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# TRANSNUCLEAR'S DESIGN FOR TRANSPORTATION, AGING, AND DISPOSAL (TAD) SYSTEM

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## ABSTRACT

Transnuclear, Inc. (TN) is designing a Transportation, Aging and Disposal (TAD) System. Current efforts are focused on the TAD Canisters, a Transportation Overpack and an Aging Overpack. The TAD Canisters include the TN21P which accommodates up to 21 PWR spent fuel assemblies (SFAs) and the TN44B accommodates up to 44 BWR SFAs. The external dimensions of both canisters are identical allowing them to be shipped and/or stored in identical overpacks.

The TN21P and TN44B Canisters will be licensed for storage under the requirements of 10CFR Part 72 with a maximum heat load of approximately 36 kW for the TN21P and 30 kW for the TN44B Canisters. As burnups of the discharged SFAs from nuclear reactors are increasing, decay heats from these SFAs are also increasing. The dry storage systems currently being procured by the utilities have high burnup, high heat load SFAs. TN is taking the design enhancements made to the 61BTH canister and incorporating them into the TN21P and TN44B canister designs to increase the heat load for storage under the requirements of 10CFR Part 72 with high burnup (up to 62 GWD/MTU) and high heat load SFAs. These TAD systems are designed to be in compliance with the DOE Transportation, Aging and Disposal System Performance Specification.

The TN TAD Transportation Overpack (TO) will be licensed for transportation of these TAD Canisters with decay heat loads of approximately 26kW under the U.S. Nuclear Regulatory Commission (NRC) requirements of 10CFR Part 71. The TN TAD TO includes the TN21P and TN44B Canisters as payloads.

The TN Aging Overpack (AO) is also being designed to meet the requirements identified in the DOE Transportation, Aging and Disposal System Performance Specification, such that following transport to the aging facility the canisters can be directly loaded into the aging overpack. The TN TAD AO is being designed to accommodate both the TN21P and TN44B Canisters with heat loads compatible with the payload of the TN TAD TO.

## INTRODUCTION

Since August 2004, Transnuclear, Inc. (TN) has developed a series of reports supporting the U.S. Department of Energy (DOE) for the Yucca Mountain Project, that evaluate various TN products for transporting to and aging of spent nuclear fuel at the Mined Geologic Repository (MGR). The latest of these reports involved development of a TN Transportation, Aging and Disposal (TAD) Canister System for commercial spent nuclear fuel. In this paper TN describes the characteristics and capabilities of key system components, and summarizes the analyses and evaluations performed to verify that the system design met the requirements of DOE's Preliminary TAD Canister System Performance Specification, Revision B.

## SYSTEM COMPONENTS

The TN TAD Canister system developed in support of DOE Contract DE-AC28-07RW12361 is fully compliant with Revision B of the DOE performance specification and includes the following major components:

### TN21P TAD PWR Canister

TN21P Canister for commercial Pressurized Water Reactor (PWR) fuel that is designed to be loaded, sealed, handled and stored at commercial reactor sites, transported to the MGR as approved contents under title 10 CFR Part 71 (10CFR71), handled in a transfer cask and/or aged at the MGR, and then disposed of in a waste package. The latter three functions will be under Title 10 CFR Part 63 (10CFR63) once the MGR is licensed. The TN21P Canister holds 21 PWR fuel assemblies including all types of associated non-fuel bearing hardware. It is designed to accept all US commercial PWR spent fuel, except the South Texas Class that is too long to fit within the specified canister length. Also, it is designed to store PWR fuel at any US reactor site in an NRC-licensed NUHOMS® storage system under the provisions of 10 CFR Part 72 (Certificates of Compliance 1004, 1029 and 1030).

### TN44B TAD BWR Canister

TN44B Canister for commercial Boiling Water Reactor (BWR) fuel that is designed for the same functions as the TN21P Canister except that it holds 44 BWR fuel assemblies including associated flow channels and channel clips. It is designed to accept all US commercial BWR spent fuel and store this fuel at any US reactor site in an NRC-licensed NUHOMS® storage system under the provision of 10 CFR Part 72 (Certificates of Compliance 1004, 1029 and 1030).

### TN TAD Transportation Overpack

TN TAD Transportation Overpack (TO) that is designed for transporting both the TN21P and TN44B Canisters as authorized contents under 10CFR71. The TN TAD TO is a lengthened version of its licensed Model No. NUHOMS® MP197 Transport Packaging (Certificate of Compliance 9302).

### TN TAD Aging Overpack

TN TAD Aging Overpack (AO) is designed to safely contain loaded TN21P and TN44B Canisters on the MGR aging pad until the repository thermal limits are met. It is a reinforced concrete structure that provides seismic, impact, fire protection and heat dissipation with natural convection cooling. It receives, stores, and discharges canisters in a vertical orientation. It is designed to be moved in a vertical orientation by a crane, forklift or air pallet.

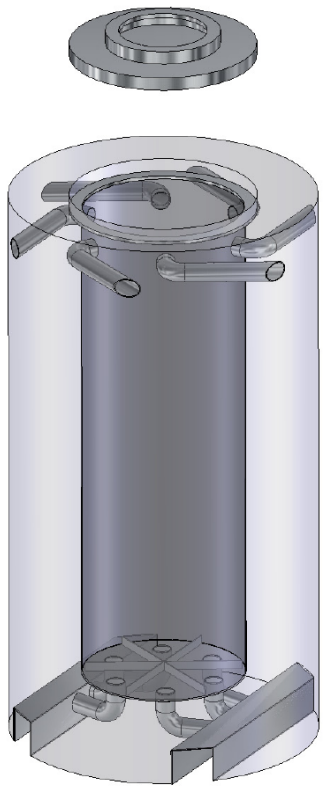

**Figure 1. TN TAD AO**

TN TAD HSM-H Storage Module (Cask) and Transfer Cask System

The TN21P and TN44B Canister designs are compatible with the existing TN NUHOMS® Horizontal Storage Module (HSM-H) dry storage systems currently licensed for heat loads in excess of 40 kwatts. The NUHOMS® transfer cask will be used for loading fuel in the canisters in utilities' spent fuel pools. The TAD Canisters will be dried, welded, backfilled with helium and then transferred in the transfer cask to a plant's ISFSI site for storage in the NUHOMS® HSM-H. The TAD Canisters will be transferred from the transfer cask to the HSM-H for dry storage. TAD Canisters can then be transferred directly from the HSM-Hs to the TN TAD TO and transported to the MGR. No safety related lift is required to transfer a canister from an HSM-H to the TN TAD TO.

**Figure 2. Array of HSM-H Modules**

## ANALYSIS/EVALUATION SUMMARY

The TN21P and TN44B Canisters are similar to the existing NUHOMS® Canisters currently licensed for both storage (10CFR72) and transport (10CFR71). Bounding analysis of the TN TAD System were performed for the Proof-of-Concept Designs. The following is a summary of the evaluations performed for the TN TAD System.

### TN21P and TN44B TAD Canister Analysis

The TN21P and TN44B Canisters (shell and closure) are designed and fabricated as a Class 1 component in accordance with the rules of the ASME Boiler and Pressure Vessel Code, Section III, Subsection NB to the extent possible. The canisters are designed to maintain a subcritical configuration during loading, handling, storage, transport, aging and disposal conditions including accident conditions. A combination of fixed neutron absorbers, favorable geometry and burnup credit (TN21P only) are employed to maintain subcriticality. The basket is designed and fabricated in accordance with the rules of the ASME Boiler and Pressure Vessel Code, Section III, Subsection NG, Article NG-3200 to the extent possible. The field closure welds used for canister containment are in accordance with ISG-15. The canister closure welds are similar to TN's NUHOMS® Canisters which are in accordance with standard nuclear industry practice.

The canister is designed for postulated drop loads to ensure the adequacy of the design for 10 CFR Part 71, 10 CFR Part 72 and 10 CFR Part 63. The postulated drops apply to all parts of the canister. The analyzed drops include a 75g side drop, 25g corner drop and 60g end drop. The TN21P and TN44B baskets are similar to that of Transnuclear's NUHOMS® 61BT canister which meets all these drop scenarios, and as the shell of the TN21P Canister is thicker than the other NUHOMS® DSCs therefore the shell is qualified for all of the postulated drops.

The basket fuel compartment wall thickness is established to meet heat transfer, nuclear criticality and structural requirements. The basket structure provides sufficient rigidity to maintain a subcritical configuration under the applied loads.

### TN TAD TO Analysis

The TN TAD Transport Overpack (TO) is a lengthen version of the NUHOMS® MP197 Transport Packaging that has been modified to transport the TN21P and TN44B Canisters.
The TN TAD TO consists of the following components:

- A cask consisting of a containment boundary, structural shell, gamma shielding material, and solid neutron shield. The containment boundary consists of a cylindrical shell, bottom end (closure) plate with a ram access penetration, top end forging ring, bottom and top cover plates (lids) with associated seals and bolts, and vent and drain port closure bolts and seals. The transport cask cavity also contains an inert gas atmosphere.
- Sets of upper and lower trunnions that provide support, lifting, and rotation capability for the cask.
- Impact limiters, consisting of balsa and redwood encased in stainless steel shells, are attached to each end of the cask during shipment. A thermal shield is provided between the impact limiter and the cask to minimize heat transfer to the bottom limiter. Each impact limiter is held in place by twelve (12) attachment bolts.

A personnel barrier is mounted to the transport skid to prevent unauthorized access to the cask body.

The TN TAD TO has smooth stainless steel surfaces to facilitate decontamination. The TO can also be loaded and unloaded either vertically or horizontally to allow it to be loaded or unloaded outside of a fuel pool preventing it from becoming contaminated.

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 shell, the o-ring seals, the borated polyester resin neutron shield material and the carbon steel closure bolts.

The TN TAD Transport Overpack containment vessel is designed, fabricated, examined and tested in accordance with the requirements of Subsection NB of the ASME Code to the maximum practical extent. In addition, the design meets the requirements of Subsection NB of the ASME Section III, Division 3.

The gamma shielding and steel shells of the TO provide shielding between the fuel and the exterior surface of the package for the attenuation of gamma radiation.

Neutron shielding is provided by a borated polyester resin compound surrounding the outer shell. The resin compound is cast into long, slender aluminum containers. The total thickness of the resin and aluminum is optimized for neutron shielding and heat transfer. The array of resin-filled containers is enclosed within a smooth outer steel shell.

The front and rear impact limiters absorb energy during impact events by crushing balsa and redwood. The top and bottom impact limiters are identical. Each has a maximum outside diameter of 126 inches and a height of 60.75 inches. The inner and outer shells are Type 304 stainless steel joined by radial gussets of the same material. The metal structure locates, supports, confines and protects the wood energy absorption material. The external surfaces of the impact limiter shells are painted.

The impact limiters are attached to the cask by twelve (12) attachment bolts. The attachment bolts are designed to keep the impact limiters attached to the cask body during all normal and hypothetical accident conditions. A thermal shield is added to the impact limiter to reduce the impact limiter wood temperature. No special tools are required to handle, attach and remove the impact limiters.

The Thermal Analysis performed demonstrates that the maximum component temperatures meet the specified temperature limits. In addition, the estimated maximum fuel cladding temperatures for BWR and PWR fuel assemblies within the TN21P and TN44B Canisters are well within the temperature limits. Thus, maximum component temperatures, including fuel cladding, are well below the allowable limits for normal transport conditions.

A shielding analysis was performed to demonstrate that the TO design is adequate for the design basis fuel.

TN TAD AO Analysis

TN performed structural calculations for the aircraft impact event and for the seismic events to assess the capabilities of its TN TAD AO design. The other structural design criteria were judged to be less critical from a design standpoint based on TN's experience in designing and licensing

other storage systems, both vertical metal casks and reinforced concrete horizontal storage modules.

Structural analysis results for the seismic and aircraft impact events are that the design meets are the requirements defined in Revision B of the DOE performance specification.

A combined fluid flow and heat transfer model of the TN TAD AO was developed to assure that the conceptual design of the overpack can dissipate the decay heat while maintaining all component and fuel cladding temperatures within their normal operating limits. The analysis shows that all temperature limits are met with significant margin.

The shielding analysis performed verified that the TN TAD AO design, containing a TN21P or TN44B Canister is acceptable from a shielding perspective. Dose rates at the side and top surfaces of the TN TAD AO are significantly below the limit of 40 mrem/hr on the AO cylindrical surface. In addition, the vent dose rates are all below 40 mrem/hr.

## CONCLUSIONS

Transnuclear, Inc. (TN) intends to continue to support the U.S. Department of Energy (DOE) for the Yucca Mountain Project, through the development of the TN Transportation, Aging and Disposal (TAD) Canister System for commercial spent nuclear fuel. The TN Proof-of-Concept design meets Revision B of the DOE Performance Specification. In addition, TN has reviewed Revision 0 of the Transportation, Aging and Disposal Canister System Performance Specification issued by DOE in June 2007 and will modify its conceptual design to meet the revised requirements.

## REFERENCES

US Department of Energy, “Preliminary Transportation, Aging and Disposal Canister System Performance Specification”, Doc ID: WMO-TADCS-0000001, DOE/RW-0585, Revision B, November 2006.

ASME Boiler and Pressure Vessel Code, Section III, Division 1, Subsections NB, NG, and NCA, 2004.

U.S. NRC Spent Fuel Project Office, “Materials Evaluation,” ISG-15, Approved January 10, 2001.

 