Summary of Design Criteria for Dry Cask Storage Systems for ISFSI Storage of Shutdown Reactor Spent Nuclear Fuel

Fuel Cycle Research & Development

Prepared for
U.S. Department of Energy
Nuclear Fuels Storage and Transportation Planning Project
Brian Gutherman
Gutherman Technical Services
Daniel LeDuc
Savannah River National Laboratory

April, 2015
FCRD-NFST-2015-000538, Rev. 0
SRNL-TR-2015-00106

Context for This Study

This report does not take into account the contractual limitations under the Standard Contract. Under the provisions of the Standard Contract, DOE does not consider spent fuel in canisters to be an acceptable waste form, absent a mutually agreed to contract modification.

EXECUTIVE SUMMARY

The purpose of this report is to research and document the dry storage design criteria for the cask systems currently storing or planned for storage of UNF and GTCC at from permanently shutdown reactor sites by 2019. The design criteria for the ISFSIs and storage systems storing shutdown reactor UNF and GTCC waste are documented in the licensing basis documents applicable to the ISFSI or cask system, based on the type of Part 72 license being used.

The scope of this report is to research the license basis documents for the UNF and GTCC waste cask systems in ISFSI service at the 17 sites that have at least one permanently shutdown reactor (20 total reactors). The list of these shutdown reactors, their relevant licenses or certificates of compliance, and the storage systems and capacity at these reactors is provided in Table-1. Note that three shutdown reactors on operating plant sites (Millstone Unit 1, Indian Point Unit 1, Dresden Unit 1) as well a one reactor to be permanently shut down in 2019 (Oyster Creek) are also part of this report scope.

CONTENTS

ACRONYMS AND ABBREVIATIONS

BRC	Blue Ribbon Commission on America's Nuclear Future
BWR	Boiling Water Reactor
CFR	Code of Federal Regulations
CIS	Consolidated Interim Storage
CoC	Certificate of Compliance
DSFM	Division of Spent Fuel Management (NRC)
DOE	U.S. Department of Energy
DSC	Dry Shielded Canister
FSAR	Final Safety Analysis Report
GTCC	Greater-than-Class C
HBU	High Burnup
HI-STAR	Holtec International Storage, Transport and Repository
HI-STORM	Holtec International Storage Module
ISF	Interim Storage Facility
ISFSI	Independent Spent Fuel Storage Installation
MAGNASTOR	Modular, Advanced Generation, Nuclear All Purpose Storage
MPC	Multi-Purpose Canister
MTU	Metric Tons Uranium
MWd/MTU	Megawatt-day per Metric Ton Uranium
NAC-MPC	NAC International – Multi-purpose Purpose Canister
NAC-UMS	NAC International - Universal Storage System
NFST	Nuclear Fuel Storage and Transportation
NRC	U.S. Nuclear Regulatory Commission
NUHOMS	Nutech Horizontal Modular System
PWR	Pressurized Water Reactor
SNM	Special Nuclear Material
SFP	Spent Fuel Pool
SNF	Spent Nuclear Fuel
SSC	Structure, System, Component
TSC	Transportable Storage Canister
UNF	Used Nuclear Fuel
ANSI	American Nuclear Standards Institute
FC-DSC	Fuel Control – Dry Shielded Canister
FO-DSC	Fuel Only – Dry Shielded Canister
FF-DSC	Failed Fueled – Dry Shielded Canister

SUMMARY OF STORAGE SYSTEM DESIGN CRITERIA FOR DRY CASK STORAGE AT SHUTDOWN COMMERCIAL PLANT SITES

1. INTRODUCTION

1.1 Background

Commercial used nuclear fuel (UNF) and greater-than-class-C (GTCC) waste is stored in wet and dry storage facilities at operating and shutdown nuclear power plant sites across the United States[1]. This is a normal part of plant operation and decommissioning. The Administration's "Strategy for the Management and Disposal of Used Nuclear Fuel and High Level Waste" [1] (DOE 2013) states that the Administration currently plans, with appropriate authorization from Congress, to site, design, license, and construct a pilot interim storage facility (ISF) with an initial focus on the UNF at the shutdown reactor sites. Although not discussed in the Strategy, reactor-related GTCC waste[2] is included in the scope of this report because several of the shutdown reactor ISFSIs include casks containing GTCC waste. Eventually, all commercial UNF and GTCC waste will need to be removed from all commercial plant sites.
Nine shutdown reactor sites have not had an operating reactor on the site for at least the last 15 years. They are as follows[3]:

- Humboldt Bay (shutdown in 1976)
- LaCrosse Boiling Water Reactor (1987)
- Ranch Seco (1989)
- Yankee Rowe (1991)
- Trojan (1992)
- Connecticut Yankee (1996)
- Maine Yankee (1997)
- Big Rock Point (1997)
- Zion (1997)

All of the UNF and GTCC waste at the above nine shutdown reactor sites is in dry cask storage.

---

[1] One additional facility, the Morris Spent Fuel Facility, also stores UNF in a storage pool but is not part of this report.

[2] Removal of GTCC low-level radioactive waste at shutdown sites was analyzed in this report because the Court of Appeals for the Federal Court has held that because the U.S. Nuclear Regulatory Commission (NRC) has determined by rule that, unless the NRC has determined by rule that, unless the NRC approves an alternative method GTCC low-level radioactive waste requires disposal in a geologic repository, such waste is considered high-level radioactive waste under the terms of the Standard Contract (Yankee Atomic electric Co. v. U. S. 536 F.3d 1268 (Fed. Cir. 2008); Pacific Gas & Electric Co. V. U. S. 536F.3d 1282 (Fed. Cir. 2008)).

[3] Fort St. Vrain also meets the criterion to be a "legacy" shutdown reactor site, but is not included because the UNF stored there is owned by DOE.

Four additional reactors were permanently shut down over the past several years:

- Crystal River Unit 3 (2009)
- San Onofre Nuclear Generating Station Units 2 and 3(2012)[4]
- Kewaunee Power Station (2013)
- Vermont Yankee (2014)

Exelon has also announced their intention to permanently shut down the Oyster Creek reactor in 2019.

The UNF and GTCC waste at Crystal River is all currently in wet storage with design work complete for an ISFSI. The UNF and GTCC waste at San Onofre Unit 1 is all in dry storage. The UNF at Kewaunee, San Onofre Units 2 and 3, Vermont Yankee, and Oyster Creek is split between wet storage and dry storage. Eventually, all shutdown reactor UNF and GTCC waste will be moved to dry storage based on site-specific business considerations.

Lastly, there are five additional shutdown reactors at operating plant sites:

- Peach Bottom Unit 1
- Fermi Unit 1
- Dresden Unit 1
- Indian Point Unit 1
- Millstone Unit 1.

All UNF from Peach Bottom-1 and Fermi-1 has been removed from those sites. Therefore, these two reactors will not be discussed further in this report. All UNF from Dresden-1 and Indian Point-1 is in dry storage at the ISFSIs on those sites and these two spent fuel pools (SFP)s have been decommissioned. Millstone-1 UNF is all in wet storage in the spent fuel pool at that unit.

For the purposes of this report all twenty shutdown reactors with UNF and GTCC waste remaining at 17 sites will be evaluated. See Table -1 for a full list of reactors included in this project.

[4] As of the permanent shutdown of Units 2 and 3. San Onofre Unit 1 was permanently shut down in 1992.

Each shutdown reactor UNF and GTCC waste canister[5] is stored at the plant site ISFSI in a vertical cask or HSM that, as a system, was licensed using design criteria that were either specific to the site or were confirmed to bound the site. This results in different design criteria applicable to the various ISFSIs storing shutdown reactor UNF and GTCC waste.

1.2 Objective

The objective of this report is to identify and document relevant environmental and other design criteria for each cask design currently used to store shutdown reactor UNF and GTCC waste at the plant ISFSIs. This report simply collects and presents in one place all of the relevant cask design criteria for shutdown reactor UNF and GTCC waste currently in dry storage. This report also makes about fuel UNF and GTCC waste from those reactors that has yet to be moved to dry storage. See Section 2 of this report for specifics.

1.3 Scope

The scope of this report is to research and document the dry storage design criteria for the UNF and GTCC waste cask systems in ISFSI service at the 17 sites that have at least one permanently shutdown reactor (20 total reactors).

1.4 Approach

Table -1 provides the Part 72 license information for the in-ISFSI for shutdown reactors.

For the shutdown reactor ISFSIs operated under Part 72 specific licenses, the design information of interest is found in the ISFSI license and the ISFSI Final Safety Analysis Report (FSAR).

Shutdown reactors with UNF and GTCC waste being stored at an ISFSI under a specific license are:

- Humboldt Bay
- Rancho Seco
- Trojan

For the shutdown reactor ISFSIs operated under a Part 72 general license, the generic cask design information is found in the certificates of compliance (CoCs) and FSARs for the casks in which the UNF and GTCC waste is stored at the ISFSI. The generic cask design criteria provide the ultimate capability of the cask design and must bound the site-specific design criteria as a condition of the general license.

The shutdown reactors within the scope of this report with UNF and GTCC waste either currently being stored at an ISFSI under a general license or with an intention of using a general license in the future are:

[5] Per 10 CFR 72.120(b)(1), UNF and GTCC waste may not be stored in the same cask without an exception granted by the NRC.

- LaCrosse Boiling Water Reactor
- Yankee Rowe
- Connecticut Yankee
- Maine Yankee
- Big Rock Point
- Zion
- Crystal River
- San Onofre-1, -2, and -3
- Kewaunee
- Vermont Yankee
- Oyster Creek
- Indian Point-1
- Dresden-1
- Millstone-1

Table -1: List of Shutdown Reactor Sites Included in Review Scope

Category	Site (SL = Specific License) (GL = General License)	Storage System and Capacity	Docket Number	License or Cask CoC
Nine shutdown reactor sites that have not had an operating reactor on the site for at least 15 years. These are referred to hereafter as "legacy" shutdown reactor sites.	Humboldt Bay (SL)	Holtec HI-STAR HB MPC-HB (80)	72-27	SNM-2514
	LaCrosse (GL)	NAC-MPC MPC-LACBWR (68)	72-46	72-1025
	Rancho Seco (SL)	NUHOMS FC, FF, FO-DSC (24)	72-11	SNM-2510
	Yankee Rowe (GL)	NAC-MPC Yankee-MPC (26)	72-31	72-1025
	Trojan (SL)	Hybrid MPC-24 (Transtor Concrete Cask)	72-17	SNM-2509
	Connecticut Yankee (GL)	NAC-MPC CY-MPC (36)	72-39	72-1025
	Maine Yankee (GL)	UMS PWR (24)	72-30	72-1015
	Big Rock Point (GL)	Fuel Solutions W74	72-43	72-1026
	Zion-1 and 2 (GL)	MAGNASTOR TSC (37)	72-1037	72-1031
Recently added four additional shutdown reactor sites.	San Onofre-1 (GL)	Advanced NUHOMS 24PT1	72-41	72-1029
	Crystal River[a] (GL)	Standardized NUHOMS 32PTH	72-1035	72-1004
	San Onofre-2 and 3[b] (GL)	Advanced NUHOMS 24PT4	72-41	72-1029
		UMAX MPC-37		72-1040
	Kewaunee[b] (GL)	Standardized NUHOMS 32PTH	72-64	72-1004
		NAC-MAGNASTOR TSC (37)		72-1031
	Vermont Yankee (GL)	HI-STORM MPC-68	72-59	72-1014
Shutdown reactors on operating plant sites	Indian Point-1 (GL)	HI-STORM MPC-32	72-51	72-1014
	Dresden-1 (GL)	HI-STAR, MPC-68	72-37	72-1008
		HI-STORM MPC-68		72-1014
	Millstone-1[a] (GL)	Standardized NUHOMS 61BTH	72-47	72-1004
Near-term shutdown reactor site	Oyster Creek (GL)	Standardized NUHOMS 61BTH	72-15	72-1004

[a] No dry storage systems have been deployed for this reactor yet, although the storage technology has been chosen.
[b] SONGS-2/3 and Kewaunee moved some of their UNF into dry storage in the Advanced NUHOMS and Standardized NUHOMS Systems, respectively, during plant operation. After the plants permanently shut down, the owners chose the HI-STORM UMAX System and the MAGNASTOR systems, respectively, to complete the movement of all fuel from wet to dry storage.

2. SUMMARY OF REVIEWS

In the following subsections, the design criteria are summarized for each specifically-licensed shutdown reactor ISFSI and for each group of generally-licensed shutdown reactors using the same storage system CoC under a general license. The criteria selected for inclusion within this report are those criteria directly affecting implementation of the subject cask system at an interim storage site. Because of differences in cask systems and safety analysis methods, not all criteria is applicable to all sites listed. See Table -1 for a listing of the shutdown reactors and Part 72 license types, including cask technology used by each general licensee.

2.1 Humboldt Bay Review Summary (SNM License 72-2514)

2.1.1 Overview

Five UNF canisters and one GTCC waste canister are currently in storage at the Humboldt Bay ISFSI. Each UNF canister has a capacity of 80 BWR fuel assemblies. The Humboldt Bay ISFSI stores a total of 390 UNF assemblies or about 31 MTU of UNF waste.

The Humboldt Bay ISFSI is operated under a 10 CFR 72 specific license (SNM-2514, Docket 72-27). The storage technology is the HI-STAR 100 HB System. Each HI-STAR 100 HB System, comprised of the multi-purpose canister – Humboldt Bay (MPC-HB) inside an unventilated, all-metal HI-STAR 100 HB overpack, is situated in a below-ground concrete vault with a lid. The HI-STAR 100HB overpack is a shortened version of the standard HI-STAR 100 storage cask certified under CoC 72-1008.

2.1.2 Results of Review

The Humboldt Bay ISFSI license and FSAR were reviewed and the design criteria in the table below were extracted.

DESIGN CRITERION	VALUE	SOURCE	NOTES
Normal Ambient Temperature (Max/Min)	52^{o}F/NA	FSAR Table 3.4-1	Annual average
Off-Normal Ambient Temperature (Max/Min)	60^{o}F/NA	FSAR Table 3.4-1	72-hr average
Accident Ambient Temperature (Max/Min)	90^{o}F/15^{o}F	FSAR Table 3.4-1	72-hr average
Soil Temperature below ISFSI Pad (Max)	52^{o}F	FSAR Table 3.2-3	
Wind Velocity (Max)	300 MPH 240 MPH rotational 60 MPH translational 2.25 psi pressure drop	FSAR Table 3.4-1	

DESIGN CRITERION	VALUE	SOURCE	NOTES
Tornado Missiles	1800kg @ 126 MPH 125 kg @ 126 MPH 0.22 kg @ 126 MPH	FSAR Table 3.2-2	Large, intermediate, and small missile
Seismic Horizontal (Max g) Vertical (Max g)	See Footnote 9.	FSAR Sections 2.6.6, 3.2.4, 8.2.1	The seismic design at the HB ISFSI is complex, but known to be very high because the site is in one of the highest seismic regions in the country[6].
Snow/Ice Load	None	FSAR Table 3.4-1	Casks are located in vaults with separate lids.
Flooding	6 ft submergence	FSAR Table 3.4-1	Flooding (moving water) not credible
Storage Pad Compressive Strength (Max/Min)	4,000 psi @ 28 days	FSAR Table 3.4-3	No drop or tipover analysis performed due to SFP lifting devices and vault design.
Storage Pad Thickness (Max/Min)	NA		Casks are stored in vaults
Storage Pad Reinforcement	60,000 psi	FSAR Table 8.2-6	
Storage Pad Subsoil Modulus (Max)	32,000 psi	FSAR Table 8.2-8	
Cask Drop Height	NA	FSAR Section 4.2.3.3.2.5	No drop analyzed. Considered not credible.
ISFSI Elevation	NA		

2.2 Rancho Seco Review Summary (SNM License 72-2510)

2.2.1 Overview

Twenty-one UNF canisters and one GTCC waste canister are currently in storage at the Rancho Seco ISFSI. Each UNF canister has a capacity of 24 PWR fuel assemblies or 13 failed fuel assemblies. The twenty-one canisters contain a total of 493 UNF assemblies, damaged fuel assemblies in damaged fuel cans, and reconfigured fuel assemblies, or about 228 MTU of UNF waste.

The Rancho Seco ISFSI is operated under a 10 CFR 72 specific license (SNM-2510, Docket 72-11). The storage technology is based on a version of the NUHOMS-24P storage system, which consists of a transportable dry shielded canister (DSC) in a horizontal, ventilated, concrete storage module. Three types of DSCs are deployed at the Rancho Seco ISFSI, designated FC-DSC, FO-DSC and FF-DSC respectively.

[6] Humboldt Bay casks are currently stored in below-grade vaults. New design analyses, such as seismic and tipover analyses, will be required if they will be stored at an ISF on an above-grade ISFSI pad.

2.2.2 Results of Review

The Rancho Seco ISFSI license and FSAR were reviewed and the design criteria in the table below were extracted.

DESIGN CRITERION	VALUE	SOURCE	NOTES
Normal Ambient Temperature (Max/Min)	100°F/+17°F	FSAR 8.1.1.3	
Off-Normal Ambient Temperature (Max/Min)	117°F/-20°F	FSAR 8.1.1.3	
Accident Ambient Temperature (Max/Min)	125°F/-20°F	FSAR 8.2.3	
Soil Temperature below ISFSI Pad (Max)	NA		
Wind Velocity (Max)	360 MPH	FSAR Table 3.12	The maximum resulting pressure load = 397 psf on the winward side of the storage module and -357 psf (suction) on the leeward side per FSAR 3.2.1.2.
Tornado Missiles	Automobile Weight = 3967 lbs Area = 20 ft^2 Velocity = 126 mph Penetration Resistant Missile Weight = 276 lbs Diameter = 8.0 inches Velocity = 126 mph Barrier Impingement Missile Diameter = 1.0 in Velocity = 126 mph	FSAR Table 3.4	
Seismic Horizontal (Max g) Vertical (Max g)	Horizontal 0.25g (Both Directions) Vertical 0.17 g	FSAR Table 3.4	
Snow/Ice Load	110 psf	FSAR 3.2.4	
Flooding	50 ft. submergence 15 fps velocity	FSAR 3.2.2	Flooding at site is not credible. Standardized NUHOMS 50 foot flood height and15fps velocity incorporated by reference.
Storage Pad Compressive Strength (Max/Min)	4000 psi 4.0 ksf	SER 5.5.1.3. Dead Load Plus Live Load Bearing Stress limit	
Storage Pad Thickness (Max/Min)	24 inches under HSM, 12 to 18 inches base mat remainder of pad	Tech Spec 4.2.3	

DESIGN CRITERION	VALUE	SOURCE	NOTES
Storage Pad Reinforcement	60 ksi yield reinforcing steel	SER 5.5.1.3.	
Storage Pad Subsoil Modulus (Max)	NA		No subsoil modeled in TC drop analysis
Cask Drop Height	80 inches	Tech Specs 5.6.2.	Transfer cask drop
ISFSI Elevation	NA		

2.3 Trojan Review Summary (SNM License 2509)

2.3.1 Overview

Thirty-four UNF canisters are currently in storage at the Trojan ISFSI. There are no GTCC waste canisters at the Trojan ISFSI. Each UNF canister has a capacity of 24 pressurized water reactor (PWR) fuel assemblies. The 34 canisters contain a total of 801 UNF assemblies, including various forms of damaged fuel assemblies/fuel assembly components, or about 345 MTU of UNF waste.

The Trojan ISFSI is operated under a 10 CFR 72 specific license (SNM-2509, Docket 72-17). Trojan uses a “hybrid” storage technology comprised of a Holtec International MPC-24E or MPC-24EF canister in a FuelSolutions TranStor vertical ventilated concrete storage cask.

2.3.2 Results of Review

The Trojan ISFSI license and FSAR were reviewed and the design criteria in the table below were extracted.

DESIGN CRITERION	VALUE	SOURCE	NOTES
Normal Ambient Temperature (Max/Min)	100°F/-40°F	FSAR Table 3.6-1	
Off-Normal Ambient Temperature (Max/Min)	None	FSAR Table 3.6-1	
Accident Ambient Temperature (Max/Min)	100°F/None	FSAR Table 3.6-1	
Soil Temperature (Max)	NA		
Wind Velocity (Max)	360 MPH total 290 MPH rotational 70 MPH translational 3.0 psi pressure drop	FSAR Table 3.6-1	
Tornado Missiles	Automobile (3960 lb) Armor Piercing shell (275 lb) Steel sphere (0.22 lb)	FSAR Table 3.6-1 FSAR Table 3.2-2	

DESIGN CRITERION	VALUE	SOURCE	NOTES
	All at 125 MPH		
Seismic Horizontal (Max g) Vertical (Max g)	0.38 g (horizontal) 0.25 g (vertical)	FSAR Table 3.6-1	
Snow/Ice Load	67.2 psf	FSAR Table 3.6-1	
Flooding	NA	FSAR Table 3.6-1	
Storage Pad Compressive Strength (Max/Min)	See Note 1		
Storage Pad Thickness (Max/Min)	See Note 1		
Storage Pad Reinforcement	See Note 1		
Storage Pad Subsoil Modulus (Max)	See Note 1		
Cask Drop Height	See Note 1		
ISFSI Elevation	NA		

Note 1: The design criteria for the Trojan ISFSI pad and subsoil, and the cask drop height were not able to be retrieved from the publicly available documents. However, the Trojan spent fuel canisters (Holtec MPC-24E and -24EF models) are currently stored in TransStor concrete casks, which are no longer in fabrication. It is highly likely that the Trojan canisters will be licensed for use at the pilot ISF in another storage cask, such as the HI-STORM 100 overpack. That re-licensing will require new analyses for the cask drop and tipover accident events performed for the actual pilot ISF storage pad design criteria.

2.4 NAC-MPC Review Summary (CoC 72-1025)

2.4.1 Overview

Three ISFSIs store shutdown reactor UNF and GTCC waste in the NAC-MPC Storage System under a general license (CoC 72-1025) in conjunction with their respective reactor operating licenses:

- Yankee Rowe: 15 UNF casks, 533 UNF assemblies (122 MTU), 1 GTCC waste cask
- Connecticut Yankee (Haddam Neck): 40 UNF casks, 1,019 UNF assemblies (422 MTU), 3 GTCC waste casks
- LaCrosse Boiling Water Reactor: 5 UNF casks, 333 UNF assemblies (38 MTU), No GTCC waste casks

Fuel from each of the above shutdown reactors is stored in a different NAC-MPC canister design inside the same concrete cask design. Canister capacities are shown in Table -1. The design criteria below apply to all three combinations of NAC-MPC canisters and casks.

2.4.2 Results of Review

The NAC-MPC CoC and FSAR were reviewed and the design criteria in the table below were extracted.

DESIGN CRITERION	VALUE	SOURCE	NOTES
Normal Ambient Temperature (Max/Min)	75 °F/NA	FSAR 2.2.6.	High annual average temperature in U.S.
Off-Normal Ambient Temperature (Max/Min)	100°F/-40°F	FSAR 2.2.6.	Solar for high temperature, no solar for low temperature
Accident Ambient Temperature (Max/Min)	125°F/NA	FSAR 2.2.6.	Includes maximum solar loading. Thermal assessments with half the air inlets blocked and with all air inlets and outlets blocked considered.
Soil Temperature below ISFSI Pad (Max)	NA		
Wind Velocity (Max)	360 MPH 290 MPH rotational 70 MPH translational Radius: 150 feet Pressure Drop: 3.0 psi	FSAR 2.2.1.1.	Regulatory Guide 1.76 Region 1
Tornado Missiles	<u>Massive Missile</u> Deformable Weight: 3960 pounds Frontal Area: 20 sq.-ft. <u>Penetration Missile</u> Rigid hardened steel Weight: 275 pounds Diameter: 8.0 inches <u>Protective Barrier Missile</u> Solid steel sphere Weight: 0.15 pounds Diameter: 1.0 inch	FSAR 2.2.1.3.	NUREG-0800 applies. Velocity of missiles is 126 miles per hour which is 35% of maximum wind velocity.
Seismic Horizontal (Max g) Vertical (Max g)	Horizontal: 0.25 g Vertical: 0.167 g	FSAR 2.3.3.1	
Snow/Ice Load	100.8 psf	FSAR 2.2.4	

DESIGN CRITERION	VALUE	SOURCE	NOTES
Flooding	15 fps 50 feet above the base of storage cask	FSAR 2.2.2.1	
Storage Pad Compressive Strength (Max/Min)	6000 psi Yankee MPC 4000 psi LACBWR-MPC	FSAR 11.A.2.12.2.1	
Storage Pad Thickness (Max/Min)	36 inches maximum	Technical Specification B 3.4	Yankee MPC and Connecticut Yankee MPC
Storage Pad Reinforcement	NS		
Storage Pad Subsoil Modulus	≤30,000psi	Technical Specification B 3.4	Connecticut Yankee limit
Cask Drop Height	6 inches	FSAR 11.2.11	
ISFSI Elevation	NA		

2.5 NAC-UMS Review Summary (CoC 72-1015)

2.5.1 Overview

One shutdown reactor (Maine Yankee) stores UNF and GTCC waste in the NAC-UMS Storage System under a general license. Sixty (60) UNF canisters and four GTCC waste canisters are currently in storage at the Maine Yankee ISFSI in the NAC-UMS System. Each UNF canister has a capacity of 24 PWR fuel assemblies. The 60 canisters contain a total of 1,436 UNF assemblies and damaged fuel assemblies in damaged fuel cans, or about 542 MTU of UNF waste.

2.5.2 Results of Review

The NAC-UMS CoC and FSAR were reviewed and the design criteria in the table below were extracted.

DESIGN CRITERION	VALUE	SOURCE	NOTES
Normal Ambient Temperature (Max/Min)	76°F/0°F	FSAR 8.1.1.4	Minimum temperature is only for transfer cask while lifting FSAR 8.1.1.4
Off-Normal Ambient Temperature (Max/Min)	106°F/-40°F	FSAR 11.1.1.1.	Labelled as severe ambient conditions
Accident Ambient Temperature (Max/Min)	76°F/NA	FSAR 11.1.2.	Accident scenario includes blockage of half of the vents
Soil Temperature below ISFSI Pad (Max)	NA		
Wind Velocity (Max)	360 MPH	FSAR 11.2.11.3	Maximum tornado wind

DESIGN CRITERION	VALUE	SOURCE	NOTES
Tornado Missiles	4000 pound automobile with a frontal area of 20 square feet that deforms on impact. 280 pound, 8 inch diameter armor-piercing artillery shell. 1 inch diameter solid steel sphere.	FSAR 11.2.11.3	All of these missiles are assumed to impact in a manner that produces the maximum damage at a velocity of 126 mph or 35% of the maximum tornado wind speed of 360 mph.
Seismic Horizontal (Max g) Vertical (Max g)	Horizontal : 0.26 g Vertical: 0.173 g	Technical Specifications B3.4.1.	Horizontal g-level in each of two orthogonal directions Vertical g-level upward Values listed are site specific values, Maine Yankee values are higher.
Snow/Ice Load	100.8 psf	FSAR 2.2.4	
Flooding	50 ft submergence 15fps velocity	Technical Specifications B3.4.1.	
Storage Pad Compressive Strength (Max)	≤ 4,000 psi at 28 days	FSAR 11.2.4.3	Strength assumed for drop (4 ksi) is less than that used for tipover analysis (5 ksi)
Storage Pad Thickness (Max)	36 inches	FSAR 11.2.12.13.	
Storage Pad Concrete Dry Density	125 – 160 lb/ft^3	FSAR 11.2.12.13	
Storage Pad Subsoil Density	100 – 160 lb/ft^3	FSAR 11.2.12.13	
Storage Pad Subsoil Modulus	≤ 60,000 psi (PWR) ≤ 30,000 psi (BWR)	FSAR 11.2.12.3.	
Cask Drop Height	24 inches	FSAR 11.2.4.	Vertical Concrete Cask drop height
ISFSI Elevation	NA		

2.6 NAC-MAGNASTOR Review Summary (CoC 72-1031)

2.6.1 Overview

Two ISFSIs store, or will store shutdown reactor UNF and GTCC waste in the NAC-MAGNASTOR System under their respective general licenses:

- Zion: 61 UNF casks, 2,226 UNF assemblies (1,019 MTU), 4 GTCC waste casks
- Kewaunee: 24 UNF casks, 887 assemblies (347 MTU), no GTCC waste casks[7]

Fuel from each of the above shutdown reactors is stored in a different NAC-MPC canister design inside the same concrete cask design. Canister capacities are shown in Table -1. The design criteria below apply to all three combinations of NAC-MPC canister and cask.

2.6.2 Results of Review

The MAGNASTOR CoC and FSAR were reviewed and the design criteria in the table below were extracted.

DESIGN CRITERION	VALUE	SOURCE	NOTES
Normal Ambient Temperature (Max/Min)	76 °F/NA	FSAR 2.3.6.	High annual average temperature in U.S.
Off-Normal Ambient Temperature (Max/Min)	106°F/-40°F	FSAR 2.3.6.	Solar for high temperature, no solar for low temperature
Accident Ambient Temperature (Max/Min)	133°F/NA	FSAR 2.3.6.	Includes maximum solar loading. Thermal assessments with half the air inlets blocked and with all air inlets and outlets blocked considered.
Soil Temperature below ISFSI Pad (Max)	NA		
Wind Velocity (Max)	360 MPH 290 MPH rotational 70 MPH translational	FSAR 2.3.1.1.	

[7] The number of UNF casks is estimated based on the total UNF inventory on site at this time and current canister capacity Kewaunee currently stores its used fuel in the Standardized NUHOMS System but will be switching to the MAGNASTOR System. It is uncertain at this time exactly how many MAGNASTOR casks will be required to completely decommission the spent fuel pool.

DESIGN CRITERION	VALUE	SOURCE	NOTES
Tornado Missiles	Massive Missile Deformable Weight: 4000 pounds Frontal Area: 20 sq.-ft. Penetration Missile Rigid hardened steel Weight: 280 pounds Diameter: 8.0 inches Protective Barrier Missile Solid steel sphere Weight: 0.15 pounds Diameter: 1.0 inch	FSAR 2.3.1.3.	
Seismic Horizontal (Max g) Vertical (Max g)	0.37 g (horizontal) 0.25 (vertical)	FSAR 3.7.3.4 and 12.2.8	NAC applies a safety factor of 1.1 to these values.
Snow/Ice Load	100.8 psf	FSAR 2.3.4	
Flooding	50 ft. submergence 15 fps velocity	FSAR 12.2.9	
Storage Pad Compressive Strength (Max)	None specified	FSAR 12.2.4.3	Drop surface is assumed to be infinitely rigid
Storage Pad Thickness (Max/Min)	None specified		
Storage Pad Reinforcement	None specified		
Storage Pad Subsoil Modulus	None specified		
Cask Drop Height	24 inches	FSAR 12.2.4	Vertical drop height
ISFSI Elevation	NA		

2.7 HI-STAR 100 Review Summary (CoC 72-1008)

2.7.1 Overview

One shutdown reactor (Dresden Unit 1) stores UNF in the HI-STAR 100 Storage System under a general license. Four UNF canisters and no GTCC waste canisters are currently in storage at the Dresden ISFSI in the HI-STAR 100 System. The four canisters contain a total of 272 UNF assemblies and damaged fuel assemblies in damaged fuel cans, or about 47 MTU of UNF waste.

2.7.2 Results of Review

The HI-STAR 100 CoC and FSAR were reviewed and the design criteria in the table below were extracted.

DESIGN CRITERION	VALUE	SOURCE	NOTES
Normal Ambient Temperature (Max/Min)	80^{o}F/NAe	CoC Appendix B, Section 1.4.1	Annual average
Off-Normal Ambient Temperature (Max/Min)	100^{o}F/-40^{o}F	FSAR Table 2.2.2	
Accident Ambient Temperature (Max/Min)	125^{o}F/-40^{o}F	CoC Appendix B, Section 1.4.2	72-hr average
Soil Temperature below ISFSI Pad (Max)	NA		
Wind Velocity (Max)	360 MPH 290 MPH rotational 70 MPH translational 3.0 psi pressure drop	FSAR Table 2.2.4	
Tornado Missiles	1800kg @ 126 MPH 125 kg @ 126 MPH 0.22 kg @ 126 MPH	FSAR Table 2.2.5	
Seismic Horizontal (Max g) Vertical (Max g)	H (g) / V (g) 0.314 / 0.222 0.332 / 0.176 0.339 / 0.160 0.354 / 0.125	CoC Appendix B, Section 1.4.3/Table 1-4	Any combination or equivalent is acceptable.
Snow/Ice Load	100 psf	FSAR Table 2.2.8	
Flooding	656 ft submergence 13 ft/sec moving water	CoC Appendix B, Section 1.4.4	
Storage Pad Compressive Strength (Max/Min)	4,200 psi/None	FSAR Table 2.2.9	Maximum based on drop/tipover analyses. Minimum is based on structural requirements.

DESIGN CRITERION	VALUE	SOURCE	NOTES
Storage Pad Thickness (Max/Min)	36 inches/None	FSAR Table 2.2.9	Maximum based on drop/tipover analyses. Minimum is based on structural requirements.
Storage Pad Reinforcement	60 ksi yield ASTM material	FSAR Table 2.2.9	
Storage Pad Subsoil Modulus (Max)	28,000 psi	FSAR Table 2.2.9	Maximum soil effective modulus of elasticity based on drop/tipover analyses. See note modifying HI-STAR FSAR Table 2.2.9 for how to determine this value.
Cask Drop Height	End: 21 inches Side: 72 inches	FSAR Table 2.0.2	
ISFSI Elevation	NA		

2.8 HI-STORM 100 Review Summary (CoC 72-1014)

2.8.1 Overview

Three ISFSIs store shutdown reactor UNF and GTCC waste in the HI-STORM 100 System under their respective general licenses:

- Dresden Unit 1: 8 UNF casks, 516 UNF assemblies[8] (93 MTU), no GTCC waste casks
- Indian Point Unit 1: 5 UNF casks, 160 UNF assemblies (33 MTU), no GTCC waste casks
- Vermont Yankee: 58 UNF casks, 3,880 UNF assemblies, 706 MTU, and an unknown number of GTCC waste casks[9]

Fuel from each of the above shutdown reactors is stored in a different NAC-MPC canister design inside the same concrete cask design. Canister capacities are shown in Table -1. The design criteria below apply to all three combinations of NAC-MPC canister and cask.

[8] One cask includes the last of the Dresden Unit 1 fuel mixed with Unit 2 or 3 fuel in order to completely fill a canister.

[9] Vermont Yankee permanently shut down in 2014. The UNF inventory is currently split between wet and dry storage. The number of UNF casks is estimated based on the total UNF inventory on site at this time and current canister capacity. The last cask will be short-loaded. It is unclear at this time if, or how many GTCC waste casks will be required.

2.8.2 Results of Review

The HI-STORM 100 CoC and FSAR were reviewed and the design criteria in the table below were extracted.

DESIGN CRITERION	VALUE	SOURCE	NOTES
Normal Ambient Temperature (Max/Min)	80^{o}F/None	CoC Appendix B, Section 3.4.1	Annual average for casks in service. CoC Appendix B, Section 3.4.8 also includes limits on ambient temperature during transfer cask operations.
Off-Normal Ambient Temperature (Max/Min)	100^{o}F/-40^{o}F	FSAR Table 2.2.2	
Accident Ambient Temperature (Max/Min)	125^{o}F/-40^{o}F	CoC Appendix B, Section 3.4.1	
Soil Temperature below ISFSI Pad (Max)	77^{o}F	FSAR Table 2.2.2	
Wind Velocity (Max)	360 MPH 290 MPH rotational 70 MPH translational 3.0 psi pressure drop	FSAR Table 2.2.4	
Tornado Missiles	1800kg @ 126 MPH 125 kg @ 126 MPH 0.22 kg @ 126 MPH	FSAR Table 2..2.5	
Seismic Horizontal (Max g) Vertical (Max g)	$G_H + \mu G_V \leq \mu$ G_H and G_V are vectorial sum of two horizontal ZPAs and vertical ZPA, for the site respectively For two definitions of μ: 1. Coefficient of friction 2. Ratio of cask radius over cask center-of-gravity	CoC Appendix B, Section 3.4.3	μ (as COF) = 0.53 unless testing demonstrates a different value Site-specific analysis is permitted if inequality cannot be met. It must show that casks do not tip over or slide excessively in a design basis earthquake. Sites with seismic characteristics beyond these values must use anchored casks.
Snow/Ice Load	100 psf	FSAR Table 2.2.8	

DESIGN CRITERION	VALUE	SOURCE	NOTES
Flooding	125 ft submergence 15 ft/sec moving water	CoC Appendix B, Section 3.4.4	
Storage Pad Compressive Strength (Max/Min)	A: 4,200 psi/None B: 6,000 psi/None	FSAR Table 2.2.9	Two standard pad design criteria sets are established, labeled "A" and "B". Maximum based on drop/tipover analyses. Minimum is based on structural requirements.
Storage Pad Thickness (Max/Min)	A: 36 inches/None B: 28 inches/None	FSAR Table 2.2.9	Maximum based on drop/tipover analyses. Minimum is based on structural requirements.
Storage Pad Reinforcement	A: 60 ksi Yield/ASTM material B: 60 ksi Yield/ASTM material	FSAR Table 2.2.9	
Storage Pad Subsoil Modulus (Max)	A: 28,000 psi B: 16,000 psi	FSAR Table 2.2.9	Maximum soil effective modulus of elasticity based on drop/tipover analyses.
Cask Drop Height	11 inches (overpack, vertical) 42 inches (transfer cask, horizontal)	CoC Appendix A, Table 5-1	Value taken from cask drop analyses. Cask drop may not need to be postulated if lifting system is single-failure-proof.
ISFSI Elevation	1500 ft.	FSAR 4.4.4.3	ISFSIs above this elevation require site-specific thermal analysis.

2.9 HI-STORM UMAX Review Summary (CoC 72-1040)

2.9.1 Overview

Two shutdown reactors (San Onofre Units 2 and 3) will store UNF in the HI-STORM UMAX System under a general license. Southern California Edison currently stores UNF in the Advanced NUHOMS System but has chosen to switch storage technologies to the HI-STORM UMAX System to move the remainder of the Units 2 and 3 UNF from wet storage to dry storage. It is unclear at this time exactly how many HI-STORM UMAX Systems will ultimate store San Onofre Units 2 and 3 UNF and GTCC waste.

2.9.2 Results of Review

The HI-STORM UMAX Storage System is a below-grade vault storage system. Unlike the Humboldt Bay below-grade vault system where the stored canisters are inside metal casks and the casks located in the vaults, the canisters are directed stored in the UMAX vaults. The pilot ISF is contemplated as an above-ground ISFSI where canisters would be stored in traditional ventilated vertical storage casks. The canisters from the San Onofre UMAX ISFSI, therefore, would be licensed for above ground storage in a ventilated cask, such as the HI-STORM FW overpack (CoC 72-1032) in which the canisters used with UMAX are already generically licensed.

Based on the above, the design criteria for the UMAX system were not documented as part of this report.

2.10 Standardized NUHOMS Review Summary (CoC 72-1004)

2.10.1 Overview

Four ISFSIs store, or will store shutdown reactor UNF and GTCC waste in the Standardized NUHOMS Storage System under their respective general licenses:

- Kewaunee: 14 UNF casks, 448 UNF assemblies (175 MTU), no GTCC waste casks
- Oyster Creek: 77 UNF casks, 4,692 UNF assemblies (815 MTU), unknown number of GTCC waste casks[10]
- Millstone Unit 1: 48 UNF casks, 2,884 UNF assemblies (522 MTU), unknown number of GTCC waste casks[11]
- Crystal River Unit 3. 39 UNF casks, 1,243 UNF assemblies, (544 MTU), unknown number of GTCC waste casks.[12]

Canister capacities are shown in Table -1. The design criteria below apply to all combinations of NUHOMS canisters and HSMs.

[10] Oyster Creek is scheduled to permanently shut down in 2019. The UNF inventory is currently split between wet and dry storage. The number of UNF casks is estimated based on the projected total UNF inventory on site after reactor operations cease and current canister capacity. The last cask will be short-loaded. It is unclear at this time if or how many GTCC waste casks will be required.

[11] Millstone Unit 1 permanently shut down in 1998. The UNF inventory is currently all in wet storage. The number of UNF casks is estimated based on total UNF inventory on site at this time and the BWR canister capacity for the Standardized NUHOMS System. The last cask will be short-loaded. It is unclear at this time if or how many GTCC waste casks will be required.

[12] Crystal River Unit 3 permanently shut down in 2009. The UNF inventory is currently all in wet storage. The number of UNF casks is estimated based on total UNF inventory on site at this time and the PWR canister capacity for the Standardized NUHOMS System. The last cask will be short-loaded. It is unclear at this time if or how many GTCC waste casks will be required.

2.10.2 Results of Review

The Standardized NUHOMS CoC and FSAR were reviewed and the design criteria in the table below were extracted.

DESIGN CRITERION	VALUE	SOURCE	NOTES
Normal Ambient Temperature (Max/Min)	70°F (24P, 52B and 61BT DSCs) 100°F (52B, 61BT, 32PT, 24PHB, 24PTH, 61BTH, 69BTH, and 37 PTH) 106°F (32 PTH1) No minimum specified	Technical Specification 4.3.3.3	70°F is maximum yearly average 100°F and 106°F are maximum daily averages
Off-Normal Ambient Temperature (Max/Min)	None specified		
Accident Ambient Temperature (Max/Min)	125°F (24P, 52B and 61BT) 117°F (32PT,24PHB, 24PTH, 61BTH, 32 PTH1, 69BTH, and 37PTH) -40°F Minimum	Technical Specification 4.3.3.4	117°F corresponds to a 24-hour calculated average temperature of 102°F for the 32PT DSC only
Soil Temperature below ISFSI Pad (Max)	NA		
Wind Velocity (Max)	360 MPH 290 MPH rotational 70 MPH translational Radius of maximum rotational wind speed: 150 feet 3.0 psi pressure drop at a maximum rate of 2.0 psi/sec	FSAR 3.2.1.1.	

DESIGN CRITERION	VALUE	SOURCE	NOTES
Tornado Missiles	Massive, high energy missile : 3,967 pound automobile traveling 195 ft/sec. Rigid, penetration-resistant missile: 276 pound, 8 inch diameter shell traveling at 185 ft/sec. Protective barrier impingement missile: 1 inch diameter, solid steel sphere. Wood plank missile: 200 pound, 4 inch x 12 inch x 12 ft long, traveling at 440 ft/sec.	FSAR 3.2.1.2.	
Seismic Horizontal (Max g) Vertical (Max g)	Standardized HSM: Horizontal: 0.25g Vertical: 0.17g HSM-H with 24PTH and 61BTH: Horizontal: 0.3g Vertical: 0.2g HSM-H with 32PTH1, 69BTH, and 37PTH: Horizontal: 0.3g Vertical: 0.25g HSM-H (high seismic model) with 32PT, 61BT, 24PTH, 61BTH, 32PTH1, 69 BTH, and 37 PTH: Horizontal : 1.0g Vertical: 1.0g	Technical Specification 4.3.3.8	
Snow/Ice Load	110 psf	Technical Specification 4.3.3.2	
Flooding	50 ft submergence 15 fps velocity	Technical Specification 4.3.3.1.	

DESIGN CRITERION	VALUE	SOURCE	NOTES
Storage Pad Design Criteria	Storage pad design criteria are not included in the FSAR. Design must comply with 10CFR 72.212(b)(5)(ii)	FSAR 8.2.5.1	Transfer cask drop analyses were performed based on EPRI Report NP-4830, The Effects of Target Hardness on the Structural Design of Concrete Storage Pads for Spent Fuel Casks" assuming a drop onto a 36-inch thick pad would create deceleration no greater than 59g. Structural analyses were performed for 75g.
Storage Pad Thickness (Max)	36 inches	FSAR 8.2.5.1	Applies to pad aprons where transfer cask is handled.
Cask Drop Height	80 inches	Technical Specification 4.3.2.	Transfer cask drop
ISFSI Elevation	NA		

2.11 Advanced NUHOMS Review Summary (CoC 72-1029)

2.11.1 Overview

Three shutdown reactors (San Onofre Units 1, 2, and 3) store UNF in the Advanced NUHOMS System under a general license. Fifty (50) UNF canisters and no GTCC waste canisters are currently in storage at the San Onofre ISFSI. The 50 UNF canisters contain a total of 1,187 UNF assemblies or about 497 MTU of UNF waste.

Southern California Edison has chosen to switch storage technologies to the HI-STORM UMAX System to move the remainder of the Units 2 and 3 UNF from wet storage to dry storage. It is unclear at this time exactly how many Advanced NUHOMS Systems that have already been delivered to the site will ultimate store UNF and GTCC waste.

2.11.2 Results of Review

The Advanced NUHOMS CoC and FSAR were reviewed and the design criteria in the table below were extracted.

DESIGN CRITERION	VALUE	SOURCE	NOTES
Normal Ambient Temperature (Max/Min)	104°F/0°F	Technical Specification 4.4.3.4	
Off-Normal Ambient Temperature (Max/Min)	117°F/-40°F	Technical Specification 4.4.3.5	
Accident Ambient Temperature (Max/Min)	117°F/NA	FSAR Rev. 0 3.1.2.2.1.6	
Soil Temperature below ISFSI Pad (Max)	70°F	FSAR Rev. 0, Section B.4.4.3.2	70°F is assumed at depth of 10 feet below the ISFSI pad for hot condition
Wind Velocity (Max)	360 MPH 290 MPH rotational 70 MPH translational	Technical Specification 4.4.3.1	
Tornado Missiles	Utility Pole, 12 inch schedule 40 , 1500 pound steel pipe, Armor Piercing Artillery Shell, 8 inch 276 pounds	UFSAR Revision 3, Section 3 B.11.2.2.2.2.	4000 pound automobile impact removed from missile evaluation in later revisions. Evaluated for cask sliding and overturning vs penetration. Utility pole missile dismissed as non-penetrating. Velocity is 35% of maximum wind velocity or 185 feet per second (126 mph)
Seismic Horizontal (Max g) Vertical (Max g)	Horizontal: 1.5g Vertical 1.0g	FSAR Rev. 0, Section 3.6.2.2.8	Top shield block response is conservatively amplified to 2.25g (horizontal) to allow for the effect of un-grouted shear keys.
Snow/Ice Load	110 psf	Technical Specification 4.4.3.3	
Flooding	50 ft submergence 15 fps velocity	Technical Specification 4.4.3.2	
Storage Pad Design Criteria	Storage pad design criteria are not included in the FSAR. Design must comply with 10CFR 72.212(b)(5)(ii)	Technical Specification 4.4.2	Transfer cask drop analyses were performed based on EPRI Report NP-4830, The Effects of Target Hardness on the Structural Design of Concrete Storage Pads for Spent Fuel Casks" assuming a drop onto a 36-inch thick pad would create deceleration no greater than 59g. Structural analyses were performed for 75g.

DESIGN CRITERION	VALUE	SOURCE	NOTES
Storage Pad Thickness (Max/Min)	5000psi/4500psi	FSAR Table 3.3-6 Concrete Material Properties at Temperature	28 Day compressive strength 100°F and 500°F respectively
Cask Drop Height	80 inches	Technical Specification 4.4.2.	Transfer cask
ISFSI Elevation	NA		

2.12 FuelSolutions Review Summary (CoC 72-1026)

2.12.1 Overview

One shutdown reactor (Big Rock Point) stores UNF and GTCC waste in the FuelSolutions Storage System under a general license. Seven UNF canisters and one GTCC waste canister are currently in storage at the Big Rock Point ISFSI in the Fuel Solutions System. Each UNF canister has a capacity of 74 BWR fuel assemblies. The seven canisters contain a total of 441 UNF assemblies and damaged fuel assemblies in damaged fuel cans, or about 58 MTU of UNF waste.

2.12.2 Results of Review

The FuelSolutions CoC and FSAR were reviewed and the design criteria in the table below were extracted.

DESIGN CRITERION	VALUE	SOURCE	NOTES
Normal Ambient Temperature (Max/Min)	100°F/0°F	Technical Specification 5.3.8	
Off-Normal Ambient Temperature (Max/Min)	125°F/-40°F	Technical Specification 5.3.8	
Accident Ambient Temperature (Max/Min)	100°F/NA	FSAR Table 2.0-1	Ambient conditions for postulated accident events (all vents blocked, loss of transfer cask neutron shield)
Soil Temperature below ISFSI Pad (Max)	NA		
Wind Velocity (Max)	150 MPH 360 MPH tornado	FSAR Table 2.0-1	150 mph straight wind criteria for both transfer cask and storage cask. Tornado velocity results in pressure load of 356 psf on storage cask and 425 psf on transfer cask.
Tornado Missiles	4,000 pound Automobile 275-pound 8inch diameter solid steel sphere	FSAR Table 2.0-1 and FSAR 2.3.4.3.	Missiles are assumed to impact with a horizontal velocity equal to 35% of the maximum wind velocity (vertical impact velocity is70% of same), in accordance with NUREG-0800.

DESIGN CRITERION	VALUE	SOURCE	NOTES
Seismic Horizontal (Max g) Vertical (Max g)	Horizontal 0.25g (Two orthogonal directions) Vertical 0.25g	Technical Specification 4.1.1.1	
Snow/Ice Load	101 psf	FSAR 2.3.4.8	Bounded by other loads
Flooding	50 ft submergence 21 fps velocity	FSAR 2.3.4.1.1	
Storage Pad Compressive Strength (Max)	3,000 psi at 28 days	Technical Specifications 4.2.2.1 and 4.2.2.2	Storage cask and transfer cask
Storage Pad Thickness (Max)	Varies with maximum reinforcing steel and subsoil maximum effective modulus of elasticity (storage cask): 1. 24 inches 2. 30 inches 3. 36 inches Transfer cask: 24 inches	Technical Specifications 4.2.2.1 and 4.1.1.2	
Storage Pad Reinforcement	Varies with pad maximum thickness and subsoil maximum effective modulus of elasticity (storage cask): 1. #8 @ 18 inches 2. #9 @ 18 inches 3. #8 @ 12 inches Transfer cask: #8 @ 18 in.	Technical Specifications 4.2.2.1 and 4.2.2.2	

DESIGN CRITERION	VALUE	SOURCE	NOTES
Storage Pad Subsoil Modulus	Varies with pad maximum thickness and maximum reinforcing steel (storage cask): 1. 30,000 psi 2. 20,000 psi 3. 10,000 psi Transfer cask: 60,000 psi	Technical Specifications 4.2.2.1 and 4.2.2.2	
Cask Drop Height	Storage cask: 36 inches Transfer cask: 72 inches	Technical Specifications 4.2.2.1 and 4.2.2.2	
ISFSI Elevation	NA		

3. REFERENCES

1. United States Department of Energy, *Strategy for the Management and Disposal of Used Nuclear Fuel and High-Level Radioactive Waste*, January 2013.

2. Title 10, U.S. Code of Federal Regulations, *Energy*, Part 72, "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor-Related Greater-than-Class-C Waste."

3. U.S. Nuclear Regulatory Commission Special Nuclear Materials License No 2514 for the Humboldt Bay Independent Spent Fuel Storage Installation, as amended, and associated Final Safety Analysis Report, as updated, Docket 72-27.

4. U.S. Nuclear Regulatory Commission Special Nuclear Materials License No 2510 for the Rancho Seco Spent Fuel Storage Installation, as amended, and associated Final Safety Analysis Report, as updated, Docket 72-11.

5. U.S. Nuclear Regulatory Commission Special Nuclear Materials License No 2509 for the Trojan Spent Fuel Storage Installation, as amended, and associated Final Safety Analysis Report, as updated, Docket 72-17.

6. U.S. Nuclear Regulatory Commission 10 CFR 72 Certificate of Compliance 1025 for the NAC-MPC Storage Cask System, as amended, and associated Final Safety Analysis Report, as revised, Docket 72-1025.

7. U.S. Nuclear Regulatory Commission 10 CFR 72 Certificate of Compliance 1015 for the NAC-UMS Storage Cask System, as amended, and associated Final Safety Analysis Report, as revised, Docket 72-1015.

8. U.S. Nuclear Regulatory Commission 10 CFR 72 Certificate of Compliance 1031 for the MAGNASTOR Storage Cask System, as amended, and associated Final Safety Analysis Report, as revised, Docket 72-1031.

9. U.S. Nuclear Regulatory Commission 10 CFR 72 Certificate of Compliance 1008 for the HI-STAR 100 Storage Cask System, as amended, and associated Final Safety Analysis Report, as revised, Docket 72-1008.

10. U.S. Nuclear Regulatory Commission 10 CFR 72 Certificate of Compliance 1014 for the HI-STORM 100 Storage Cask System, as amended, and associated Final Safety Analysis Report, as revised, Docket 72-1014.

11. U.S. Nuclear Regulatory Commission 10 CFR 72 Certificate of Compliance 1004 for the Standardized NUHOMS Storage Cask System, as amended, and associated Final Safety Analysis Report, as revised, Docket 72-1004.

12. U.S. Nuclear Regulatory Commission 10 CFR 72 Certificate of Compliance 1029 for the Advanced NUHOMS Storage Cask System, as amended, and associated Final Safety Analysis Report, as revised, Docket 72-1029.

13. U.S. Nuclear Regulatory Commission 10 CFR 72 Certificate of Compliance 1026 for the FuelSolutions Storage Cask System, as amended, and associated Final Safety Analysis Report, as revised, Docket 72-1026.