TN-68 DUAL PURPOSE CASK DESIGN

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ABSTRACT

The TN-68 is an optimized, dual-purpose dry storage design which can be loaded in the spent fuel pool and transferred to the ISFSI for storage, or with impact limiters attached used as a transport packaging. The loaded cask weights about 115 US tons and has a capacity of 68 intact BWR fuel assemblies. This cask, the TN-68, is a longer, BWR fuel version of Transnuclear's standard TN-32 Advanced Storage Cask design for PWR fuel. The design is based on the high capacity casks which Transnuclear has previously designed, licensed, fabricated, and delivered (the TN-BRP, TN-REG, TN-24P, TN-40, and TN-32).

The TN-68 is very similar in design to the TN-40, a site-specific cask system which was developed and licensed for NMC's Prairie Island Plant, and the TN-32, a generic PWR storage cask which was licensed for Surry and North sites Anna of Dominion. Several significant improvement in storage cask design have been incorporated into this dual-purpose cask system, providing the TN-68 system with the capital economics which have historically been available only with storage system employing concrete technology. At the same time, the highly regarded operational features of the TN-32 and TN-40 have been incorporated into the design, keeping operational costs and radiation exposure far below those of conventional concrete system that require welding of canister lids and transfer casks. These advantages have been achieved while ensuring that none of the features which enhance cask and operational economics would jeopardize designing the cask for transportability, a significant feature of the metal cask storage.

The approach to the development of the TN-68 dual-purpose cask focused on the following major improvements over many current metal cask systems.

- The separation of the containment function from the gamma shielding function in the cask design, so that shielding can be provided by a lower alloy (and lower price) steel.
- The design of a plate and box basket structure which produce a lighter basket, but having strength and heat transfer properties equivalent to those of much heavier basket designs.
- The use of cask and basket fabrication methods which are currently utilized by specific fabricators and which have been developed for other industries and/or product lines; thus reducing fabrication costs by minimum initial tooling requirements and by initiating cask and basket fabrication farther down the learning curve.
- An overpressure system which monitors the pressure between the cask closure seals and provides a positive pressure differential between the seals.

INTRODUCTION

The TN-68 dual-purpose cask provides containment, shielding, criticality control, and passive heat removal, independent of any other facility structures or components. The cask also maintains structural integrity of the fuel during normal storage and transport.

These casks can be used for the storage of spent fuel in an independent spent fuel storage installation (ISFSI) at a power reactor site or with impact limiters installed transported off-site.

The TN-68 cask is designed to maintain the fuel cladding temperature below 343° C during storage. It is also designed to maintain the fuel cladding temperature below 570° C during short-term accident conditions, short-term off-normal conditions and fuel transfer operations.

The criticality control features of the TN-68 cask are designed to maintain the neutron multiplication factor k-effective less than the upper subcritical limit equal to 0.95 minus benchmarking bias and modeling bias under all conditions.

During dry storage of the spent fuel, no active systems are required for the removal and dissipation of the decay heat from the fuel. The TN-68 cask is designed to transfer the decay heat from the fuel to the basket, from the basket to the cask body and ultimately to the surrounding air by radiation and natural convection. The cask is capable of removing 21.2 kW of decay heat without external fins, thus providing a smooth outer surface for ease of decontamination.

DESIGN DESCRIPTION

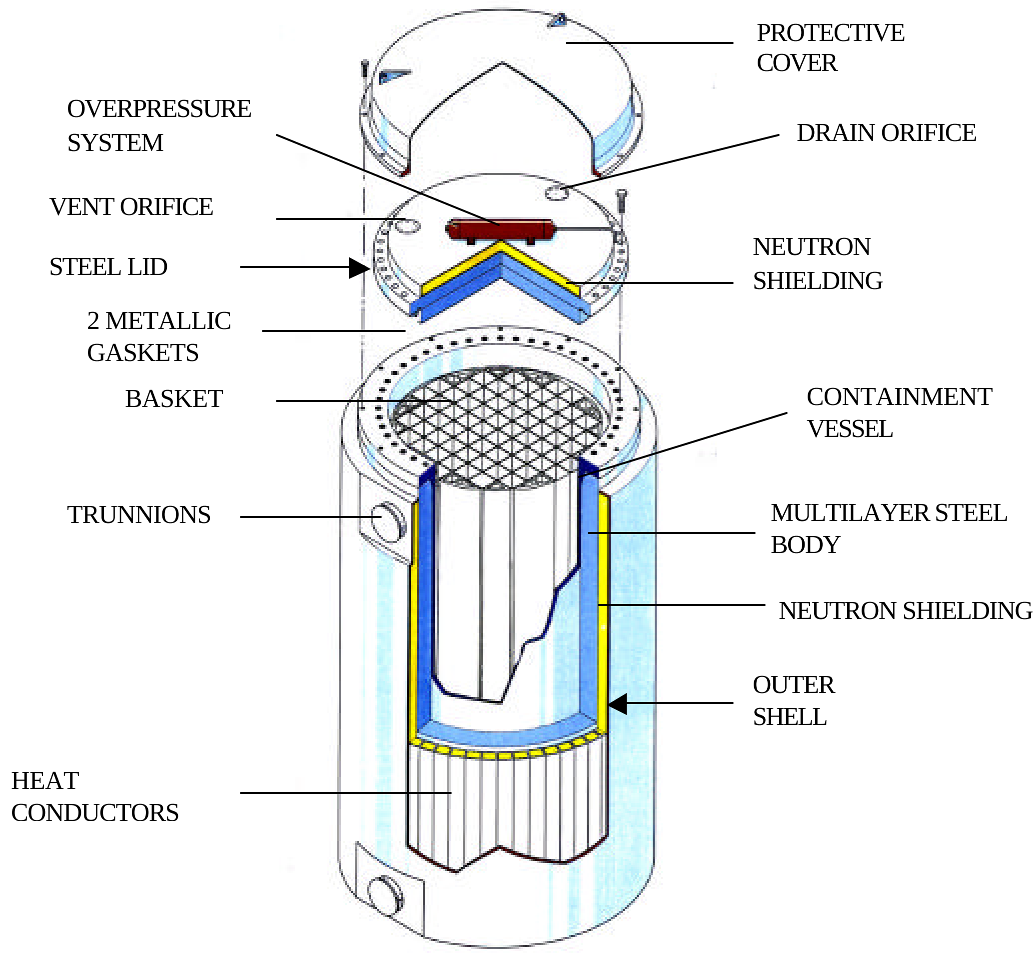
Storage

The TN-68 cask consists of the following components in its storage configuration:

- A basket assembly, which locates and supports the fuel assemblies, transfers heat to the cask body wall, and provides neutron absorption to satisfy nuclear criticality requirements.
- A containment vessel including a closure lid and seals, which provides radioactive material containment and a cavity with an inert gas atmosphere.
- Gamma shielding surrounding the containment vessel.
- Radial neutron shielding surrounding the gamma shield, which provides additional radiation shielding. This neutron shielding is enclosed in an outer steel shell.
- A neutron shield at the top, which rests on the cask lid and provides additional neutron shielding.
- A protective cover, which provides weather protection for the closure lid, a top neutron shield and overpressure system which monitors the pressure between the cask closure seals and provides a positive pressure differential between the seals.

- Sets of upper and lower trunnions, which provide support, lifting and rotation capability for the cask

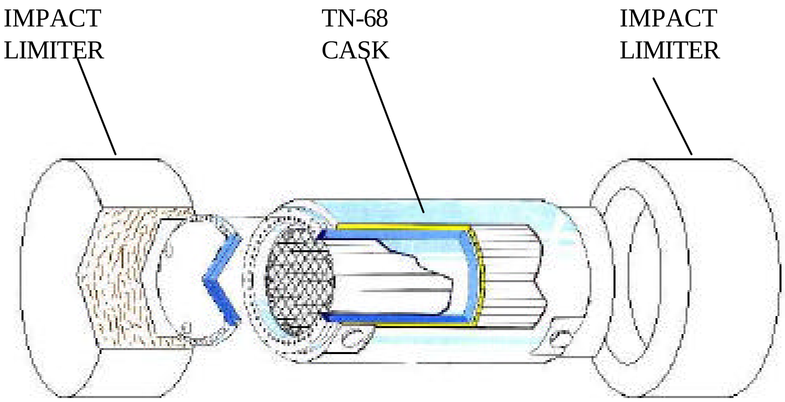
The casks are intended for storage on a reinforced concrete pad at a nuclear power plant.



Transport

Impact limiters consisting of balsa and redwood, encased in stainless steel shells, are attached to both ends of the cask during the transport (protective cover, overpressure system and top neutron shielding are removed). An aluminum spacer is also used to provide a smooth contact surface between the top impact limiter and the cask lid. A thermal shield, provided between the bottom impact limiter and the cask, minimizes the heat transfer to the cask bottom.

Thirteen 1.5 inch diameter tie-rods are used to hold the impact limiters in place. The tie-rods span the length of the cask and connect to both impact limiters via mounting brackets. The impact limiters are also attached to the outer shell of the cask with 1.5 inch diameter bolts. The bolts are attached to brackets (welded to the cask outer shell) and thread into each impact limiter. There are a total of eight bolt-bracket sets, four per impact limiter.



DESIGN/FABRICATION CODES

The TN-68 is designed to satisfy the requirements of 10CFR 72[(1)] for the storage of radioactive materials and the requirements of 10CFR 71[(2)] for the transport of radioactive materials.

The TN-68 cask is designed and fabricated in accordance with the ASME Boiler and Pressure Vessel Code[(3)].

The cask confinement boundary is designed, fabricated and inspected in accordance with the ASME Code Subsection NB to the maximum practical extent. The basket is designed, fabricated and inspected in accordance with ASME Code Subsection NG to the maximum practical extent. The gamma shielding, which is primarily for shielding, but also provides structural support to the confinement boundary during accident events, is designed in accordance with Subsection NF of the code.

CASK MATERIAL

The TN-68 cask is fabricated from ASME code materials. The materials have been chosen to ensure that all structural, thermal shielding, criticality and containment requirements are met with safety margin. The table below lists the major components and their materials.

Description	Material
Shell	SA-105/SA-516 Gr.70/SA-266 Cl2
Lid	SA-350 LF3 or SA-203 Gr.E
Inner Containment	SA-203 Gr. E
Bottom	SA-105/SA- 516 Gr.70/SA-266CL2
Bottom Containment	SA- 203 Gr. E
Trunnion	SA-105
Shield Plate	SA-105/SA-516 Gr.70
Radial Neutron Shield	Borated polyester
Outer Shell	SA-516 Gr.70
Protective Cover	SA-516 Gr.70
Top Neutron Shield	Polypropylene SA-516 Gr.70 Shell
Radial n-Shield Box	6063-T5 Alum
Lid Bolts	SA-320 Gr. L43
Protective Cover Bolt	SA-193 Gr. B-7
Lid Seal	Double metallic O-ring
Protective Cover Seal	Viton O-ring
Over Pressure Port Cover	SA-240 TP304
OP Port Cover SealSingle	MetallicO-ring
Top Neutron Shield Bolt	SA-193 Gr B-7
Over Pressure Tank	Carbon Steel
Drain Port Cover	SA-240 TP 304
Vent Port Cover	SA-240 TP 304
Port Cover Seals	Double Metallic O-rings
Port Cover Bolts	SA-193 Gr B-7
OP PortCover Bolts	SA-193 Gr B-7
Basket Rails	B221,6061-T6
Fuel Compartment	SA-240 Type 304
Poison Plate	Aluminum metal-matrix composite/borated aluminum
Flange	SA-350 Gr. LF3

DIMENSIONS AND WEIGHTS

Specific dimensions are provided in the table below.

Component	Storage (in.)	Transport (in.)
Overall length	215 (w/protective Cover)	217 (w/Impact Limiter)
Outside Diameter	98 (Cask OD)	144 (Impact Limiter OD)
Cavity Diameter	69.5	69.5
Cavity Length	178	178
Containment Shell Thickness	1.5	1.5
Body Wall Thickness	7.5	7.5
Lid Thickness	9.5	9.5
Bottom Thickness	9.75	9.75
Resin and Aluminum Box Thickness	6	6
Outer Shell Thickness	0.75	0.75
Overall Basket Length	164	164
Top Neutron Shield Thickness	4	-
Protective Cover Thickness	0.25	-
Impact Limiter	-	48×144
Weigth on Storage Pad	**115 US Tons**	
Weight in Transport Configuration	**130 US Tons**	

DYNAMIC DROP TESTS

A series of dynamic tests have been performed on one-third scale models of the TN-68 impact limiters. The tests were performed to evaluate the effect of the 30 foot free drop hypothetical accident defined in 10 CFR 71.73(c)(1). The unyielding drop surface consisted of a two inch thick steel plate secured to the surface of a concrete pad. The test model was a solid steel 1/3 scale mockup of the cask body with impact limiter. The steel body was designed to scale the weight and the center of gravity of the package. The test results will be used to verify the analyses performed for the TN-68 cask and basket. The objectives of the TN-68 impact limiter test program were to:

- Demonstrate that the inertia *g* values and forces used in the analyses presented are conservative.
- Demonstrate that the extent of crush depths are acceptable, i.e., limiters do not bottom out and trunnions would not impact target.
- Demonstrate the adequacy of the impact limiter enclosure.
- Demonstrate adequacy of attachment design.
- Evaluate the effects of low temperature (-20° F) on the crush strength and dynamic performance of the impact limiters.
- Evaluate the effects (puncture depth and shell damage) of a 40 inch drop onto a six inch diameter puncture bar on a previously crushed impact limiter, as per 10 CFR 71.73(c)(3).

Four 1/3 scale impact limiters that were constructed for the drop testing. The various drop test orientations were performed in the following sequence.

Test Number	Drop Orientation	Drop Height	Impact Limiter Number	Location of Impact Limiter	Comments
1	15° Slap Down	30 feet	1	Top (1st Impact)	
			4	Bottom (2nd Impact)	
2	90° End Drop	30 feet	1	Top	Bottom impact limiter (2) chilled to –20° F
			2	Bottom (Impact End)	
3	0° Side Drop	30 feet	1	Top	
			3	Bottom	
4	90° End Drop	40 inches	2	Top (Puncture End)	Drop onto 6 inch diameter puncture bar.
			3	Bottom	

The four drop tests were performed without any unusual observations. The impact limiters contained the wood during the drop tests, and none of the attachment bolts failed. The predicted performance of the impact limiters in terms of decelerations and crush depths agrees well with the measured data.

LICENSING/FABRICATION

The design and analysis of the TN-68 storage cask was completed in November, 1997 and the Safety Analysis Report for storage was submitted to NRC by Transnuclear in January 23, 1998. Transnuclear received the NRC approval of the storage Safety Analysis Report in May 20, 2000.

The transport SAR was submitted in May 19, 1999 and Transnuclear received the NRC approval of the transport Safety Analysis Report in January 31, 2001.

Transnuclear's fabricators were released to procure cask materials in September, 1998 and completed the initial cask supply option of 9 casks in July, 2001. These nine casks have been delivered, and loaded at Exelon's Peach Bottom plant. Eleven additional TN-68 casks are presently in fabrication for use at Peach Bottom.

SUMMARY

The TN-68 design is based on Transnuclear's cask designs that have been proven in two decades of worldwide use as trouble-free means to transport and store spent fuel. The TN-68 is a conventional bolted-lid cask that requires neither a canister for containment nor an overpack for shielding. The containment and shielding functions are integrated into the cask itself. In addition, operation is simplified by this design and requires neither welding, the subsequent inspections and accompanying operator exposures, nor the time consuming loading and unloading of a transfer cask. The containment is maintained by the use of a conventional bolted lid with metallic seals. Once loaded and sealed, the cask is in its storage configuration and only needs to be transfered to the ISFSI.

Retrieval or inspection of the fuel can be accomplished by returning the cask to a pool or by the use of a dry transfer system. These operations are not normally required at the reactor site, however, since the TN-68 is directly transportable by rail, barge, or heavy haul trailer following the addition of impact limiters.

There are several advantages of using the TN-68 cask over conventional canister systems:

- The TN-68 casks are reusable. They are designed so that fuel can be loaded and unloaded with ease, without the need for grinding containment boundary welds. This is especially important because the contract between the utilities and the Department of Energy only covers acceptance of bare fuel assemblies, not canistered fuel.
- The TN-68 casks have been analyzed for storage and transport loads. To transition from the storage to the transport configuration requires only rotation to the horizontal position on a transport frame and installing impact limiters on each end.
- The system requires minimal operational time, reducing doses to workers and minimizing the impact of operations on plant activities.
- There is no need for complicated transfer systems. The transfer cask, storage cask and transport cask are one and the same equipment.

- Since the TN-68 cask is transportable, the casks will be ready to leave the storage site as soon as DOE is willing to accept fuel at a repository or an other storage facility becomes available, without the need to transfer fuel into a transport overpack.
- The system contains a pressure monitoring system, which will alarm if there is any indication of leakage. This system also ensures that if a leak were to occur, helium will flow into the containment system preventing leakage of radioactive gases from the containment.
- TN-68 casks are easy to decontaminate, and when it comes time to decommission the site, the casks can be transported off-site and only the ISFSI pad will remain.
- Metal casks are durable and will easily be able to withstand the license period of 20 years and further license extensions.
- The TN-68 casks are based on the TN-32 and TN-40 casks which have been used safely to store fuel at ISFSI's for several years. Cask operations and performance have been demonstrated. There are no unknown surprises that might arise when using the casks.

REFERENCES

1. Title 10, Code of Federal Regulations, Part 72, "Licensing Requirements for the Storage of Spent Fuel in an Independent Spent Fuel Storage Installation."

2. Title 10, Code of Federal Regulations, Part 71, "Packaging and Transportation of Radioactive Materials."

3. ASME Boiler & Pressure Vessel Code, Section III, Division 1,Subsections NB, NG, and NF.