RECENT DEVELOPMENTS IN DRY STORAGE TECHNOLOGY AT TNY

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SUMMARY

Transnuclear, Inc. (TNY) has developed enhanced cask designs to meet the needs of utilities at an economical price. The products are based on the proven technology of the TN-24, TN-32 and TN-40 Pressurized Water Reactor (PWR) dry storage casks which have been licensed, fabricated and are in use in the United States at Northern States Power's Prairie Island Station and Virginia Power's Surry Station. They are also planned for use at Virginia Power's North Anna Station. The TN advanced storage casks are metal casks designed for ease of operation and minimal radiation dose rates to workers and the public.

An amendment to the TN-32 Topical Safety Analysis Report is under review by the US Nuclear Regulatory Commission to increase the allowable maximum burnup and initial enrichment limits of the fuel.

Transnuclear is licensing a similar design to meet the needs of Boiling Water Reactor (BWR) plants. The TN-68 cask is designed to transport and store 68 intact BWR fuel assemblies with a maximum initial enrichment of 3.3% w/o U235, 40,000 MWD/MTU maximum burnup and a 10 year minimum cooling time. These casks are planned for first use at the Philadelphia Electric Company's Peach Bottom Plant.

The TN advanced storage casks are uncanistered, allowing fuel removal and inspection at any time during the storage period. There is no on-site welding required, allowing the casks to be completely fabricated and inspected before leaving the fabricator's facility. Thus quality can be ensured by radiographing all containment welds. Transnuclear has demonstrated a high level of fabrication control and quality assurance necessary to meet the U.S. Nuclear Regulatory Commission (NRC) and utility requirements.

INTRODUCTION

In a market increasingly driven by cost, Transnuclear, Inc. has chosen to provide rugged casks which are conservatively designed and easy to operate. TN storage casks are metal, not concrete. Although metal casks are more expensive to procure than concrete systems, they are inherently safer, and can provide considerable life cycle cost savings.

The stored fuel is readily retrievable from the casks. If there were any concerns regarding the performance or safety of the cask system, it is easily unloaded. This is in contrast to canistered systems which have not and could not be easily opened for reinspection or any other purpose.

TN cask materials are selected so there is no concern regarding chemical, galvanic or other reactions which might reduce their effectiveness during storage.

TN storage cask systems are designed with a continuous monitoring system to alert operators in the highly unlikely event of a seal leak, prior to release of any radioactive material. This will facilitate off-site shipment of the casks in the future by providing positive evidence that the inert atmosphere has been maintained throughout the storage period.

Transnuclear has consistently demonstrated the high level of fabrication control and quality assurance necessary to meet NRC and utility requirements. The NRC has audited TN's fabrication records and has been complementary on the quality of the fabrication of these casks.

Fourteen (14) TN storage casks have been delivered and loaded at U.S. Nuclear Power Plants. Forty-three(43) additional casks are currently in fabrication. The plant operations personnel have been extremely pleased with the casks, since they are simple to load, dry and test. There are no difficult operations, such as welding, to perform on site.

To date, the casks have been used for storage only at PWR plants. Transnuclear has now developed a BWR cask, designated the TN-68, which can accommodate sixty-eight (68) BWR assemblies with and without channels. The safety evaluation report was submitted to the NRC in January, 1998. The first TN-68 will be in operation in Spring, 2000. The TN-68 cask is designed for both storage and transport.

Transnuclear has also reevaluated the TN-32 cask and has recently submitted an amendment to the TN-32 Topical Report to the NRC for accommodating higher burnup fuel. This amendment includes new thermal and nuclear analyses to extend the envelope of the TN-32 to include spent fuel with a maximum initial enrichment of 4.05 w/o U235, 45,000 MWD/MTU maximum burnup and 7 year minimum cooling time. It also includes storage of fuel with burnable poison rod assemblies and thimble plugs.

Other enhancements that are under development include new basket materials for criticality control and a redesign of the basket periphery for ease of installation and enhanced heat transfer.

PWR CASK DESIGNS

Transnuclear, Inc. has developed three storage casks for PWR fuel:

- The TN-24 cask is a forged carbon steel cask designed to hold twenty-four (24) PWR spent fuel assemblies. A prototype of the TN-24 designated as the TN-24P was designed in cooperation with Transnucleaire, S.A. of Paris, France. This cask was the predecessor of the TN advanced storage casks.

- The TN-40 cask is designed to hold forty (40) 14 x 14 PWR fuel assemblies. The cross section of the basket compartment is 204 mm (8.05 inches) square, since the 14 x 14 assemblies have a smaller cross-section than standard PWR fuel. The reduced cross section of the basket allows a higher capacity cask. The TN-40 cask accommodates fuel with an initial enrichment of up to 3.85 w/o U-235, a maximum burnup of 45,000 MWD/MTU and 10-year minimum cooling time.

- The TN-32 cask is designed to hold thirty-two (32) standard PWR fuel assemblies (15x15 or 17x17 arrays) with an initial enrichment of 3.8 w/o U-235, a maximum burnup of 40,000 MWD/MTU and 7 year cooling time.

Burnup Credit Evaluation in the TN-40

Burnup credit has been evaluated for the TN-40 in order to investigate the possibility of transporting a loaded TN-40 cask from the Independent Spent Fuel Storage Installation (ISFSI) at some future date. The current storage license allows boron credit to be utilized for criticality control. The calculation model assumes a completely flooded cask cavity with the cask body water reflected all around. The fuel rod plenum and assembly end fittings are modeled as water. The Westinghouse 14x14 optimized fuel assembly (OFA) is modeled discretely. The ORNL SCALE 4.3 code package was utilized to perform the criticality calculations for taking credit for fuel burnup.

For a specific initial enrichment and burnup, the 15 year isotopics provided by the U.S. Department of Energy (DOE) were used to perform a series of calculations to determine the reactivity of the TN-40 cask loaded with 40 fuel assemblies. Horizontal tilt (variation in burnup) was accounted for in the analyses. The burnups for the assemblies were increased and decreased by predetermined percentages based on the range of the nominal burnup. Figure 1 plots the final required burnup versus initial enrichment. Spent fuel assemblies with a minimum burnup and initial enrichment in the region above the loading curve can be loaded safely into the TN-40 cask. No credit for pool boron would be required.

Increased Burnup Fuel in the TN-32

Like other utilities, Virginia Power chose to store the oldest spent fuel first. Virginia Power has now stored over 800 spent fuel assemblies. As a result, they are running out of the lower burnup fuel at the Surry Nuclear Power Station. The limiting condition on the TN-32 was the heat load. Therefore, TN has refined its thermal analysis and increased the fuel parameters to include fuel with a maximum initial enrichment of 4.05 w/o U235, 45,000 MWD/MTU maximum burnup and 7 year minimum cooling time. This analysis was submitted to the U.S. NRC for approval in February 1998.

The thermal analysis refinements include:

- Taking credit for the conductivity of the spent fuel
- Developing a 3D thermal model.
- Modeling the cask protective cover for conduction.
- Taking credit for thermal contact between the bottom of the basket and the bottom of the cask.
- Averaging insolance over a 24 hour day.

By refining the finite element model, the calculated cask and basket temperatures were maintained at about the same temperatures as calculated in the previous model, even though the heat load per assembly increased from 0.85 kW/assembly (2900 Btu/hr) to 0.99 kW/assembly (3392 Btu/hr). As a result, the structural analysis did not require modification. Shielding and criticality analyses were reperformed. The required boron in the pool water was increased from 2,000 parts per million (ppm) to 2,200 ppm.

BWR CASK DESIGNS

Transnuclear is currently licensing the TN-68 cask to meet the needs of BWR plants. The TN-68 cask is designed to transport and store 68 intact BWR fuel assemblies with a maximum initial enrichment of 3.3% w/o U235, 40,000 MWD/MTU maximum burnup and 10 year minimum cooling time. These casks are planned for first use at the Philadelphia Electric Company's Peach Bottom Plant.

The TN-68 cask consists of a containment vessel surrounded by gamma shielding. The gamma shielding is provided around the walls of the containment vessel by an independent carbon steel shell that is welded to a bottom shielding plate and to the closure flange.

Neutron shielding is provided by a polyester resin compound. The resin compound is enclosed in aluminum boxes that surround the cask body. These boxes are enclosed in a painted carbon steel shell.

The fuel basket is a plate and box structure that uses existing proprietary laminating methods to produce a light basket with the heat transfer and strength properties of a heavier basket. The basket structure consists of an assembly of stainless steel cells joined by a fusion welding process to stainless steel bars. The stainless steel bars hold the boxes together and provide structural support. Between the stainless steel bars are poison (borated aluminum or equivalent) plates which form an egg crate structure.

The poison plates are used for criticality control and heat transfer. No structural credit is taken for the poison plates.

Double metallic O-ring seals with interspace leakage monitoring are provided for the lid closure. The cask cavity is pressurized with helium. The interspace between the metallic seals is monitored and pressurized with helium so that any seal leakage would be into the cavity.

Unlike the PWR casks, the BWR casks have been designed for transport from the initial design stage. Several design enhancements have been made to accommodate transportation and simplify fabrication:

- The stainless steel boxes have been increased in thickness to meet the structural requirements without relying on aluminum for strength.
- Structural stainless steel bars have been added between layers of poison materials to increase strength during the hypothetical accidents during storage and transport.
- The peripheral rails used to enhance heat transfer between the basket and cask are now attached to the basket rather than the cask cavity. This simplifies inspection requirements.
- The poison material thickness has been increased so that it can be manufactured more readily.
- Alternate poison materials have been evaluated.
- The poison material is used for both thermal conductivity and criticality control.
- The gamma shield and neutron shield thickness have been optimized to minimize the weight of the cask.
- The lid bolt sizes have been increased to meet transport requirements.

The result is an efficient cask which can withstand both transport and storage normal and accident conditions. The cask is designed and will be fabricated in accordance with the ASME Boiler and Pressure Vessel Code. The design of the cask is consistent with the newly published Division 3 ASME Code, Containment Systems and Transport Packagings for Spent Nuclear Fuel and High Level Radioactive Waste.

In addition to spent fuel, the TN-68 cask is also designed to store Greater than Class C Waste.

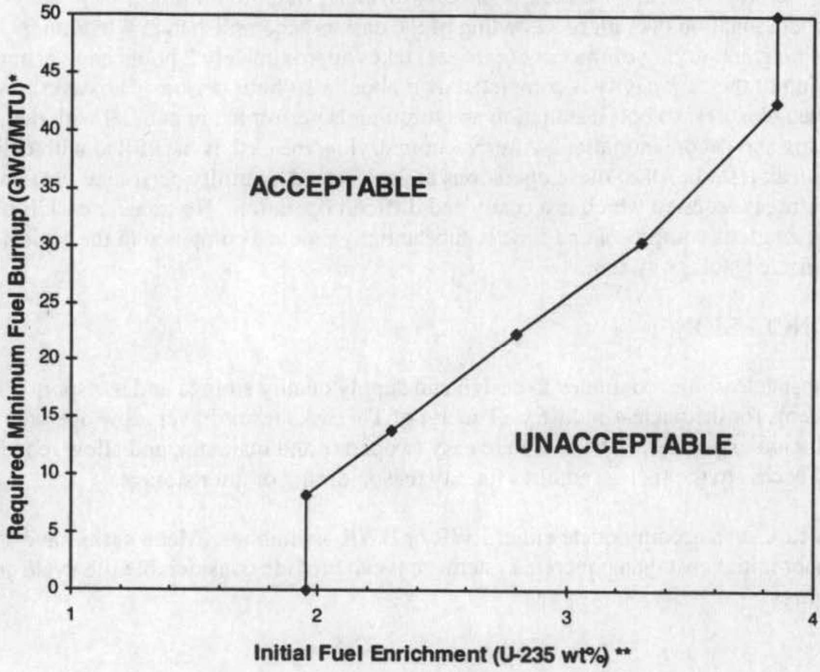
OPERATIONAL CONSIDERATIONS

TN casks are inherently simple to operate which results in considerable operational cost savings. Prior to lowering the cask into the spent fuel pool, the metallic o-ring seals are replaced, and the cask is rinsed with clean water to minimize decontamination operations. Loading of the cask is accomplished in 4 to 8 hours. Draining and drying of the cask (exterior) takes approximately 2 hours and vacuum drying of the cask cavity is completed over about a 10-hour period. The casks have bolted closures, so bolt installation and torquing is performed in parallel with the drying and decontamination. After vacuum drying, the cask is backfilled with helium and leak tested. All of these operations are performed by utility personnel. No on-site welding is required which is a costly and difficult operation. No transfer cask is used, so operations equipment and time is substantially reduced compared to the typical canistered storage system.

CONCLUSION

Transnuclear, Inc. continues to design and supply quality storage and transport systems for the nuclear industry. The use of TN casks result in very low operator radiation exposures. The casks are easy to operate and maintain, and allow reopening and access to the fuel assemblies for any reason during or after storage.

TN casks can accommodate either PWR or BWR assemblies. Metal casks have a higher initial cost than concrete systems, but can provide considerable life cycle cost savings.



Assembly Design: W 14x14

Minimum Cooling Time: 15 yr

Maximum Number of Removable Burnable Absorber Rods: 0

Note: This loading curve was generated with the following generic assumptions: Maximum Cycle Average ppm Boron of 650, Maximum Core Outlet Temperature of 570^0K, and the Maximum Pellet Average Temperature of 900^0K.

* The nominal burnup must be reduced by the utility so there is a 95% confidence level of meeting the Required Minimum Fuel Burnup.

** If the assembly has more than one enrichment, the highest enrichment must be used.

Figure 1 Development of Burnup Credit Loading Curve for the TN-40 Spent Fuel Cask