Dry Storage of Used Fuel Transition to Transport

Fuel Cycle Research & Development

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SUMMARY

This report provides details of dry storage cask systems and contents in U.S. for commercial light water reactor fuel. Section 2 contains details on the canisters used to store approximately 86% of assemblies in dry storage in the U.S. Transport cask details for bare fuels, dual purpose casks and canister transport casks are included in Section 3. Section 4 details the inventory of those shutdown sites without any operating reactors. Information includes the cask type deployed, transport license and status as well as fuel types allowed in the specified cask system and allowable parameters. Section 5 contains details on the transfer casks used with each cask system including the current number of transfer casks of each type fabricated.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACRONYMS

10CFR50	Title 10, U.S. Code of Federal Regulations, Part 50
10CFR71	Title 10, U.S. Code of Federal Regulations, Part 71
10CFR72	Title 10, U.S. Code of Federal Regulations, Part 72
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
BFS/ES	BNFL Fuel Solutions/Energy Solutions
BNFL	British Nuclear Fuels Limited
BWR	Boiling Water Reactor
DPC	Dual-Purpose Cask or Dual Purpose Canister
DSC	Dry Shielded Canister (used with NUHOMS systems)
ISFSI	Independent Spent Fuel Storage Installation
MPC	Multi-Purpose Canister (used with HOLTEC and some NAC systems)
ANSI	American National Standards Institute
NRC	Nuclear Regulatory Commission
NUHOMS	**NU**clear **HO**rizontal **MO**dular **S**torage
PWR	Pressurized Water Reactor
TC	Transfer Cask
TSC	Transportable Storage Canister (used with certain NAC and BFS/ES systems)
UMS	Universal MPC System (used with certain NAC systems)
VCC	Ventilated Concrete Cask

1. INTRODUCTION

Used U.S. light water power reactor fuel has been placed in Dry Storage Canisters (DSC) and casks since the mid-1980s and during that time the canister/cask systems have continuously evolved. Currently, there are more than 1,600 dry storage canisters containing roughly 64,000 assemblies or approximately 20,000 MTHM at Independent Spent Fuel Installations (ISFSI) in the U.S.[1] Updated information on the details of dry stored commercial light water reactor fuel is available from recently published documents including the EPRI Industry Spent Fuel Storage Handbook[2] and the Gap Analysis to Support Extended Storage of Used Nuclear[3].

2. Status of Fuel in Dry Storage

Most assemblies in dry storage in the U.S. are in welded metal canisters inside vented concrete vertical overpacks or horizontal storage module. For this configuration, the canister with its internal basket, fuel and fuel component contents is the only portion of the storage cask system which is transported. These systems all require a separate transportation cask with a type B containment vessel to overpack the fuel canister (see reference 13 for an example of this type of cask). The transfer usually requires the use of a transfer cask except for the NUHOMS transportation casks which can interface directly with the horizontal storage module (see Section 3.2). Some welded metal canisters cannot currently be transported for various design reasons. The number and types of these canisters are detailed in Appendix A.

There are four categorical descriptions of dry cask storage:

1. Metal canisters in vertical concrete overpacks or horizontal concrete modules,
2. Metal canisters in metal overpack/storage/shipping casks,
3. Metal canisters in concrete vaults and
4. Bare fuel casks that provide both primary containment and shielding for storage and transportation. (A number of these casks have never been certified for transport as detailed in section 3.1.)

The Consolidated Storage Facility concepts must be capable of receiving any of these dry storage canister and transportation over-pack configurations. Since the mid 1980's 8 cask vendors have provided 11 cask systems comprised of 30 different canister types. Table 2-1 summarizes these canister and casks, provides the quantity of each cask type, as of May 2012 as well as the storage configuration and transition required in order to ship and receive the casks at the consolidated storage facility. For those bare fuel casks which do not have a transport license, the transition to transport requires a wet transfer of the fuel to a licensed transport cask or to a canister that is capable of transport. Some bare fuel Casks may still be licensable for direct transport of their contents as identified in the footnotes.

A number of the canisters listed in Table 2-1 are designated as 'storage only" canisters by the associated cask vendor. These are identified in footnotes e and f of Table 2-1. For these canisters, repackaging in a canister capable of transport may be necessary if a direct shipment transport license cannot be obtained. This will depend on whether compensatory measures such as burnup credit or moderator exclusion can be utilized in the transport license.

Table 2-1 UNF Dry Storage Cask/Vault Systems

Vendor	**Cask System**	**Canister Type**	**Storage Configuration**	**May 2012**	**Transition to Transport Required Operation**
Welded Metal Canister in Vented Concrete Overpack (84.1%)[a]					
BFS/ES	Fuel Solutions	W150	Vertical Cylinder	8	Canister Transfer to Transport Cask
		VSC-24	Vertical Cylinder	58	Canister Transfer to Transport Cask[f]
NAC	NAC-MPC	MPC-26	Vertical Cylinder	43	Canister Transfer to Transport Cask
		MPC-36	Vertical Cylinder	16	Canister Transfer to Transport Cask
	NAC-UMS	UMS-24	Vertical Cylinder	210	Canister Transfer to Transport Cask
TransNuclear	NUHOMS	7P	Horizontal Rectangular	8	Canister Transfer to Transport Cask[e]
		24P	Horizontal Rectangular	135	Canister Transfer to Transport Cask[e]
		32P	Horizontal Rectangular	21	Canister Transfer to Transport Cask[e]
		24PT	Horizontal Rectangular	22	Canister Transfer to Transport Cask[e]
		24PT1	Horizontal Rectangular	18	Canister Transfer to Transport Cask[e]
		24PT4	Horizontal Rectangular	28	Canister Transfer to Transport Cask[e]
		32PT	Horizontal Rectangular	63	Canister Transfer to Transport Cask[e]
		12T	Horizontal Rectangular	29	Canister Transfer to Transport Cask[e]
		24PTH	Horizontal Rectangular	27	Canister Transfer to Transport Cask[e]
		32PTH	Horizontal Rectangular	66	Canister Transfer to Transport Cask[e]
		24PHB	Horizontal Rectangular	38	Canister Transfer to Transport Cask[e]
		61BT	Horizontal Rectangular	117	Canister Transfer to Transport Cask[e]
		61BTH	Horizontal Rectangular	8	Canister Transfer to Transport Cask[e]
		52B	Horizontal Rectangular	27	Canister Transfer to Transport Cask[e]

Table 2-1 (Continued)

Vendor	**Cask System**	**Canister Type**	**Storage Configuration**	**May 2012**	**Transition to Transport Required Operation**
HOLTEC	HI-STORM	MPC-24	Vertical Cylinder	22	Canister Transfer to Transport Cask
		MPC-32	Vertical Cylinder	145	Canister Transfer to Transport Cask
		MPC-68	Vertical Cylinder	258	Canister Transfer to Transport Cask
HOLTEC	TransStor	MPC-24E/EF	Vertical Cylinder	34	Canister Transfer to Transport Cask
Welded Metal Canister in Metal Sealed Overpack (1.4%)					
HOLTEC	HISTAR 100	MPC-68	Vertical Cylinder	7	Direct Ship Possible
		MPC-80	Vertical Cylinder	5	Direct Ship Possible
Welded Metal Canister in Vault Storage (2.4%)					
Foster Wheeler	MVDS	6 assembly canisters	Vault	244	Canister Transfer to Transport Cask
Bare Fuel Casks with Bolted Closure (12.1%)					
NAC	NAC I28	I28	Vertical Cylinder	2	Fuel Transfer to Transport. Cask[b]
TransNuclear	TN Metal Casks	TN-32	Vertical Cylinder	63	Fuel Transfer to Transport. Cask[c]
		TN-40	Vertical Cylinder	29	Direct Ship Possible
		TN-68	Vertical Cylinder	57	Direct Ship Possible
GNB	CASTOR	V/21,X-33	Vertical Cylinder	26	Fuel Transfer to Transport Cask[d]
Westinghouse	MC-10	MC-10	Vertical Cylinder	1	Fuel Transfer to Transport. Cask[d]

[a]% of assemblies in dry storage
[b] Direct shipment of the NAC I28 may be possible see 3.1.3.
[c] Direct shipment of the TN-32 may be possible see 3.1.1.
[d]. Cannot currently be transported for various design reasons see 3.1.2. and 3.1.4.
[e.] NUHOMS 7P, 12T, 24P, 24PHB, 32P, and 52B cannot currently be transported for various design reasons; however, NUHOMS 24PT, 24PT1, 24PT4, 24PTH, 32PT, 32PTH, 61BT, and 61BTH are transportable by canister transfer to transport cask
[f]Fuel Solutions VSC-24 canisters are classified by the cask vendor as storage only canisters

2.1 Dry Storage Canisters

Table 2-2 Key Dimensions of Dry Storage Canisters

Vendor	Cask System	Canister Type	Inside Diameter	Outside Diameter	Length	Gross Weight (lbs)	Reactor Type
Welded Metal Canister in Vented Concrete Overpack							
Fuel Solutions		W74	64.74	66.0	192.25	85,000	BWR
		VSC-24	60.5	62.5	192.5 (max)	69,000	PWR
NAC	NAC-MPC	MPC-26	69.39	70.64	151.75	67,195	PWR
		MPC-36	69.39	70.64	122.5	55,590	PWR
	NAC-UMS	UMS-24	65.81	67.06	191.75 (max)	73,000	PWR
	NAC-MAGNAS.	TSC-37	71	72	191.8/184.8	104,500	PWR
TransNuclear	NUHOMS	7P	[a]	[a]	[a]	[a]	PWR
		24P	66.0	67.25	186.0	80,000	PWR
		32P	[a]	[a]	[a]	[a]	PWR
		24PT	[a]	[a]	[a]	[a]	PWR
		24PT1	65.9	67.19	186.5(max)	82,000	PWR
		24PT4	65.9	67.19	196.5	[a]	PWR
		32PT	65.9	67.19	193(max)		PWR
		12T	[a]	[a]	[a]	[a]	PWR
		24PTH	65.9	67.19	192.2		PWR
		32PTH	68.75	69.75	185.75 (max)	82,000	PWR
		24PHB	65.9	[a]	186.17	[a]	PWR
		61BT	66.25	67.25	195.92	89,390	BWR
		61BTH	67	67	196 (max)	[a]	BWR
		52B	65.9	67.19	195.9	[a]	BWR
HOLTEC	HI-STORM	MPC-24	67.375	68.5 (max)	190.3125 (max)	82,494	PWR
		MPC-32	67.375	68.5 (max)	190.3125 (max)	89,765	PWR
		MPC-68	67.375	68.5 (max)	190.3125 (max)	87,171	BWR
HOLTEC	TransStor	MPC-24E/EF	67.375	68.5 (max)	190.3125 (max)	80,963	PWR
Welded Metal Canister in Metal Sealed Overpack							
HOLTEC	HISTAR 100	MPC-68	67.375	68.5 (max)	190.3125 (max)	240,881	BWR
		MPC-80	67.375	68.5 (max)	[a]	[a]	BWR

[a]Detail redacted from publically available licensing documents in accordance with 10 CFR 2.390. Data requested directly from cask vendor and table will be revised if and when data is received.

3. Cask Systems for Dry Fuel Storage

Dry storage in the U.S can be divided into two broad categories, those in which the fuel is stored bare in a fuel basket inside a metal cask and those in which the fuel is in a welded canister inside a vented concrete overpack or inside a metal dual purpose cask. Details on both categories are provided below.

3.1 Bare Fuel Casks

Light water power reactor transportation casks capable of meeting the 10CFR71 requirements for Normal Conditions of Transport (NCT) and Hypothetical Accident Conditions (HAC) are generally metal casks with bolted closures and containment vessels which meet leak tight requirements of ANSI N14.5[4]. For the case where fuel is placed directly into such a cask and used for long term storage in that cask, the cask is often referred to as a "bare fuel" cask since no welded canister is used. If the cask also has a licensed transport configuration it is also sometimes referred to as a dual purpose cask.

Bare fuel casks employ bolted closures with the fuel is placed directly in a basket inside the cask cavity. Each of the bare fuel casks listed below was designed for transportation cask licensing although as shown in Table 3-1, few of these casks have an existing transportation license nor are in application for a 10CFR71 license for transport. Dry storing fuel in a bare fuel cask is most beneficial if the storage times are short and a receipt facility exists that can directly handle and unload fuel from the cask. They also eliminate the need for a transfer cask and/or canister transfer operation inherent in canister storage.

Only two reactor sites in the U.S. continue to load fuel into bare fuel metal casks, Peach Bottom which uses the Transnuclear TN-68 cask and Prairie Island which continues to load TN-40 casks. Both these casks have current transport licenses as shown in Table 3-1. The remaining bare fuel casks are described as legacy casks since no new casks of these types are being loaded and reactor sites which once employed them are now loading out fuel in canister cask systems. Of the legacy casks, licensing of the TN-32 cask for transport has been discussed by Transnuclear in the past and direct shipment of these casks remains a possibility. Likewise the, NAC I28 cask is an earlier evolution of the currently licensed NAC-STC cask and direct shipment of the NAC I28 also remains a possibility although no transport license is currently being pursued.

Obtaining a transport license for the CASTOR V21 and X33 casks is more problematic since these casks are composed of monolithic cast iron which has not been licensed as a cask configuration in the U.S. as described in 3.1.2 below. Shipment of the single Westinghouse MC-10 in dry storage at Surry is also problematic since Westinghouse, although still active in radioactive material packaging, is not an active vendor supplying dry cask storage systems in the U.S. It is unclear whether the work necessary to ship this cask would be more beneficial than repackaging of its contents into a cask system with a licensed transport configuration,

Table 3-1 Bare Fuel Casks

	VENDOR	CASK	NUMBER OF CASKS (7/2012)	TRANSPORT LICENSE	LOCATION
ACTIVE CASKS (STILL LOADED)	TN	TN-68	57	71-9239	Peach Bottom
		TN-40	29	71-9313	Prairie Island
LEGACY CASKS (NO LONGER LOADED)	TN	TN-32	63	NO	Surry, McGuire, North-Anna
	GNB	CASTOR V21&X33	26	NO	Surry
	NAC	I-28	2	NO	Surry
	Westinghouse	MC-10	1	NO	Surry

Descriptions of the direct loaded bare fuel casks in storage are included below. For direct loaded bare fuel casks, the portion of the cask designated as the "containment" vessel when discussed for transportation purposes below is often referred to as a "confinement" vessel in its storage configuration.

3.1.1 Transnuclear TN-32, TN-40 and TN-68 Casks

The TN series of metal casks is currently used to store the largest amount of un-canisterized fuel in dry storage cask systems in the U.S. These are also the only bare fuel casks which continue to be loaded into dry storage in the U.S.[1] The number following the TN designator is the number of assembly positions in the internal cask basket for the various casks. The TN-32 casks hold PWR assemblies from Surry, Mcguire, and North Anna. The TN-40 casks hold PWR assemblies from Prairie Island only and the TN-68 holds GE BWR fuel from Peach Bottom only. Only Prairie Island and Peach Bottom continue to load TN-40 and TN-68 casks respectively, with Prairie Island loading 3 casks and Peach Bottom adding 5 casks in 2010. Surry and North Anna are now utilizing the NUHOMS canister system while McGuire uses the NAC-UMS canister system for new fuel loads.

The TN-68 and the TN-40 are the only casks in the TN metal cask family that have a current transportation license. The TN-40 received its license in June 2011 after a five year review period by the NRC. This transportation license is only for intact fuel from Prairie Island Unit 1 cycles 1 through 16 and Unit 2 cycles 1 through 15. The maximum initial enrichment for fuel under this license is no more than 3.85 weight percent U^{235}, and the assembly average burnup is required to be no more than 45,000MWd/MTU.

Now that the TN-40 transportation license has been obtained, TN plans to submit an application for a TN-40 variant designated as the TN-40HT. Contents under the transportation application will include fuel with a maximum initial enrichment of 5 weight percent U^{235} and a maximum bundle average burnup limited to 60 GWd/MTU. Fuel transported under this license must have a minimum cooling time of 12 years with a maximum heat load of 0.8Kw/assembly. Indications are that the initial transportation application will include intact fuel only.

There are no current transportation license applications for the TN-32 Cask design. TN has discussed applying for a transport certificate during the time period that this cask model was being produced for domestic dry fuel storage. Since the reactor sites using this cask design have switched to canister based systems, no transport license has been pursued for the TN-32 cask in the U.S. However, given the design similarity between the TN-32 and other TN casks licensed for transport and TNs continued presence in both the storage and transport cask market, it is reasonable to assume that licensing the TN-32 for transport and direct shipment remains a possibility.

Basic information for the TN family of metal casks is shown in Table 3-2 (EPRI 2010 updated for Transportation).[5,6]

Table 3-2 Transnuclear Metal Cask Parameters (NEI 2010)

TN Cask Type	TN-32	TN-40	TN-40HT	TN-68
Fuel Type	**PWR**	**PWR**	**PWR**	**BWR**
# of Assemblies	32	40	40	68
Maximum Heat Load (kilowatts)	32.7	27	32	30
Minimum Cooling Time (Years)	7	10	18	7
Maximum Fuel Burnup (GWd/MTU)	40	45	60	60
Storage Cask				
Length [m] (in)	4.9(184)	4.4(175)	4.6(181.75)	5.5(215)
Length with protective cover [m](in)	5.13(201.88)	5.13(202.0)	5.07(199.6)	
Outer Diameter [m](in)	2.48(97.75)	2.53(99.52)	2.57(101)	2.49(98)
Loaded Weight lbs.	231,000	226,000	242,000	230,000
NRC Part 71 License	None	71-9313	Planned	71-9293

3.1.2 CASTOR V/21 and X/33

The CASTOR V/21 and X/33 casks are metal cask currently used for storage at the Surry power generating station. CASTOR casks are also used in dry storage at INL which is not licensed by the NRC.

Both casks designs consist of a cask body made of thick-walled nodular cast iron with two stainless steel lids sealed with both elastomer and metal seals to provide leak tightness. Polyethylene rods are incorporated into the walls of both cask designs that enhance the neutron shielding of each cask. Otherwise, no special shielding materials are incorporated into the cask with shielding provided by the cast iron and stainless steel cask composition. In both cask designs, the external surface is covered with heat transfer fins that run circumferentially around the cask with an epoxy resin coating protecting the outside cask surface. For the V/21, the internal structure of the cask consists of a welded stainless steel basket with 21 square tube positions with borated stainless steel plates for criticality control while the X/33 has a similar internal structure with 33 square tube positions. Both these CASTOR cask systems use a pressure-sensing device to monitor the pressure in the interspace between the primary and secondary lids verifying seal integrity in storage.

Basic information for the Castor family of metal casks is shown in Table 3-3. All Castor casks used to dry store fuel under NRC license are located at Surry. Early fracture toughness concerns at the NRC prevented the licensing for transport of monolithic nodular cast iron casks like the CASTOR casks in the U.S. However, in the last 20 years, European experience with testing, analysis, use and licensing of nodular cast iron casks has garnered international acceptance of this cask type by the International Atomic Energy Agency[7]. Since then the NRC has indicated that they would accept license applications for nodular cast iron shielded casks like the CASTORs. Any such submittal would be a first time licensing cycle for this cask type and no vendor has yet approached the NRC with a submittal of transport license for this cask type.

Table 3-3 Castor, NAC and Westinghouse Metal Cask Parameters

TN Cask Description	V/21	X/33	NAC I28	Westinghouse MC-10
Fuel Type	**PWR**	**PWR**	**PWR**	**PWR**
# of Assemblies	21	33	28	24
Maximum Heat Load (kilowatts)	21	33	32.7[a]	32.7[a]
Minimum Cooling Time (Years)	7[a]	10[c]	10[c]	10[c]
Maximum Fuel Burnup (GWd/MTU)	35	35	22[c]	35[c]
Storage Cask				
Length [m] (in)	4.9(193)	4.8(189)	4.6(181.2)	4.79(188.4)
Outer Diameter [m](in)	2.8(110.25)	2.8(110.25)	2.4(94.8)	2.71(106.8)
Loaded Weight lbs[b]	233,800	236,000	250,000[d]	250,000[d]
NRC Part 71 License	None	None	None	None

[a] TN-32 cask bounding value
[b] Storage configuration gross weight
[c] Surry ISFSI SAR

[d] Surry ISFSI SAR weight limit

3.1.3 NAC-I28

The NAC-I28 is a variant of the NAC-STC cask which is licensed for transport as described in section 3.2.4. Two NAC-I28 casks are used to dry store PWR fuel assemblies at the Surry power generating station which is the only NRC licensed ISFSI location utilizing this cask design. One NAC-I28 cask is also used in dry storage at INL which is not licensed by the NRC.

The NAC-I28 S/T cask is a smooth right circular cylinder of multiwall construction with a 1.5 inch thick inner shell and a 2.63 inch thick outer shell of austenitic stainless steel separated by 3.2 inches of lead gamma shielding. The inner and outer shells are connected to each other at the ends by an austenitic stainless steel ring and plate. The upper end of the cask is sealed by an austenitic stainless steel bolted closure lid which is 6.5 inches thick in the edge flange region and has a 1-inch inner closure plate and a 5.5-inch outer closure plate. The closure plates are separated by two inches of lead gamma shielding. The closure lid utilizes a double barrier seal system with two metallic o-rings forming the seals. The lower end of the cask is 6 inch thick austenitic stainless steel with a 1 inch outer closure plate. The bottom end closure plates are separated by 1.80 inches of lead gamma shielding. The cask body is approximately 181 inches long and 94 inches in diameter. Neutron emissions from the stored fuel are attenuated by an integral neutron shield located outside the outer shell which contains a 7-inch thickness of borated solid neutron shield material. Neutron emissions from the top of the cask are attenuated during storage by a 3-inch thick solid neutron shield cap encased in stainless steel.[8]

There is no active transportation license for the NAC-I28 package.

For long term storage, the cask cavity is backfilled with helium to one atmosphere. The inner lid interseal volume between the two inner lid metallic gaskets and the interseal volume between the O-rings in the vent and drain port covers are backfilled with 15 psig of helium. The space between the inner and outer lid is pressurized with helium to 100psig and that pressure is monitored during storage for pressure loss by a transducer installed in the cask upper forging. The storage configuration of the NAC I28 Cask includes a tip over impact limiter.[8]

3.1.4 Westinghouse MC-10

The Westinghouse MC-10 cask is a metal cask designed to vertically store 24 PWR SNF assemblies. There is only one MC-10 stored at a NRC licensed ISFSI which is the model at the Surry Power station.

The cask body is a right circular cylinder composed low alloy steel with forged steel walls and a bottom. The basic parameters of the MC-10 design are shown in Table 3-3.

The inside surface of the MC-10 cask is thermally sprayed with aluminum for corrosion protection. The twenty-four carbon steel heat transfer fins are welded axially along the outside of the cask wall. Carbon steel plates are welded between the fins to provide an outer protective skin. Neutron shielding is provided by a layer of BISCO NS-3 cured in the cavity between the cask wall and outer protective skin.[2,8]

This thick walled structure provides the gamma shielding for the cask. A low alloy steel shield cover with a metallic O-ring provides the initial seal and shielding following fuel loading. A carbon steel primary cover lid, with a metallic O-ring seal, provides the primary containment seal and envelopes the shield cover. An additional seal cover, containing BISCO NS-3 neutron-absorbing material is welded over the first two seals. [2,8]

3.2 Canister Transport Casks

As detailed in Table 2-1 and Appendix A, approximately 84% of commercial fuel in the U.S. is stored in single welded canisters inside individual concrete or steel-encapsulated concrete cylindrical storage overpacks or rectangular horizontal storage modules. All of the storage systems whether cylindrical vertical overpacks or horizontal storage modules in the U.S. contain upper and lower vents that allow passive cooling of the internal canister. The canisters for these systems consist of a basket inside a steel shell with an outer diameter ranging from five to six feet in diameter as shown in Table 2-2. Cask vendors use different designators on their particular canister system. These include Multi-Purpose Canister (MPC), Dry Shielded Canisters (DSC), and Transportable Storage Canister (TSC). See the Client Canister descriptions in sections 3.2.1 through 3.2.6 for specific canister designs by cask vendor.

As noted in Table 2-1, there are 12 HISTAR 100 transportation casks which are also storing canisters at three reactor sites in the U.S. including the Humboldt Bay shutdown reactor site. These 12 casks are the only case in the U.S. where seal welded canisters of commercial fuel are stored directly in the transportation package intended for transport. Since the HISTAR 100 transportation cask provides the containment for the future transportation phase, it does not incorporate vents for passive cooling and requires more restrictive limits for heat load and cooling time than concrete overpacks (or storage modules), such as the HISTORM system.

Documents discussing canister transport casks often refer to the transportation containment vessel as an “overpack”, or “transportation over-pack” since it over-packs the canister during transport. Except in the case of the 12 direct stored HISTAR canisters, all other canisters in the U.S. require transfer of the canister from the storage over-pack into the transportation over-pack prior to shipment. This operation must be reversed at the consolidated storage facility in order to place the canister in a low cost vented concrete overpack for long term storage. The receiving facility must be configured to accommodate any of the existing transportation over-packs described below. Table 3-4 gives basic dimension of transport casks designed to ship canisters of dry stored used fuel. In no case is a transport cask of one vendor licensed to ship a canister design of another vendor listed in table 3-4.

Table 3-4 Canister Transport Cask Basic Dimensions

CASK VENDOR	TRANSPORT CASK	GROSS WEIGHT (LBS)[a]	LENGTH (in)[b]	DIAMETER (in)	CAVITY LENGTH (in)	CAVITY DIAMETER (in)
FUEL SOLUTIONS	TS-125	285,000	210.4/324.4	94.2/143.5	193.0	67
TN (NUHOMS)	MP-187	282,000	201.5/308	92.5/[c]	187	68
	MP-197	265,100	208/281.25	91.5/122	197	68
	MP-197HB	304,000	210.25/ 271.25	84.5/126	199.25	70.5
	TN-FSV	47,000	/247	31/78	199	18
NAC	NAC-STC	260,000	193/257	99[d]/128	165	71
	NAC-UMS	255,022	209.3/ 275	92.9/124	192.5	67.6
	NAC-MAGNATRAN	312,000	213.9/	109.8/	192.5	72.25
HOLTEC	HISTAR 100	282,000	203.25/ 305.875	96/128	191.25	68.56

[a] Gross Weight of Heaviest Configuration (may be bounding analytical weight)
[b] Without Impact Limiters/With Impact Limiters
[c] MP-187 Impact Limiter Not Round
[d] Across Corners

3.2.1 NUHOMS MP187

The first transportation cask licensed to ship dual purpose canisters in the U.S. is the MP187[a] Cask. The NUHOMS storage system consists of Dry Shielded Canisters (DSC) stored in concrete Horizontal Storage Modules. The MP187 is designed to accept a single DSC within its containment cavity as described below. The cask is a composite structure of steel and lead surrounded by neutron shielding material. The cask, including the DSC is protected at each end by energy absorbing impact limiters which consist of stainless steel skins filled with poly urethane foam and aluminum honeycomb. These impact limiters also provide thermal insulation

a The MP187 designator is derived from the cavity interior height of 187 inches. The cavity height of the MP197 is 197 inches.

which protects the cask top and bottom seal areas during the hypothetical fire transient event. The cask is fabricated primarily of stainless steel. Non-stainless steel members include the cast lead shielding between the containment boundary inner shell and the structural outer shell, the o-ring seals, the cementitious neutron shield material and the carbon steel closure bolts. Key features and dimension of the MP-187 cask are shown in Table 3-5 and Figure 3-1.[9,10] The maximum heat load of the MP-187 cask is 13.5kW.

Table 3-5 Key Dimensions of the NUHOMS transportation cask

Cask	Cavity Length (in)	ID (in)	Height (in)*	OD (in)*	Base Thick(in)	Structural Lid Thick. (in)	Radial Neutron Shield Thick. (in)	Inner Shell Thick. (in)	Gamma Shield Thick. (in)	Total Wall Thick (in)	Max Gross Weight (lbs.)**
MP187	187	68	201.5	92.5	8	6.5	4.3	1.25	4	12.3	282,000
MP197	197	68	208	91.5	6.5	4.5	4.5	1.25	3.25	11.75	265,100
MP197HB	199.25	70.5	210.25	97.75	6.5	4.5	6.25	1.25	3		304,000

*Does not include impact limiter

**Depends on DSC configuration reported

<u>MP 187 Client Canisters</u>[9]: The DSC is a high integrity stainless steel, welded pressure vessel that provides confinement of the radioactive materials, encapsulates the fuel in an inert atmosphere, and provides axial biological shielding during DSC closure, transfer operations, storage and transport. The DSC internal basket assembly contains a storage position for each fuel assembly. It is composed of circular spacer discs machined from thick carbon steel plates or austenitic stainless steel. Axial support for the DSC basket is provided by four high strength stainless steel support rods and four carbon steel or austenitic stainless steel support plates which extend over the full length of the DSC cavity and bear on the canister top and bottom end assemblies. Carbon steel components of each DSC basket assembly are coated with a thin corrosion resistant layer of nickel to provide corrosion resistance for the short time that the DSC is in the spent fuel pool for fuel loading. All DSC types licensed in the MP187 have an approximate outside diameter of 67 inches and a maximum external length of 186.5 inches.

Per the certificate USA/9255/B(U)F-85, the cask is currently licensed to transport four types of DSCs designated as the FO-DSC (Fuel Only), FC-DSC(Fuel/Control Components), FF-DSC(Failed Fuel) and the 24PT1 DSC. The license allows the transport of failed fuel in limited quantities. Although the MP187 is capable of handling other canisters that have a maximum length of 186.5 inches and maximum diameter of 67.2 inches, no submittals for the transport of other canisters in this cask have been pursued. Application for transport of other NUHOMS canisters have been pursued in the MP 197HB, the newest NUHOM transport cask design.

Only one production unit MP187 Cask has been fabricated as of the issue of this report.

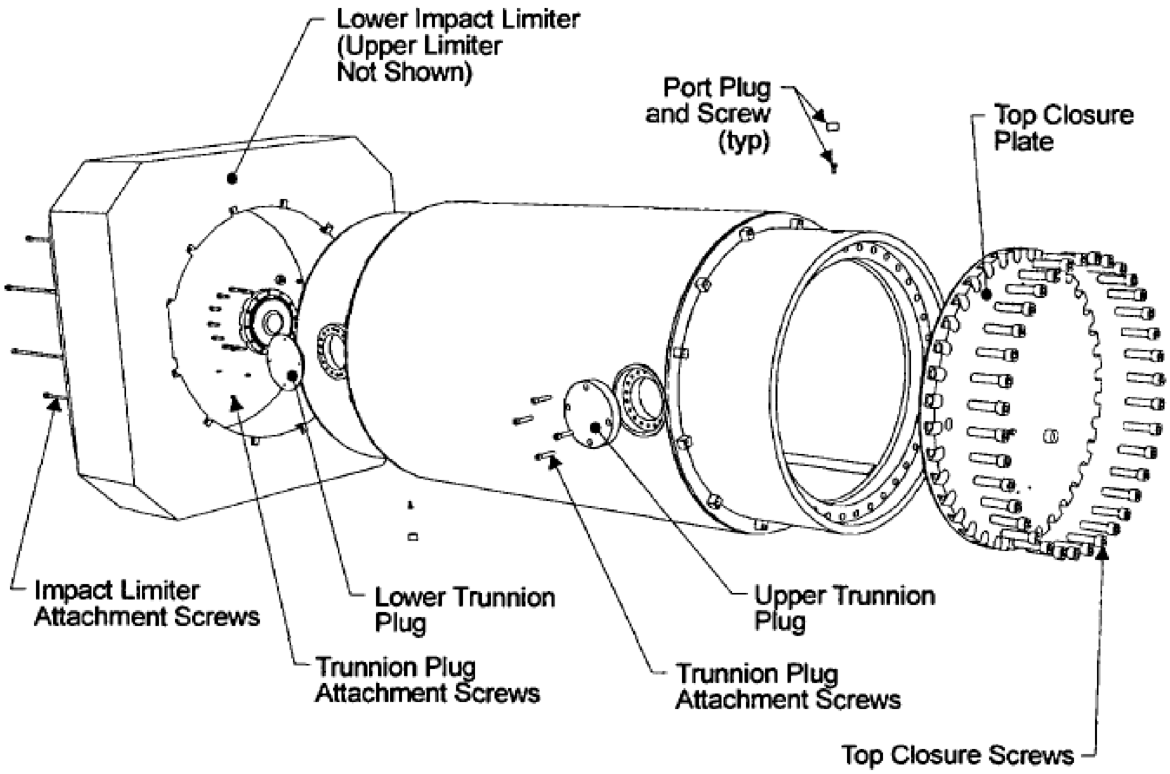

Figure 3-1 MP187 Transportation Cask

3.2.2 NUHOMS MP197 (MP-197HB)

The MP197 and the MP197HB are cask configurations for shipping a single NUHOMS canister which uses the same horizontal loading configuration as the MP187. The basic parameters of the MP197 and MP197HB are provided in Table 3-5. The MP197 and MP197HB are different cask designs with different overall dimensions as well as some difference in materials of construction even though they share the same certificate number. The MP197HB has an internal cavity that is 70.5 inches in diameter and 199.25 inches long.[b] To accommodate smaller DSC designs, an aluminum sleeve and aluminum or stainless steel spacers are provided to limit radial and axial movement of the payload. 61BT DSCs. Both the MP197 and MP197HB casks consist of a containment boundary, structural outer shell, gamma shielding material and solid neutron shield. The containment vessel of both cask designs contains an integrally-welded bottom closure and a bolted and flanged top closure lid. The maximum heat load for the MP197 and MP197 HB casks are 15.86 kW and 24 kW respectively.[10,11]

As of the date of this report, no NUHOMS MP197 or MP197HB casks have been fabricated.

[b] Thus the 197 designator is not strictly accurate with regard to the MP197HB

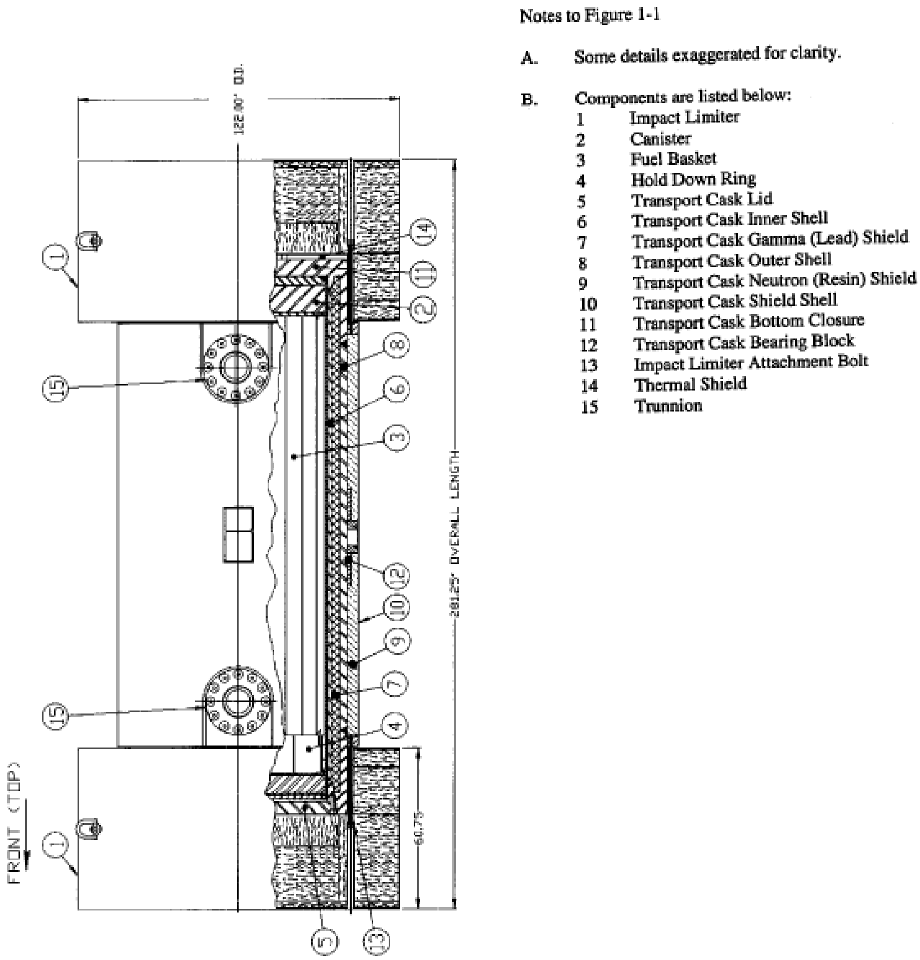

Figure 3-2 NUHOMS MP197 Cask Components[10]

MP197 Client Canisters[10,11]: The MP197 transportation cask is currently only licensed to carry the 61BT DSC. This DSC consists of a cylindrical shell, top and bottom shield plugs, inner and outer bottom closure plates, and inner and outer top cover plates. The shell assembly is a high integrity stainless steel welded pressure vessel that provides containment of radioactive material, encapsulates the fuel in an inert atmosphere (the canister is back-filled with Helium before being seal welded closed) and provides biological shielding in the axial direction. The bottom end assembly welds are made during fabrication of the DSC. The top end closure welds are made after fuel loading. Both top plug penetrations (siphon and vent ports) are redundantly sealed after the DSC drying operations are complete.

MP197HB Client Canisters[11] The MP197HB is currently licensed for transport of four DSC designs as well as radioactive waste containers. These are the 69BTH, 24PT4, 61BT and 61BTH DSC designs. The 69BTH DSC has the largest over all outside diameter at 69.8 inches. To accommodate the smaller 67.3 inch diameter of the other DSCs (24PT4, 61BT, and 61BTH) an aluminum sleeve is used in transport. Since canisters with the same designator vary in length, stainless steel or aluminum spacers are used to limit the axial gap between the DSC and the cask body to 0.5 inches or less. A crossection of the 61BT Canister is shown in figure 3-3 below. Unlike canister types from other cask vendors, shield plugs are provided at both the top and the bottom of the NUHOMS canister. The top shield plug provides shielding for personnel during final welding and drying operations while the bottom shield plug, which is put in place before fuel loading, provides shielding at the face of the horizontal storage module. TN continues to pursue licensing for transport of other NUHOMS canisters in the MP197HB.

As detailed in Appendix A, a certain subset of NUHOMS canisters are designated by TN as "storage only" canisters. These canisters have certain design features which make for a more difficult licensing process for the transport cask configuration in the transport accident sequence required to be evaluated in 10CFR71. Per the cask vendor, licensing of these canisters in transport may still be possible, especially if certain burn-up credit is allowed or moderator exclusion under 71.55 was obtained. Currently, the NUHOMs canisters and not credited with serving any containment function during transport.

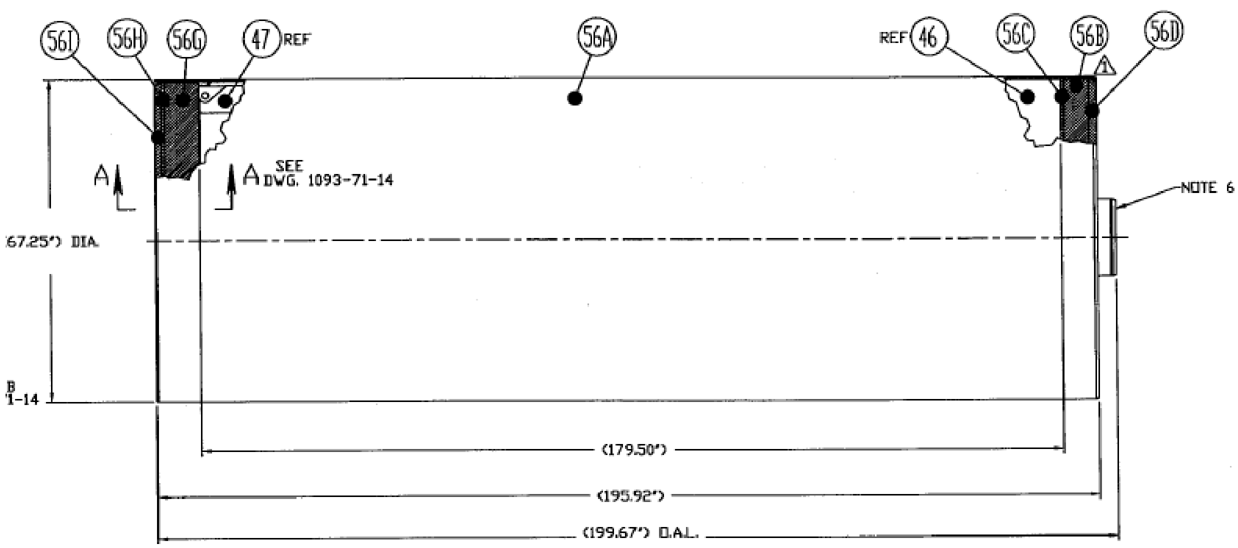

Figure 3-3 61BT DSC Canister Configuration[10]

3.2.3 HOLTECH HISTAR 100

The HISTAR 100 transportation cask consists of a single, sealed metal multi-purpose canister (MPC) contained within a multilayered overpack with impact limiters. The inner diameter of the overpack is approximately 68-3/4 inches and the height of the cavity is approximately 191-1/8 inches. The overpack inner cavity is sized to accommodate the MPCs. The outer diameter of the overpack is approximately 96 inches and the height is approximately 203-1/4 inches (Humboldt Bay overpacks have the same inner and outer diameter but have an inner height of 115 inches and an outer height of 128 inches). Fitted with impact limiters on each end which are composed of aluminum honeycomb, the cask has a maximum outside diameter of 128 inches and a total overall length of 305.9 inches. The gross weight of the HI-STAR 100 system depends on which of the MPCs is loaded into the overpack for shipment but can weigh as much as 277,299 for the heaviest licensed configuration. The maximum total heat load of the HISTAR transport cask is 20kW for PWR fuel contents and 18.5kW for BWR fuel contents. [12]

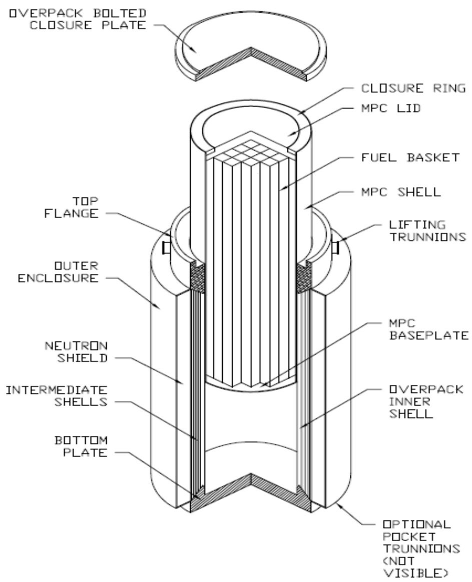

Figure 3-4 HISTAR 100 Transport Cask

Client Canisters: The HI-STAR 100 System is designed to accommodate a wide variety of spent fuel assemblies in a single overpack design by utilizing different MPC basket designs. The exterior dimensions of all Holtec MPCs (except the custom-designed Trojan and Humboldt Bay MPCs) are identical to allow the use of a single overpack design. The generic Holtec MPC design has maximum exterior dimension of approximately 68.5 inches in diameter by 190.3125 inches long. The Trojan plant MPCs are approximately nine inches shorter than the generic Holtec MPC design and have the same outer diameter. The Humboldt Bay MPCs are approximately 6.3 feet shorter than the generic Holtec MPC design and have the same outer diameter. Each of the MPCs has different design features (e.g., fuel baskets) to accommodate distinct fuel characteristics. Each MPC is identified by the maximum quantity of fuel assemblies it is capable of receiving. The MPC-24, -24E, and -24EF each can contain a maximum of 24 PWR assemblies; the MPC-32 can contain up to 32 PWR assemblies; the MPC-68 and -68F each can contain a maximum of 68BWR fuel assemblies; and the MPC-HB for Humboldt Bay can contain up to 80 fuel assemblies.[12]

The overpack containment boundary is formed by a steel inner shell welded at the bottom to an end plate and at the top to a heavy flange with a bolted closure plate.

3.2.4 NAC-STC

The NAC-STC (Storage Transport Cask)[c] is a metal cask design that is licensed for the transport of NAC Multi-Purpose Canisters (MPC) of fuel from Connecticut Yankee and Yankee Rowe "ISFSI Only" sites as well as bare fuel in an internal basket configuration. The NAC-STC is a smooth right-circular cylinder of multiwall construction, consisting of stainless steel inner and outer shells separated by lead gamma radiation shielding. The inner and outer shells are welded to the 304 stainless steel top forging, which is a ring that is machined to mate with the inner and outer lids. The inner and outer shells are also welded to the Type 304 stainless steel bottom inner and outer forgings respectively. The cask bottom consists of two forgings and a plate with neutron shield material sandwiched between the bottom inner forging and the bottom plate. Neutron shield material is also placed in an annulus that surrounds the cask outer shell along the length of the cask cavity. Twenty-four explosively bonded copper and Type 304 stainless steel

[c] Even though the "S" in the STC designator stands for storage, there are no NAC-STC casks used for storing fuel at U.S. dry storage sites although the NAC-I28 is a similar design.

fins are located in the radial neutron shield to enhance the heat rejection capability of the NAC-STC and to support the neutron shield shell and end plates.[13]

NAC STC Client Canisters: The basic NAC-STC cask body dimensions are shown in Figure 3-5. The 71.1 inch diameter cavity accommodates 24 or 26 assembly MPCs from Connecticut Yankee, 36 assembly MPCs from Yankee Rowe or 26 PWR Assemblies stored in a bare fuel basket. Since the fuel canisters include all the fuel from the shutdown reactor, both canister designs allow storage of damaged fuel assemblies. With a cavity length of 165 inches, the STC cavity is shorter than most transport casks for used commercial fuel but the diameter is slightly larger. The cask body outside diameter is approximately 87.7 inches with the outside length of 190.5 inches without impact limiters. In the transport configuration two impact limiters are fitted to either end of the cask body in a typical dumbbell configuration. These are composed of either balsa wood or a combination of redwood and balsa wood encased in stainless steel. The all balsa wood impact limiters have a lower weight and improved crush characteristics compared to the combination redwood and balsawood impact limiters and accommodate a higher cask content weight and higher cask total weight. With impact limiters, the NAC-STC has a maximum outer diameter of 124 inches and an overall length of 257 inches. [13]

The NAC STC has a bare fuel configuration included in its current transport license.[13]

The NAC-STC, when loaded, has a maximum design weight of 260,000pounds. The maximum heat load of the NAC-STC cask is 22.1 kW for direct loaded PWR fuel in the 26 position internal basket configuration with each assembly 0.85 kW or less. For Yankee Rowe fuel, the maximum canistered fuel assembly decay heat load is 0.347 kW per assembly for 36 assemblies and 0.259 kW per assembly for a canister of 24 stainless steel-clad assemblies. For Connecticut Yankee fuel, the maximum decay heat load is 0.654 kW per assembly for a canister of 26 assemblies. [13]

As of the date of this report, no NAC-STC casks have been fabricated for use in the U.S. This cask design is likely to be replaced by the NAC MAGNATRAN design for future fuel shipments upon certification of this cask design.

3.2.5 NAC UMS

The Universal Transport Cask is designed to safely transport a Transportable Storage Canisters TSCs containing 24 intact PWR spent fuel assemblies, 56 intact BWR spent fuel Assemblies or Greater Than Class C (GTCC) waste. NAC-UMS canisters are utilized to store fuel from the Maine Yankee “ISFSI Only” site. The design layout of the NAC-UMS is similar to the NAC-STC as can be seen in Figure 3-6. Some of the differences include a single lid vs. the double lid STC design and the fact that it has a cavity which is smaller in diameter but is considerably longer than the NAC-STC design. The maximum gross weight of the NAC-UMS when loaded with the heaviest TSC configuration is 254,004lbs.[14]

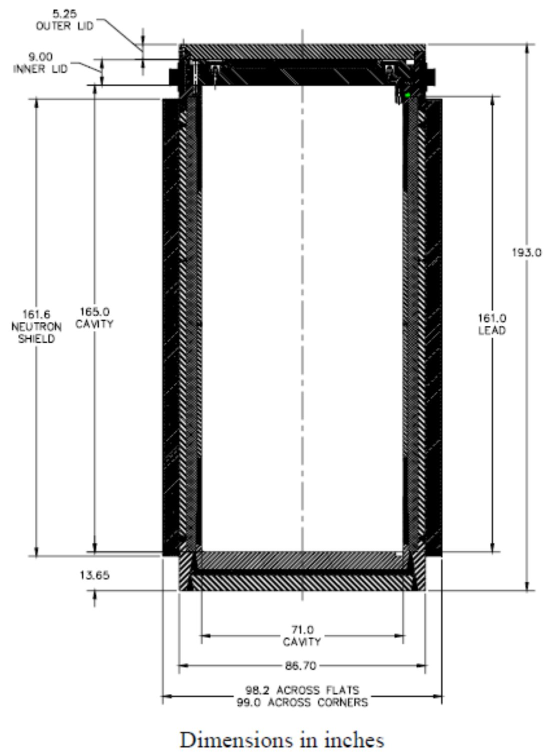

Figure 3-5 NAC-STC Basic Cask Dimensions[13]

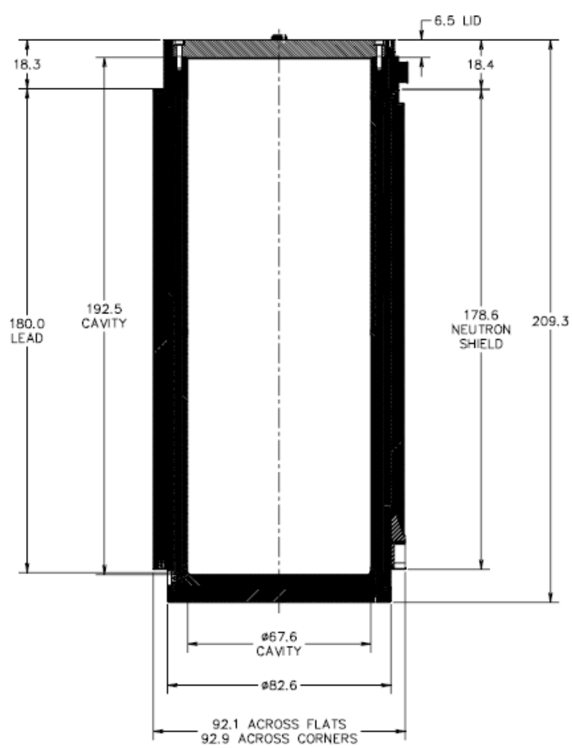

Figure 3-6 NAC-UMS Basic Cask Dimensions[14]

Like the NAC-STC, the NAC-UMS cask contains a neutron shield placed in an annulus that surrounds the cask outer shell along the length of the cask cavity. It also has twenty-four bonded copper and Type 304 stainless steel fins located in the radial neutron shield to enhance the heat rejection capability of the cask. The NAC-UMS maximum decay heat load is 20kW for PWR fuel and 16kW for BWR fuel. In the transport configuration two impact limiters are fitted to either end of the cask body in a typical dumbbell configuration (Figure 3-7). Unlike the NAC-STC design, only one impact limiter design is licensed which is composed of a combination of redwood and balsa wood enclosed in stainless steel shell. With impact limiters attached, the NAC-UMS has a maximum outer diameter of 124 inches and an overall length of approaching 275 inches.[14]

As of the date of this report, no NAC-UMS casks have been fabricated either domestically or for use overseas. This cask design is likely to be replaced be NACs new MAGNATRAN design for future fuel shipments when this cask design is certified.

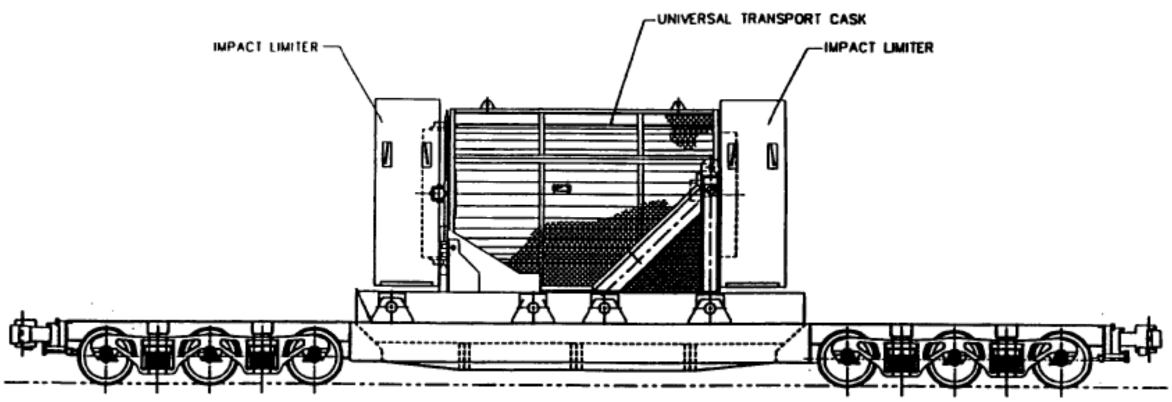

Figure 3-7 NAC-UMS on heavy haul rolling stock

3.2.6 FuelSolutions™ TS125 Cask

The FuelSolutions™ Transportation Package consists of a FuelSolutions™ TS125 Transportation Cask and impact limiters, together with a FuelSolutions™ canister and its UNF payload. This cask is designed to transport a single W21 canister containing 21 PWR assemblies or W74 canister containing up to 64 Big Rock Point[d] fuel assemblies in two stackable basket assemblies. An exploded view of the TS-125 cask is shown in Figure 3-7. The TS125 Transportation Cask body is an assembly composed of stainless steel components of an inner shell, an outer shell, a top ring forging, a closure lid with a seal test port and a cavity vent port, a bottom plate forging, and a cavity drain port. The inner and outer shells are welded to the bottom plate forging and the top ring forging. The cask body also includes an annular lead gamma shield; an annular neutron shield with cask tie-down rings, support angles, and jacket; a bottom end neutron shield with a support ring and jacket; a longitudinal shear block; and lifting trunnion mounting bosses. The inner and outer shells form the annular cavity for the lead gamma shield. The outer shell and the neutron shield jacket form the annular cavity for the solid neutron shield. The neutron shield support angles facilitate heat rejection through the solid neutron shielding material to the outer surface of the cask body.[15]

[d] Big Rock Point is an “ISFSI Only” Site

As of the date of this report, no TS125 casks have been fabricated either domestically or for use overseas. No intentions for a replacement cask have been announced.

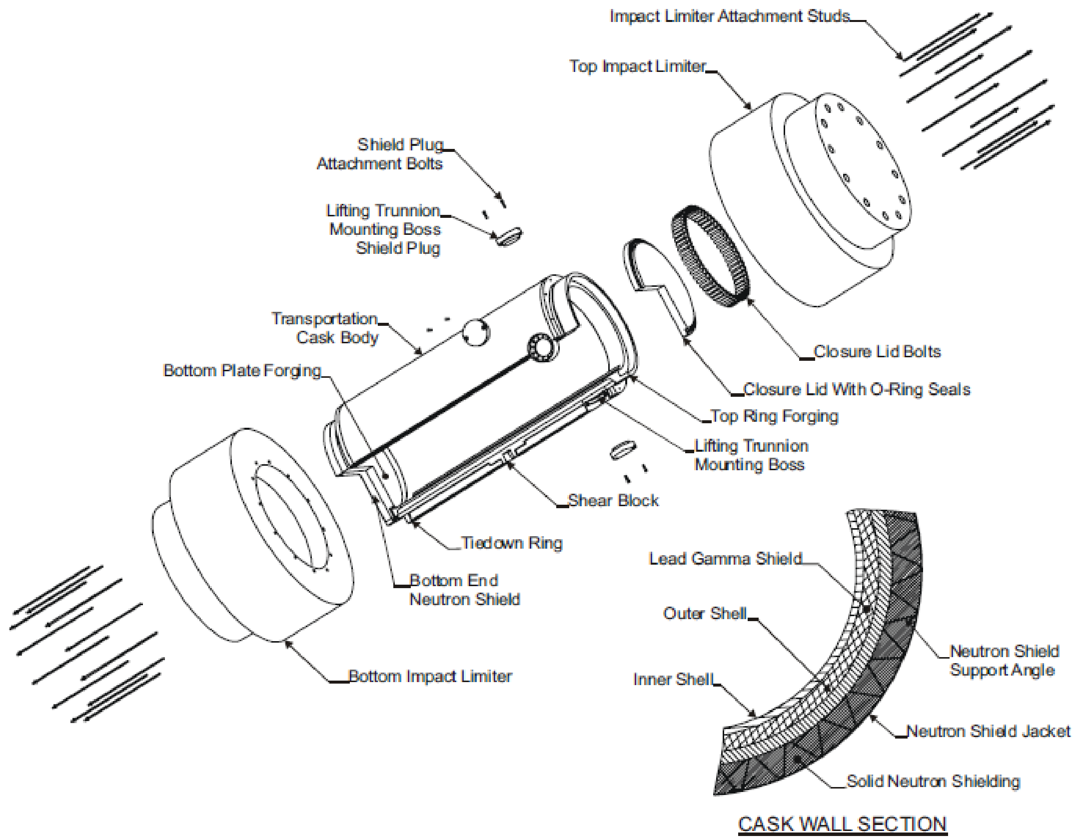

Figure 3-8 Expanded Cutaway View of FuelSolutions TS125 Transportation Package[15]

The TS125 cask cavity is 67 inches in diameter and 193 inches in length. The external dimensions of the cask body include an overall length of 324.4 inches and overall diameter of 143.5 inches diameter with impact limiters (210.4inches long by 94.2 inches without the impact limiters). The maximum gross weight of the transport cask with the maximum payload is 285,000 pounds. The design basis decay heat load for the TS-125 transportation cask is 22kW.[15]

Client Canisters: The W21 and W274 FuelSolutions canisters consist of a steel shell assembly and an internal basket assembly. The canister shell assembly consists of a steel cylindrical shell, bottom end closure, bottom shield plug, bottom shell extension, bottom outer plate, top shield plug, top inner closure plate and top outer closure plate. All structural components of the canister shell assembly are constructed of austenitic stainless steel, with the exception of the shield plugs. The shield plug materials may be composed of lead, depleted uranium or carbon steel, depending on the specific canister variant.

The W21 TSC basket consists of 21 guide tubes that are positioned and supported be a series of circular spacer plates, which in turn are positioned and supported by support rod assemblies. The W21 guide tubes include neutron absorber sheets on all four sides. The W 74 canister includes two stackable basket assemblies with a capacity to accommodate up to 64 Big Rock Point Assemblies. Details on these canister designs are contained in References 29 and 30.

3.2.7 4.2.7 TN-FSV

The TN-FSV is the smallest cask described in this report and is the only commercial used cask described that is designed primarily for road rather than rail transport. The cask body consists of two concentric shells of Type 304 Stainless Steel, welded to a bottom plate and a top closure flange. The inner shell has an inner diameter of approximately 18 inches, a typical wall thickness of 1.12 inches and an overall interior length of 199 inches. The inner cavity is capable of containing one fuel storage canister (FSC) which has exterior dimension of approximately 17.6 inches in diameter and 195 inches in overall length. The outer shell of the cask body has an outside diameter of 31 inches, a wall thickness of 1.5 inches and an overall exterior length of 247 inches. The annular space between the inner and outer shells is filled with lead. The maximum gross weight of the TN-FSV when transporting a FSC is 47,000 pounds.[16]

The TN-FSV does not include a variant for long-term storage of fuel and is sealed with butyl O-ring elastomer seals. The maximum heat load for the TN FSV with six HTGR fuel assemblies is 360 watts with an individual assembly heat load limit of 60 watts[16].

Figure 3-9 TN-FSV Cask

4. Orphan Site Storage and Transport

There are seven former commercial reactor sites in the U.S. which are considered by the NRC to be "ISFSI Only" sites where the plant license has been reduced to include only the spent fuel storage facility.[e] One of these sites stores fuel from a gas cooled reactor, Fort Saint Vrain, while the remaining

[e] Some of these sites are also storing Greater than Class C and Low Level Waste.

ISFSI sites contain the fuel of light water reactors. In addition to these sites, Humboldt Bay is a reactor site still being decommissioned and dismantled where all fuel has been placed into a below grade ISFSI. The Humboldt Bay spent fuel pool removal is scheduled for 2012. There are two more shutdown reactor sites, LaCrosse and Zion, where plans call for all spent fuel to be transferred to dry storage followed by decommissioning of all wet storage and transfer capabilities. As of the date of this report, three casks at LaCrosse have been loaded with two more planned. Collectively, these sites are often referred to as "orphan" sites, although sometimes this term is applied to only the first seven reactor sites listed in Table 4-1.

All fuel assemblies at "ISFSI Only" sites as well as those planned to become "ISFSI Only" sites in the near future, are stored in canisters that are dry, seal welded and purged with an inert gas. None of these sites use casks where the fuel is stored directly in a storage cask with a bolted closure and mechanical seal ("bare fuel" or "dual purpose" type cask).

Table 4-1 contains a listing of all the "ISFSI Only" sites as well as those planned to become "ISFSI Only" sites in the near future (Ft St Vrain is omitted from this list since it is a HTGR site). Although Table 4-1 is titled "Shutdown Reactor Site Inventory" it only refers to reactor sites where all reactors have been permanently shut down. It does not include reactor sites where one or more reactors have been permanently shutdown while others continue to operate[f].

Table 4-1 lists the shutdown date of the last reactor shutdown at each site as well as the type of reactor. The third column lists the start and end dates of the loading of all fuel assemblies into dry storage or the planned load dates. The fourth column lists the cask system used at each site, the canister types used at that site, the transport cask model number and certificate number associated with the casks/canister system. If the storage technical specifications are publically available to check for consistency with the transport certificate, this is listed in column 4. Other comments or details associated with the site inventory are also listed in column 4. The fifth column gives the expiration date of the certificate listed in column 4.

The sixth column contains the number of fuel cask canisters as well as canisters with GTCC waste in storage at the ISFSI while column seven lists the number of assemblies in dry storage.[1] the eighth column lists the Metric Tons Initial Heavy Metal included in the dry stored fuel at each reactor. The ninth column contains information on the number of damaged fuel assemblies or cans at the ISFSI or the number damaged fuel assemblies or cans allowed per cask. The remaining columns list the specific fuel types and classifications as well as the associated limits for maximum burnup initial enrichment and heat load. The information in columns nine through 13 are generally taken from the cask or ISFSI technical specification listed except for the case of the Trojan and Zion ISFSI sites. The Trojan fuel details come from a report by the State of Oregon referenced in the table while the Zion information is mostly TBD.

[f] See Appendix A, such sites include Dresden, Indian Point, Millsone, Peach Bottom, and the San Onofre Nuclear Generating Station (SONGS)

Table 4-1 Shutdown Reactor Site Inventory

Reactor Site (Shutdown Date) (1)	Type (2)	ISFSI Load Dates (3)	Cask System/Canister(s)/ Transport Cask (4)	Transport Cask Status (5)	Total Casks Fuel/GTCC (6)	Total Assemblies (7)	MTHM (8)	Damaged Fuel Assemblies or Cans (9)	Fuel Types(Cladding) (10)	Max Burnup GWD/MTU(12)	Maximum Enrichment wt.% ^{235}U (13)	Heat Load Limit Assembly/Cask (14)
Big Rock Point 8/97	BWR	12/02-03/03	Fuel Solutions W150 Storage Overpack/W74 Canister/TS-125 71-9276. BRG Tech Spec. contents match transport CoC contents including MOX fuel. -96 upgrade needed.	TS-125 Certificate Expires 10/31/2012 Timely Renewal Expected. Cask Never Fabricated	8/1	441	58	8 Maximum per Cask[18]	GE 9x9,(Zircaloy) [18] ANF 9x9 (Zircaloy) ANF 11x11 (Zircaloy) J2(9X9) MOX (Zircaloy) DA (11x11) MOX (Zircaloy) G-Pu (11x11) MOX (Zircaloy)	40 40 40 22.82 21.85 34.22	4.10 4.10 4.10 4.50/3.65 PuO_2 2.40/2.45 PuO_2 4.60/5.45 PuO_2	338W/26.4Kw 338W/26.4kW 338W/26.4kW 338W/26.4kW 338W/26.4kW 338W/26.4kW
Connecticut Yankee 12/96	PWR	05/04-03/05	NAC MPC/MPC-26 & MPC-24/ NAC-STC Cask 71-9235. CY Tech. Spec. contents match transport CoC contents including Reconfigured Fuel and Damaged Fuel cans.	NAC-STC Certificate Expires 05/31/2014. Foreign use versions of Cask have been fabricated. No domestic units fabricated.	40/3	1019	412	4 Maximum per Cask[19]	West. 15x15 (SS) [19] NUMEC 15x15(SS) B&W(GUNF) 15x15(SS) B&W 15x15 (SS) G A 15x15(Zircaloy) NUMEC 15x 15 (Zircaloy) B&W 15x15, (Zircaloy) B&W 15x15 (Zircaloy) Vantage 15x15(Zircaloy)	38 30 38 38 30 30 40 43 30	4.03 4.03 4.03 4.03 3.42 3.42 3.42 3.93 4.61	264W/17.5kW 264W/17.5kW 264W/17.5kW 264W/17.5kW 347W/17.5kW 347W/17.5kW 347W/17.5kW 347W/17.5kW 347W/17.5kW
Maine Yankee 8/97	PWR	08/02-03/04	NAC UMS/UMS-24/NAC-UMS Cask 71-9270. MY Tech. Spec. contents match transport CoC including High Burnup and Damaged Fuel. One Assembly cannot be transported until 2015	NAC-UMS Certificate Expires 10/31/2012 Timely Renewal Expected Cask Never Fabricated	60/4	1434	483	14 initial, Some of the 90 High Burnup Assemblies are Likely in MYFCs[20]	CE 14x14 (Zircaloy) [20] CE 14x14 High Burnup (Zircaloy) CE 14x14 w/SS Repl. Rods (Zr&SS)	45 50 50	4.2 4.2 4.2	830W/20kW 830W/20kW 830W/20kW
Yankee Rowe 9/91	PWR	06/02-06/03	NAC MPC/MPC-36/ NAC-STC Cask 71-9235. YR fuels called out in transport CoC including Reconfigured Fuel and Damaged Fuel cans.	NAC-STC Certificate Expires 05/31/2014. (See CY above)	15/1	533	127	4 max per canister[19]	CE Types A&B (Zircaloy), [19] ExxonTypes A&B (Zircaloy), Westinghouse Types A&B (SS) UN Types A&B (Zircaloy) Reconfigured Fuel (Zr or SS)	36 36 32 32	3.93 4.03 4.97 4.03	320W/12.5kW 320W/12.5kW 264W/12.5kW 320W/12.5kW 102W/12.5kW
Ranco Seco 6/89	PWR	04/01-08/02	TN/FO,FC,FF-DSCs/MP187 71-9255 RS fuels included in Transport CoC. Canister and fuel in RS TS match CoC	NUHOMS MP-187 Certificate Expires 11/30/2013 Timely Renewal Expected. One Cask has been Fabricated. No impact limiters Fabricated	21/1	493	228	13 in single FF DSC, 6 in FC DSC [21]	B&W 15x15 (Zircaloy-4) [21]	38.268	3.43	N.L./13.5kW
Trojan 11/92	PWR	12/02-9/03	HOLTEC MPC /MPC-24E/24EF /HISTAR 100 71-9261.	HISTAR 100 Certificate Expires 03/31/2014. Units Fabricated but not impact limiters	34/?	780	359	22 failed fuel cans [22]	17x17B (Zircaloy) [22]	42	3.7	725W/20kW
Humboldt Bay 7/76	BWR	08/08-12/08	HOLTEC HISTAR HB/ MPC-HB (MPC-80)/HISTAR HB 71-9261 HB Contents in TS match transport certificate	HISTAR HB Certificate Expires 03/31/2014. Fuel in Fabricated Casks. Impact Limiters not Fabricated	5/1	390	29	28 max per canister [23]	GE TYPE II 7x7 (Zircaloy) [23] GE TYPE III, 6x6 (Zircaloy) Exxon Types III 6x6 (Zircaloy) Exxon Type IV 6x6 (Zircaloy)	23 23 23 23	2.60 2.60 2.60 2.60	50W/2kW 50W/2Kw 50W/2kW 50W/2kW
LaCrosse 4/87	BWR	07/12-Ongoing	NAC MPC-LACBWR/MPC-LACBWR 68 positions/ NAC-STC 71-9235 Contents described to right are included in current transport cert.	NAC-STC Certificate Expires 05/31/2014. (See CY above)	5(estimated)	333	38	155 (preliminary) [19]	Allis Chalmers (SS) [19] Allis Chalmers (SS) Exxon (SS)	22 22 21	3.64 3.94 3.71	63W/4.5kW 63W/4.5kW 62W/4.5kW
Zion 1 and 2 7/98	PWR	Planned 2013	NAC MAGNATRAN/TSC-37/MAGNATRAN 71-9356 UNDER REVIEW.	NAC MAGNATRAN License under review. Never Fabricated	61(estimated)	2,226	1018	10 damaged or reconsolidated fuel cans (preliminary)[1]	LOPAR (Zircaloy) OFA (Zircaloy-4) VANTAGE 5(Zircaloy-4) VANTAGE 5 w/ IFMs (Zircaloy-4)	TBD TBD TBD TBD	TBD TBD TBD TBD	TBD TBD TBD TBD

5. Transfer Cask Designs

Transfer casks are lead and steel casks used for handling of fuel canisters during loading, drying, welding and transfer operations. Transfer casks provide biological (gamma and neutron) shielding during canister closure, drying, welding and transfer but do not provide containment or criticality control features. Unlike the Canister Transport Casks described in Section 3.2, the transfer casks described in this section do not meet 10CFR 71 requirements for shipment of used fuel in commerce. In general, transfer casks are not pressure vessels and do not consist of a pressure boundary. Some transfer casks are designed to ASME Section III Subsection NF or NC, and other aspects of the ASME Boiler & Pressure Vessel code such as welding and weld inspections may apply to their fabrication and inspection. Each transfer cask in use at U.S. ISFSIs is designed to transfer and handle a single canister at a time. Transfer casks are a heavy lift device designed, fabricated and proof load tested to the requirements of NUREG-0612 and ANSI N14.6 (withdrawn ANSI standard still cited by the industry). Transfer casks are fabricated predominantly of carbon steel meeting ASTM specification.

Neutron shielding is provided by either water jacket or solid neutron absorber material. Water jackets often contain ethelyne glycol or another agent to prevent freezing.

5.1 NAC Transfer Casks

There are four NAC transfer cask designs, three of which have been used for canister loading and transfer operations and the fourth planed for use at Zion. There are two different cask designs originally designed for interface with the MPC canister systems used at Connecticut Yankee and Yankee Rowe respectively. The transfer cask for Connecticut Yankee has a slightly thicker gamma shield and neutron shield. The inner and outer shells of both these cask designs consisted of ASTM A588 Low alloy steel. The transfer cask from Yankee Rowe has been purchased by Dairyland power for transfer of fuel into dry storage at Lacrosse.

Table 5-1 NAC Transfer Cask Models (NEI 2010)[24]

Transfer Cask	NAC MPC YR	NAC MPC CY	NAC UMS	MAGNASTOR
Number of Fabricated Casks	1	2	4	2
Transfer Cask Dimensions				
Length [m] (in)	3.39(133.4)	4.8(189)	4.6(181.2)	4.79(188.4)
Outer Diameter [m](in)	2.20(86.5)	2.26(89)	2.4(94.8)	2.71(106.8)
Loaded Weight with water	61.45	78.34	90.6-97.2	104.1
[t.] (lbs.)	135,473	172,708	199,800-214,300	229,500

NAC prefers to use machined bricks which are curved at interface surfaces to reduce shine paths rather than pouring monolithic shield assemblies (Figure 5-1). Between the lead brick and the transfer cask outer shell is an annulus filled with a solid synthetic polymer neutron shield material. The solid neutron shield material placement stabilizes the lead brick structure although neither is a credited structural component. Shielding at the bottom of the transfer cask is provided by thick (~9 inch) sliding shield doors. The top of the transfer cask is essentially open except for a retaining ring which bolts to the cask body preventing a loaded canister from being inadvertently removed through the top of the transfer cask. Shielding at the top of the transfer cask is provided by the canister shield lid while loaded.[24]

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Figure 5-1 NAC Transfer Cask Fabrication

The transfer cask has retractable bottom shield doors which slide in rails incorporated in the transfer cask bottom. During loading operations, the doors are closed and secured by lock bolts/lock pins, so they cannot inadvertently open.   During unloading, the doors are retracted using hydraulic cylinders to allow the canister to be lowered into the storage or transport cask. During transfer of the cask with a loaded canister, only the doors held in place by two door rails and the lock bolts/lock pins. The hydraulic actuators are integrated into an adaptor plate that attaches to a storage overpack or to a transport cask. With NAC systems, the transfer of the loaded canister to the storage overpack usually occurs inside the 10CFR50 facility. The storage overpack is then moved from the 10CFR50 facility to the ISFSI pad using either a heavy haul trailer or cask transporter. The transfer cask and adaptor plate are designed to also be capable of directly loading the storage overpack at the ISFSI pad.

To minimize potential contamination of the canister and transfer cask during loading operations in the spent fuel pool, clean water is circulated in the gap between the transfer cask interior surface and the canister exteriors surface using fill and drain lines in the wall of the transfer cask. Clean water is injected into the annular space during the entire time the transfer cask is submerged. No seals are used on the bottom door interface or at the top of the canister. This design and process has been adequate in ensuring acceptable contamination levels on the canister exterior. Each of the fill and drain ports are offset to minimize shine paths from the unshielded fuel canister sidewall.[24]

Figure 5-2 shows a picture of the basic transfer cask body without the bottom doors in place. Figure 5-3 shows the adaptor plate mechanism with the doors in the open position

Figure 5-2 NAC Transfer Cask Body (NAC SNFDS Seminar)

Figure 5-3 NAC Adaptor Plate Door Operation (NAC SNFDS Seminar)

5.2 HOLTEC Transfer Casks

HI-TRAC is an acronym for **H**oltec **I**nternational **T**ransfer **C**ask. There are four basic HI-TRAC cask designs, the 125-ton standard design (HI-TRAC-125), the 125-ton dual- purpose lid design (HI-TRAC-125D), the 100 ton standard design (HI-TRAC -100) and the 100-ton dual purpose lid design (HI-TRAC-100D. The 100 ton HI-TRAC is used at sites with a maximum crane capacity less than 125 tons. All the HI-TRAC design variations use lead for gamma shielding and a water jacket for neutron shielding, the configuration of layers from interior to exterior being steel, lead, steel, water space, steel. Each of the transfer casks listed in Table 5-2 is designed and constructed in accordance with ASME Section III, Subsection NF, with certain NRC approved alternatives. Since all HOLTEC canisters have the same exterior dimensions, the basic internal diameter of all HI-TRAC transfer casks is the same.

Table 5-2 HOLTEC Transfer Cask Models[25]

Transfer Cask	HI-TRAC 100	HI-TRAC 100D	HI-TRAC 125	HI-TRAC 125D
Number of Fabricated Casks	2	4	5	11
Transfer Cask Dimensions				
Length (in)	191.25	191.25	201.5	201.5
Outer Diameter (in)	89	91.25	Water J. 93.75 Base Plate 104	Water J. 93.75 Base Plate 104
Inner Diameter (in)	68.75	68.75	68.75	68.75
Loaded Weight with water(lbs.)	192,000- 199,999	192,000- 199,000	228,500- 236,000	228,500- 236,000

5.2.1 HI-TRAC Standard Design

The standard design HI-TRAC transfer casks are heavy-walled cylindrical vessel composed of carbon steel and lead with an exterior water jacket. The top lid of the HI-TRAC 125 has additional neutron shielding to provide neutron attenuation of neutrons from the top of the MPC. The MPC access hole through the HI-TRAC top lid allows the lowering and raising of the MPC between the HI-TRAC transfer cask and the HI-STORM or HI-STAR overpacks. The standard design HI-TRAC (comprised of HI-TRAC 100 and HI-TRAC 125) is provided with two bottom lids, each used separately. The pool lid is bolted to the bottom flange of the HI-TRAC and is utilized during MPC fuel loading and sealing operations. In addition to providing shielding in the axial direction, the pool lid incorporates a seal that is designed to hold clean water in the HI-TRAC inner cavity preventing contamination of the MPC exterior from fuel pool water. After the MPC has been drained, dried and sealed, the pool lid is removed and the HI-TRAC transfer lid is attached (standard design only). The transfer lid incorporates two sliding doors that allow the opening of the HI-TRAC bottom for the MPC to be raised and lowered. Figure 5-4 shows the cross section of a HI-TRAC 125 standard cask with both a pool lid and a transfer lid attached. Both lid types are attached to the cask body bottom flange with 36 1” diameter bolts in the case of the HI-TRAC 100. Both lid types are blind drilled and tapped to accept the 36 attachment bolts.[25]

There are two standard designs HI-TRAC transfer casks classified by total gross weight of the loaded cask. The HI-TRAC-125 weight does not exceed 125 tons during any loading or transfer operation while the HI-TRAC-100 weight does not exceed 100 tons during any loading or transfer operation. The internal cylindrical cavities of the two standard design HI-TRACs are identical while the exterior dimensions vary. The HI-TRAC 100 has a reduced thickness of lead and water shielding leading to reduction of the outside diameter at several locations, the thickness of the structural steel of the two standard HI-TRAC is identical such that most structural analyses of the HI-TRAC 125 bound the HI-TRAC 100 design. [25]

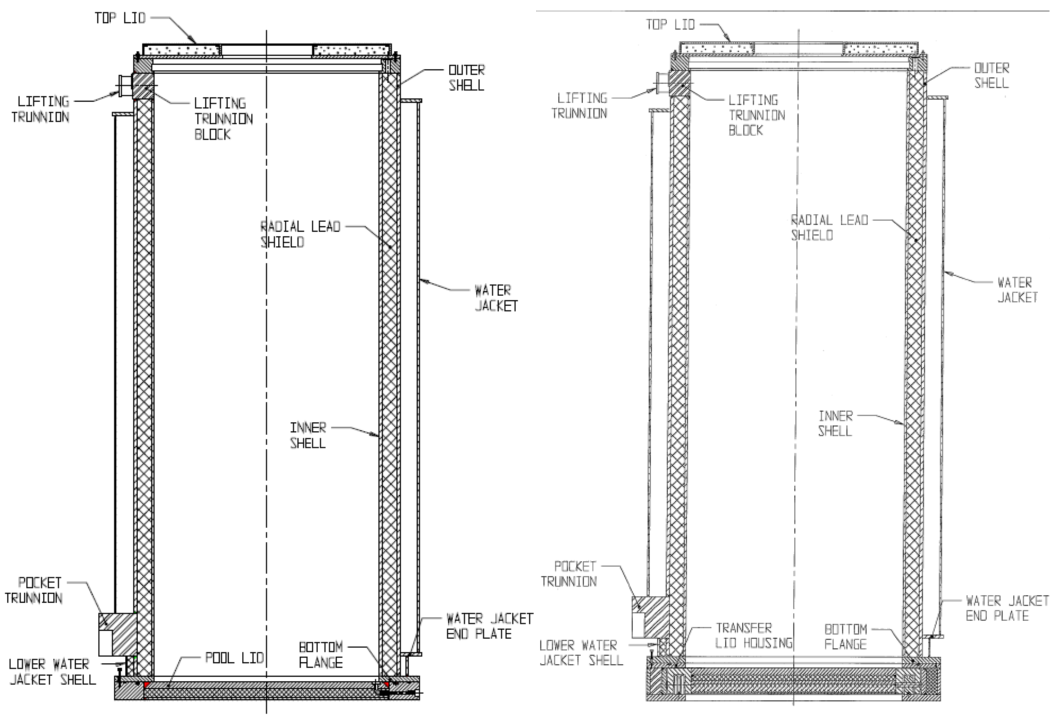

Figure 5-4 HI-TRAC 125 Pool Lid (Left) Transfer lid (Right)[25]

5.2.2 HI-TRAC 100D and 125D Transfer Casks

The HI-TRAC 100D and 125D designs are functionally equivalent to the standard design variants but have the following primary differences.

- No pocket trunnions
- No transfer lid (not required)
- HI-STORM mating device is required during MPC transfer operations
- A wider baseplate with attachment points for the mating device is included
- The baseplate incorporates gussets for added structural strength

Unlike the standard transfer cask variants, the 100D and 125D HI-TRAC transfer casks do not require swapping the pool lid for a transfer lid to facilitate transfer of the MPC. The HI-STORM mating device is located between the HI-TRAC and HI-STORM and secured with bolting to both. Figure 5-5 shows the lower assembly detail of a 125 D HI-TRAC. This patented[26] design allows for removal of the pool lid by loosening the inner bolts on the bottom flange lowering it into the cask mating device assembly shown in Figure 5-6.

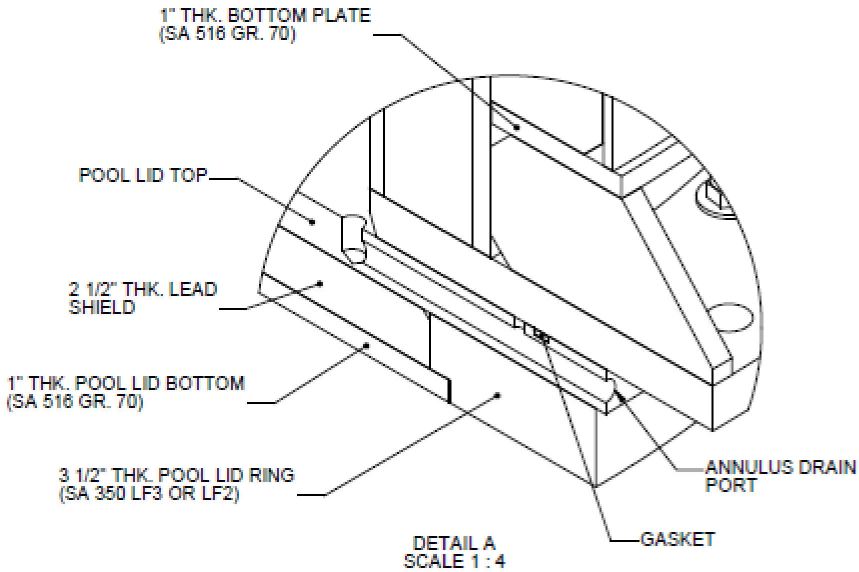

Figure 5-5 HI-TRAC 125D Lower Assembly Detail[25,26]

The patented design incorporates two gasket seals, one between the pool lid top and the bottom flange (Figure 5-5) and the other between the canister outer wall and the transfer cask inner wall close to the top lid of the transfer cask. These seals provide a barrier from pool water contamination while the transfer cask is submerged in the pool.

5.2.3 TN/NUHOMS Transfer Casks

TN/NUHOMS systems are unique in that the canister transfer from the transfer cask to the storage module is performed while the transfer cask is in the horizontal position. This transfer to the horizontal storage usually occurs at the ISFSI site such that the transfer cask carries the fuel canister between the 10CFR50 facility and the ISFSI pad vs. the storage overpack being heavy hauled to the storage sites in other systems. The TN systems are also unique in that the TN canister transport casks described in sections 3.2.1 and 3.2.2. above can also be used as transfer casks if desired. They can also be used to directly remove and transport canisters from the Horizontal Storage Modules without the need to an intermediary cask required by other systems. The TN transfer casks listed in Table 5-3 are fabricated and designed to ASME Section III, Division I, Subsection NC, Class 2 (non-pressure retaining components).

Table 5-3 TN Transfer Cask Designs [2,27]

Transfer Cask	OS187H[c]	0S197	OS197L	OS200
Number of Fabricated Casks	2	4	1	1
Transfer Cask Dimensions				
Length (in)	207.22[c]	207.22	[a]	206.72
Outer Diameter (in)	85.5[c]	85.5	[a]	92.11
Inner Diameter (in)	68	68	[a]	68
Payload limit(dry) (lbs.)[b]	80,000	97,250	[a]	116,000
Loaded Weight with water (lbs.)	<200,000[c]	<200,000	<150,000	<250,000

[a]Proprietary Information withheld in accordance with 10 CFR 2.390

[b] Payload limit for analysis. Actual payload depends on as built cask weight and configuration

[c] Values from Reference 2. Reference 27 reports OS187H length of 197.1 in, outer diameter of 92.2in and a gross weight of 114.5 tons or 229,000 pounds.

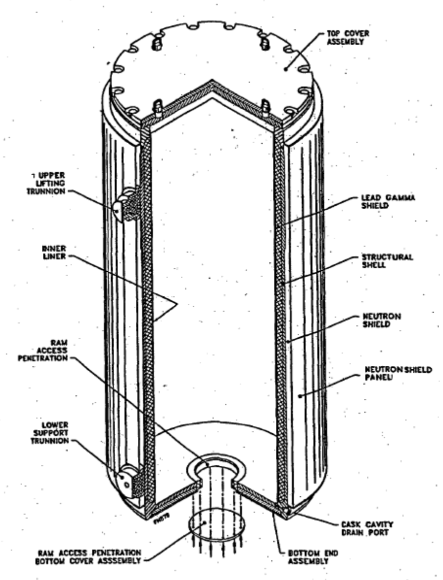

Figure 5-6 OS187H On-Site Transfer Cask27

5.2.4 Fuel Solutions Transfer Casks

Fuel Solutions have two transfer cask designs for use with Fuel Solutions systems. The W100 transfer cask used with the W21 and W74 Dual Purpose Canisters[13] and the MTC (**M**ulti-assembly Sealed Basket **T**ransfer **C**ask) used with the VSC 24 canister system[12]. Details of these cask designs have been redacted under 10 CFR 2.390. From the canister specifications, the W100 transfer cask must have a cavity capable of accepting a canister 66 inches in outer diameter, 192.25inches in length with a gross weight of 85,000 pounds. Likewise, the MTC must have a cavity capable of accepting a canister 62.5 inches in outer diameter, 192.5 inches long with a gross weight of 69,000pounds. Per available information both casks are capable of horizontal transfer to the TS-125 transport Cask. Actual number of each cask type fabricated are not reported in licensing documents but current storage conditions indicate that at least one W100 and MTC have been fabricated with possibly more than one MTC given two utility use of the VSC 24. .

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20. Technical Specifications for the NAC-UMS System Amendment 2 COC No. 1015 ML020250599
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25. Holtec International Final Safety Analysis Report for the HI-STORM 100 Cask System, 72-1014, HI-2002444, Revision 9, February 2010.

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28. VSC-24 Multi-Assembly Sealed Basket Transportation Safety Analysis Report, 0000-0632, Revision 0, September 2006

29. FuelSolutions W74 Canister Transportation Safety Analysis Report, WSNF-123, Revision 10, September 2006

30. FuelSolutions W21 Canister Transportation Safety Analysis Report, WSNF-121, Revision 6, September 2006

Appendix A

Transportation Matrix for Commercial Power Reactor Fuel (Dry Storage, and Away from Reactor Wet Storage)

The accompanying chart details each cask or canister system in dry storage in the U.S. and cross-references these to a transportation pathway. Each row in the chart represents a cask system type at a certain reactor site listed by name of generating station (e.g. if the reactor ISFSI or ISFSIs contains three cask types in total, the chart contains three rows, one for each canister or cask type).

The first entry contains the utility name followed by the reactor name, reactor type (PWR or BWR), ISFSI license type (general or site specific), and year of first load. Next comes the Cask vendor followed by the Cask/Canister System and the specific canister/cask type employed. Generally the canister cask type includes a number that represents the number of assembly storage positions in that cask or canister type. The next column contains the total canisters or casks loaded followed by the assemblies stored in these canisters or casks. After the number of assemblies at each site, a rough estimate of the Metric Tons Initial Heavy metal of the fuel stored in each cask type is provided. **(NOTE: These numbers are based on an average value for PWR and BWR fuel. Actual MTIHM at each site can vary greatly from the number reported here depending on fuel type)**

Column 12 describes the storage configuration (fuel is stored directly in a bare fuel cask, in a canister in a concrete overpack (this includes NUHOMS storage modules and HISTORM concrete overpacks which have a metal skin), in a canister in a metal overpack (HISTAR 100) or in a canister inside a vault (Ft. St.Vrain is the only instance). If the storage configuration is a canister in a metal or concrete storage overpack, column 13 lists the primary transport cask currently licensed to transport the canister (if any) as well as any license applications for transportation casks which include the canister as a licensed content. Column 14 lists whether working units of the primary cask have been fabricated. For canister casks, only models of the NUHOMS MP187, HISTAR 100 and the TN-FSV have been fabricated. There are versions of the NAC-STC that have been fabricated for use overseas which are not available or licensable in the U.S. The NUHOMS MP197 cask has yet to be built as of the date of this report and will likely be replaced by the MP 197HB variant by the time working units are needed. The only domestic HISTAR 100 working transport casks are the 12 used for storage at Humboldt Bay, Dresden and Hatch. No production or full scale prototype units of the Fuel Solutions TS-125 cask have been fabricated as of the date of this report.

Column 15 lists any alternate transport casks which may be licensed for the same canister type or under application or even being considered for licensing of the canister type. If a certificate number is listed along with the cask name in columns 13 or 15, this signifies that that canister is included in the transport certificate. If the cask name is listed but no number is listed, this signifies that either the canister is under application for transport in the cask type named or is considered licensable for transport in the named cask by the cask vendor. Column 16 lists whether working units of the alternate cask in column 15 have been fabricated.

Column 17 applies to bare fuel casks and lists whether a transport license exists for the bare fuel cask with footnotes providing details.

For those systems which employ a fuel canister, Column 18 delineates whether the canister has been classified by the cask vendor as “storage only” canister. Storage only canisters may lack neutron absorbing material or may have simply not been evaluated in the 10 CFR71 accident sequence in a transportation overpack. By definition, each of the canisters listed in this column are not included in any transportation cask license. These canisters may still ultimately be shipped without repackaging of the fuel depending on the reasons for classification as “storage only”.

The final column of the chart contains the minimum lead time for shipment for canisters and casks at each reactor location. The lead time listed in this column only includes the time to prepare existing casks for shipment, time to fabricate casks and the time to obtain transportation licenses. It does not include factors such as approval of routing, security requirements, requirements for special rolling stock or the implementation of “smart train” technology, or most importantly the time to make available a repository or interim storage site.

The wet storage table on the following page contains most of the same columns as the dry storage stable except that there are no references to bare fuel casks or “storage only” canisters. There are only two shutdown site currently transitioning into “ISFSI Only” status; LaCrosse and Zion   Both these sites have selected cask systems and in the case of LaCrosse, three casks have already been loaded as of August 2012 and the remaining two are expected to be completed in the coming weeks.

GE Morris is an away from reactor used fuel storage facility. There are no announced plans to transition fuel at GE Morris into dry cask storage as of the date of this report.

The final table in Appendix A is a storage summary table that gives a breakdown of the % of assemblies in each category of cask/vault storage listed.

Table A-1Transportation Matrix for Commercial Reactor Fuel (Dry Storage, and Away from Reactor Wet Storage)

U.S. Dry Storage Details (08/01/2012)

Utility	Reactor	Type	License Type	Year of First Load [14]	Vendor	Cask System	Canister or Cask Type	Total Canisters or Casks Loaded	Assemblies Stored	MTiHM (Based on Average Assembly)	Storage Configuration	Primary Canister Transportation Cask (License Num.)	Primary Transport Cask Fabricated?	Alternative Canister Transportation Cask	Alternate Transport Cask Fabricated?	Bare Fuel Cask Transportation License (License Number)	"Storage Only" Canisters or Casks	Minimum Lead Time for Shipment
AEP	D.C.Cook	PWR	GL	2012	Holtec	HI-STORM	MPC-32	1	32	13.9	Canister in Vertical Concrete Overpack	HI-STAR100 (71-9261)	Yes[1]		No			14 Months[8]
APS	Palo Verde	PWR	GL	2003	NAC	NAC-UMS	UMS-24	94	2256	982.5	Canister in Vertical Concrete Overpack	NAC-UMS (71-9270)	No	NAC-MAGNASTOR	No			24 Months[8]
Constellation	Calvert Cliffs	PWR	SS	1992	TN	NUHOMS	24P	48	1152	501.7	Canister in Horizontal Concrete Overpack		No		No		24P	36 Months[10]
Constellation	Calvert Cliffs	PWR	SS	1992	TN	NUHOMS	32P	21	672	292.7	Canister in Horizontal Concrete Overpack		No		No		32P	36 Months[10]
Constellation	Ginna	PWR	GL	2010		NUHOMS	32PT	6	192	83.6	Canister in Horizontal Concrete Overpack		No		No			24 Months[9]
Consumers	Big Rock Point[12]	BWR	GL	2002	BFS/ES	FuelSolutions	W150	8	441	78.8	Canister in Vertical Concrete Overpack	TS-125 (71-9276)	No		No			24 Months[9]
Ct.Yankee	Conn Yankee[12]	PWR	GL	2004	NAC	NAC-MPC	MPC-26	43	1019	443.8	Canister in Vertical Concrete Overpack	NAC-STC (71-9235)	No	NAC-MAGNASTOR	No			24 Months[9]
Dairyland Power	Lacrosse	BWR	GL	2012	NAC	NAC	LACBWR	3	204	36.4	Canister in Horizontal Concrete Overpack	NAC-STC (71-9235)	No	NAC-MAGNASTOR	No			24 Months[9]
DOE	INEEL	PWR	SS		TN	NUHOMS	12T	29	177	77.1	Canister in Horizontal Concrete Overpack		No		No		12T	36 Months[10]
Dominion	Kewaunee	PWR	GL	2009	TN	NUHOMS	32PT	8	256	111.5	Canister in Horizontal Concrete Overpack		No	MP197HB	No			24 Months[9]
Dominion	Millstone	PWR	GL	2005	TN	NUHOMS	32PT	18	576	250.8	Canister in Horizontal Concrete Overpack		No	MP197HB	No			24 Months[9]
Dominion	North Anna	PWR	SS	1998	TN	TN Metal Casks	TN-32	27	864	376.3	Bare Fuel	-	-		-	No[3]		24 Months[7]
Dominion	North Anna	PWR	GL	2008	TN	NUHOMS	32PTH	13	416	181.2	Canister in Horizontal Concrete Overpack		No	MP197HB	No			24 Months[8]
Dominion	Surry	PWR	SS	1986	GNB	Castor	V/21 and X33	26	558	243.0	Bare Fuel	-	-		-	No[4]		36 Months[10]
Dominion	Surry	PWR	SS	1986	NAC	NAC-I28	NAC-I28	2	56	24.4	Bare Fuel	-	-		-	No[5]		24 Months[7]
Dominion	Surry	PWR	GL	2007	TN	NUHOMS	32PTH	18	576	250.8	Canister in Horizontal Concrete Overpack		No	MP197HB	No			24 Months[8]
Dominion	Surry	PWR	SS	1986	TN	TN Metal Casks	TN-32	26	832	362.3	Bare Fuel	-	-		-	No[3]		24 Months[7]
Dominion	Surry	PWR	SS	1986	W	MC-10	MC-10	1	24	10.5	Bare Fuel	-	-		-	No[6]		24 Months[7]
Duke	Catawba	PWR	GL	2007	NAC	NAC-UMS	UMS-24	24	576	250.8	Canister in Vertical Concrete Overpack		No	NAC-MAGNASTOR	No			24 Months[8]
Duke	McGuire	PWR	GL	2001	NAC	NAC-UMS	UMS-24	28	672	292.7	Canister in Vertical Concrete Overpack	NAC-UMS (71-9270)	No	NAC-MAGNASTOR	No			24 Months[8]
Duke	McGuire	PWR	GL	2001	TN	TN Metal Casks	TN-32	10	320	139.4	Bare Fuel	-	-		-	No[3]		24 Months[7]
Duke	Oconee	PWR	GL/SS	1990	TN	NUHOMS	24P	84	2016	878.0	Canister in Horizontal Concrete Overpack		No		No		24P	36 Months[10]
Duke	Oconee	PWR	GL	2000	TN	NUHOMS	24PHB	38	912	397.2	Canister in Horizontal Concrete Overpack		No		No		24PHB	36 Months[10]
Energy Northwest	Columbia	BWR	GL	2002	Holtec	HI-STORM	MPC-68	27	1836	327.9	Canister in Vertical Concrete Overpack	HI-STAR100 (71-9261)	Yes[1]		No			14 Months[8]
Entergy	ANO	PWR	GL	1996	BFS/ES	FuelSolutions	VSC-24	24	576	250.8	Canister in Vertical Concrete Overpack		No		No		VSC-24	36 Months[10]
Entergy	ANO	PWR	GL	1996	Holtec	HI-STORM	MPC-24	22	528	229.9	Canister in Vertical Concrete Overpack	HI-STAR100 (71-9261)	Yes[1]		No			14 Months[8]
Entergy	ANO	PWR	GL	1996	Holtec	HI-STORM	MPC-32	16	512	223.0	Canister in Vertical Concrete Overpack	HI-STAR100 (71-9261)	Yes[1]		No			14 Months[8]
Entergy	Fitzpatrick	BWR	GL	2002	Holtec	HI-STORM	MPC-68	15	1020	182.2	Canister in Vertical Concrete Overpack	HI-STAR100 (71-9261)	Yes[1]		No			14 Months[8]
Entergy	Grand Gulf	BWR	GL	2006	Holtec	HI-STORM	MPC-68	17	1156	206.5	Canister in Vertical Concrete Overpack	HI-STAR100 (71-9261)	Yes[1]		No			14 Months[9]
Entergy	Indian Point 1	PWR	GL	2008	Holtec	HI-STORM	MPC-32	5	160	69.7	Canister in Vertical Concrete Overpack	HI-STAR100 (71-9261)	Yes[1]		No			14 Months[9]
Entergy	Indian Point 2	PWR	GL	2008	Holtec	HI-STORM	MPC-32	14	448	195.1	Canister in Vertical Concrete Overpack	HI-STAR100 (71-9261)	Yes[1]		No			14 Months[8]
Entergy	Palisades	PWR	GL	1993	BFS/ES	FuelSolutions	VSC-24	18	432	188.1	Canister in Vertical Concrete Overpack		No		No		VSC-24	36 Months[10]
Entergy	Palisades	PWR	GL	1993	TN	NUHOMS	24PTH	13	312	135.9	Canister in Horizontal Concrete Overpack		No	MP197HB	No			24 Months[8]
Entergy	Palisades	PWR	GL	1993	TN	NUHOMS	32PT	11	352	153.3	Canister in Horizontal Concrete Overpack		No	MP197HB	No			24 Months[8]
Entergy	River Bend	BWR	GL	2005	Holtec	HI-STORM	MPC-68	15	1020	182.2	Canister in Vertical Concrete Overpack	HI-STAR100 (71-9261)	Yes[1]		No			14 Months[8]
Entergy	Vermont Yankee	BWR	GL	2008	Holtec	HI-STORM	MPC-68	14	952	170.0	Canister in Vertical Concrete Overpack	HI-STAR100 (71-9261)	Yes[1]		No			14 Months[8]
Exelon	Waterford	PWR	GL	2011	Holtec	HI-STORM	MPC-32	9	288	125.4	Canister in Vertical Concrete Overpack	HI-STAR100 (71-9261)	Yes[1]		No			14 Months[8]
Exelon	Braidwood	PWR	GL	2011	Holtec	HI-STORM	MPC-32	3	96	41.8	Canister in Vertical Concrete Overpack	HI-STAR100 (71-9261)	Yes[1]		No			14 Months[8]
Exelon	Byron	PWR	GL	2010	Holtec	HI-STORM	MPC-32	14	448	195.1	Canister in Vertical Concrete Overpack	HI-STAR100 (71-9261)	Yes[1]		No			14 Months[9]
Exelon	Dresden	BWR	GL	2000	Holtec	HI-STORM	MPC-68	49	3332	595.1	Canister in Vertical Concrete Overpack	HI-STAR100 (71-9261)	Yes[1]		No			14 Months[9]
Exelon	Dresden	BWR	GL	2000	Holtec	HI-STAR	MPC-68	4	272	48.6	Canister in Metal Cask	HI-STAR100 (71-9261)	Yes[1]		No			12 Months[11]
Exelon	LaSalle	BWR	GL	2010	Holtec	HI-STORM	MPC-68	6	408	72.9	Canister in Vertical Concrete Overpack	HI-STAR100 (71-9261)	Yes[1]		No			14 Months[8]
Exelon	Limerick	BWR	GL	2008	TN	NUHOMS	61BT	19	1159	207.0	Canister in Horizontal Concrete Overpack	MP197 (71-9302)	No	MP197HB (71-9302)	No			24 Months[8]
Exelon	Oyster Creek	BWR	GL	2002	TN	NUHOMS	61BT	23	1403	250.6	Canister in Horizontal Concrete Overpack	MP197 (71-9302)	No	MP197HB (71-9302)	No			24 Months[9]
Exelon	Peach Bottom	BWR	GL	2000	TN	TN Metal Casks	TN-68	59	4012	716.5	Bare Fuel	-	-		-	Yes (71-9293)		12 Months[11]
Exelon	Quad Cities	BWR	GL	2005	Holtec	HI-STORM	MPC-68	35	2380	425.1	Canister in Vertical Concrete Overpack	HI-STAR100 (71-9261)	Yes[1]		No			14 Months[8]
FirstEnergy	Davis-Besse	PWR	GL	1995	TN	NUHOMS	24P	3	72	31.4	Canister in Horizontal Concrete Overpack		No		No		24P	36 Months[10]
FPL	Duane Arnold	BWR	GL	2003	TN	NUHOMS	61BT	20	1220	217.9	Canister in Horizontal Concrete Overpack	MP197 (71-9302)	No	MP197HB	No			24 Months[8]
FPL	Point Beach	PWR	GL	1995	BFS/ES	FuelSolutions	VSC-24	16	384	167.2	Canister in Vertical Concrete Overpack		No		No		VSC-24	36 Months[10]
FPL	Point Beach	PWR	GL	1995	TN	NUHOMS	32PT	17	544	236.9	Canister in Horizontal Concrete Overpack		No	MP197HB	No			24 Months[8]
FPL	St.Lucie	PWR	GL	2008	TN	NUHOMS	32PTH	14	448	195.1	Canister in Horizontal Concrete Overpack		No	MP197HB	No			24 Months[8]
FPL	Seabrook	PWR	GL	2008	TN	NUHOMS	32PTH	6	192	83.6	Canister in Horizontal Concrete Overpack		No	MP197HB	No			24 Months[8]
FPL	Turkey Point	PWR	GL	2011	TN	NUHOMS	32PTH	18	576	250.8	Canister in Horizontal Concrete Overpack		No	MP197HB	No			24 Months[8]
Luminant	Comanche Peak	PWR	GL	2012	Holtec	HI-STORM	MPC-32	9	288	125.4	Canister in Vertical Concrete Overpack	HISTAR 100 (71-9261)	Yes[1]		No			14 Months[9]
Maine Yankee	Maine Yankee[12]	PWR	GL	2002	NAC	NAC-UMS	UMS-24	64	1434	624.5	Canister in Vertical Concrete Overpack	NAC-UMS (71-9270)	No	NAC-MAGNASTOR	No			24 Months[9]
NPPD	Cooper	BWR	GL	2010	TN	NUHOMS	61BT	8	488	87.2	Canister in Horizontal Concrete Overpack	MP197 (71-9302)	No	MP197HB (71-9302)	No			24 Months[8]
OPPD	Fort Calhoun	PWR	GL	2006	TN	NUHOMS	32PT	10	320	139.4	Canister in Horizontal Concrete Overpack		No	MP197HB	No			24 Months[9]

Table Appendix A-1 (Continued) Transportation Matrix for Commercial Power Reactor Fuel (Dry Storage, and Away from Reactor Wet Storage)

Portland	GE Trojan	PWR	GL	2002	Holtec	TranStor Cask	MPC-24E/EF	34	780	339.7	Canister in Vertical Concrete Overpack	HISTAR 100 (71-9261)	Yes[1]		No			14 Months[8]
PPL	Susquehanna	BWR	GL	1999	TN	NUHOMS	52B	27	1404	250.8	Canister in Horizontal Concrete Overpack		No		No		52B	36 Months[10]
PPL	Susquehanna	BWR	GL	1999	TN	NUHOMS	61BT	40	2440	435.8	Canister in Horizontal Concrete Overpack	MP197 (71-9302)	No	MP197HB(71-9302)	No			24 Months[8]
Progress	Brunswick	BWR		2010	TN	NUHOMS	61BTH	8	488	87.2	Canister in Horizontal Concrete Overpack	MP197HB (71-9302)	No	MP197HB(71-9302)	No			24 Months[8]
Progress	Robinson	PWR	SS	1989	TN	NUHOMS	7P	8	56	24.4	Canister in Horizontal Concrete Overpack		No		No		7P	36 Months[10]
Progress	Robinson	PWR	GL	2007	TN	NUHOMS	24PTH	14	336	146.3	Canister in Horizontal Concrete Overpack		No	MP197HB	No			24 Months[8]
PS Colorado	Ft. St. Vrain [13]	HTGR	SS	1991	DOE	Foster Wheeler	MVDS		1464	1,023.3	Canister in Vault	TN-FSV (71-9253)	Yes[2]		No			12 Months[2]
PSE&G	Hope Creek	BWR	GL	2006	Holtec	HI-STORM	MPC-68	16	1088	194.3	Canister in Vertical Concrete Overpack	HI-STAR100 (71-9261)	Yes[1]		No			14 Months[8]
PSE&G	Salem	PWR	GL	2010	Holtec	HI-STORM	MPC-32	14	448	195.1	Canister in Vertical Concrete Overpack	HI-STAR100 (71-9261)	Yes[1]		No			14 Months[8]
PG&E	Diablo Canyon	PWR	SS	2009	Holtec	HI-STORM	MPC-32	23	736	320.5	Canister in Vertical Concrete Overpack	HI-STAR100 (71-9261)	Yes[1]		No			14 Months[8]
PG&E	Humboldt Bay[12]	BWR	SS	2008	Holtec	HI-STAR	MPC-80	5	390	69.7	Canister in Metal Cask	HI-STAR100 (71-9261)	Yes[1]		No			12 Months[11]
SMUD	Rancho Seco[12]	PWR	SS	2001	TN	NUHOMS	24PT	22	493	214.7	Canister in Horizontal Concrete Overpack	MP187 (71-9255)	Yes[2]	MP197HB	No			12 Months[2]
Southern Cal Edison	SONGS 1 [12,13]	PWR	GL	2003	TN	NUHOMS	24PT1	18	395	172.0	Canister in Horizontal Concrete Overpack	MP187 (71-9255)	Yes	MP197HB	No			24 Months[8]
Southern Cal Edison	SONGS 2	PWR	GL	2003	TN	NUHOMS	24PT4	29	696	303.1	Canister in Horizontal Concrete Overpack		No	MP197HB (71-9302)	No			24 Months[8]
Southern Nuclear	Farley	PWR	GL	2005	Holtec	HI-STORM	MPC-32	15	480	209.0	Canister in Vertical Concrete Overpack	HI-STAR100 (71-9261)	Yes[1]		No			24 Months[8]
Southern Nuclear	Hatch	BWR	GL	2000	Holtec	HI-STORM	MPC-68	47	3196	570.8	Canister in Vertical Concrete Overpack	HI-STAR100 (71-9261)	Yes[1]		No			24 Months[8]
Southern Nuclear	Hatch	BWR	GL	2000	Holtec	HI-STAR	MPC-68	3	204	36.4	Canister in Metal Cask	HI-STAR100 (71-9261)	Yes[1]		No			12 Months[11]
TVA	Browns Ferry	BWR	GL	2005	Holtec	HI-STORM	MPC-68	37	2516	449.4	Canister in Vertical Concrete Overpack	HI-STAR100 (71-9261)	Yes[1]		No			14 Months[8]
TVA	Sequoyah	PWR	GL	2004	Holtec	HI-STORM	MPC-32	32	1024	446.0	Canister in Vertical Concrete Overpack	HI-STAR100 (71-9261)	Yes[1]		No			14 Months[8]
Xcel Energy	Prairie Island	PWR	SS	1993	TN	TN Metal Casks	TN-40	29	1160	505.2	Bare Fuel	-	-		-	Yes (71-9313)		12 Months[9]
Xcel Energy	Monticello	BWR	GL	2008	TN	NUHOMS	61BT	10	610	108.9	Canister in Horizontal Concrete Overpack	MP197 (MP197HB)	No		No			24 Months[8]
YAEC	Yankee Rowe[13]	PWR	GL	2002	NAC	NAC-MPC	MPC-36	16	533	232.1	Canister in Vertical Concrete Overpack	NAC-STC (71-9235)	No					24 Months[8]
							Totals:	**1640**	**64804**	**19,966.0**								

Table A-2 Storage Summary – U.S. Wet Storage at Shutdown Reactor Sites

U.S.Wet Storage at Shutdown Reactor Sites

Utility	Reactor / Storage Facility	Reactor Type	ISFSI License Type	Planned Load Date	Vendor	Cask System	Canister or Cask Type	Estimated Canisters or Casks to be Loaded	Assemblies in Wet Storage	Future Dry Storage Configuration	Primary Canister Transportation Cask	Primary Transport Cask Fabricated?	Alternative Canister Transportation Cask	Alternate Transport Cask Fabricated?
Dairyland Power	Lacrosse	BWR	SS	2012	NAC	MPC-LACBWR	MPC-LACBWR	2	129	Canister in Vertical Concrete Overpack	NAC-STC (71-9235)	No	NAC-MAGNATRAN	No
Zion Solutions	Zion	PWR	SS	2013	NAC	MAGNASTOR	TSC-37	61	2,226	Canister in Vertical Concrete Overpack	NAC-MAGNATRAN	No	-	-
General Electric	GE Morris	NA	SS	NA	NA	NA	NA		3,217	Storage Sytem not Selected	NA	NA	NA	NA
							Totals:	63	5572					

Storage Summary

	Number of Casks	Number of Assemblies	% of Dry Stored Assemblies
Bare Fuel Casks	180	7826	12.1 %
Canisters in Concrete Overpacks	1447	54648	84.3 %
Canisters in Transport Casks	12	866.0	1.3 %
Vault Storage	NA	1464	2.3 %
			100 %

Red Border indicates "ISFSI Only Site"

Orange Border indicates a Site with a Shutdown Reactor but One or More Operating Reactors Remaining

[1] 12 units actively storing fuel are the only HISTAR 100 Casks available in U.S. 7 of these can accommodate standard size MPCs

[2] One MP187 staged empty at Rancho Seco Site; one TN-FSV staged empty at INL.(Only one canister per shipment possible)

[3] No TN-32 Transporation License under review

[4] Castor Casks not licensed for shipment in the U.S.

[5] No NAC-I28 Transportation License under review

[6] No MC-10 Transporation License under review

[7] Lead time mostly cask license application and review

[8] Lead time due to primary cask not yet fabricated

[9] TN-40 Certificate issued June 2011, TN-40HT Submittal which includes High Burnup Fuel as Content to follow in 2011

[10] Lead time addressess "Storage Only" canister issue, and cast iron bare-fuel casks. Repackaging might be required.

[11] Designates Shortest Lead Time for Shipment of Fuel in Dry Storage. Fuel is Already in Cask Licensed for Transportation. 6 Months Includes Cask Preparation Time, Leak Tests, Impact Limiter Mounting, etc.

[12] includes GTCC waste

[13] All the spent fuel from the shuttered Unit 1

[14] For multiple cask ISFSI sites the earlies load date applies to all casks

[15] Ft St Vrain Initial Heavy Metal does not include Thorium

Green shading indicates shortest lead time of 12 months -- fuel is already in casks licensed (Impact Limiter Fabrication Required) for transportation.

Red shading indicates indefinite lead time to first shipment -- canisters are "storage only" and casks are not licensed, or fuel is in cast iron bare-fuel casks that are not licensable.

Unshaded indicates intermediate lead time -- cask is licensed but not fabricated (or available), or cask license is in progress but not fabricated, or fuel is in (bare-fuel) cask but cask not licensed.

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