CONSIDERATIONS FOR TRANSPORTATION LICENSING OF USED FUEL ALREADY IN INTERIM DRY STORAGE

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ABSTRACT

Currently in the United States of America (USA) used fuel assemblies from commercial nuclear power plants are in interim dry storage at various sites. The typical interim dry storage systems used for these assemblies are either storage casks or canisters stored in storage overpacks. Some of these systems were licensed and have had fuel assemblies in dry storage for a period of more than 20 years. The majority of the systems used for storage are also designed to comply with transportation regulations. However, some of the earlier vintage interim dry storage systems were not designed to be compliant with the requirements of transportation. It is desirable from a safety and economics point of view that these storage systems also be qualified for transportation. This qualification for transportation would eliminate the need to remove and repackage used fuel from these storage containers prior to eventual transportation.

The transportation regulations have several requirements that are different than those for storage. Additionally, transportation regulations have evolved over the time period that the used fuel has been in storage. Design analysis methods and computer codes have undergone significant changes over time. The current accepted practices and regulatory expectations have also evolved and are different than they were when these systems were designed and licensed. Therefore, if a user of these interim dry storage systems desires to have them qualified to meet current transportation regulations, evaluations are required to demonstrate that these systems are compliant with current transportation requirements and regulations.

This paper examines some of the challenges that a user might encounter during these evaluations. The differences in design and analysis methods including computer codes are discussed. Fabrication, testing and inspections requirements during fabrication, loading, operation and maintenance are examined to evaluate the suitability of these interim dry storage systems for transportation. The impacts on the already designed, fabricated and storage licensed containers due to changes in the current practices and regulatory expectations are presented.

INTRODUCTION

The approaches for handling used fuel assemblies in the USA are, for the most part; at the reactor "Site" wet storage and/or dry storage. Both of these storage options are considered as "interim" awaiting eventual recycling or disposal. It appears highly unlikely that site specific recycling will be the long term solution for used fuel in the USA. It is reasonably certain that, at some point, the commercial nuclear used fuel will need to be "Transported". This transportation could conform to any of several scenarios all of which are currently employed at various locations throughout the world.

Site to Site

Site to Central Storage Facility

Site to Recycling Facility

Recycling to Site

Site to Disposal Facility

The Transportation of used fuel from Wet Storage in the USA will be performed in accordance with the appropriate 10CFR Part 71 rules in place at the time of transport. The major challenge becomes the requirements associated with Transportation of used fuel in Dry Storage. There are close to 50,000 used fuel assemblies in Dry Storage today in the USA and the number is growing rapidly.

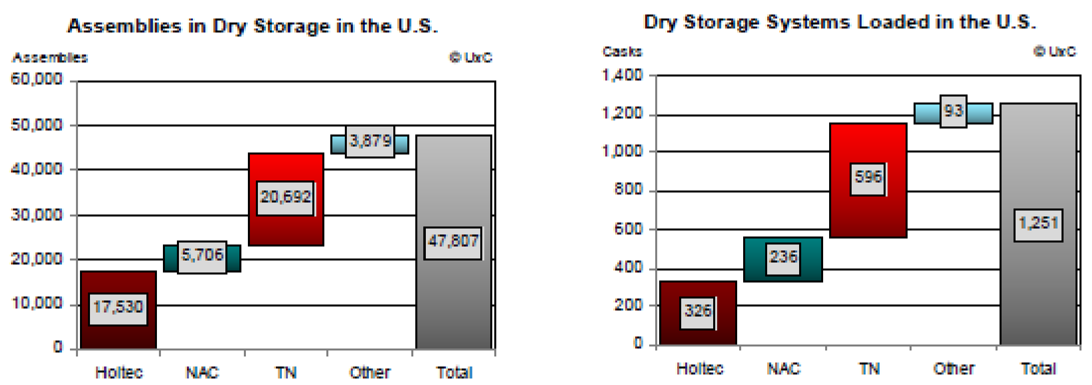

Figure 1. Summary of Dry Fuel Storage in the USA as of May 2010 (taken from StoreFUEL May 4, 2010)

Transnuclear, Inc. (TN) belonging to the Logistics Business Unit of AREVA currently has used fuel storage systems installed at 31 sites in the USA.

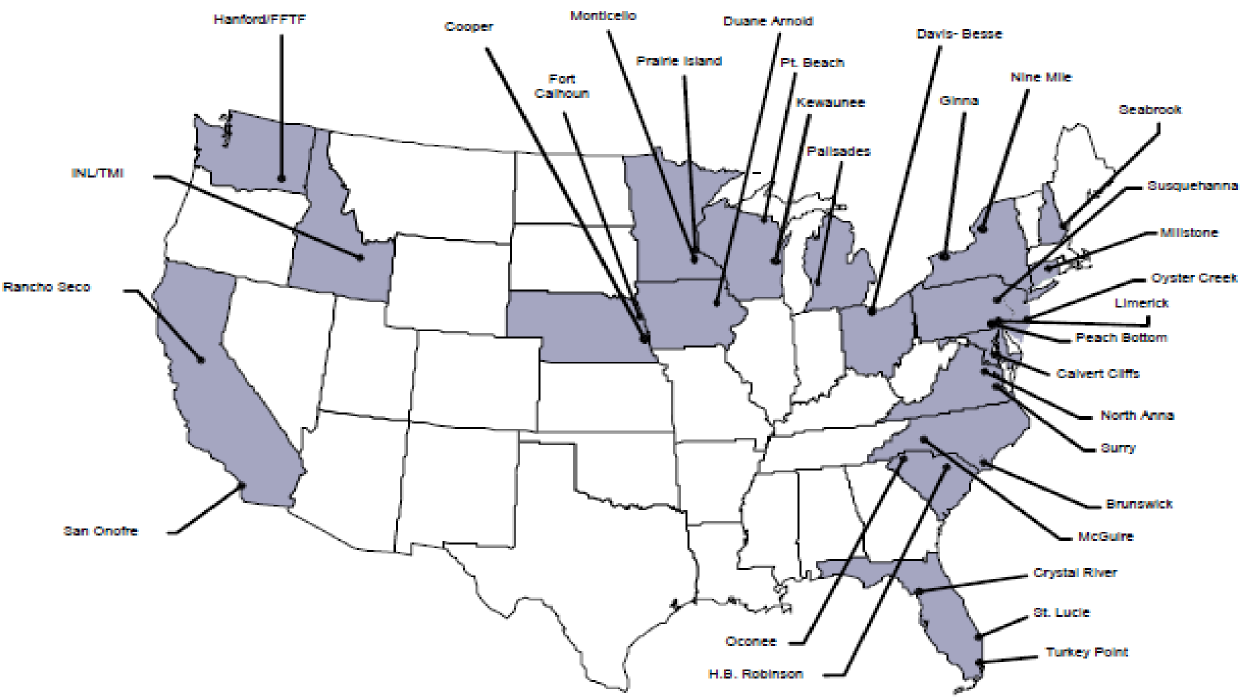

Figure 2 Transnuclear Used Fuel Storage Sites in the USA

The Dry Storage systems vary, but in general, are of the form of an independent metal cask as a storage overpack or a storage canister within some concrete overpack. Some of these used fuel dry storage systems have been in use for more than 20 years and will continue to be used for perhaps another 40 years or even longer. Typical TN dry storage systems are shown in the Figure 3.

Figure 3 Representative Used Fuel Storage – NUHOMS® & TN Metal Casks

Dry storage of used fuel began in the 1980s and the storage requirements have evolved over the years along with increase in base of knowledge due to experience gained, changes in the burnups, enrichment of used fuel assemblies, political climate, regulatory climate and the evolution of analytical techniques due to advances in computers. Since the late 1990s into the 2000s most dry fuel storage systems are qualified for both 10CFR Part 72 storage and 10 CFR Part 71 transportation regulations at the time of storage licensing.

CURRENT SITUATION

The overall evolution of applicable requirements affects all aspects of Transportation including design, licensing, fabrication, loading and the "in-storage" configuration. The effect is more pronounced for the earlier casks and canisters as they were, in general, designed for storage only with limited transportation considered in the design using the concept that the cask would be taken back to the pool and repackaged for transport at a later date. As mentioned previously, it appears that in a number of cases, the interim storage duration will exceed the useful life of the Nuclear Power Plant and there may be no fuel pool available for repackaging. This condition already exists at several decommissioned sites in the USA.

Transnuclear is currently relicensing to 2010 transportation requirements a group of metal casks that were designed, licensed, fabricated, loaded and are currently in-storage. The original storage license for these casks was approved in 1993. This effort has surfaced a number of potential impacts on the ability to transport systems licensed for storage only. Some of the more pronounced impacts for the relicensing effort are highlighted in the following discussion.

DESIGN AND LICENSING CONSIDERATIONS

Cask Drop Analysis

The biggest impacts in the design and licensing areas are associated with the postulated transportation Cask Drop. The current approach is to perform a droptest or perform analysis using current computer codes which have been subjected to extensive test vs analysis correlation. The analytical models used can be quite extensive and the number of drop cases is significant. This is required since it is impractical to perform drop testing on the older storage only systems.

Fuel Drop Analysis

Coupled with the drop analysis is the very conservative approach for the analysis of fuel rod integrity during the drop. In the USA approaches have been developed that account for all of the gaps between the fuel, the container, the cask and the impact limiters. Due to availability of limited data on the fuel cladding material properties after irradiation of the actual fuel, no structural credit is assumed for the fuel pellets. This is an extremely conservative approach. This approach challenges the storage designs that were not originally evaluated to this conservative criteria or subjected to the postulated transportation drop loading.

Fuel Cladding Material Properties

A third significant impact for re-licensing is associated with the fuel cladding material properties being used for high burn-up fuel. A conservative approach is being taken to account for the limited data and to address the potential for hydride re-orientation in the irradiated cladding material.

Computer Codes

Computer codes and analysis capabilities have significantly evolved over the past 20 years. The computer models have become more detailed including multi-dimensions, gaps, more detailed resolution of stress states, better representation of fluid flow, etc. Previously, hand calculations, static-elastic analysis, 1 and 2 dimensional models, simplistic natural convection correlations formed the basis of qualification for both storage and transportation system designs. The current methods required in each of the evaluation areas of shielding, criticality, structural and thermal use full 3-D models along with other changes such as complex modeling, non-linear elastic-plastic evaluations, explicit dynamic computer analysis and complex computation fluid dynamic codes. The included figure provides a good demonstration of the evolution of modeling detail requirements for the same component.

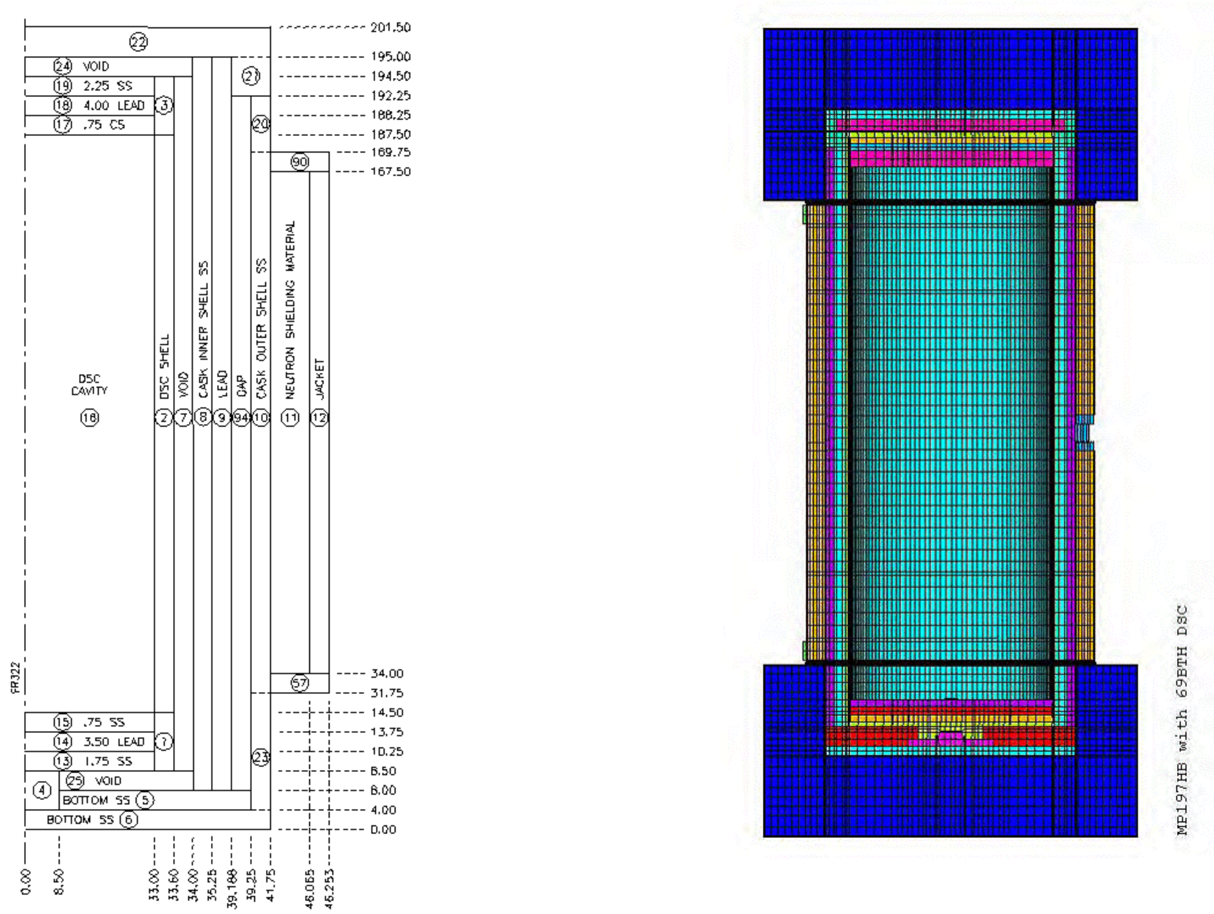

FIGURE 4 Thermal Model Comparison

FABRICATION CONSIDERATIONS

One key evolution in the USA concerns leak testing of the containment boundary as part of fabrication to satisfy an optional requirement in 10CFR Part 71. While this type of testing requirement is able to be performed during the actual fabrication, this is essentially impossible to implement this requirement on in-storage casks prior to shipment. Additional fabrication testing that was not required for storage but is currently required for all new transportation casks is shielding material integrity, stricter qualification of neutron absorber materials and thermal testing of each copy to verify gaps and thermal performance.

LOADED AND IN-STORAGE CONSIDERATION

One of the key impacts associated with loading and in-storage conditions is the verification of fuel assembly parameters. For the fuel currently stored, some of the information now required for transportation has not been previously collected and there may be difficulties with record availability if all of the current parameters are to be verified. Some of the parameters currently requiring verification are fuel assembly burn-up, fuel assembly geometry and individual fuel assembly irradiation history.

CONCLUSIONS

It is recognized that the industry has naturally moved toward storage and transportation of payloads with increases in:

- Capacity
- Heat load
- Source term
- Burn-up
- Enrichment

With these changes in payload comes the evolution of requirements to better quantify and demonstrate margin in design to assure safety. However, Transnuclear believes that significant consideration should be give to the fact that the original storage only and storage with transportation systems already loaded contain payloads that are not subjected to these increases which challenge the current design. The existing licensing requirements and approaches should be evaluated against a graded set of requirements that still maintain adequate margins to safety consistent with the currently loaded payload. Transnuclear addressed all of these design and licensing considerations during the licensing process for obtaining a transportation license to a currently storage only system.