DRY STORAGE TECHNOLOGY FROM TRANSNUCLEAR

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ABSTRACT

Transnuclear's dry storage technology is presented from the perspectives of its past, present and future. Predecessor dry transport designs from the TN-8, TN-9 and TN-12 series show the demonstrated and operationally proven bases of current dry storage cask designs such as the TN-24, TN-BRP and TN-REG. These current designs are reviewed in the context of their present application and utilization in development programs. Future expansion of the capabilities of current cask designs and examples of new developments in dry storage casks are also discussed.

INTRODUCTION

Transnuclear, Inc. has been at the forefront of dry, spent fuel cask technology in the U.S. since the development of the TN-8 and TN-9 overweight truck transport casks in the mid-1970's. Internationally, Transnucleaire, S.A., pioneered dry cask systems development and operation more than two decades ago. Today, the Transnuclear Group operates a large number of high payload, rail and marine casks for the dry transport of spent fuel.

This dry transport cask experience provides the basis for the development of Transnuclear's spent fuel storage cask systems. The modular nature of thick-walled, metal storage casks allows utilities to use an incremental approach for increasing at-reactor storage capacity of spent fuel. With the added capability of serving as the ultimate transport packaging for stored spent fuel, metal casks offer utilities an attractive alternative to other methods of increasing on-site spent fuel storage.

This paper presents Transnuclear's dry storage technology from the perspectives of its past, present and future. It looks briefly at the historical transport cask designs that have led to Transnuclear's storage cask systems which are now playing a major role in the Department of Energy's (DOE) storage cask development programs. After reviewing today's storage cask systems, the paper also discusses future development efforts for current generation storage casks and examines possible directions for new generations of storage casks.

PAST: TECHNOLOGY BASIS FOR DRY STORAGE

While long term storage of spent fuel in large metal casks is a relatively recent development, dry transport in such casks has been Transnuclear's business for over 20 years. Some of this transport experience by the Transnuclear Group has led to situations in which these large transport casks have provided "de facto" interim storage for spent fuel over extended periods. For example, in transporting spent fuel from Japan to the reprocessing facilities at La Hague in the TN-12 casks (12 PWR assemblies), there can be 3-6 months of spent fuel storage in the casks, including the transport time by ship and the time that the TN-12's spend on the receiving pad before unloading at La Hague. This represents a significant fraction of the fuel's discharge lifetime. The Transnuclear Group has obviously benefitted from the data collected from these spent fuel shipments which involve not only the transport but the storage of medium-sized quantities of spent fuel. This experience with these large dry transport cask designs has formed the technology base for Transnuclear's storage cask development.

These transport cask designs have a long history. Starting with the TN-2 in 1966, Transnucleaire, S.A. pioneered the use of dry transport of spent fuel, the only method now being used in the U.S. Over the last decade, the Transnuclear Group has developed a family of high payload, dry casks for the transport of spent fuel from light water reactors to storage facilities or reprocessing centers. These transport casks are designed for rail and marine transport, and have payloads in excess of Transnuclear, Inc.'s TN-8/9 family of dry truck casks (3 PWR, 7 BWR assemblies). Many of these casks are presently being used for shipments within Europe and between Japan and Europe. These casks, called the TN-12 series, consist of four models: the TN-12/1, TN-12/2, TN-13/2 and TN-17/2. The design of these casks has been presented in earlier papers and will not be repeated here. However, the capacity of these casks is typically 12 PWR or 32 BWR assemblies with variations in cask dimensions resulting from the size, burnup, and heat rate of the design basis fuel. There are more than 60 of the TN-12 series of casks now in operation throughout the world. Within a few years there will be approximately 100 in operation.

Key design features of the TN-12 series of cask systems that have proven successful for transport conditions and that have direct applicability in storage cask designs include:

- forged, carbon steel cask body for both structural strength and gamma shielding;
- solid, borated resin for neutron shielding;
- double O-ring cask sealing systems with interspace test connections;
- methods for efficient heat transfer from the fuel assemblies to the cask outer body;
- operationally proven ancillary equipment.

With this fundamental experience and technology as a base, Transnuclear has been able to address the utilities' need for dry spent fuel storage systems.

PRESENT: CURRENT DRY STORAGE CASK DESIGNS

In the early 1980's, Transnuclear began development of a standard dry storage cask design, recognizing that government inaction in the areas of spent fuel reprocessing and disposal would mean that at-reactor storage in wet pools would become seriously strained in the near future. By the end of 1983, a preliminary design of the TN-24 was essentially complete.

The TN-24 is a logical extension of the cask designs described earlier. The main purpose of the TN-24 is to provide economical, long-term storage of spent fuel at the plant site. To fulfill that purpose, the payload had to be significantly better than earlier transport cask designs. Thus, the TN-24 has been designed for a capacity 24 intact PWR assemblies, with twice this capacity for consolidated fuel. The innovation of the TN-24 comes from the effective combination of a number of demonstrated approaches in a new and expanded application.

The TN-24 utilizes the same basic design principles as the TN-12 series and provides the primary spent fuel containment module in an Independent Spent Fuel Storage Installation (ISFSI). The cask can be stored in a vertical or horizontal position in the open or in a suitable building. Table I provides the general design requirements for the TN-24. A Topical Report on the TN-24 design is currently under review by the NRC for approval for use at facilities licensed under 10CFR72.

In 1985, Virginia Power purchased a prototype of the TN-24 which had already been fabricated and was available as a result of a joint development program between Transnucleaire, S.A., and Kobe Steel Limited. This TN-24 prototype cask was delivered to Idaho National Engineering Laboratory (INEL) in October of 1985 as part of Virginia Power's program with DOE for dry storage cask demonstrations.

TABLE I

TN-24 General Design Requirements

1. Design Life	20 years
2. Maximum weight on the crane hook	100 U.S. tons
3. Capacity	24 PWR or 52 BWR assemblies
4. Maximum fuel assembly weight	1500 lbs.
5. Fuel paramaters	
a. Nominal burnup	35,000 MWD/MTU
b. Enrichment	3.7%
c. Decay time	5 years
d. Maximum heat generation	24 kw, total
6. Effective multiplication factor	keff $\leq$0.95
7. Maximum fuel clad temperature	375°C
8. Internal cask atmosphere	Inert gas
9. Ambient temperature	-30F to 116F
10. Solar heat load	1475 BTU/ft^2
11. Maximum dose at cask surface	site specific to meet 10CFR72
12. Handling/Storage orientation	Horizontal or vertical

In February 1984, Transnuclear signed a contract with Nuclear Fuel Services, Inc. to design, certify, fabricate and deliver two transportable storage casks. These casks are to be used by DOE for long term storage of 85 Big Rock Point BWR assemblies and 40 Ginna PWR assemblies at INEL. At the start of this contract, Transnuclear had essentially completed the preliminary design of its TN-24 storage cask. Using this preliminary design as a base, Transnuclear designed two high capacity casks, the TN-BRP and the TN-REG, and incorporated several innovative features which make them unique among storage cask designs.

The TN-BRP is designed to hold 85 Big Rock Point spent fuel assemblies which are an early generation BWR design. The TN-REG is designed for 40 Ginna PWR assemblies. Because the fuel is of low burnup, no neutron specific shield is required for either cask. The fuel has been cooled for at least 12 years and, as a result, has a relatively low heat generation rate. Other than these two factors, the design bases for the TN-BRP and TN-REG were very similar to those of the standard TN-24. The BRP will limit peak fuel clad temperature to 336°C, will have a dry loaded weight of 97.5 tons and will meet all the other 10CFR71 and 72 requirements for transport and storage of spent fuel.

The TN-REG will limit peak fuel clad temperature to 375°C, will have an actual dry loaded weight of 102.5 tons and will also meet all 10CFR71 and 72 requirements.

Table II provides the design requirements for the TN-BRP and TN-REG. Both casks were delivered ahead of schedule in the summer of 1985.

TABLE II

TN-BRP and TN-REG Requirements

1. Design Life	20 years
2. Number of assemblies	TN-BRP: 85 BWR (Big Rock Point) TN-REG: 40 PWR (Ginna)
3. Fuel assembly weight	TN-BRP: 465 lbs. TN-REG: 1271 lbs.
4. Initial enrichment	3.5 W/O U235
5. Maximum fuel clad temperature	375°C (707°F)
6. Ambient temperature	Reg. Guide 7.8
7. Weight of loaded cask,dry	TN-BRP: 100 tons TN-REG: 105 tons
8. Heat load	5 KW
9. Handling/storage orientation	Horizontal or vertical
10. Cavity atmosphere	Inert gas
11. Outer surface	Smooth (no fins)
12. Regulatory requirements	10CFR72 10CFR71

Oak Ridge National Laboratory (ORNL) reviewed the Safety Analysis Reports for Packaging (SARP) for compliance with DOE's transport regulations and recommended to DOE-Idaho that a Certificate of Compliance (COC) be issued. The COC was to be issued in accordance with DOE's February 1984 draft of "Administrative and Technical Procedures for Hazardous Material Packagings".

In August of 1985 the DOE decided to have Transnuclear apply for a Certificate of Compliance from the NRC rather than issue a Certificate under DOE rules as planned. The SARP's were revised to conform to NRC format requirements and submitted to NRC on September 13, 1985 and October 22, 1985 for the TN-BRP and the TN-REG, respectively.

Transnuclear's current dry storage cask technology is directed at addressing specific storage needs rather than trying to force-fit a standard design to every situation. Standardization is important, but so is optimization when it produces both immediate and longer term benefits. This is Transnuclear's approach and it should lead to more interesting developments in dry storage.

FUTURE: DRY STORAGE DIRECTIONS AND DEVELOPMENTS

Over the next several years, dry storage cask development efforts will have two major themes or areas of emphasis. The first emphasis area will be in the expansion of capabilities of current generation storage cask designs. Currently, storage casks are being licensed by NRC for storage of intact spent fuel as part of a 10CFR72 licensed facility. The two areas of possible capabilities expansion for these casks are the storage of consolidated fuel and transport certification under 10CFR71. DOE development programs are focusing on these two areas now and Transnuclear is actively participating in these programs.

In the area of storage of consolidated fuel, it is anticipated that the TN-24 prototype will be loaded with consolidated fuel from Virginia Power's Surry Station sometime in 1987 as part of DOE's dry storage demonstration program. The data from this demonstration will be useful in the certification of the TN-24 and other cask designs for storage of consolidated fuel.

Regarding transport certification of storage casks, Transnuclear is actively pursuing such certification for the TN-BRP and TN-REG. This experience will have direct application to the transport certification of the TN-24, as well. In line with DOE and utility needs, Transnuclear anticipates having storage cask designs certified for storage of both intact and consolidated fuel. Transport certification of intact and consolidated fuel may also be achievable within the next two years.

The other area of emphasis in future dry storage cask development will involve new generations of storage casks that offer innovative approaches to spent fuel storage. Transnuclear has already taken a step in this direction with the TN-BRP and TN-REG designs. However, we are developing even more novel approaches to dry storage. As an example of this, Transnuclear proposed to evaluate a radically new storage cask concept as part of DOE's Program Research and Development Announcement (PRDA) for a Nuclear Waste Packaging and Handling Design Initiative. The storage cask concept is called the Extra Large Storage Cask (XLSC) and grew out of Transnuclear's 1981 concept development of very large transportable spent fuel storage casks to address the at-reactor spent fuel storage needs of the utilities in the late 1980's and beyond. This early development work centered on cask capacities that were limited by the cask weight which could be lifted by the cranes of spent fuel handling facilities at most reactor sites. It was concurrently determined that if cask weight could be decoupled from reactor crane lifting limits, great improvements could be achieved in cask carrying capacity and in the associated storage and transport economics.

In 1984, Transnuclear was awarded a contract by DOE to perform a technical feasibility study of such high capacity XLSC's which are defined as casks that are too large or heavy to be handled by the spent fuel loading cranes at most reactor sites.

The scope of this study included a technical evaluation of and conceptual designs for storage/transport and storage-only XLSC's, each containing either intact assemblies or consolidated fuel rods. For the consolidated fuel case, a conceptual design is presented for a transportable fuel disassembly and rod consolidation hot cell called the Mobile Equipment for Consolidation (MEC). The MEC, located and operated within a utility-provided structure, would consolidate spent fuel into triangular cross-section cans. Triangular cross section storage cans offer 3 major advantages: (i) fuel rods have a natural tendency to assume a close-packed arrangement when placed in a triangular can; (ii) the XLSC for such cans does not require a basket since the cans can be loaded into the cask in an hexagonal close-packed arrangement and are self-supporting; (iii) heat transfer characteristics with triangular cans loaded in such an arrangement are greatly improved when compared with those of cask-with-basket designs.

With the XLSC's independence of reactor site limitations comes the need to establish different methods to get spent fuel into (and out of) the XLSC. These methods must interface with the XLSC, the MEC (if desired) and the reactor site. Therefore, these new fuel transfer systems must be able to meet reactor site handling limitations.

To accomplish spent fuel transfer on the reactor site, smaller casks and ancillary equipment, termed support cask systems, were developed. These support cask systems can be used repeatedly at a large number of reactor sites (i.e., each reactor site does not require its own dedicated support cask system). Several general concepts for transferring intact fuel were developed.

In 1985, Transnuclear completed the study with the conclusion that an order of magnitude increase in storage cask capacities is achievable with the XLSC concept and that these casks also have a very real potential for being transportable. The economics of XLSC's appear to be quite good. Transnuclear intends to pursue further development in this area, as well as in others that involve new materials or new configurations.

A word of caution, however, is necessary regarding future developments in storage cask technology. Dry storage casks offer their greatest economic benefit when they are transportable. Yet, utilities are responsible only for at-reactor storage, and DOE is responsible for transport to the MRS or repository. DOE is independently pursuing the development of new transport cask systems for this purpose. Because of this division of responsibility, the economics of transportable storage casks may be lost in the shuffle of competing interests unless DOE gives utilities monetary credits for such transportable storage casks or continues to fund their development in other ways. Demand obviously drives the development of storage cask technology and failure of these DOE development incentives could retard new storage cask designs.

CONCLUSION

Transnuclear's dry storage technology is founded on two decades of dry, spent fuel transport cask experience. Current storage cask designs are at the forefront of today's technology, and Transnuclear has already begun the process of innovative change to address non-standard situations. For the future, Transnuclear is proceeding down parallel paths, expanding the capabilities of current generation cask designs and conceptualizing the new generation of designs that can advance dry storage technology safely and economically.