Fabrication and Operational Experience with the TN-40 and TN-32 Casks

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INTRODUCTION

Transnuclear has developed an Advanced Storage Cask design that is consistent with utilities' storage needs and price expectations. The advanced storage casks:

- Reduce fuel assembly unit storage costs by increasing cask capacity through the use of the superior weight-to-capacity ratio of metal casks, credit for pool water boron, and longer cooled fuel.
- Make the storage system materials more appropriate for their function by separating the containment and shielding functions;
- Reduce basket material costs; and
- Maintain the excellent operating characteristics of the Transnuclear transport casks.

The immediate predecessor of the Advanced Storage Cask design is the TN-24P Dry Storage Cask, which was sold to Virginia Power as part of its Cooperative Agreement with the Department of Energy. Extensive thermal and shielding tests were performed on the TN-24P at the Idaho National Engineering Laboratories (INEL). EPRI report No. NP-5128 (Creer, 1987) documents the excellent results obtained during the testing of both intact and consolidated fuel at INEL.

ADVANCED STORAGE CASK DESIGN

The main components of the Advanced Storage Cask design are the containment vessel, the gamma shield, the neutron shield, the fuel basket, the sealing system, and the weather cover. Two advanced storage casks have been designed: the TN-40 which is used at Northern States Power's Prairie Island plant, and the TN-32 which is being fabricated for Virginia Power for use at the Surry and North Anna plants.The attached figure provides an overall view of the TN-32 Advanced Storage Cask design.

The containment vessel for the advanced storage casks consists of an inner vessel that is a welded, carbon steel cylinder with an integrally-welded, carbon steel bottom closure; a welded flange forging; a flanged and bolted carbon steel top lid with bolts; and lid penetration assemblies with bolts. The inner shell wall thickness is 1.5 inches. The containment vessel meets the requirements for a Class 1 component in accordance with the ASME Boiler and Pressure Vessel Code, Section III, Subsection NB, 1995.

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 long, slender aluminum containers that surround the cask body. The array of resin-filled containers is enclosed by a smooth, outer carbon steel shell constructed of two half cylinders.

The fuel basket is a plate and box structure which uses existing proprietary laminating methods to produce a lighter 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 and separated by aluminum plates which form a sandwich panel. Neutron poison is sandwiched between aluminum plates and is structurally secured around each box for criticality control and heat removal. Water gaps are not utilized in the basket due to the allowance of credit for water containing boron.

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.

The storage casks are safety-related although some components may be designated as augmented quality or non-safety related. As such, the casks must be designed, fabricated, and tested in compliance with a quality assurance program/plan based on 10CFR72 criteria. Additionally, although the cask is not truly a pressure vessel, the rules of the ASME B&PV Code are utilized to the maximum practical extent.

FABRICATION

The containment vessel is fabricated to the maximum practical extent in accordance with the ASME Code Section III, Subsection NB. ASME or equivalent ASTM materials are used in the construction of the casks. Fracture toughness properties of the carbon steel containment material are determined in accordance with Section III and/or Section II requirements. Welding is performed and qualified in accordance with

Section IX and Section III requirements, as appropriate. Containment vessel welds are examined by radiography and magnetic particle or liquid penetrant methods per Section V of the Code.

The containment vessel is installed into a heated gamma shield shell to ensure close contact between the two shells. The bottom gamma shield is then welded to the gamma shield shell. Non-containment welds are examined by Section V methods including magnetic particle, liquid penetrant, or visual, as appropriate.

The aluminum boxes that will hold the resin compound are assembled around the cask body, and the resin is poured in place. To ensure proper shielding, the resin-pouring operation is carefully monitored and controlled. The resin-pouring operation and resin-pouring personnel are first qualified by making sample pours. The sample pours are cured, cut, and inspected for cracks or voids. Samples of each resin production batch are taken and utilized to verify resin density.

The inside surfaces of the cask are metal sprayed for corrosion protection, and the outside surfaces of the cask are coated with an epoxy paint.

Tests performed during fabrication of the cask include: load testing of the trunnions to 1.5 times design load followed by liquid penetrant or magnetic particle examination and deformation measurement; hydrostatic test of the cask body to 1.25 times normal operating pressure; leak testing of the lid seals, lid penetration seals, and the overpressure system; and functional testing of the fit up and removal of the lid, penetration covers, weather cover, and all bolts.

The baskets for the casks are constructed by a different fabricator than the cask bodies. The basket fabricator must also possess a qualified QA program and qualify his welding procedures according to Section IX of the Code. The basket pieces (boxes and plates) are assembled in a fixture, held tightly, and welded together. The welds are visually inspected, the assembled basket removed from the fixture and the basket dimensionally inspected. A plate gauge is placed into each fuel compartment (box) to assure proper inside dimension and the basket cleaned and packaged for shipment to the cask body fabricator for installation at the facility.

OPERATIONS

The TN-40 dry storage cask is designed to store 40 intact Prairie Island spent-fuel assemblies with an initial enrichment of 3.85%, burnup of 45,000 MWD/T, and at least 10 years cooling time. Northern States Power (NSP) was awarded a Site Specific License for using the TN-40 casks on October 19, 1993. Transnuclear is under contract with NSP to supply seven TN-40 casks to the Prairie Island site. The first cask was delivered to Northern States in January 1995. Preoperational testing including a dry run was performed prior to the cask being loaded with spent fuel. The first cask, loaded with 40 Prairie Island spent-fuel assemblies, was placed on the ISFSI storage pad on May 24, 1995.

The operational performance of the cask was excellent. The preparation time for placing the cask into the fuel pool was approximately one week. Loading of 40 fuel assemblies into the fuel basket was accomplished in about 7 hours. Draining and drying of the cask (exterior) took 2 hours, and vacuum drying of the cavity was completed over a 10-hour period. The total dose accumulated for the complete loading and placement of the first TN-40 cask on the pad was 64 mrem.

Although the TN-40 cask is NRC licensed for 45,000 MWD/T burnup with a 10-year cool time, the ISFSI license from the state of Minnesota allows an average burnup of only 40,000 MWD/T and a minimum 15-year cooling time . The fuel placed into the first cask had burnups ranging from around 19,600 to 38,800 MWD/T and cooling times of approximately 18 years. The measured contact gamma dose rate on the sides of the cask were 1-2 mrem/hr. The contact side neutron dose rates were also in the 1-2 mrem/hr range with readings near the trunnions about 3 mrem/hr and above and below the neutron shield in the 7-10 mrem/hr range. Contact dose rates on the weather cover ranged from 1-2 mrem/hr gamma and 3-4 mrem/hr neutron. The temperature measured on the cask surface ranged from 90 °F - 110 °F with an 80 °F ambient temperature.

At this time, two more TN-40 casks have been delivered to Prairie Island. The second cask arrived at Prairie Island by rail on October 12, 1995. Loading began November 1 and final preparations for moving the cask to the pad were completed November 10 with radiation and temperature data similar to the first cask. The loaded cask was placed on the ISFSI pad on November 13, 1995. The other delivered cask is expected to be loaded before the end of this year. A fourth cask is scheduled to be delivered to Prairie Island before the end of this year. The additional three casks are in various stages of fabrication and are expected to be completed during the first quarter of 1996.

The TN-32 dry storage cask is nearly identical to the TN-40 cask, except that it is designed to store standard PWR fuel. It has a capacity of 32 intact PWR fuel assemblies whose initial enrichment was 3.85%, with a burnup of 40,000 MWD/T and 7 years cooling time. A Topical Report was submitted to the NRC for review in December, 1993. NRC approval is anticipated shortly. Transnuclear is concurrently fabricating 14 of the TN-32 casks for use at Virginia Power's Surry Station. The first TN-32 cask is scheduled for delivery to Surry in April 1996.

REGULATORY ENVIRONMENT

The NRC has taken a heightened awareness in the area of dry storage. The NRC staff has observed an inconsistent level of quality assurance performance by licensees and cask fabricators. This has contributed to a variety of problems associated with code interpretations, standards, and design commitments in Safety Analysis Reports, with utilities, vendors, and the NRC staff adopting differing positions.

In the NRC staff's opinion, some licensees have not focused their attention on dry cask issues until late in the project, contributing to their difficulties. In many cases fabrication activities were carried on with minimal utility oversight. As a result, many utilities were not aware of problems until late in the fabrication process.

With the rapid growth of dry storage activities, the NRC staff has recognized a need for a better understanding of dry storage issues and improved communications both within the NRC, with the licensees and with the public. The NRC recently issued a Dry Cask Storage Action Plan that has two basic goals:

- To resolve problems identified with dry cask storage and to address anticipated licensing and inspection issues for dry cask storage; and
- To develop and maintain more efficient communication within the NRC, within involved industry entities, and between the industry and the NRC staff.

Technical issues identified in the current action plan are near-term and long-term. The near-term issues are:

- Heavy-load control/crane issues - suitability and adequacy of crane qualifications at sites;
- Cask Trunnions - Acceptance and maintenance testing requirements;
- Hydrostatic Testing - Define specific requirements for hydrostatic testing, if any; and
- Seismic Requirements for Spent Fuel Storage Pads - correct implementation of requirements for seismic analysis.

The long-term issues identified are cask weeping, cask loading and unloading, offloading capability, failed fuel storage, and safeguards concerns. Other issues contained in the action plan concern communications and procedural issues. This action plan is expected to be updated quarterly with new issues arising and hopefully, old issues being resolved. The important issue is that the NRC staff has become very proactive in the dry storage area and this should in the long run help all parties involved in the process: the cask designer, the fabricator, and the utility.

CONCLUSION

The TN advanced storage casks are less expensive than currently available metal storage casks. Experience at Prairie Island has shown that loading of the TN-40's results in very low operator radiation exposures, and that the casks are easy to operate. The casks also require minimum maintenance, and allow reopening of the cask and access to the fuel assemblies for any reason during or after storage.

REFERENCES

American Society of Mechanical Engineers, *Boiler and Pressure Vessel Code, Section III, Subsection NB, Rules for Construction of Nuclear Power Plant Components*, (1995).

Code of Federal Regulations, Title 10 Part 72, *Licensing Requirements for the Independent Storage of Spent Nuclear Fuel and High-Level Radioactive Waste*, (January 1995)

Creer, J.M. et al, *The TN-24 PWR Spent-Fuel Storage Cask: Testing and Analyses*, EPRI NP-5128, (April 1987).

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