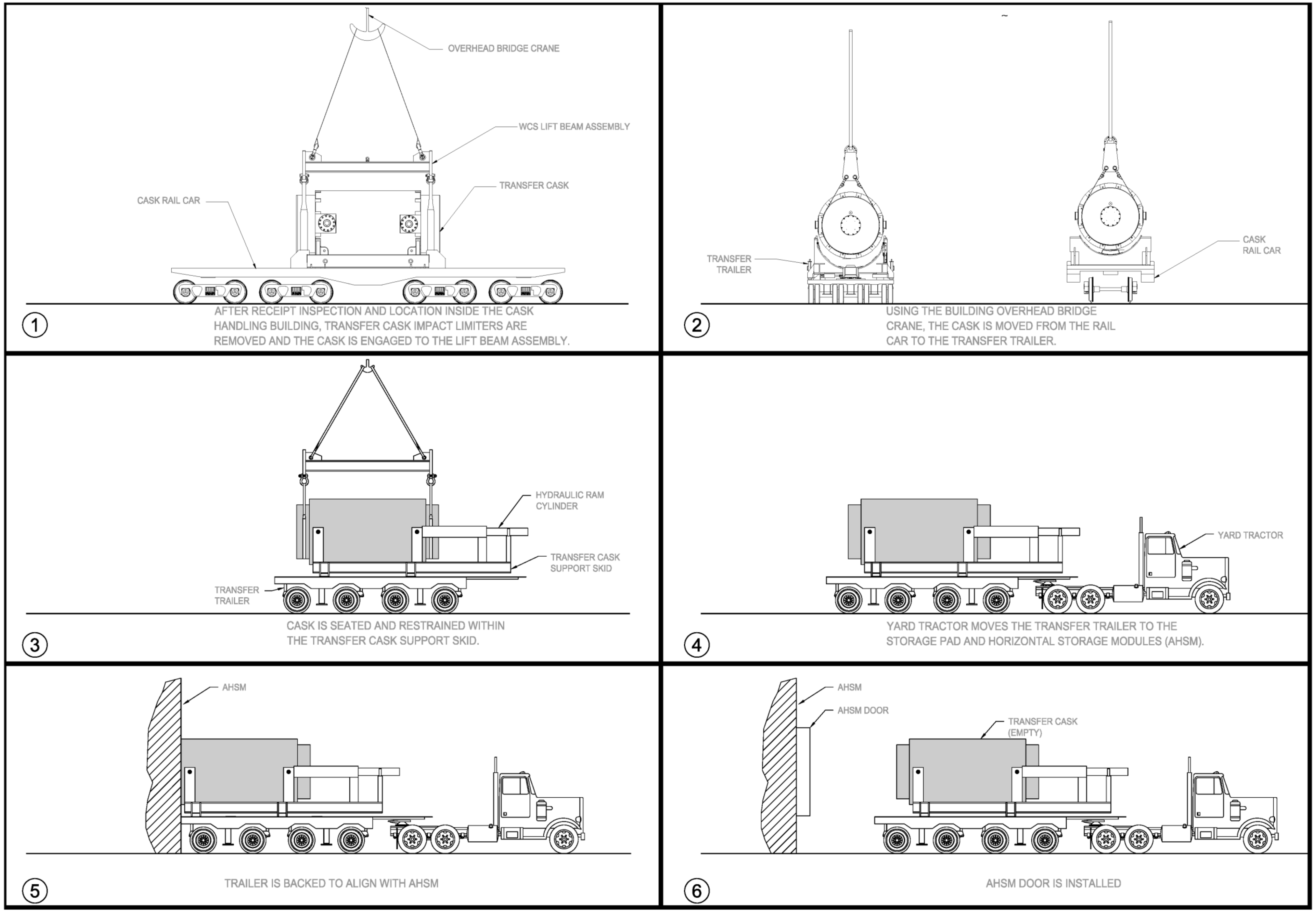

Figure B.5-1
Standardized Advanced NUHOMS® System Loading Operations

APPENDIX B.6
WASTE CONFINEMENT AND MANAGEMENT
Standardized Advanced NUHOMS® System

Table of Contents

B.6. WASTE CONFINEMENT AND MANAGEMENT B.6-1

B.6. WASTE CONFINEMENT AND MANAGEMENT

No change or additional information required for the Advanced NUHOMS® System containing the NUHOMS® 24PT1-DSCs for Chapter 6.

APPENDIX B.7
STRUCTURAL EVALUATION
Standardized Advanced NUHOMS® System

Table of Contents

B.7. STRUCTURAL EVALUATION B.7-1

B.7.1 Discussion B.7-3

B.7.2 Summary of Mechanical Properties of Materials B.7-4

B.7.3 Structural Evaluation of MP187 Transfer Cask with Canister (Transfer Configuration at WCS CISF) B.7-5

B.7.3.1 Evaluation of MP187 Cask Loaded with a Canister B.7-5

B.7.3.2 Evaluation of the Canister in the MP187 Transfer Cask B.7-6

B.7.4 Structural Analysis of AHSM with a Canister (Storage Configuration) B.7-7

B.7.5 Seismic Reconciliation of the Advanced NUHOMS® 24PT1 DSC and AHSM Storage Components and the MP187 Transfer Cask B.7-8

B.7.6 Thermal Stress Reconciliation of the Standardized Advanced NUHOMS® System Components B.7-9

B.7.6.1 Reconciliation of WCS CISF Environmental Ambient Conditions with Environmental Ambient Conditions used for the AHSM Analyses in the Standardized Advanced NUHOMS® UFSAR B.7-9

B.7.6.2 Reconciliation of WCS CISF Environmental Ambient Conditions with Environmental Ambient Conditions used for the Canister Analysis in the Standardized Advanced NUHOMS® UFSAR B.7-9

B.7.7 Conclusions of the Structural Analysis B.7-10

B.7.8 Cask Stability and Missile Penetration Evaluation of the MP187 Cask (On-Site Transfer Configuration) B.7-11

B.7.8.1 Assumptions B.7-11

B.7.8.2 Material Properties B.7-11

B.7.8.3 Design Criteria B.7-11

B.7.8.4 Methodology B.7-12

B.7.8.5 Design Input Loads & Data B.7-14

B.7.8.6 Tornado & Missile Impact Loads Analysis - Stability Evaluations B.7-16

B.7.8.7 Tornado Wind and Missile Analysis - Stress Evaluations B.7-19

B.7.8.8 Tornado Missile Analysis - Penetration Evaluations B.7-20
B.7.8.9 Summary of Results B.7-21

B.7.9 Structural Evaluation of 24PT1-DSC Confinement Boundary under Normal Conditions of Transport B.7-22

B.7.10 References B.7-23

List of Tables

Table B.7-1 Configuration of the FO-DSC Compared to the 24PT1 DSC (from Table A2.1-1 of [B.7-5]) B.7-24

Table B.7-2 Comparison of Canister Weights, Centers of Gravity and Moments of Inertia (from Table A2.2-1 of [B.7-5]) B.7-25

Table B.7-3 MP187 and OS197 Casks – Comparison of Basic Design Parameters B.7-26

Table B.7-4 DBT Wind Load Characteristics for WCS CISF B.7-27

Table B.7-5 Design-Basis Tornado Missile Spectrum and Maximum Horizontal Speeds.B.7-28

Table B.7-6 NUHOMS®-MP187 Cask and Canister Weights for Analyzed Configurations....B.7-29

Table B.7-7 Materials, Properties and Allowable Stresses for MP187 Cask at 400 ºF B.7-30

Table B.7-8 Stress Results for MP187 Cask due to Tornado Wind and Missile Loads B.7-31

Table B.7-9 Combined Tornado Effect on MP187 Cask – Stress Results B.7-32

List of Figures

Figure B.7-1 Location of Cask Rails in the MP187 and OS197 Casks................................B.7-33

Figure B.7-2 Design Basis Response Spectra for Canister, and AHSM compared to the Spectra at the C.G. of the HSM from WCS CISF Soil Structure Interaction Analysis..B.7-34

Figure B.7-3 Arrangement of MP187 Cask Shell, Skid and Trailer at Rest B.7-35

Figure B.7-4 Geometry Utilized in Cask Stability Assessments..B.7-36

Figure B.7-5 Angle of Rotation due to Wind and Massive Missile Loading Combination.B.7-37

B.7. STRUCTURAL EVALUATION

This Appendix describes the structural evaluation of the Standardized Advanced NUHOMS® System components utilized for storage of canisterized spent nuclear fuel (SNF) at the WCS Consolidated Interim Storage Facility (WCS CISF). As presented in Chapter 1, Table 1-1, the Standardized Advanced NUHOMS® System storage components include the 24PT1 Dry Shielded Canister (DSC or canister) and the AHSM concrete overpack.

The 24PT1 DSC is described in Section 3.1.1.1 of the Standardized Advanced NUHOMS® Updated Final Safety Analysis Report (UFSAR) [B.7-1]. The AHSM is described in Section 3.1.1.2 of [B.7-1]. Both of these components are approved by the NRC [B.7-6] for storage of SNF under the requirements of 10 CFR Part 72.

At the WCS CISF, the NUHOMS®-MP187 cask will be used for on-site transfer operations. The MP187 cask is a multi-purpose cask approved by the NRC for on-site transfer of the FO-, FC-, and FF- DSCs and Greater Than Class C (GTCC) waste canisters [B.7-2], and as a transportation cask for off-site shipments of the FO-, FC-, FF-, 24PT1 DSCs [B.7-3]. Volume I and Volume III of the Rancho Seco Independent Spent Fuel Storage Installation Final Safety Analysis Report (ISFSI FSAR) [B.7-4] describe the MP187 cask when used as on-site transfer cask under 10 CFR Part 72. Section 1.2 of the NUHOMS®-MP187 Multi-Purpose Transportation Package Safety Analysis Report (SAR) [B.7-5] describes the MP187 cask when used as a transportation cask under 10 CFR Part 71.

This appendix is prepared to demonstrate that the licensed canisters and AHSM storage components are qualified to safely transfer and store SNF and GTCC waste at the WCS CISF. Additionally, this appendix provides the justification to allow use of the MP187 cask for on-site transfer of the canister, consistent with the cask's allowable payloads in the MP187 cask's transportation license.

The structural evaluations presented herein are based on existing analyses as documented in [B.7-1] for the 24PT1 DSC and the AHSM and [B.7-4] for the MP187 cask except for the qualification of the 24PT1-DSC confinement boundary during Normal Conditions of Transport in Section B.7.9 *(to provide reasonable assurance that the confinement boundary is not adversely impacted by transport to the WCS CISF)* which points to the evaluation documented in Section A.7.7.2.

<u>MP187 Cask</u>

The design basis design criteria for the MP187 cask as an on-site transfer cask for the canisters is provided in [B.7-4] Volume I Table 3-4, Table 3-8, Table 3-9, and Table 3-10. The loading criteria summary shown in [B.7-4] Table 3-4 bounds the loading criteria for the WCS CISF as specified in Appendix B.3, Table B.3-1 (with the exception of seismic loading which is addressed in Section B.7.5).

Canister

The 24PT1 DSC design approach, design criteria and load combinations for transfer and storage conditions are summarized in Section 2.2, Section 3.1.2, and Table 3.1-2 through Table 3.1-7 of [B.7-1]. The codes and standards used for design and fabrication of the canister are provided in Table 3.1-1 of [B.7-1]. Section 3.6.1 discusses the results of the analyses for the canister.

Advanced Horizontal Storage Module (AHSM)

The design approach, design criteria and loading combinations for the reinforced concrete AHSM and its DSC support structure are discussed in Section 2.2, Section 3.1.2, and Table 3.1-9 through Table 3.1-13 of [B.7-1]. The codes and standards used for design and fabrication of the AHSM are provided in Table 3.1-1 of [B.7-1]. Section 3.6.2 discusses the results of the analyses for the AHSM.

B.7.1 Discussion

As discussed in Chapter 1, the 24PT1 DSCs, currently stored inside AHSMs at the San Onofre Nuclear Generating Station (SONGS) ISFSI, will be transported to the WCS CISF utilizing the NUHOMS®-MP187 Transportation Cask. The canisters and the AHSM are Standardized Advanced NUHOMS® System components for the storage of SNF under NRC Certificate of Compliance No. 1029 [B.7-6] and are described in Chapter 1 of [B.7-1]. The MP187 transportation cask is licensed under NRC Certificate of Compliance (CoC) No. 9255 [B.7-3].

At the WCS CISF, the canisters will be stored inside newly fabricated AHSMs utilizing the MP187 cask for on-site transfer operations. The MP187 cask is a multi-purpose cask licensed as an on-site transfer cask [B.7-2] under 10 CFR Part 72 as described in [B.7-4].

As described in [B.7-1] the canister and the AHSM utilize the OS197 transfer cask for on-site transfer operations. The OS197 transfer cask is licensed under CoC No. 1004 and is described in the Standardized NUHOMS® UFSAR [B.7-7]. This appendix reconciles the design basis analyses of the 24PT1 DSC in the OS197 transfer cask (that will not be used at the WCS CISF) to justify use of the MP187 cask for transfer of the 24PT1 DSC at the WCS CISF.

The design basis seismic criteria for the canister and AHSM significantly exceed the seismic criteria for the WCS CISF (see Figure B.7-2). Hence, no reconciliation for seismic loads for the canister and AHSM need to be performed in this appendix.

The qualification of the MP187 cask for use as the on-site transfer cask at WCS CISF is based on the design basis analysis as documented in [B.7-4]. *The cask stability evaluations in [B.7-4] consider the MP187 cask in the transfer horizontal configuration, the only configuration for the MP187 cask.*

Finally, a bounding evaluation in Section B.7.9 is performed to demonstrate that the confinement boundaries for the 24PT1-DSC does not exceed ASME B&PV Subsection NB Article NB-3200 (Level A allowables) during normal conditions of transport to provide reasonable assurance that the confinement boundary is not adversely impacted by transport to the WCS CISF.

B.7.2 Summary of Mechanical Properties of Materials

The material properties for the canister and the AHSM are provided in Section 3.3 of [B.7-1].

The material properties for the MP187 cask are provided in Section 2.3 of [B.7-5].

B.7.3 Structural Evaluation of MP187 Transfer Cask with Canister (Transfer Configuration at WCS CISF)

This section reconciles the use of the MP187 cask for transfer of the canister at the WCS CISF. This section also evaluates the 24PT1 DSC as a payload in the MP187 cask.

B.7.3.1 Evaluation of MP187 Cask Loaded with a Canister

The 10 CFR Part 71 evaluation of the canister in the MP187 cask is contained in Appendix A of the NUHOMS®-MP187 Multi-Purpose Transportation Package Safety Analysis Report (SAR) [B.7-5]. This section presents the evaluation of the canister in the MP187 cask for transfer operations under 10CFR Part 72. As in the 10 CFR Part 71 evaluations in Appendix A of [B.7-5], the evaluation presented herein is based on the design similarities between the FO- and FC- DSCs and the 24PT1 DSC.

As shown in Table A2.1-1 of [B.7-5], reproduced here as Table B.7-1, the 24PT1 DSC in [B.7-1] is the same as the FO DSC in [B.7-4], except that the 24PT1 DSC has a modified spacer disc spacing and support rod configuration. Sections A2.6.11.A and A2.6.11.B of [B.7-5] addressed these differences and concluded that the FO- and FC-DSCs configuration bounds the 24PT1 DSC configuration.

Table A2.2-1 of [B.7-5], reproduced here as Table B.7-2, shows that the 24PT1 DSC weight, center of gravity (cg) and weight moment of inertia (MOI) are bounded by those of the FO-, FC-, and FF- DSCs. As shown in this table, the 24PT1 DSC weight (78,400 lbs) is between the weight of the heaviest DSC (the FC- DSC with a weight of 81,120 lbs) and the lightest DSC (the FF- DSC with a weight of 74,900 lbs). This ensures that the effect of the lighter canister (increasing g-loads during postulated drop) and a heavier canister (higher stresses for non-drop loading conditions) envelop the 24PT1 DSC.

The total weight of the loaded MP187 cask (on-site transfer configuration) ranges from 239,700 lbs (with FC- DSC) to 233,500 lbs (with FF- DSC). This range bounds the total weight of 237,200 lbs (with 24PT1 DSC). Thus, the MP187 cask loaded with a FO- and FC- DSC configuration bounds the MP187 loaded with a 24PT1 DSC configuration [B.7-5, Table A2.2-2].

Section B.7.8 presents an evaluation of the MP187 cask in the transfer configuration at the WCS CISF.

Based on the evaluation above, the structural evaluation of the MP187 cask documented in [B.7-4] for the MP187 cask loaded with the FO- and FC- DSCs is applicable to the MP187 cask loaded with a 24PT DSC.

B.7.3.2 Evaluation of the Canister in the MP187 Transfer Cask

The structural analysis of the canister for normal, off-normal, and accident loads is presented in Section 3.6.1, Section 11.1, and Section 11.2, respectively, of [B.7-1]. Pertinent transfer and handling loads and load combinations applicable to the canister are described in Table 3.6-1 of [B.7-1]. Results for normal and off-normal conditions for the canister shell assembly are summarized in Table 3.6-2, and for accident conditions in Table 3.6-3 of [B.7-1]. Controlling load combination results for the canister shell assembly subcomponents for normal, off-normal, and accident conditions are presented in Table 3.6-4 through Table 3.6-6 of [B.7-1]. Results for normal, off-normal, and accident conditions for the basket assembly subcomponents are summarized in Table 3.6-7 through Table 3.6-9 of [B.7-1].

The above design basis structural evaluations involved transfer operations of the canister in the OS197 transfer cask. The OS197 transfer cask is described in Section 4.2.3.3 of [B.7-7]. The discussion below provides the basis for acceptance of the MP187 cask for transfer operations of the canister.

Table B.7-3 presents a comparison of the OS197 transfer cask and the MP187 cask. In the canister design basis analysis the transfer cask is conservatively assumed to be rigid. Therefore, differences in stiffness due to different cask dimensions (shell thickness, cask length, etc.) between the OS197 transfer cask and MP187 cask have no impact on the canister analyses. Only the interface dimensions (cask cavity diameter, cask rail thickness and cask rail locations) may have an effect on the analyses only when the cask is in the horizontal orientation (e.g., side drop is the controlling case). As shown in Table B.7-3 the interface dimensions are the same between the two casks, except for the cask rail locations, where the rails are located at ±18.5º in the OS197 transfer cask and at ±30º in the MP187 cask. However, as shown in Figure B.7-1 the rails in the MP187 cask are located in the thickened region of the spacer disc, whereas in the OS197 transfer cask the rails are located in the thin region of the spacer disc perimeter. The side drop analyses are performed at multiple drop orientations of 0º, 18.5º and 45º. The 18.5º case corresponds to a drop on a single rail and represents the worst drop case. Thus, basket spacer disc stresses in the OS197 transfer cask are considered bounding.

Based on the evaluation above, the structural evaluation of the canister documented in Section 3.6 and Section 11.0 of [B.7-1] is applicable to the canister loaded in the MP187 cask for transfer operations at the WCS CISF.

B.7.4 Structural Analysis of AHSM with a Canister (Storage Configuration)

This section evaluates the AHSM loaded with the canister for service at the WCS CISF. The evaluation is based on the design basis stress analyses of these components documented in [B.7-1].

The structural analysis of the canister in the storage configuration and the AHSM (reinforced concrete and DSC steel support structure) for normal, off-normal, and accident conditions is presented in Section 3.6, Section 11.1 and Section 11.2, respectively, of [B.7-1]. Pertinent storage loads and load combinations applicable to the canister are described in Table 3.6-1 of [B.7-1]. AHSM loading summary descriptions are provided in Table 3.6-10. Load combinations applicable to the AHSM and DSC steel support structure are described in Table 3.6-12, and Table 3.6-13 of [B.7-1], respectively.

Results for normal and off-normal conditions for the canister shell assembly are summarized in Table 3.6-2, and for accident conditions in Table 3.6-3 of [B.7-1] as applicable. Controlling load combination results for the canister shell assembly subcomponents for normal, off-normal, and accident conditions are presented in Table 3.6-4 through Table 3.6-6, as applicable. Results for normal, off-normal, and accident conditions for the basket assembly subcomponents are summarized in Table 3.6-7 through Table 3.6-9 of [B.7-1], as applicable.

Calculated ultimate capacities of the AHSM concrete components are tabulated in Table 3.6-14 of [B.7-1], and the comparison with the resulting forces and moments is summarized in Table 3.6-15 of [B.7-1]. Stress analysis results for the DSC steel support structure are summarized in Table 3.6-16 (for the rail components), Table 3.6-17 (for the rail extension plates), and Table 3.6-18 (for the support structure cross members) of [B.7-1]. The stress qualification for these components is provided in Table 3.6-19 and Table 3.6-20 of [B.7-1]. The stress qualification for the AHSM ties and concrete keys is provided in Table 3.6-21 of [B.7-1].

B.7.5 Seismic Reconciliation of the Advanced NUHOMS® 24PT1 DSC and AHSM Storage Components and the MP187 Transfer Cask

The site-specific seismic ground motion developed for the WCS CISF in the form of the 10,000-year return period uniform hazard response spectra for the horizontal and vertical directions are described in Chapter 2.

As described in Section 2.2.3.1 of [B.7-1] the design basis seismic design criteria for the canister and AHSM components consists of the standard NRC Regulatory Guide 1.60 response spectrum shape anchored at a ZPA of 1.5g for the horizontal direction. The vertical spectrum is set at two-thirds of the horizontal direction over the entire frequency range. The horizontal and vertical spectra are specified at the top of the basemat. The horizontal and vertical components of the design response spectra, at 4% damping, are shown in Figure 2.2-1 and Figure 2.2-2 of [B.7-1].

A comparison of the seismic design basis for the Standardized Advanced NUHOMS® components and the ±15% peak broadened response spectra obtained at the center of gravity (CG) level from the soil structure interaction analysis of the pad are shown in Figure B.7-2 for the horizontal and vertical directions.

As shown in Figure B.7-2, the design basis seismic criteria for the canister and AHSM significantly exceed the seismic criteria for the AHSMs and 24PT1s on the pad. Hence, the canister and the AHSM designs have significant margins and no reconciliation for seismic loads needs to be performed for these components.

As discussed in Appendix A.7, the design basis response spectra for the MP187 cask is the standard NRC Regulatory Guide 1.60 spectrum shape anchored at 0.25g for the horizontal direction and 0.17g for the vertical direction. These spectra are compared to the WCS CISF site-specific spectra in Figure A.7-1, for damping values of 3%, 5%, and 7%. The WCS CISF site-specific spectra are compared to the ±15% peak broadened response spectra at the HSM base, which are obtained from the soil-structure interaction analysis of the pad, in Figure A.7-5 and A.7-6 for a damping value of 3%.

The discussion in Section B.7.3 demonstrates the similarity of the canister, described in [B.7-1], and the FO- DSC, described in [B.7-4]. Therefore, the seismic reconciliation of the MP187 cask loaded with a bounding FO-, FC- and FF- DSC presented in Section A.7.5.1 is applicable to the MP187 cask loaded with a 24PT1 DSC.

B.7.6 Thermal Stress Reconciliation of the Standardized Advanced NUHOMS® System Components

From Chapter 3, the maximum ambient temperatures at the WCS CISF are 81.5°F, 113°F and 113°F for normal, off-normal, and accident conditions. Based on the discussion in Chapter 8, the corresponding 24-hour daily average temperatures of 95°F and 105°F for normal and off-normal conditions, respectively, are justified for use in the structural reconciliation evaluations for the WCS CISF.

The lowest off-normal ambient temperature at the WCS CISF is 30.1°F. This is above the -20°F minimum temperature used in [B.7-4] (for use of the MP187) and is bounded by the -40°F in [B.7-1] (for use of the canister and AHSM).

B.7.6.1 Reconciliation of WCS CISF Environmental Ambient Conditions with Environmental Ambient Conditions used for the AHSM Analyses in the Standardized Advanced NUHOMS® UFSAR

The AHSM structural analysis is performed for normal ambient temperature range of 0 °F to 104 °F and off-normal maximum temperature range of -40 °F to 117°F, respectively, in Section 3.6.2 of [B.7-1]. These temperatures bound the daily average ambient temperatures of 95°F and 105°F used for normal and off-normal conditions, respectively at the WCS CISF. The lowest off-normal ambient temperature at the WCS CISF is 30.1°F, which is bounded by the -40°F used in [B.7-1]. Therefore, the maximum temperatures and thermal stress evaluation results reported in [B.7-1] for the AHSM remain bounding for the WCS CISF.

B.7.6.2 Reconciliation of WCS CISF Environmental Ambient Conditions with Environmental Ambient Conditions used for the Canister Analysis in the Standardized Advanced NUHOMS® UFSAR

As documented in Table 4.1-1 (See also Table 3.1-8) of [B.7-1], the ambient temperature range for normal conditions is 0 °F to 104 °F. The ambient temperature range for off-normal and accident conditions is -40 °F to 117 °F. These temperatures bound the daily average ambient temperatures of 95°F, 105°F and 105°F for normal, off-normal and accident conditions, respectively used at the WCS CISF. Therefore, the maximum temperatures and thermal stress evaluation results reported in [B.7-1] for the canister in the AHSM remain bounding for the WCS CISF.

B.7.7 Conclusions of the Structural Analysis

This appendix demonstrates that the AHSM and the canister as described in [B.7-1] are suitable for storage at the WCS CISF. This appendix also demonstrates that the MP187 cask as described in [B.7-4] is suitable for transfer of the canister at the WCS CISF.

Furthermore, the design requirements and environmental conditions that form the design basis upon which the MP187 cask, the canister, and the AHSM components were licensed by the NRC bound the requirements and environmental conditions at the WCS CISF (with the exception of the seismic loading on the MP187 cask which is addressed in Section A.7.5.1). Therefore, the AHSM as described in [B.7-1] is acceptable for storage of the canister at the WCS CISF.

The structural performance of the MP187 cask with a canister (Conditions of Storage) at the WCS CISF, evaluated under normal, off-normal, and accident conditions of operation, satisfies all the 10 CFR Part 72 stress limits and criteria.

Finally, the structural performance of the canister confinement boundary was evaluated for Normal Conditions of Transport (See Section B.7.9) against ASME B&PC Code Subsection NB Article NB-3200 (Level A allowables) and were found to satisfy all of the stress limits and criteria demonstrating that the confinement boundaries are not adversely impacted by transportation of the canisters to the WCS CISF in the MP187 transport cask.

B.7.8 Cask Stability and Missile Penetration Evaluation of the MP187 Cask (On-Site Transfer Configuration)

This section presents *a* structural evaluation of the MP187 cask for tornado, seismic, and missile impact loads. The evaluation encompasses stability, stress, and missile penetration effects, as applicable.

The following evaluation considers the MP187 cask loaded with an FO-, FC-, FF-DSC. The MP187 cask with 24PT1 DSC configuration is bounded by the MP187 cask with an FO-, FC-, or FF-DSC (Section B.7.3).

B.7.8.1 Assumptions

1. The gust factor, G, value for wind loading of 0.85 is taken from Section 6.5.8.1 of ASCE 7-05 standard [B.7-8].

2. The stability calculations use a weight of the MP187 cask with transfer skid and transfer trailer of W_c = 270 kips. Per Table B.7-6, the minimum weight of the loaded cask for the analyzed configurations is 221.98 kips. The weight for the MP187 cask transfer trailer is 40 kips, and for the transfer skid is 21 kips. Therefore, the total weight of the cask with transfer trailer and skid is expected to be at minimum 221.98+40+21 = 282.98 kips. Thus, assuming a minimum weight of 270 kips to calculate the resisting moment is conservative.

3. The MP187 transfer trailer length, width, and height dimensions are 264 inches, 10.5 feet and 42 inches, respectively. The length, width, and height of the transfer skid are 186 inches, 10.5 feet, and 15 inches, respectively (refer to Figure B.7-3). These dimensions are representative dimensions for NUHOMS® Systems' transfer equipment.

B.7.8.2 Material Properties

Material properties of the cask outer shell, top cover plate, and ram access cover plate at 400 °F are taken from [B.7-5]. The material properties for the analyzed components are summarized in Table B.7-7.

B.7.8.3 Design Criteria

For stability analyses, the permissible angle of rotation is considered to be equal to one third of the critical angle of rotation – i.e. the angle of tilt at which the center of gravity of the configuration is directly over the configuration's edge (tip-over angle).

Stress allowables are based on ASME Code, Section III, Division 1, Appendix F, [B.7-9].

For missile penetration analyses, the required material thickness is calculated using Nelms' formula from [B.7-10] and the Ballistic Research Laboratory methodology contained in [B.7-11].

B.7.8.4 Methodology

The following analyses are performed for the MP187 cask and components using hand calculations:

- stability analysis
- stress analysis
- penetration analysis

Methodology assumptions used in the evaluations are discussed below:

Stability Analysis Methodology

The stability evaluation for the overturning force caused by the DBT wind pressure is performed in Section B.7.8.6.1 by comparing the overturning moment acting on the cask-skid-trailer configuration (presented in Figure B.7-3) with the restoring moment of the assembly due to its self-weight. The analyses consider the lightest weights of the MP187 cask/canister configurations since they produce the smallest restoring moment.

The stability evaluation for the effects of seismic ground motion is performed in Section B.7.8.6.2 by comparing the overturning moment acting on the cask-skid-trailer configuration with the restoring moment of the assembly due its self weight. The seismic loads are conservatively assumed to act as constant (static) loads and the vertical acceleration is considered to act concurrently with the horizontal acceleration.

The stability evaluation for the tornado missile impact is conducted in Section B.7.8.6.3 using the equations of conservation of energy and conservation of angular momentum.

The stability evaluation for the combined tornado wind and missile load is performed in Section B.7.8.6.4 using the approximate force time-history of the missile impact from [B.7-11] and the standard equations of motion.

In the DBT wind effect evaluations, it is assumed that the combined geometry of the cask-skid-trailer system has a solid vertical projected area. The reduction in total wind pressure due to the open areas and shape factor is conservatively ignored.

Case B of Table B.7-5 (the massive high kinetic energy missile) is used for overturning stability of the cask since it produces the maximum force and the highest overturning moment. Conservatively, the impact is assumed as perfectly inelastic.

The tornado loads are generated for three separate loading phenomena. These phenomena are considered individually and then are considered in combination in accordance with Section 3.3.2 of NUREG-0800 [B.7-12] as follows:

1. Pressure or suction forces created by drag as air impinges and flows past the casks with a maximum tornado wind speed of 200 mph

2. Suction forces due to a tornado generated pressure drop or differential pressure load of 0.9 psi

3. Impact forces created by tornado-generated missiles impinging on the casks

Per [B.7-12], the total tornado load on a structure needs to be combined in accordance with formula:

$W_t = W_w + 0.5W_p + W_m$

where,

W_t = Total tornado load

W_w = Load from tornado wind effect

W_p = Load from tornado atmospheric pressure change

W_m = Load from tornado missile impact effect

Load from tornado atmospheric pressure change effect, Wp, in the above formula is ignored since temporary differential pressure load does not cause unbalanced loads on the symmetric design of the cask leading to overturning of the cask.

Stress Analysis Methodology

The stresses in the Cask Shell, Top Cover Plate (Lid) and Ram Closure Plate components due to DBT wind load and DBT missile load are calculated using the applicable analytic formulas for thin walled cylindrical vessels and flat circular plates, documented in [B.7-13].

The stresses evaluated in the analyzed components are:

- Primary Membrane Stress (P_M)
- Primary Membrane plus Bending Stress ($P_M + P_B$)

Stress allowables are based on the ASME Code, Section III, Division 1, Appendix F, [B.7-9].

The loads are specified in Sections B.7.8.5.1 and B.7.8.5.2 and are summarized in Table B.7-4 and Table B.7-5. Specific formulas used in the stress evaluations are presented in Section B.7.8.7.

Penetration Analysis Methodology

The critical thickness of plates that results in penetration by missile load is calculated by using Nelms' formula from [B.7-10] and the Ballistic Research Laboratory formula from [B.7-11]. These magnitudes are compared with the thickness of the Cask Shell, Top Cover Plate and Ram Closure Plate.

For this evaluation, the Case A missile (6" NPS Schedule 40 pipe, 15 ft. long) from Table B.7-5 is used. Missile Case B is judged less severe for penetration effects due to the large area of impact. Case C is judged less severe for penetration effects due to the much lower kinetic energy. The calculation evaluates missile impacts in the normal direction to the cask shell or plate to maximize penetration effect.

B.7.8.5 Design Input Loads & Data

DBT Velocity Pressure Load

The cask is evaluated for stress and overturning due to the Design Basis Tornado (DBT) loads specified in Table B.7-4. The DBT load characteristics correspond to those in Regulatory Guide 1.76 Region II parameters from [B.7-14] and ASCE 7-05 standard [B.7-8]. The MP187 cask dimensions and weight data are based on the design described in [B.7-5]. Load specifications are consistent with requirements of Section 3.3.2 of NUREG-0800 [B.7-12].

Per Table B.7-4 and per Section 6.5.10 of [B.7-8] (for the MP187 cask-skid-trailer assembly dimensions), the maximum velocity pressure load q_z at the height of the centroid of the analyzed assembly is

$$q_z = 0.00256\ K_z\, K_{dt}\, K_d\, I(v)^2$$
$$= 0.00256\ \times 0.87\ \times 1.0\ \times 1.0\ \times 1.15 \times\ 200^2 = 102.45\ \text{lb/ft}^2$$

Per Section 6.5.15 of [B.7-8], the design wind force, F, is calculated as:

$$F = q_z G C_f A_f = 102.45 \times 0.85 \times 0.82 \times 226 = 16.14\ kips.$$

In the above equation, the gust factor G=0.85 (per assumption 1 of Section B.7.8.1), the force coefficient C_f=0.82 (for cask-skid-trailer configuration dimensions), and the projected area normal to the wind for the analyzed assembly, A_f=226 ft^2. (for cask-skid-trailer dimensions).

DBT Generated Missile Impact Forces

The tornado-generated missile impact evaluation is performed for the missiles specified in Table B.7-5.

Automobile Missile (Table B.7-5 – Case B)

The impact force acting on the cask due to this missile is based on the Bechtel topical report ([B.7-11] equation D-6):

$$F = 0.625 \times V_i \times W_m \times \sin(20\,t) = 0.625 \times 134.81 \times 4000 \times \sin(20 \times 0.0785) \approx 340\,kip$$

In above equation:

t = time from the instant of initial impact (sec) = 0.0785 sec for maximum impact force to occur, [B.7-11]

V_i = total striking velocity of the missile

= $\sqrt{112^2 + (0.67 \times 112)^2} = 134.81$ fps (Table B.7-5)

W_m = weight of missile =4000 lb. (Table B.7-5)

Schedule 40 Pipe Missile (Table B.7-5 – Case A)

The impact force is calculated using the principle of conservation of momentum and the relation

$$F\Delta T = G_f - G_i$$

$$F = \frac{M_m(V_i - V_f)}{(T_f - T_i)} = \frac{M_m(V_i - V_f)}{(\Delta T)} = \frac{287 \times (134.81 - 0)}{32.2 \times 0.05 \times 1000} = 24.03\,kips$$

where:

ΔT = the time of contact = 0.05 sec (conservatively shorter than impact time 0.075 seconds, from [B.7-11])

$G_f = M_m V_f = 0$ the linear momentum after impact at time $T = T_f$

$G_i = M_m V_i$ the linear momentum at time $T = T_i$

V_i = total striking velocity of the missile

= $\sqrt{112^2 + (0.67 \times 112)^2} = 134.81$ fps (Table B.7-5)

M_m = the mass of the missile

B.7.8.6 Tornado & Missile Impact Loads Analysis - Stability Evaluations

Cask Stability for Design Basis Tornado Wind Pressure Load

The restoring moment will be the smallest for the assembly with minimum weight. Conservatively, the total weight of the loaded cask and transfer trailer and skid, W_c, is taken as 270 kips (refer to Section B.7.8.1, Assumption 2). The restoring moment, M_{st} = (Total Weight) × (Half Width of the Trailer) = 270 × 5.25 = 1,417.50 kips-ft.

The maximum overturning moment (M_{ot}) for the cask-skid-trailer due to DBT wind pressure is calculated by taking both the windward force and the leeward force into account. Conservatively, it is assumed that the wind loads on the windward side and leeward side are the same and are equal to the design wind load, F = 16.14 kips (calculated in Section B.7.8.5.1)

Per Figure B.7-3, the height corresponding to the centerline of the MP187 Cask is taken as the point of load application: H=(42+15+83.5/2) = 98.75 inches = 8.23 ft.

Therefore, the overturning moment, M_{ot} = 2×F×H = 2× 16.14 x (8.23) = 265.66 kip-ft

Factor of safety against overturning $\dfrac{M_{st}}{M_{ot}} = \dfrac{1417.50}{265.66} = 5.34$

Cask Stability for Massive Missile Impact Load

A stability analysis is performed to analyze the most critical impact, when the missile hits the cask on the side. However, it is conservatively assumed that the missile hits the top most point of the cask as shown in Figure B.7-4.

The Case B missile from Table B.7-5, i.e. the massive high kinetic energy automobile missile, is used since it produces the maximum force and the highest overturning moment. Conservatively, the impact is assumed as perfectly inelastic

Using the geometrical relations of Figure B.7-4 and the missile characteristics from Table B.7-5, the evaluation is based on conservation of momentum at impact and the conservation of energy to estimate the angle of rotation, θ, due to the impact (cask stops rotating when the angular velocity after impact becomes zero).

The resultant formula for the angle of rotation due to impact, θ, for the analyzed geometry has the following form:

$$\sin(\phi + \theta) = \frac{(R_1 V_i M_m)^2}{2W_c R_2[(I_c)_o + R_1^{\,2} M_m]} + \sin\phi$$

with:

$\phi = \tan^{-1}(L_1/R) = \tan^{-1}(\frac{42+15+83.5/2}{5.25\times12})$

= 57.46° (refer to Figure B.7-3 and Figure B.7-4),

$(H_i)_o$ = the angular momentum about point O before impact $= R_1 V_i M_m$ (Figure B.7-4),

$(H_a)_o$ = the angular momentum about point O after impact $= R_1{}^2 \omega_i M_m + (I_c)_o \omega_i$ (Figure B.7-4),

R_1 $= \sqrt{L^2 + R^2} = \sqrt{11.71^2 + 5.25^2} = 12.83\ ft$ is the distance from point O to the impact point (Figure B.7-4),

R_2 $= \sqrt{L_1{}^2 + R^2} = \sqrt{8.23^2 + 5.25^2} = 9.76\ ft$ is the distance from point O to the center of the cask. (Figure B.7-4),

V_i = total striking velocity of the missile = $\sqrt{112^2 + (0.67\times112)^2} = 134.81$ fps (Table B.7-5),

M_m = the mass of the missile (4000/32.2 = 124.22 lbm, per Table B.7-5),

W_c = the minimum weight of the cask assembly (270 kips),

$(I_c)_o$ = the mass moment of inertia of the cask about an axis through point O,

$(I_c)_o = (I_c)_{CG} + M_c R_2{}^2$ (from the parallel axis theorem),

M_c = the mass of the cask assembly (270×1000)/32.2=8385.09 lbm,

$(I_c)_{CG}$ = the mass moment of inertia of the cask about center of gravity of MP187 cask.

Conservatively, $(I_c)_{CG} = \frac{M_c R_c{}^2}{2} = \frac{8385.09\times3.48^2}{2} = 50{,}773.40\ ft^2 lbm$

Ultimately, angle of rotation due to impact can be determined as:

$$\theta = sin^{-1}(0.8531) - \emptyset = 58.55° - 57.46° = 1.09°$$

Tip over occurs when the C.G. is directly above the point of rotation, therefore the tip over angle is $\theta_{tip} = 90.0° - 57.46° = 32.54°$, and $1/3\,\theta_{tip} = 1/3 \times 32.54° = 10.85°$. Since $\theta < 1/3 \times \theta_{tip}$, the tip over of the cask will not occur.

Cask Stability for Design Basis Tornado Wind and Missile Load Combination

A time-dependent analysis is performed to determine the maximum angle of rotation attained by the cask-skid-trailer assembly due to concurrent DBT wind and missile loading. The input loading is the summation of the wind pressure loading from Section B.7.8.5.1 and the massive missile impact force from Section B.7.8.5.2. The standard equations of rotational motion are solved with an approximate step-wise linear procedure to determine the rotational motion of the assembly subjected to the combined wind and missile loading.

The overturning moment causing rotational acceleration is:

$$M_{acc} = M_{ot} - M_{st}$$

The angular velocity is:

$$\omega_i = \frac{\left[\frac{M_{acc,i} + M_{acc,i-1}}{2} * (t_i - t_{i-1})\right]}{(I_c)_o} + \omega_{i-1}$$

The angle of rotation is:

$$\theta_i = \left[\frac{\omega_i + \omega_{i-1}}{2} * (t_i - t_{i-1})\right] + \theta_{i-1}$$

where,

i = index for the current time step

$i-1$ = index for the previous time step

In the above equations the overturning moment and stabilizing moments are, respectively:

$$M_{ot} = F_{missile} * \mathrm{L} + \mathrm{q}_z * L_\theta^2 * \mathrm{L}_T$$

$$M_{st} = W_c * R_2 * \cos(\emptyset + \theta)$$

where:

L_θ = height to the top of cask system which is dependent on rotation angle θ,

L = 42+15+83.5=140.5 inch, initial total height of the cask system (Figure B.7-3),

L_T = 264 inch, length of trailer (Section B.7.8.1)

$F_{missile}$ $= 0.625 V_i W_m sin(20t)$, missile force, refer to Section B.7.8.5.2, per Ref. [B.7-11], equation D-6

W_c = 270 kips, is the minimum weight of the cask assembly (Section B.7.8.1),

R_2 = 9.76 ft, is the distance from point O to the center of the cask. (Figure B.7-4).

The solution to the equation of motion is documented in Figure B.7-5. The governing angle of rotation is θ=3.0°.

As indicated in Section B.7.8.6.3, the tip over angle $\theta_{tip} = 32.54°$ and $1/3 \times \theta_{tip} = 10.85°$. Since $\theta < 1/3 \times \theta_{tip}$, the tip over of the cask will not occur.

B.7.8.7 Tornado Wind and Missile Analysis - Stress Evaluations

Stress evaluations for cask components exposed to tornado loads are discussed below. The evaluations consider the cask as a thin walled vessel and the cover plates as simply supported thin circular plates, and use stress formulas from [B.7-13] appropriate for the analyzed load characteristics. Specifications of the stress formulas and basic assumptions employed in the analyses are summarized below. Stress results are listed in Table B.7-8 and Table B.7-9.

Stress Formulas Used in Tornado Loads Evaluations		
Load Description	**Component Analyzed**	**Stress Formula Reference & Assumptions**
Wind Pressure Load	Outer Shell	[B.7-13], case 8c from Table 13.3, page 650; Simply supported thin cylindrical shell, subjected to a uniform pressure load over the entire length
	Top Cover Plate	[B.7-13], case 10a from Table 11.2, page 509; Simply supported thin circular plate, subjected to a uniform pressure load over the entire area
	RAM Closure Plate	[B.7-13], case 10a from Table 11.2, page 509; Simply supported thin circular plate, subjected to a uniform pressure load over the entire area
Massive Missile Load	Outer Shell	[B.7-13], case 8b from Table 13.3, page 650; Simply supported thin cylindrical shell, subjected to a concentrated load over the short length
	Top Cover Plate	[B.7-13], case 10a from Table 11.2, page 509; Simply supported thin circular plate, subjected to a uniform load over the entire area
	RAM Closure Plate	[B.7-13], case 10a from Table 11.2, page 509; Simply supported thin circular plate, subjected to a uniform load over the entire area
Local	Outer Shell	[B.7-13], case 8a from Table 13.3, page 649; Simply supported thin cylindrical shell, subjected to load P distributed over a

Load		small area at midspan
	Top Cover Plate	[B.7-13], case 16 from Table 11.2, page 514; Simply supported thin circular plate, subjected to a load over the small central area
	RAM Closure Plate	[B.7-13], case 16 from Table 11.2, page 514; Simply supported thin circular plate, subjected to a load over the small central area

B.7.8.8 Tornado Missile Analysis - Penetration Evaluations

Nelms' Formula Evaluation

Nelms' formula [B.7-10] is used to determine the thickness value due to incipient puncture energy, which is directly proportional to the mass and velocity of the missile and inversely proportional to the diameter of the missile.

$$E_F = \frac{1}{2} M_m V_m^{\ 2}$$

$$E_F / S = 2.4 d^{1.6} t^{1.4}$$

where:

M_m = the mass of the missile (287 lbs)/(32.2 ft/sec^2) = 8.91 lbm,

V_m = the total velocity of the striking missile normal to target surface (=134.81 fps),

S = the ultimate tensile strength of the jacket material (refer to Table B.7-7),

t = the maximum thickness of plate material leading to onset of plate puncture (inch),

d = the diameter of the punch/missile (6.625 inch, refer to Table B.7-7),

E_F = the incipient puncture energy of the prismatic cask jacket (inch - lb).

The threshold thickness values causing perforation for the Outer Shell, Top Cover Plate and RAM Closure Plate according to Nelms' correlation are 0.43 inch, 0.43 inch, and 0.43 inch, respectively.

Ballistic Research Laboratory Formula Evaluation

In the Ballistic Research Laboratory report, the relation for the determination of the thickness is also directly proportional to mass and velocity and inversely proportional to diameter of the missile.

$$t = \frac{\left(\frac{M_m V_m^2}{2}\right)^{2/3}}{672d} = 0.42 \text{ inch}$$

In the above relation:

t = the maximum thickness of plate material leading to onset of plate puncture (inch),

d = the diameter of the punch/missile (= 6.625 inch),

M_m = the mass of the striking missile, (=287/32.2 = 8.91 lbm),

V_m = the velocity of the striking missile normal to target surface (=134.81 fps).

Reference [B.7-11] recommends increasing the thickness, t, by 25 percent to prevent perforation. Therefore, the minimum thickness required to prevent perforation of the MP187 cask is 0.53 inch.

B.7.8.9 Summary of Results

The factor of safety on overturning from DBT tornado wind pressure load is 5.34.

The resultant stresses for the bounding individual DBT, missile impact and combined tornado load are summarized in Table B.7-8 and Table B.7-9, respectively. The primary membrane stress and combined membrane plus bending stresses due to DBT and missile impact are below the allowable stresses.

The minimum thickness of the steel components required to prevent perforation by tornado missiles is found to be 0.53 inch, which is less than the thickness of the MP187 cask Outer Shell, Top Cover Plate, and RAM Closure Plate of 2.49 inches, 6.50 inches, and 3.18 inches, respectively.

The maximum rotation angle of the MP187 cask transfer configuration due to combined tornado wind plus massive missile impact load is θ=3.0°, which is significantly below the permissible angle of rotation, 10.85°.

B.7.9 Structural Evaluation of 24PT1-DSC Confinement Boundary under Normal Conditions of Transport

The 24PT1-DSC shell assembly consists of a cylindrical shell, top outer/inner cover plates, bottom inner/outer cover plates and bottom and top shield plugs. The 24PT1-DSC consists of a shell, which is a welded, stainless steel cylinder with a stainless steel bottom closure assembly, and a stainless steel top closure assembly. Additional details, geometry and shell and plate thicknesses are provided on the drawings in Section B.4.6. The confinement boundary is addressed in Section B.11.1. The 24PT1-DSC shell is evaluated for Normal Conditions of Transport in the MP187 Transport cask in Section A.7.7.2 with the FO-DSC of the NUHOMS® MP187 Cask System.

Result of the FO- and 24PT1 DSCs structural analysis are acceptable for the loads and combinations described in Table A.7-3 and hence structurally adequate for normal conditions of transport loading conditions.

B.7.10 References

B.7-1 TN Document, ANUH-01.0150, Revision 6, "Updated Final Safety Analysis Report for the Standardized Advanced NUHOMS® Horizontal Modular Storage System for Irradiated Nuclear Fuel, NRC Docket No. 72-1029.

B.7-2 U.S. Nuclear Regulatory Commission, "License for Independent Storage of Spent Nuclear Fuel and High-Level Radioactive Waste," License Number SNM-2510, Docket Number 72-11.

B.7-3 U.S. Nuclear Regulatory Commission, "Certificate of Compliance No. 9255, Revision 12 for the Model No. NUHOMS®-MP187 Multi-Purpose Cask (Docket 71-9255).

B.7-4 "Rancho Seco Independent Spent Fuel Storage Installation Safety Analysis Report," NRC Docket No. 72-11, Revision 4.

B.7-5 TN Document NUH-05-151 Rev. 17, "NUHOMS®-MP187 Multi-Purpose Transportation Package Safety Analysis Report." (Basis for NRC CoC 71-9255).

B.7-6 U.S. Nuclear Regulatory Commission, Certificate of Compliance for the Standardized Advanced NUHOMS® Horizontal Modular Storage System for Irradiated Nuclear Fuel, Certificate No. 1029.

B.7-7 TN Document NUH-003, Revision 14, "Updated Final Safety Analysis Report for the Standardized NUHOMS® Horizontal Modular Storage System for Irradiated Nuclear Fuel." (Basis for NRC CoC 72-1004).

B.7-8 American Society of Civil Engineers Standard ASCE 7-05, "Minimum Design Loads for Buildings and Other Structures," (Formerly ANSI A58.1).

B.7-9 ASME Boiler and Pressure Vessel Code, Section III, Appendix F, 2004 Edition with 2006 Addenda.

B.7-10 H.A. Nelms, "Structural Analysis of Shipping Casks, Effects of Jacket Physical Properties and Curvature on Puncture Resistance," Vol. 3, ORNL TM-1312, Oak Ridge National Laboratory, Oak Ridge Tennessee, June 1968.

B.7-11 R.B. Linderman, J.V. Rotz and G.C.K. Yek "Design of Structures for Missile Impact," Topical Report BC-TOP-9A, Bechtel Power Corporation, Revision 2, September 1974.

B.7-12 U.S. NRC Document, NUREG-0800, Section 3.3.2, Revision 3, "Tornado Loads," Standard Review Plan (Formerly NUREG-76/087), 2007.

B.7-13 R.G Budynas and W.C Young, "Roark's Formula for Stress and Strain," Eighth Edition, McGraw-Hill Book Company.

B.7-14 Reg Guide 1.76, "Design-Basis Tornado And Tornado Missiles For Nuclear Power Plants," Revision 1, March 2007.

Table B.7-1
Configuration of the FO-DSC Compared to the 24PT1 DSC (from Table A2.1-1 of [B.7-5])

Characteristic	FO-DSC Configuration	24PT1-DSC Configuration
Shell Outside Diameter x Length	67.19 " x 186.5"	67.19" x 186.5"
DSC Internal Cavity Length	167.0"	167.0"
Shell (SA240)	5/8" thick, Type 304	5/8" thick, Type 316
Support Rod Diameter/Preload	2"/80 +/- 5 kips	1.25"/40 +/- 15 kips
Support Rod Spacer Sleeves, Outside Dia./Inside Dia.	3" / 2.08"	3" / 1.33"
Spacer Discs (Number-Material)	26 – SA537, Cl 2	26 – SA537, Cl 2
Spacer Disc Spacing	See Section 1.3.2 of [B.7-5] for spacing	See Section A1.3.2 of [B.7-5] for spacing
Guidesleeves (inside width x length)	8.9" x 161.8"	8.9" x 165.25"
Top and Bottom Fuel Spacers	Not Required	See Section A1.3.2 of [B.7-5]
Failed Fuel Cans	Not Permitted	Up to four, symmetrically loaded (similar to FF-DSC)

Table B.7-2
Comparison of Canister Weights, Centers of Gravity and Moments of Inertia
(from Table A2.2-1 of [B.7-5])

Parameter	FO-DSC	FC-DSC	FF-DSC	24PT1-DSC
Total Canister weight (lbs)	80,710	81,120	74,900	78,400[1,2]
Canister cg location, along center line of canister, with respect to the outer surface of the MP187 Cask bottom cover plate (inches)	100.4	98.7	102.4	99.3
Canister MOI (lbm-in^2), relative to cg	3.36E+08	2.88E+08	3.03E+08	3.29E+08

1 This weight is increased by 1,000 lbs. when four failed fuel cans are included in the canister.

2 This weight is made up of (rounded to nearest 100 lbs.):

Shell Assembly	15,600 lbs.
Basket Assembly	18,500 lbs.
Shield Plug	8,000 lbs.
Inner Cover Plate	700 lbs.
Outer Cover Plate	1,200 lbs.
Fuel Spacers	2,700 lbs.
WE 14x14 fuel/including NFAH	31,700 lbs.

Table B.7-3
MP187 and OS197 Casks – Comparison of Basic Design Parameters

Parameter	MP187 Cask	OS197 Cask
Outer Shell Thickness (*in*)	2.49	1.50(1)
Inner Shell Thickness *(in)*	1.24	0.50
Bottom End Closure Thickness *(in)*	8.00	5.00
Top Lid Thickness (*in*)	6.50	5.25
Lead Gamma Shield Thickness *(in)*	4.00	3.56
Cask Body Outer Diameter (*in*)	83.50	79.12
Cask Cavity Diameter *(in)*	68.00	68.00
Cask Rails Locations (from bottom centerline)	±30.0º	±18.5º
Cask Rail Thickness (*in*)	0.12	0.12
Overall Length of Cask Body (*in*)	201.50	207.22
Cavity Length (*in*)	187.00	196.75
Cask Weight (Dry, Empty) (*kips*)	158.58	111.25
Cask Weight (Dry, Loaded) (*kips*) w/ bounding FC-DSC	239.70	N/A
Cask Weight (Dry, Loaded) (*kips*) w/ 24PT1 DSC	237.20	189.65

Note: (1) Thickened to 2.00 inches at upper trunnion regions

Table B.7-4
DBT Wind Load Characteristics for WCS CISF

Design Parameter	Design Criteria
Maximum wind speed	200 miles per hour
Maximum rotational speed	160 miles per hour
Translational speed	40 miles per hour
Radius of the maximum rotational speed	150 feet
Pressure drop across the tornado	0.9 psi
Rate of pressure drop	0.4 psi per second

Table B.7-5
Design-Basis Tornado Missile Spectrum and Maximum Horizontal Speeds

Case #	Missile	Weight (lb)	Horizontal Impact Velocity V_{MH}^{max} (fps)
A	Schedule 40 Pipe (ϕ 6.625 inch x 15 ft long)	287	112
B	Automobile (16.4 ft x 6.6 ft x 4.3 ft)	4,000	112
C	Solid Steel Sphere (ϕ 1 inch)	0.147	23

Note: V_{MH}^{max} = Horizontal velocity of missile, vertical velocity of missile = 0.67 V_{MH}^{max}

Table B.7-6
NUHOMS®-MP187 Cask and Canister Weights for Analyzed Configurations

	Configuration of Cask/DSC for MP187 Cask			
	Configuration	**(Ref. [B.7-5, Table 2.1.2-1])**	**(Ref. [B.7-5, Table A2.2-1])**	
Case No.	**Cask/Canister**	**Weight of Cask without NSP Assembly (lb)**	**DSC Weight (lb)**	**Total Weight (lb)**
1	MP187/FC-DSC	147,080	81,120	228,200
2	MP187/FO-DSC	147,080	80,710	227,790
3	MP187/FF-DSC	147,080	74,900	221,980
4	MP187/24PT1 DSC (14x14 Fuel Assembly)	147,080	78,400	225,475

Table B.7-7
Materials, Properties and Allowable Stresses for MP187 Cask at 400 ºF

Material Properties for MP187 at 400°F							
Component	**Material**	**S_m (ksi)**	**S_y (ksi)**	**S_u (ksi)**	**E (10^3 ksi)**	**Primary Membrane (ksi)**	**Primary Membrane plus Bending (ksi)**
Top Structural Shell (4)	SA-240 Type 304	18.7	20.7	64.4	26.5	44.90	64.40
Bottom Structural Shell (4)	SA-240 Type XM-19	30.2	40.8	90.7	26.5	63.50	90.70
Ram Access Closure Plate	SA-240 Type XM-19	30.2	40.8	90.7	26.5	63.50	90.70
Top Closure Plate	SA-240 Type 304	18.7	20.7	64.4	26.5	44.90	64.40

Note:

1. Primary Membrane stress for Service Level D, $P_m \leq$ min ($2.4S_m$, $0.7S_u$) (Ref. [B.7-9])
2. Membrane plus Bending stress for Service Level D, $P_m + P_b \leq$ min ($3.6S_m$, S_u) (Ref. [B.7-9])
3. Material properties are taken from Ref. [B.7-5].
4. Conservatively, material properties of the top structural shell are used in the evaluation as the allowables are less and will bound bottom structural shell as well.

Table B.7-8
Stress Results for MP187 Cask due to Tornado Wind and Missile Loads

MP187 Cask Results						
Load Description	Stress Category	Calculated Stress (ksi)			Allowable Stress (ksi)	Impact Force
		Structural Shell	Top Cover Plate	Ram Access Closure Plate		
Wind Pressure Load	Primary Membrane	0.19	0.00		44.9	16.14 kips
	Primary Membrane plus Bending	0.72	0.04		64.4	
	Primary Membrane			0.00	63.5	
	Primary Membrane plus Bending			0.15	90.7	
Massive Missile Loads	Primary Membrane	15.37	0.07		44.9	340 kips
	Primary Membrane plus Bending	55.21	3.24		64.4	
	Primary Membrane			1.50	63.5	
	Primary Membrane plus Bending			14.74	90.7	
Local Load	Primary Membrane	1.24	0.70		44.9	24.03 kips
	Primary Membrane plus Bending	3.88	1.87		64.4	
	Primary Membrane			0.70	63.5	
	Primary Membrane plus Bending			5.57	90.7	

Table B.7-9
Combined Tornado Effect on MP187 Cask – Stress Results

Load Description	Stress Category	Combined Stress (ksi)			Allowable Stress (ksi)
		Structural Shell	Top Closure Plate	Ram Access Closure Plate	
Wind Pressure Load + Missile Load	Primary Membrane	15.56	0.07		44.9
	Primary Membrane plus Bending	55.93	3.28		64.4
	Primary Membrane			1.50	63.5
	Primary Membrane plus Bending			14.90	90.7

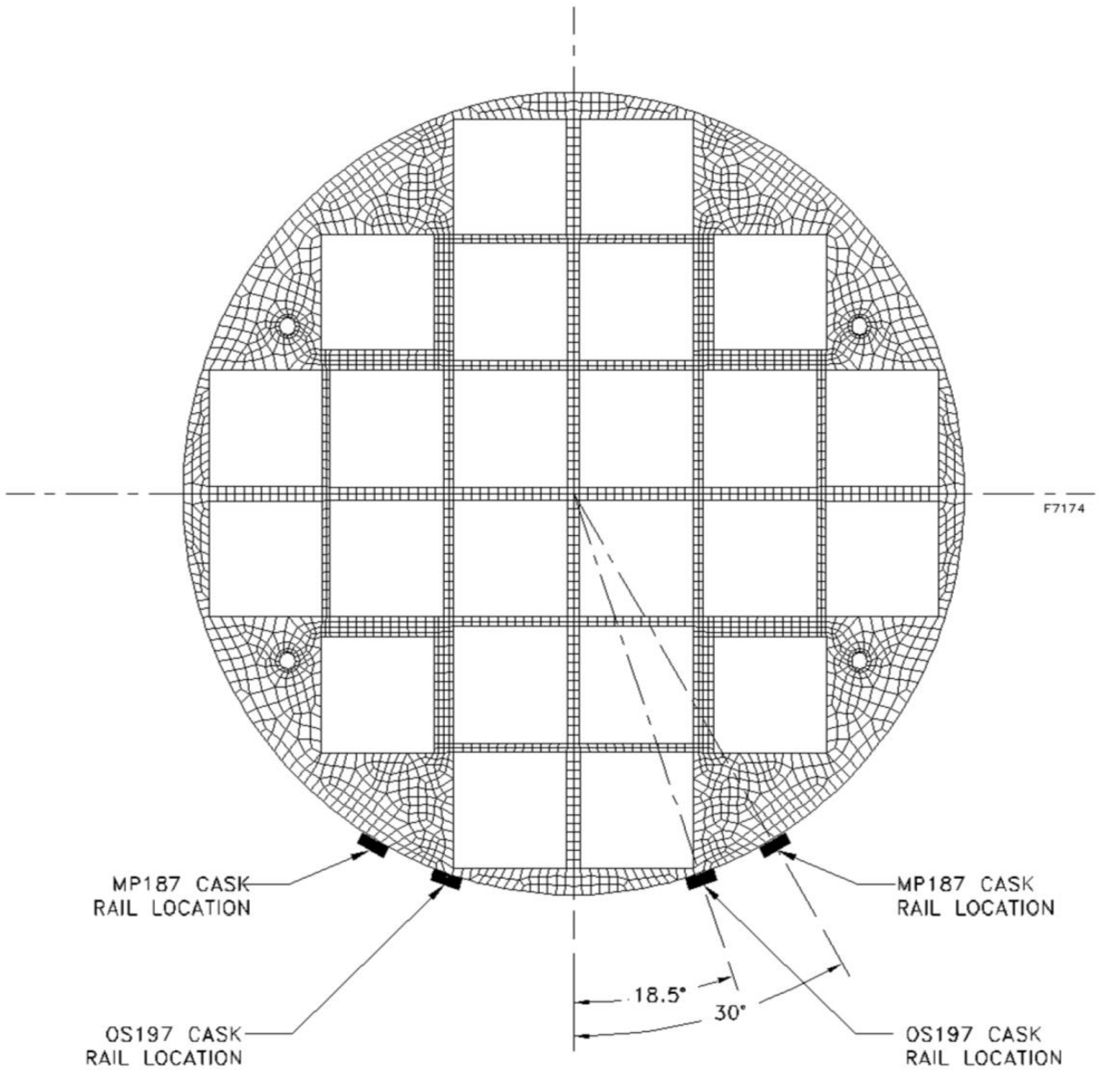

Figure B.7-1
Location of Cask Rails in the MP187 and OS197 Casks

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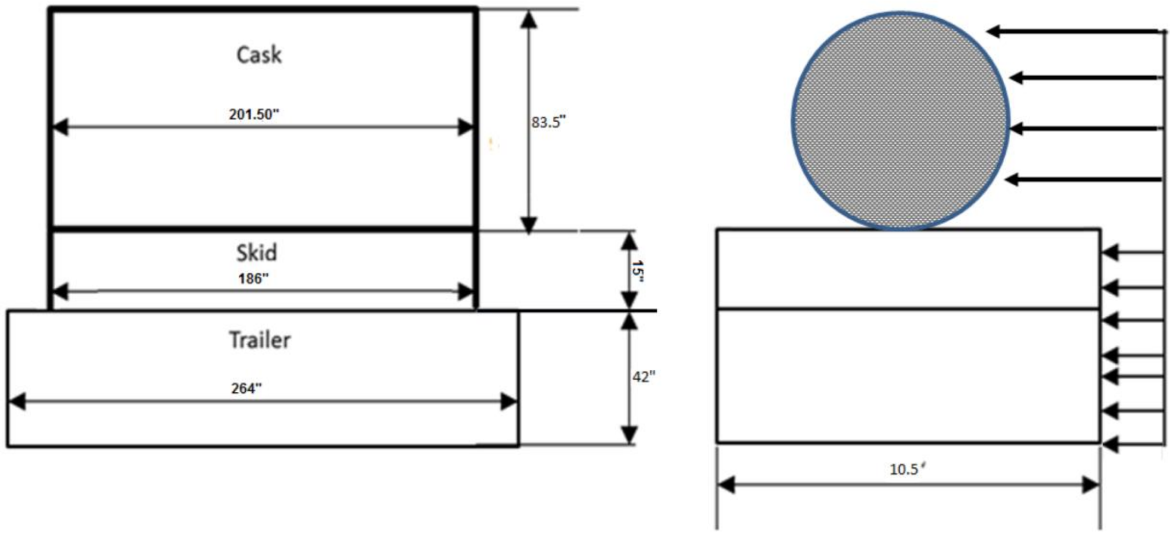


Figure B.7-3
Arrangement of MP187 Cask Shell, Skid and Trailer at Rest

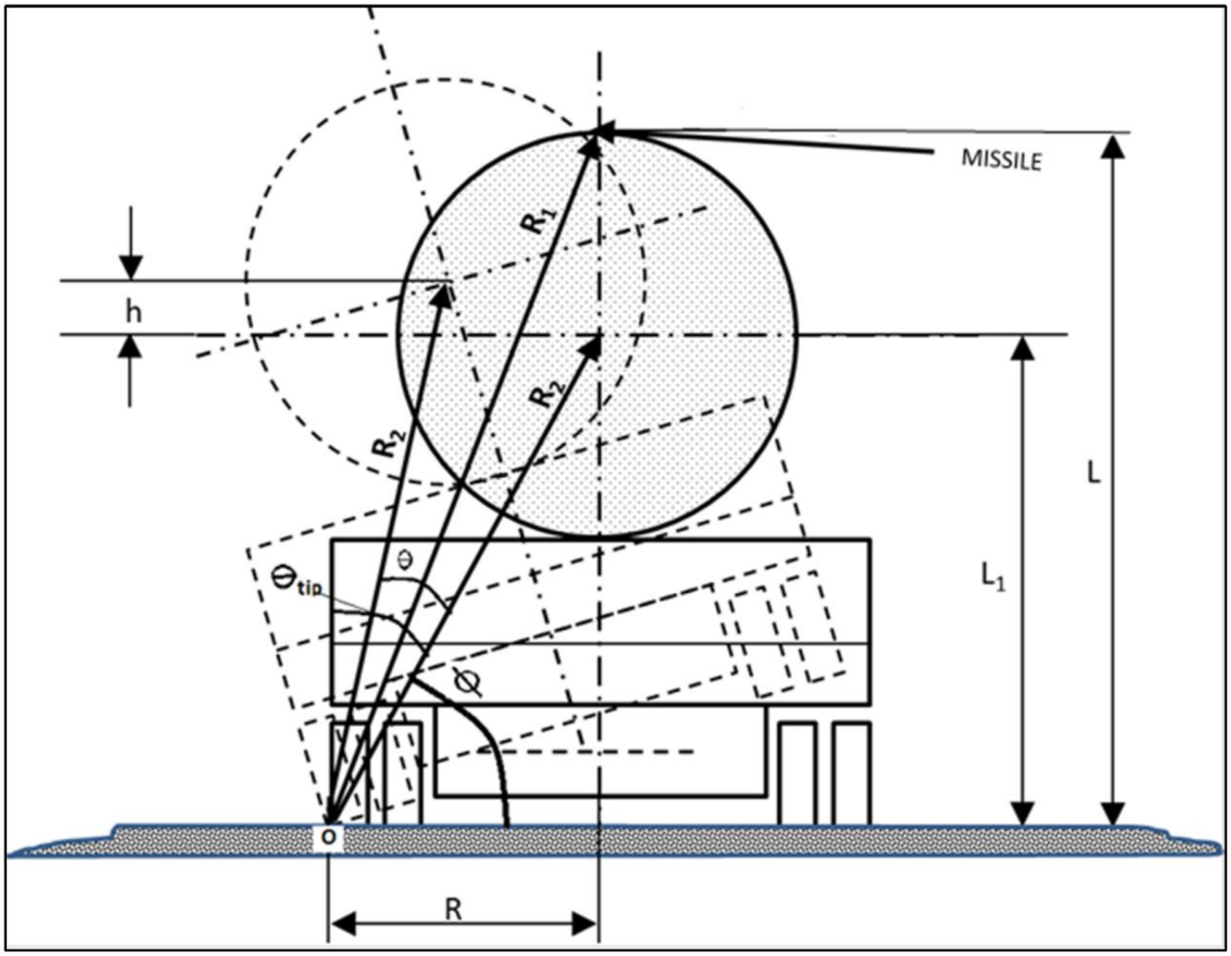


Figure B.7-4
Geometry Utilized in Cask Stability Assessments

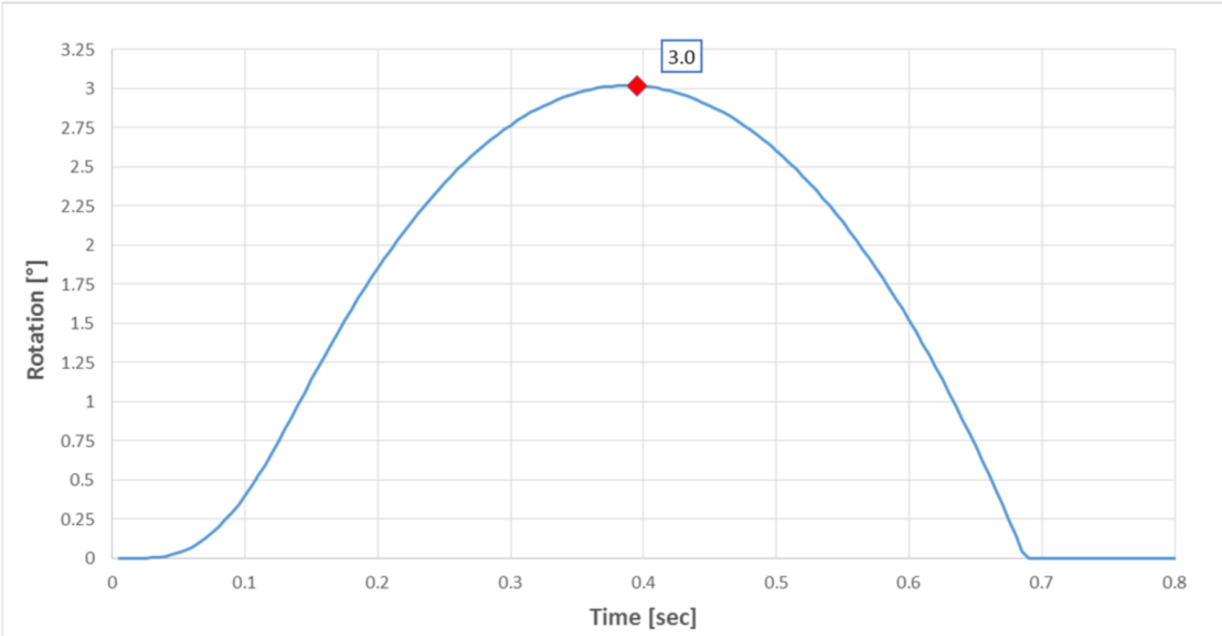


Figure B.7-5
Angle of Rotation due to Wind and Massive Missile Loading Combination

APPENDIX B.8
THERMAL EVALUATION
Standardized Advanced NUHOMS® System

Table of Contents

B.8. THERMAL EVALUATION B.8-1

B.8.1 Discussion B.8-2

B.8.2 Summary of Thermal Properties of Materials B.8-3

B.8.3 Specification for Components B.8-4

B.8.4 Ambient Conditions at the WCS CISF B.8-5

B.8.4.1 Ambient Temperature Specification at WCS CISF B.8-5

B.8.4.2 Comparison of WCS CISF Ambient Conditions with Ambient Conditions Used in the AHSM Thermal Evaluation from ANUH UFSAR [B.8-1] for Storage Conditions B.8-5

B.8.4.3 Comparison of WCS CISF Ambient Conditions with Ambient Conditions Used in the Rancho Seco ISFSI SAR [B.8-4] for Transfer Conditions B.8-5

B.8.5 Thermal Analysis of AHSM with 24PT1 DSC for Storage Conditions B.8-6

B.8.5.1 Thermal Model of the AHSM with 24PT1 DSC B.8-6

B.8.5.2 AHSM Thermal Model Results B.8-6

B.8.5.3 Evaluation of AHSM Performance with 24PT1 DSC B.8-7

B.8.5.4 NUHOMS®-24PT1 DSC Basket Model Results B.8-7

B.8.6 Thermal Analysis of MP187 Transfer Cask with 24PT1 DSC for Transfer Conditions B.8-8

B.8.6.1 Evaluation of MP187 Cask Performance B.8-9

B.8.7 References B.8-10

B.8. THERMAL EVALUATION

This Appendix qualifies the Standardized Advanced NUHOMS® System for storage and transfer at the WCS Consolidated Interim Storage Facility (WCS CISF) with the same heat load of 14 kW under the WCS CISF environmental conditions. No new thermal analysis is performed in this Appendix. This qualification demonstrates that all the 10 CFR Part 72 thermal requirements for storage and transfer of the 24PT1 Dry Shielded Canisters (DSCs or canisters) at the WCS CISF are met.

As presented in Chapter 1, Table 1-1, the Standardized Advanced NUHOMS® System storage components include the 24PT1 DSC and the AHSM concrete overpack.

The 24PT1 DSC is described in Section 3.1.1.1 of the Standardized Advanced NUHOMS® Updated Final Safety Analysis Report (UFSAR) [B.8-1]. The AHSM is described in Section 3.1.1.2 of the UFSAR [B.8-1].

At the WCS CISF, the NUHOMS®-MP187 cask will be used for on-site transfer operations. The MP187 cask is a multi-purpose cask approved by the NRC as a transportation cask for off-site shipments of the 24PT1 DSC [B.8-2]. This Appendix qualifies the thermal design of the MP187 cask for transfer operations with the 24PT1 DSC.

B.8.1 Discussion

As discussed in Chapter 1, loaded 24PT1 DSCs from an existing ISFSI site are to be transported to the WCS CISF inside a NUHOMS®-MP187 Multi-Purpose Cask [B.8-2] under NRC Certificate of Compliance 9255 [B.8-3]. At the WCS CISF, the 24PT1 DSCs are to be stored inside AHSM modules described in the Standardized Advanced NUHOMS® Updated Final Safety Analysis Report [B.8-1]. The MP187 cask is also to be used for on-site transfer of loaded 24PT1 DSCs.

A description of the 24PT1 DSC and AHSM design features is presented in Section 3.1.1.1 and 3.1.1.2, respectively of [B.8-1]. The thermal analysis for storage of the 24PT1 DSC inside the AHSM module is presented in Chapter 4 of [B.8-1]. This Appendix reconciles the thermal evaluation performed in [B.8-1] for the storage of the 24PT1 DSC in the AHSM for normal, off-normal and accident conditions at the WCS CISF.

A description of the MP187 Cask is presented in Volume 1, Section 4.2.5.3 of the Rancho Seco SAR [B.8-4] and is licensed at that site for on-site transfer of FO- FC- FF- DSCs and GTCC waste canisters. The use of the NUHOMS® MP187 Cask for the on-site transfer of the 24PT1 DSC at the WCS CISF under 10 CFR Part 72 is qualified in this Appendix.

B.8.2 Summary of Thermal Properties of Materials

The thermal properties of the materials used in the analysis of the AHSM storage module and the 24PT1 DSC are described in Section 4.2 of [B.8-1]. The thermal properties of the materials used in the analysis of the MP187 Cask are discussed in Volume III, Section 8.1.1.1 of the Rancho Seco SAR [B.8-4].

B.8.3 Specification for Components

Allowable temperature ranges for the structural materials used in the design are given in Table 4.1-3, Table 4.1-4, and Table 4.1-5 of [B.8-1].

B.8.4 Ambient Conditions at the WCS CISF

B.8.4.1 Ambient Temperature Specification at WCS CISF

As specified in Table 1-2, normal ambient temperature is considered in the range of 44.1°F to 81.5°F. Off-normal ambient temperature is considered in the range of -30.1°F to 113°F. Accident ambient temperature is considered as 113°F.

B.8.4.2 Comparison of WCS CISF Ambient Conditions with Ambient Conditions Used in the AHSM Thermal Evaluation from ANUH UFSAR [B.8-1] for Storage Conditions

A review of the ambient temperatures used in the thermal evaluation of AHSM in Section 4.1.2 of [B.8-1] shows that average daily ambient temperatures of 97°F and 107°F corresponding to a maximum ambient temperatures of 101°F and 117°F are used for normal and off-normal hot storage conditions, respectively. These temperatures bound the ambient temperatures for normal and off-normal conditions at the WCS CISF. In addition, the accident ambient temperature of 113°F listed in Table 1-2 for the WCS CISF is the daily maximum ambient temperature. This is bounded by the daily maximum temperature of 117°F considered for the off-normal conditions. The lowest off-normal ambient temperature evaluated is the -40°F considered for the off-normal conditions as noted in Table 4.1-1 of [B.8-1].

Based on this discussion, the ambient conditions used for the thermal evaluations for storage operations in the thermal evaluation of AHSM in [B.8-1] are bounding for the WCS CISF.

B.8.4.3 Comparison of WCS CISF Ambient Conditions with Ambient Conditions Used in the Rancho Seco ISFSI SAR [B.8-4] for Transfer Conditions

A review of the thermal evaluation presented in Section 8.1.1.1, Volume II of [B.8-4] shows that average daily ambient temperatures of 101°F and 117°F are used for normal and off-normal hot storage conditions, respectively. These temperatures bound the ambient temperatures for normal, off-normal, and accident conditions, respectively at the WCS CISF. Similarly, the lowest off-normal ambient temperature at the WCS CISF is 30.1°F and is bounded by the -20°F, cold conditions considered in [B.8-4].

Based on this discussion, the ambient conditions used for the thermal evaluations for transfer operations in [B.8-4] are bounding for the WCS CISF.

B.8.5 Thermal Analysis of AHSM with 24PT1 DSC for Storage Conditions

As discussed in Section B.8.1, 24PT1 DSCs will be stored inside the AHSM storage modules at the WCS CISF. This configuration for storage operations is approved under CoC 1029 and a discussion on the thermal evaluation for this configuration is presented in Chapter 4 of [B.8-1]. Because this configuration is previously approved, this section only presents a reconciliation of the ambient temperatures between the thermal evaluation in [B.8-1] and the WCS CISF.

Based on this discussion in Section B.8.4.2, the ambient conditions used for the thermal evaluations of AHSM in [B.8-1] are bounding for the WCS CISF and therefore, no additional evaluations are performed. Sections B.8.5.2 through B.8.5.4 present the references to the appropriate section within [B.8-1] as it relates to the thermal evaluations performed for 24PT1 DSC during storage in AHSM.

B.8.5.1 Thermal Model of the AHSM with 24PT1 DSC

The HEATING7 thermal model of the AHSM used for evaluation of normal and off-normal conditions of the AHSM components is described in Section 4.4.2.2 of [B.8-1].

The thermal model used for the evaluation of the AHSM components for a 40-hour AHSM blocked vent accident is essentially the same as that described in Section 4.4.2.2 of [B.8-1] with minor modifications as described in Section 4.6.2.2 of [B.8-1]. The thermal model of the 24PT1 DSC basket is described in Section 4.4.4.1 of [B.8-1].

B.8.5.2 AHSM Thermal Model Results

Normal and Off-Normal Conditions:

As documented in Section 4.4.2.2 of [B.8-1], the AHSM is qualified for a heat load of 24 kW. The design basis heat load for the AHSM at the WCS CISF for storage of the 24PT1 DSC is 14 kW.

The AHSM thermal model results presented in Table 4.4-3 and Table 4.4-5 of [B.8-1] are evaluated for a heat load of 24 kW. These tables present the maximum temperatures of the AHSM concrete, heat shields, DSC steel support structure, DSC shell and the DSC shell assembly subcomponents for normal and off-normal conditions. The calculated maximum temperatures of the AHSM and the 24PT1 DSC subcomponents are below their respective allowable material limits listed in Table 4.1-3 and Table 4.1-4 of [B.8-1]. These results bound the results of a 24PT1 DSC/AHSM with a 14 kW heat load stored at the WCS CISF for normal and off-normal conditions.

AHSM Blocked Vent Accident

The AHSM thermal model results for a 40-hour blocked vent accident are presented in Table 4.4-3 and Table 4.4-5 of [B.8-1]. Theses tables present the maximum temperatures of the AHSM and 24PT1 DSC shell assembly subcomponents based on a design basis heat load of 24 kW. The calculated maximum temperatures are below the allowable material limits listed in Table 4.1-5 of [B.8-1]. These results bound the results for AHSM/24PT1 DSC with a 14 kW heat load at the WCS CISF for accident conditions.

The bounding internal pressure for the 24PT1 DSC for normal, off-normal and accident conditions of storage are listed in Table 4.4-11 of [B.8-1].

B.8.5.3 Evaluation of AHSM Performance with 24PT1 DSC

The thermal performance of the AHSM module with a 24PT1 DSC at the WCS CISF under normal, off-normal, and accident conditions of operation is bounded by the evaluation documented in [B.8-1]. The bounding evaluation demonstrates that all the 10 CFR Part 72 thermal limits and criteria for the WCS CISF are met.

B.8.5.4 NUHOMS®-24PT1 DSC Basket Model Results

Normal, Off-Normal and Accident Conditions

The AHSM model is used to calculate the maximum 24PT1 DSC shell temperatures for a decay heat load of 16 kW and 14 kW in [B.8-1] for normal, off-normal and AHSM blocked vent accident conditions. The DSC shell temperatures, presented in Table 4.4-4 of [B.8-1], are used as boundary conditions in the 24PT1 DSC basket model for calculating basket component temperatures and fuel cladding temperatures. The calculated basket component temperatures and fuel cladding temperatures are presented in Table 4.4-6 and 4.4-7, respectively of [B.8-1]. These calculated temperatures are below their respective allowable material temperature limits listed in Tables 4.1-3, 4.1-4 and 4.1-5 of [B.8-1].

B.8.6 Thermal Analysis of MP187 Transfer Cask with 24PT1 DSC for Transfer Conditions

As discussed in Section B.8.1, the 24PT1 DSC will be transported to the WCS CISF under the NRC Certificate of Compliance No. 9255 [B.8-3]. The use of 24PT1 DSC in MP187 cask is approved for 10CFR Part 71 off-site transportation with a maximum heat load of 14 kW [B.8-3]. Within the WCS CISF, the transfer operations i.e. movement of the DSC from the transfer cask into the storage module will be performed under 10CFR Part 72. This section presents the thermal evaluation for this on-site transfer operation with the MP187 cask.

A review of the thermal evaluation presented for 24PT1 in the MP187 cask during off-site transportation in Chapter A.3 of the [B.8-2, B.8-3] indicates that the thermal evaluation for 24PT1 is bounded by the thermal evaluation presented for FO- and FC-DSCs in Chapter 3 of [B.8-2, B.8-3]. This is because the 24PT1 DSC is nearly identical to the FO- DSC as noted in Section A2.1, Section A.3.2 of [B.8-2, B.8-3]. The similarities are also described in the Executive Summary Section of [B.8-1].

A similar approach is presented in this section, wherein the thermal evaluation performed for on-site transfer of FO- DSCs in MP187 cask at the Rancho Seco Independent Spent Fuel Storage Installation (ISFSI) [B.8-4] bounds the maximum temperatures for transfer of 24PT1 in MP187 cask at the WCS CISF.

<u>Comparison of Heat Loads between the FO- DSC and 24PT1 DSC</u>

a. Heat Loads within the MP187 cask

Bounding axial peaking factors for the different burnup ranges are shown for pressurized water reactor (PWR) spent nuclear fuel (SNF) assemblies in Table 2 of NUREG/CR-6801 [B.8-5]. As seen from the table, the axial peaking profile of a PWR fuel assembly causes a slight increase in the heat generation rate at the middle of the fuel assembly while reducing the heat generation at the ends. However, the axial peaking profile does not increase the total heat load.

In the thermal evaluation presented in Section 8.1.1.1, Volume III of [B.8-4], a peaking factor of 1.08 is used over the total heat load of 13.5 kW in evaluating the MP187 cask component and DSC Shell temperatures. Because of this the total heat load considered in the MP187 cask model is 14.58 kW (13.5 kW x 1.08 = 14.58 kW). This exceeds the maximum heat load of 14 kW for the 24PT1 DSC and based on the discussion for the axial peaking profile, this evaluation remains bounding.

b. Heat Loads within the DSC

The DSC shell temperature profile determined from the MP187 cask model is used as boundary condition in determining the maximum fuel cladding and spacer disc temperature in Section 8.1.1.2, Volume II of [B.8-4]. As discussed in Section 8.1.1.2, Volume II of [B.8-4], the maximum decay heat per fuel assembly of 0.764 kW allowed for the FC- DSC is used in determining the maximum fuel cladding temperature. This increases the total heat load used in the DSC model to 18.34 kW.

In comparison, the maximum decay heat per fuel assembly allowed within the 24PT1 DSC is 0.583 kW as noted in Section 1.2.3 of [B.8-1] while the maximum allowable heat load for the DSC is limited to 14 kW. This indicates that the heat load used in the evaluation of FO- and FC- DSC in Section 8.1.1.2, Volume II of [B.8-4] bounds the maximum decay heat per fuel assembly (0.583 kW in 24PT1 vs. 0.764 kW for FO- and FC- DSC) and the total heat load of the DSC (14 kW for 24PT1 vs 18.34 kW used in thermal evaluation of FO- and FC- DSC).

Based on the discussion presented in Item “a” and “b”, the maximum heat load used in the thermal evaluation of the FO- and FC- DSCs during transfer in MP187 cask at Rancho Seco ISFSI bounds the transfer at the WCS CISF and no further evaluations are presented. The results of thermal evaluation for FO- and FC- DSCs during transfer in MP187 cask at Rancho Seco ISFSI are presented in Section A.8.5 of this application.

B.8.6.1 Evaluation of MP187 Cask Performance

The thermal performance of the MP187 cask is evaluated under normal, off-normal and accident conditions of operation, and all the temperature limits and criteria are satisfied.

B.8.7 References

B.8-1 TN, "Updated Final Safety Analysis Report for the Standardized Advanced NUHOMS® Horizontal Modular Storage System for Irradiated Nuclear Fuel," ANUH-01.0150, Revision 6.

B.8-2 TN Document NUH-05-151 Rev. 17, "NUHOMS®-MP187 Multi-Purpose Transportation Package Safety Analysis Report." (Basis for NRC CoC 71-9255).

B.8-3 U.S. Nuclear Regulatory Commission, "Certificate of Compliance No. 9255, Revision 12 for the Model No. NUHOMS®-MP187 Multi-Purpose Cask (Docket 71-9255).

B.8-4 "Rancho Seco Independent Spent Fuel Storage Installation Safety Analysis Report," NRC Docket No. 72-11, Revision 4.

B.8-5 Office of Nuclear Regulator Research, USNRC, "Recommendations for Addressing Axial Burnup in PWR Burnup Credit Analysis," NUREG/CR-6801, Published March 2003.

APPENDIX B.9
RADIATION PROTECTION
Standardized Advanced NUHOMS® System

Table of Contents

B.9. RADIATION PROTECTION B.9-1

B.9.1 Radiation Protection Design Features B.9-2

B.9.2 Occupational Exposure Evaluation B.9-3

B.9.2.1 Analysis Methodology B.9-3

B.9.2.2 Dose Assessment B.9-3

B.9.3 References B.9-5

List of Tables

Table B.9-1 Analyses Used for Receipt and Transfer Configurations B.9-6

Table B.9-2 Occupational Collective Dose for Receipt of MP187 Cask Loaded with 24PT1 DSC B.9-7

Table B.9-3 Occupational Collective Dose for Transfer of 24PT1 DSC from MP187 Cask to AHSM B.9-8

List of Figures

Figure B.9-1 Worker Locations Around Cask B.9-9

B.9. RADIATION PROTECTION

The Standardized Advanced NUHOMS® System Cask System radiation protection evaluations are documented in Section 10 of the "Standardized Advanced NUHOMS® Horizontal Modular Storage System Safety Analysis Report" [B.9-1].

B.9.1 Radiation Protection Design Features

Details of the Storage Area shielding design features for the Standardized Advanced NUHOMS® System Cask System which includes the NUHOMS®-24PT1 Dry Shielded Canister (DSC) stored in an AHSM are documented in Section 10.2.1 of reference [B.9-1]. Drawings showing the shield thicknesses for the MP187 cask are included in Section A.4.6 and drawings showing the shield thicknesses for the NUHOMS®-24PT1 DSC and AHSM are included in Section B.4.6.

B.9.2 Occupational Exposure Evaluation

B.9.2.1 Analysis Methodology

Dose rates are known in the vicinity of the AHSM and MP187 cask based upon the existing FSAR[B.9-1] and SAR[B.9-2]. The operational sequence is determined for each system, as well as the associated number of workers, their location, and duration per operation. The collective dose per step is then computed as:

$$C = D*N*T,$$

where

C is the collective dose (person-mrem),

D is the dose rate for each operation (mrem/hr),

N is the number of workers for that operation, and

T is the duration of the operation (hr)

Once the collective dose is determined for each step, the collective doses are summed to create the total collective dose. The total collective dose is determined for a single receipt/transfer operation.

B.9.2.2 Dose Assessment

A dose assessment is performed for receipt and transfer of an NUHOMS®-24PT1 DSC to AHSM using the MP187 cask.

Seven general locations around the cask are defined, as shown in the top half of Figure B.9-1: top, top edge, top corner, side, bottom corner, bottom edge, and bottom. These seven general locations are reduced to only three locations for which dose rate information is available, as shown in the bottom half of Figure B.9-1: top, side, and bottom.

A loading operation is divided into receipt and transfer operations. Dose rates for receipt operations are obtained from Table 5.1-1 of the transportation SAR for the MP187 cask [B.9-2]. Dose rates for the transfer operations are obtained from Table 5.1-2 of the storage FSAR [B.9-1] for the AHSM.

For some configurations, dose rates are not available in the reference transportation SAR or storage FSAR. In these instances, bounding dose rates are obtained for similar systems:

- For transfer of the 24PT1 DSC inside the MP187 cask, bounding dose rates for transfer of the 24PT1 DSC inside the OS197 transfer cask from Tables 5.1-3, 5.1-4 and 5.1-5 of reference [B.9-1] are utilized. This approach is conservative because the OS197 transfer cask contains less shielding than the MP187 cask.

The configurations used in the dose rate analysis are summarized in Table B.9-1. Results for the various loading scenarios are provided in Table B.9-2 and Table B.9-3. Separate tables are developed for receipt and transfer operations. These tables provide the process steps, number of workers, occupancy time, distance, dose rate, and collective dose for all operations.

The total collective dose for an operation is the sum of the receipt and transfer collective doses. The total collective dose for receipt and transfer of NUHOMS®-24PT1 DSC to an AHSM using the MP187 cask: 1097 person-mrem.

The total collective dose for unloading a 24PT1 DSC or reactor related GTCC waste canister from an AHSM and preparing it for transport off-site is bounded by the loading operations (1097 person-mrem). Operations for removing the canister from the AHSM and off-site shipment are identical to loading operations, except in reverse order. The collective dose for unloading is bounded because during storage at the WCS CISF the source terms will have decayed reducing surface dose rates. The total collective dose is the sum of the receipt, transfer, retrieval, and shipment is 2194 person-mrem.

B.9.3 References

B.9-1 TN Document, ANUH-01.0150, Revision 6, "Updated Final Safety Analysis Report for the Standardized Advanced NUHOMS® Horizontal Modular Storage System for Irradiated Nuclear Fuel, NRC Docket No. 72-1029.

B.9-2 TN Document NUH-05-151 Rev. 17, "NUHOMS®-MP187 Multi-Purpose Transportation Package Safety Analysis Report." (Basis for NRC CoC 71-9255).

Table B.9-1
Analyses Used for Receipt and Transfer Configurations

Actual Configuration	Receipt Analysis Configuration	Transfer Analysis Configuration
24PT1 DSC transferred from the MP187 cask into an AHSM	24PT1 inside MP187 cask [B.9-2]	24PT1 inside OS197 transfer cask (bounds MP187 cask) [B.9-1]

Table B.9-2
Occupational Collective Dose for Receipt of MP187 Cask Loaded with 24PT1 DSC

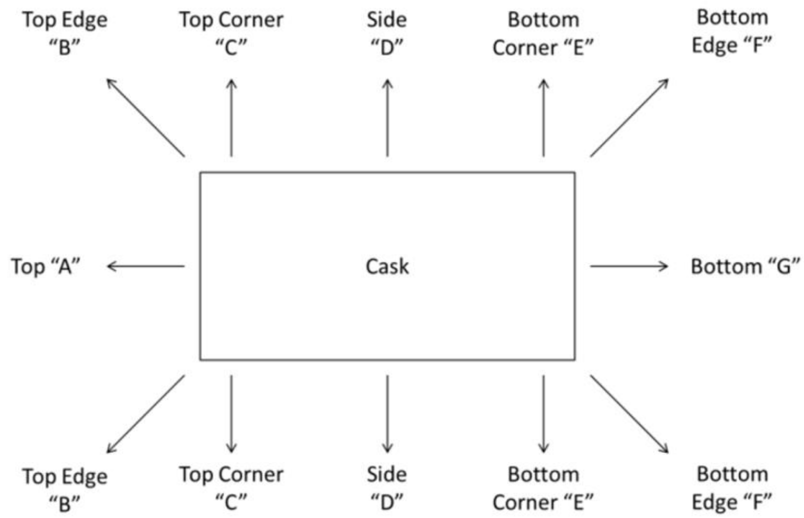
Process Step	Number of Workers	Occupancy Time (hours)	Worker Location Around Cask	Worker Distance (m)	Total Dose Rate (mrem/hr)	Total Dose (person-mrem)*
Verify that the tamperproof seals are intact.	1	0.07	Top	1	1.19	1
	1	0.07	Bottom	1	1.63	
Remove the tamperproof seals.	1	0.07	Top	1	1.19	1
	1	0.07	Bottom	1	1.63	
Remove personnel barrier	3	0.5	Side	1	57.5	87
Remove the impact limiter attachment bolts from each impact limiter and remove the impact limiters from the cask.	2	0.5	Top Edge	1	1.19	3
	2	0.5	Bottom Edge	1	1.63	
Remove the transportation skid closure assembly.	2	0.25	Top Corner	1	57.5	58
	2	0.25	Bottom Corner	1	57.5	
Take contamination smears on the outside surfaces of the cask. If necessary, decontaminate the cask until smearable contamination is at an acceptable level.	2	0.17	Top	1	20	48
	2	0.17	Side	1	57.5	
	2	0.17	Bottom	1	62	
Place suitable slings around the cask top and bottom ends.	2	0.5	Top Corner	1	57.5	115
	2	0.5	Bottom Corner	1	57.5	
Using a suitable crane lift the cask from the railcar	2	0.1	Side	1	57.5	12
Remove the cask trunnion plugs.	2	0.5	Top Corner	1	57.5	115
	2	0.5	Bottom Corner	1	57.5	
Inspect the trunnion sockets and install the upper and lower trunnions. Torque the trunnion attachment screws for each of the four trunnions.	2	0.5	Top Corner	1	57.5	115
	2	0.5	Bottom Corner	1	57.5	
Place cask onto the on-site transfer vehicle.	2	0.5	Side	2	57.5	58
Remove the slings from the cask.	2	0.5	Top Corner	1	57.5	115
	2	0.5	Bottom Corner	1	57.5	
Install the on-site support skid pillow block covers.	1	0.2	Side	2	57.5	12
Transfer the cask to a staging module.	1	0.2	Side	2	57.5	12
					Total (person-mrem)	752

*Rounded up to nearest whole number

Table B.9-3
Occupational Collective Dose for Transfer of 24PT1 DSC from MP187 Cask to AHSM

Process Step	Number of Workers	Occupancy Time (hours)	Worker Location Around Cask	Worker Distance (m)	Total Dose Rate (mrem/hr)	Total Dose (person-mrem)*
Remove the Cask Lid	2	0.5	Top	1	7.14	8
Align and Dock the Cask with the AHSM	2	0.25	Top/Front Half HSM Vent	1	113.17	57
Insert 24PT1-DSC into the AHSM	4	0.5	Bottom	1	18.9	38
Transfer the 24PT1-DSC to the AHSM	---	---	---	Far	Background	0
Lift the Ram Onto Transfer Vehicle and Un-Dock the Cask	2	0.25	HSM Front Vent	1	45.28	23
Install the AHSM Access Door	2	0.5	HSM Front Surface	1	1.93	2
Adjust 24PT1-DSC seismic restraint	2	0.5	HSM Front Surface	1	1.93	217
	2	0.5	HSM Front Surface	1	1.93	
	2	0.08	Bottom	1	1326	
					Total (person-mrem)	345

*Rounded up to nearest whole number



Detailed Cask Locations

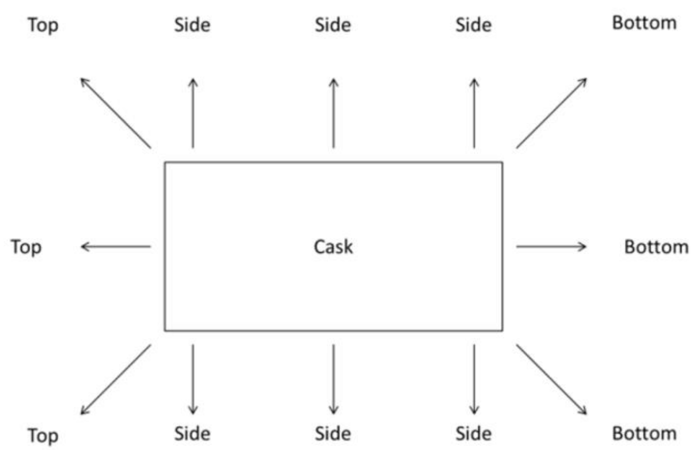


Figure B.9-1
Worker Locations Around Cask

APPENDIX B.10
CRITICALITY EVALUATION
Standardized Advanced NUHOMS® System

Table of Contents

B.10. CRITICALITY EVALUATION B.10-1

B.10.1 Discussion and Results B.10-2

B.10.2 Package Fuel Loading B.10-3

B.10.3 Model Specification B.10-4

B.10.4 Criticality Calculation B.10-5

B.10.5 Critical Benchmark Experiments B.10-6

B.10.6 References B.10-7

B.10. CRITICALITY EVALUATION

The design criteria for the Standardized Advanced NUHOMS® 24PT1 DSC require that the canister is designed to remain subcritical under normal, off-normal, and accident conditions associated with spent nuclear fuel (SNF) handling, storage and off-site transportation. The design of the canister is such that, under all credible conditions, the highest effective neutron multiplication factor (k_{eff}) remains less than the upper safety limit (USL) of 0.9401 including an administrative margin of 0.05, code bias and bias uncertainties.

B.10.1 Discussion and Results

The 24PT1 DSC criticality analysis is documented in Chapter 6 of the "Standardized Advanced NUHOMS® System Updated Final Safety Analysis Report" [B.10-1]. This criticality analysis bounds the conditions for transfer and on-site storage at the WCS Consolidated Interim Storage Facility (WCS CISF) because there is no credible event which would result in the flooding of a canister in HSM storage which would result in k_{eff} exceeding the worst case 10 CFR 72 storage conditions evaluated in [B.10-1]. Specific information on the criticality safety analysis which bounds the WCS CISF is discussed in this section.

The 24PT1 DSC consists of a shell assembly and an internal basket assembly. The basket assemblies are composed of four axially oriented support rods and twenty-six spacer discs. This basket assembly provides positive location for twenty-four SNF assemblies under normal operating conditions, off-normal operating conditions and accident conditions. The basket assembly uses fixed neutron absorbers that isolate each SNF assembly. Guide sleeves are designed to permit unrestricted flooding and draining of SNF cells. The canister system is designed to be resistant to corrosion in marine environments and to permit storage of control components integral with the SNF and/or damaged SNF assemblies. The 24PT1 DSC accommodates up to 24 PWR SNF assemblies with stainless steel or Zircaloy cladding, uranium dioxide (UO_2) or U-Pu mixed-oxide (MOX) fuel pellets, Integral Fuel Burnable Absorber (IFBA) assemblies, and control components. It can also store up to four stainless steel clad damaged SNF assemblies in lieu of an equal number of undamaged SNF assemblies or one failed MOX assembly with no other failed assemblies. The criticality analysis credits the fixed borated neutron absorbing material Boral™, placed between the SNF assemblies and does not credit the presence of soluble boron during loading and unloading operations. Subcriticality during wet loading or unloading, drying, sealing, transfer, and storage operations is maintained through the geometric separation of the SNF assemblies by the basket assembly and the neutron absorbing capability of the 24PT1 DSC materials.

The continued efficacy of the neutron absorbers is assured when the canister arrives as the WCS CISF because the basket, including poison material, is designed and analyzed to maintain its configuration for all normal, off-normal and accident conditions of storage and for normal and hypothetical accidents during transport in the MP187 cask as documented in Section A.6.1.2 and A.6.3 of the "Safety Analysis Report for the NUHOMS®-MP187 Multi-purpose Cask" [B.10-4].

The design basis criticality analysis performed for the 24PT1 DSC assumes the most reactive configuration of the canister and contents in an infinite array of casks bounding all conditions of receipt, transfer and storage at the WCS CISF where the canisters will remain dry under all conditions of transfer and storage including normal, off-normal and accident conditions as demonstrated in Chapter 12 of this SAR.

The results of the evaluations demonstrate that the maximum calculated k_{eff}, including statistical uncertainty and bias, are less than 0.9401.

B.10.2 Package Fuel Loading

Section 2.1 of the Technical Specifications [B.10-3] lists the SNF assemblies authorized for storage at the WCS CISF. Section 6.2 Spent Fuel Loading of [B.10-1] provides the Package Fuel Loading.

B.10.3 Model Specification

Section 6.3 Model Specification of [B.10-1] provides a discussion of the criticality model canister regional densities used to calculate the bounding k_{eff} for the 24PT1 DSC.

B.10.4 Criticality Calculation

Section 6.4 Criticality Calculation of [B.10-1] provides a discussion of the criticality calculations that demonstrate that the maximum calculated k_{eff} for the 24PT1 DSC is less than 0.9401.

B.10.5 Critical Benchmark Experiments

Section 6.5 Critical Benchmark Experiments of [B.10-1] provides a discussion of the benchmark experiments and applicability, details of benchmark calculations, and the results of benchmark calculations, including calculation of the USL.

B.10.6 References

B.10-1 TN Document, ANUH-01.0150, Revision 6, "Updated Final Safety Analysis Report for the Standardized Advanced NUHOMS® Horizontal Modular Storage System for Irradiated Nuclear Fuel, NRC Docket No. 72-1029.

B.10-2 TN "Technical Specifications for the Standardized Advanced NUHOMS® System Operating Controls and Limits," USNRC Docket Number 72-1029.

B.10-3 Proposed SNM-1050, WCS Consolidated Interim Storage Facility Technical Specifications, Amendment 0.

B.10-4 TN Document NUH-05-151 Rev. 17, "NUHOMS®-MP187 Multi-Purpose Transportation Package Safety Analysis Report." (Basis for NRC CoC 71-9255).

APPENDIX B.11
CONFINEMENT EVALUATION
Standardized Advanced NUHOMS® System

Table of Contents

B.11 CONFINEMENT EVALUATION......B.11-1

B.11.1 Confinement Boundary......B.11-2

B.11.2 Requirements for Normal Conditions of Storage......B.11-3

B.11.3 Confinement Requirements for Hypothetical Accident Conditions......B.11-4

B.11.4 References......B.11-5

List of Tables

Table B.11-1 Canister Confinement Boundaries B.11-6

B.11 CONFINEMENT EVALUATION

The design criteria for the Standardized Advanced NUHOMS® 24PT1 Dry Shielded Canister (DSC or canister) require that the canister is designed to maintain confinement of radioactive material under normal, off-normal, and accident conditions associated with spent nuclear fuel (SNF) handling, storage and off-site transportation.

As stated in Section 5.1.3.1, a post-transportation evacuated volume helium leak test will be conducted for each canister, as prudent measure, to confirm that a canister remains able to perform its safety function and is, therefore, acceptable for storage at the WCS CISF. Table B.11-1 identifies the accessible portions of the canister confinement boundary along with those portions that are inaccessible for the post-transportation leak test.

B.11.1 Confinement Boundary

The 24PT1 DSC confinement is documented in Chapter 7 of the "Standardized Advanced NUHOMS® System Updated Final Safety Analysis Report" [B.11-1]. Section 7.1 of [B.11-1] details the requirements of the confinement boundary. Figure 7.1-1 of reference [B.11-1] provides a figure that shows the components and welds that make up the confinement boundary for the 24PT1-DSC. Drawings for the canisters, including the confinement boundary are referenced in Section B.4.6. In addition, a bounding evaluation in Section A.7.7 (also referenced in Section B.7.9) is performed to demonstrate that the confinement boundary for the 24PT1-DSC does not exceed ASME B&PV Subsection NB Article NB-3200 (Level A allowables) during normal conditions of transport to provide reasonable assurance that the confinement boundary is not adversely impacted by transport to the WCS CISF.

The Technical Specifications for Standardized Advanced NUHOMS® [B.11-2] outline the requirements for preventing the leakage of radioactive materials in the 24PT1 DSC. Section 4.3, "Codes and Standards," lists the codes and standards for design, fabrication, and inspection of the 24PT1 DSC, including alternatives to the ASME Code for the 24PT1 DSC shell assembly and basket.

Section 3.1, "DSC Integrity," of the Technical Specifications for the Standardized Advanced NUHOMS® [B.11-2] includes limiting condition for operation (LCO) 3.1.1.a for DSC vacuum drying time and pressure and LCO 3.1.2.a for DSC helium backfill pressure. These LCOs create a dry, inert atmosphere, which contributes to preventing the leakage of radioactive material.

B.11.2 Requirements for Normal Conditions of Storage

Section 7.2 of [B.11-1] describes how the 24PT1 DSC is designed, fabricated and tested to be "leaktight" to prevent the leakage of radioactive materials. The Technical Specifications for Standardized Advanced NUHOMS® [B.11-2] outline the requirements for preventing the leakage of radioactive materials in the 24PT1 DSC. Section 4.3, "Codes and Standards," lists the codes and standards for design, fabrication, and inspection of the 24PT1 DSC, including alternatives to the ASME Code for the 24PT1 DSC shell assembly and basket.

Section 3.1, "DSC Integrity," of the Technical Specifications for the Standardized Advanced NUHOMS® [B.11-2] includes limiting condition for operations (LCO) 3.1.1.a for DSC vacuum drying time and pressure and LCO 3.1.2.a for DSC helium backfill pressure. These LCOs create a dry, inert atmosphere, which contributes to preventing the leakage of radioactive material.

B.11.3 Confinement Requirements for Hypothetical Accident Conditions

Section 7.3 of [B.11-1] provides a discussion on how the 24PT1 DSC is designed, fabricated and tested to be “leak tight” to prevent the leakage of radioactive materials following hypothetical accident conditions. The Technical Specifications for Standardized Advanced NUHOMS® [B.11-2] outline the requirements for preventing the leakage of radioactive materials in the 24PT1 DSC. Section 4.3, “Codes and Standards,” lists the codes and standards for design, fabrication, and inspection of the 24PT1 DSC, including alternatives to the ASME Code for the 24PT1 DSC shell assembly and basket.

Section 3.1, “DSC Integrity,” of the Technical Specifications for the Standardized Advanced NUHOMS® [B.11-2] includes limiting condition for operation (LCO) 3.1.1.a for DSC vacuum drying time and pressure and LCO 3.1.2.a for DSC helium backfill pressure. These LCOs create a dry, inert atmosphere, which contributes to preventing the leakage of radioactive material.

B.11.4 References

B.11-1 TN Document, ANUH-01.0150, Revision 6, "Updated Final Safety Analysis Report for the Standardized Advanced NUHOMS® Horizontal Modular Storage System for Irradiated Nuclear Fuel," NRC Docket No. 72-1029.

B.11-2 TN, "Technical Specifications for the Standardized Advanced NUHOMS® System Operating Controls and Limits," Amendment 3, USNRC Docket Number 72-1029.

Table B.11-1
Canister Confinement Boundaries

Accessible Portions	***Inaccessible Portions***
Advanced Standardized NUHOMS® System Canisters *NUHOMS® 24PT1*	
• *Shell* • *Shell long seam welds* • *Shell circumferential welds, if present*	• *Inner Bottom Cover Plate (IBCP)* • *IBCP to Shell weld* • *Siphon and Vent block (S&VB)* • *S&VB Cover Plates* • *Inner Top Cover Plate (ITCP)* • *ITCP to shell weld* • *S&VB Cover to S&VB welds* • *S&VB to Shell weld*

APPENDIX B.12
ACCIDENT ANALYSIS
Standardized Advanced NUHOMS® System

Table of Contents

B.12 ACCIDENT ANALYSIS B.12-1

B.12.1 Off-Normal Operations B.12-2

B.12.1.1 Off-Normal Transfer Loads B.12-2

B.12.1.2 Extreme Ambient Temperatures B.12-2

B.12.1.3 Off-Normal Release of Radionuclides B.12-3

B.12.2 Postulated Accident B.12-4

B.12.2.1 Blockage of Air Inlet/Outlets B.12-4

B.12.2.2 Drop Accidents B.12-4

B.12.2.3 Earthquakes B.12-5

B.12.2.4 Lightning B.12-6

B.12.2.5 Fire and Explosion *B.12-7*

B.12.2.6 Flood B.12-7

B.12.2.7 Tornado Wind and Missiles B.12-8

B.12.3 References B.12-9

B.12 ACCIDENT ANALYSIS

This section describes the postulated off-normal and accident events that could occur during transfer and storage for the Standardized Advanced NUHOMS® System. Detailed analyses are provided in the "Standardized Advanced NUHOMS® Horizontal Modular Storage System Safety Analysis Report" [B.12-1] for the NUHOMS® 24PT1 canister and AHSM are referenced herein. Qualification for use of the NUHOMS® MP187 cask as a transfer cask for off-normal and accident conditions is also addressed.

B.12.1 Off-Normal Operations

The off-normal conditions considered for the Standardized Advanced NUHOMS® System are off-normal transfer loads, extreme temperatures and a postulated release of radionuclides.

B.12.1.1 Off-Normal Transfer Loads

Off-Normal transfer loads are addressed in Section 11.1.1 of [B.12-1] which is a "jammed" canister during loading or unloading from the AHSM.

Postulated Cause of the Event

The postulated cause of the event is described in Section 11.1.1.1 of [B.12-1]

Detection of the Event

Detection of the event is described in Section 11.1.1.2 of [B.12-1].

Analysis of Effects and Consequences

Section 11.1.1.3 of [B.12-1] provides a discussion of the analysis performed and effects and consequences of the event. There is no breach of the confinement pressure boundary and, therefore, no potential for release of radioactive materials.

Corrective Actions

Consistent with Section 11.1.1.4 of [B.12-1], the required corrective action is to reverse the direction of the force being applied to the canister by the ram, and return the canister to its previous position. Since no permanent deformation of the canister occurs, the sliding transfer of the canister to its previous position is unimpeded. The transfer cask alignment is then rechecked, and the transfer cask repositioned as necessary before attempts at transfer are renewed.

B.12.1.2 Extreme Ambient Temperatures

The design of the Standardized Advanced NUHOMS® System envelopes the extreme temperatures at the WCS Consolidated Interim Storage Facility (WCS CISF) as demonstrated in Section B.8.4.

Postulated Cause of the Event

The postulated cause of the event is described in Section 11.1.2.1 of [B.12-1]

Detection of the Event

Detection of the event is described in Section 11.1.2.2 of [B.12-1].

Analysis of Effects and Consequences

Section 11.1.2.3 of [B.12-1] provides a discussion of the analysis performed and effects and consequences of the event. There is no breach of the confinement pressure boundary and, therefore, no potential for release of radioactive materials.

Corrective Actions

Consistent with Section 11.1.2.4 of [B.12-1], the corrective action is to install a transfer cask solar shield if the ambient temperature exceeds 100°F. The extreme ambient temperatures analyzed do not adversely impact operation of the Standardized Advanced NUHOMS® System.

B.12.1.3 Off-Normal Release of Radionuclides

As described in Section 11.1.3 of [B.12-1], the canister is designed, fabricated and tested to be leak-tight, therefore, there is no possibility for release of radionuclides from the canister under normal, off-normal and accident conditions.

B.12.2 Postulated Accident

The postulated accident conditions for the Standardized Advanced NUHOMS® System addressed in this SAR section are:

- Blockage of Air Inlets/Outlets
- Drop Accidents
- Earthquakes
- Lightning
- Fire/Explosion
- Flood
- Tornado Wind and Missiles

B.12.2.1 Blockage of Air Inlet/Outlets

Cause of Accident

Section 11.2.7.1 of [B.12-1] provides the causes of blocked air vents for the AHSM.

Accident Analysis

The structural and thermal consequences of blocking the air inlet and outlets are addressed in Section 11.2.7.2 of [B.12-1]. In addition, Chapter B.8 demonstrates that the thermal analysis performed for the Standardized Advanced NUHOMS® System in [B.12-1] is bounding for WCS CISF conditions.

Accident Dose Calculations

As documented in Section 11.2.7.3 of [B.12-1], there are no radiological consequences for this accident condition.

Corrective Actions

Consistent with Section 11.2.7.4 of [B.12-1], blockage of the AHSM vents is to be cleared within the 40-hour time frame analyzed to restore AHSM ventilation.

B.12.2.2 Drop Accidents

Cause of Accident

Section 11.2.5.1 of [B.12-1] discusses the cask drop for the MP187 cask in the transfer configuration when it contains the canister.

Accident Analysis

The structural, thermal, and radiological consequences and the recovery measures required to mitigate the effects of a drop accident are addressed in Section 8.2.1.3 of Volume I of [B.12-5] for the MP187 cask in the transfer configuration. Section 3.6 of [B.12-1] demonstrates that the canister remains leak tight and the basket maintains its configuration following the drop event. In addition, Chapter B.8 demonstrates that the thermal analysis performed for the NUHOMS® MP187 Cask System in [B.12-1] is bounding for WCS CISF conditions.

Corrective Action

Consistent with Section 11.2.5.4 of [B.12-1], the canister will be inspected for damage *for drop heights greater than fifteen inches*, as necessary. Removal of the transfer cask top cover plate may require cutting of the bolts in the event of a corner drop onto the top end. These operations will take place in the Cask Handling Building. *The extent of the damage will also be evaluated using calculations to demonstrate that there is no impact to the ability of the canister to continue to perform its intended design functions.*

Following recovery of the transfer cask and transfer of the canister in the AHSM, the transfer cask will be inspected, repaired and tested as appropriate prior to reuse.

For recovery of the cask and contents, it may be necessary to develop a special sling/lifting apparatus to move the transfer cask from the drop site to the Cask Handling Building. This may require several weeks of planning to ensure all steps are correctly organized. During this time, temporary shielding may be added to the transfer cask to minimize on-site exposure to WCS CISF operations personnel. The transfer cask would be roped off to ensure the safety of personnel.

B.12.2.3 Earthquakes

Cause of Accident

Site-specific ground-surface uniform hazard response spectra (UHRS) with 1E-4 annual frequency of exceedance (AFE) having peak ground acceleration (PGA) of 0.250 g horizontal and 0.175 g vertical are shown in Table 1-2, Table 1-5 and Figure 1-5. The site-specific response spectra are used in the WCS CISF SSI analysis to obtain the enveloped acceleration spectra at the HSM CG and base. Section B.7.5 demonstrates that the enveloping WCS CISF site-specific seismic forces remain below their applicable capacities for the MP187 cask and Standardized Advanced NUHOMS® System components.

Accident Analysis

The structural and thermal consequences of an earthquake are addressed in Section 11.2.1.2 of [B.12-1]. The MP187 cask, when mounted on the transfer vehicle during an earthquake is subjected to stresses which are bounded by the 80-inch cask drop analysis. In addition, Chapter B.8 demonstrates that the thermal analysis performed for the Standardized Advanced NUHOMS® System in [B.12-1] is bounding for WCS CISF conditions.

Accident Dose Calculations

As documented in Section 11.2.1.3 of [B.12-1], there are no radiological consequences as a result of a seismic event.

Corrective Actions

Consistent with Section 11.2.1.4 of [B.12-1], inspection of AHSMs subsequent to a significant earthquake is required to identify potential damage or change in AHSM configuration. Repair of damage to AHSM concrete components, including shield walls may be necessary. Movement of AHSMs as a result of the seismic event will require evaluation and possible repositioning of AHSMs and shielding to preseismic event configuration.

B.12.2.4 Lightning

Cause of Accident

As stated in Section 11.2.6.1 of [B.12-1], the likelihood of lightning striking the AHSM and causing an off-normal or accident condition is not considered a credible event. Simple lightning protection equipment for the AHSM structures is considered a miscellaneous attachment acceptable per the AHSM design.

Accident Analysis

Should lightning strike in the vicinity of the AHSM the normal storage operations of the AHSM will not be affected. The current discharged by the lightning will follow the low impedance path offered by the surrounding structures or the grounding system installed around each block of AHSMs. The heat or mechanical forces generated by current passing through the higher impedance concrete will not damage the AHSM. Since the AHSM requires no equipment for its continued operation, the resulting current surge from the lightning will not affect the normal operation of the AHSM.

Since no accident conditions will develop as the result of a lightning strike near the AHSM, no corrective action would be necessary. In addition, there would be no radiological consequences

B.12.2.5 Fire and Explosion

Cause of Accident

As described in Section 11.2.4.1 of [B.12-1] combustible materials will not normally be stored at the storage pad. Therefore, a credible fire would be very small and of short duration such as that due to a fire or explosion from a vehicle or portable crane.

However, a hypothetical fire accident is evaluated for the Standardized Advanced NUHOMS® System based on a diesel fuel fire. The source of fuel is postulated to be from a ruptured fuel tank of the transfer vehicle or portable crane. The bounding capacity of the fuel tank is 300 gallons and the bounding hypothetical fire is an engulfing fire around the transfer cask. Direct engulfment of the AHSM is highly unlikely. Any fire within the WCS CISF boundary while the canister is in the AHSM would be bounded by the fire during transfer cask movement. The AHSM concrete acts as a significant insulating firewall to protect the canister from the high temperatures of the fire.

Accident Analysis

The structural and thermal consequences of a fire accident are addressed in Section 12.2.4.2 of [B.12-1]. Appendix B.8 demonstrates that the MP187 cask performs its safety functions during and after the postulated fire/explosion accident. As stated above, the maximum flammable fuel either during the transfer operation or inside the WCS CISF is 300 gallons of diesel fuel.

Accident Dose Calculations

As documented in Section 11.2.4.3 of [B.12-1], there are minimal radiological consequences for this accident condition.

Corrective Actions

Consistent with Section 11.2.4.4 of [B.12-1], evaluation of AHSM or cask neutron shield damage as a result of a fire is to be performed to assess the need for temporary shielding (for AHSM or cask, if fire occurs during transfer operations) and repairs to restore the transfer cask and AHSM to pre-fire design conditions.

B.12.2.6 Flood

Cause of Accident

The Probable Maximum flood is considered to occur as a severe natural phenomenon.

Accident Analysis

As documented in Sections 2.4.2.2 and 3.2.2, the WCS CISF is not in a floodplain and is above the Probable Maximum Flood elevation and, therefore, will remain dry in the event of a flood.

B.12.2.7 Tornado Wind and Missiles

Cause of Accident

In accordance with ANSI-57.9 [B.12-3] and 10 CFR 72.122, the Standardized Advanced NUHOMS® System components are designed for tornado effects including tornado wind effects. In addition, the AHSM and MP187 cask in the transfer configuration are also design for tornado missile effects. The Standardized Advanced NUHOMS® System components are designed and conservatively evaluated for the most severe tornado and missiles anywhere within the United States (Region I as defined in NRC Regulatory Guide 1.76 [B.12-4]) while the WCS CISF is in Region II, a less severe location with respect to tornado and tornado missiles.

Accident Analysis

The structural and thermal consequences of the effect of tornado wind and missile loads on the AHSM are addressed in Section 11.2.2.2 of [B.12-1]. Similarly, the structural and thermal consequences of tornado wind and missile loads for the NUHOMS® MP187 cask are addressed in Section 8.3.1.3 of Volume III of [B.12-5].

Accident Dose Calculations

As documented in Section 11.2.2.3 of [B.12-1], there are no radiological consequences for this accident condition.

Corrective Actions

Consistent with Section 11.2.2.4 of [B.12-1], evaluation of AHSM damage as a result of a Tornado is to be performed to assess the need for temporary shielding and AHSM repairs to return the AHSMs to pre-tornado design conditions.

B.12.3 References

B.12-1 TN Document, ANUH-01.0150, Revision 6, “Updated Final Safety Analysis Report for the Standardized Advanced NUHOMS® Horizontal Modular Storage System for Irradiated Nuclear Fuel, NRC Docket No. 72-1029.

B.12-2 NRC Regulatory Guide 1.60, Rev. 1, "Design Response Spectra for Seismic Design of Nuclear Power Plants." Dec 1973.

B.12-3 American National Standards Institute, American Nuclear Society, ANSI/ANS 57.9 1984, Design Criteria for an Independent Spent Fuel Storage Installation (Dry Storage Type).

B.12-4 NRC Regulatory Guide 1.76, “Design Basis Tornado and Tornado Missiles for Nuclear Power Plants,” 1974.

B.12-5 “Rancho Seco Independent Spent Fuel Storage Installation Safety Analysis Report,” NRC Docket No. 72-11, Revision 4.

APPENDIX B.13
AGING MANAGEMENT

Table of Contents

B.13 AGING MANAGEMENT **B.13-1**

B.13.1 Aging Management Review **B.13-1**

B.13.2 Time Limited Aging Analyses **B.13-2**

B.13.3 Aging Management Programs **B.13-4**

B.13.4 References **B.13-5**

B.13 AGING MANAGEMENT

B.13.1 Aging Management Review

The Aging Management Review (AMR) of the Standardize Advanced NUHOM® System contained in the application for the renewal of the CoC 1029 [B.13-1] provides an assessment of aging effects that could adversely affect the ability of in-scope structures, systems, and components (SSC) to perform their intended functions beyond the initial 20 year storage period. Aging effects, and the mechanisms that cause them, were evaluated for the combinations of materials and environments identified for the subcomponent of the in-scope SSCs based on a review of Managing Aging Process in Storage (MAPS) Report [B.13-2]. Aging effects that could adversely affect the ability of the in-scope SSC to perform their safety function(s) require additional aging management activity to address potential degradation that may occur during the period of extended operation. The TLAAs and AMPs that are credited with managing aging effects during the period of extended operation are discussed in Sections B.13.2 and B.13.3, respectively

B.13.2 Time Limited Aging Analyses

The renewal submittal for CoC 1029 [B.13-1] describes the comprehensive review performed to identify the TLAAs for the in-scope SSCs of the Standardized Advanced NUHOMS® System to determine the analyses that could be credited with managing aging effects over the extended storage period. That review identified the following TLAAs associated with the 24PT1 DSC or AHSM:

- Boron depletion in the BORAL® plates in the 24PT1 dry shielded canisters (DSCs)
- Fatigue analyses for the 24PT1 DSC shells
- Irradiation embrittlement of metals in the 24PT1 DSC
- Irradiation effects on the concrete in the Advanced Horizontal Storage Modules (AHSM)
- Establishment of cladding temperature limits for fuel stored in the 24PT1 DSC

The identified TLAAs were dispositioned by demonstrating that the pre-renewal analysis remains valid for the period of extended operation or the analysis was updated. Of the above identified TLAAs it was determined that only the following TLAAs did not bound the period of extended operation and thus were updated:

- Fatigue analyses for the 24PT1 DSC shells
- Irradiation embrittlement of metals in the 24PT1 DSC
- Irradiation effects on the concrete in the Advanced Horizontal Storage Modules (AHSM)

A. Fatigue Evaluation of the DSCs

This TLAA evaluated the DSC shell for pressure and temperature fluctuations in accordance with the provisions of NB 3222.4(d) of the ASME B&PV Code, Section III, Division 1, 1992 Edition, with Addenda through 1994. As provided by NB 3222.4(d) of the ASME B&PV Code, fatigue effects need not be specifically evaluated provided the six criteria in NB 3222.4(d) are met. Reference [B.13-1] describes an evaluation performed considering a 100-year service life using maximum bounding initial DSC pressures and temperatures (at the beginning of storage). The evaluation showed that the six criteria of NB 3222.4(d) are met. The fatigue evaluation was revisited in Section C.13.2 to address the actions and loadings associated with the transportation of the DSC from the original ISFSI to the ISP/WCS CISF facility.

B. Irradiation embrittlement of metals in 24PT1 and Irradiation effects on the concrete in the AHSM

Reference [B.13-1] describes an analysis performed that demonstrates that the irradiation embrittlement of metals in the 24PT1 DSCs and the irradiation effects on the concrete in the AHSM will not lead to a loss of intended safety functions for a 100-year service life.

B.13.3 Aging Management Programs

The aging management programs (AMPs) described in Appendix C, Section C.13.3 are applicable to the SSCs of the Standardized Advanced NUHOMS® system.

B.13.4 References

B.13-1 Letter from Prakash Narayanan (TN Americas LLC) to NRC Document Control Desk, E-55203, Response to Request for Supplemental Information for the Technical Review of the Application for Certificate of Compliance No. 1029 (Docket No. 72-1029, CAC/EPID Nos. 001028/L-2019-RNW-0014), dated December 4, 2019.

B.13-2 NRC NUREG-2214, "Managing Aging Process in Storage (MAPS) Report" (draft report for comment, October 2017) (ML17289A237).