A Complete NUHOMS® Solution for Storage and Transport of High Burnup Spent Fuel

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1.0 INTRODUCTION

The discharge burnups of spent fuel from nuclear power plants keep increasing with plants discharging or planning to discharge fuel with burnups in excess of 60,000 MWD/MTU. Due to limited capacity of spent fuel pools, transfer of older cooler spent fuel from fuel pool to dry storage, and very limited options for transport of spent fuel, there is a critical need for dry storage of high burnup, higher heat load spent fuel so that plants could maintain their full core offload reserve capability. A typical NUHOMS® solution for dry spent fuel storage is shown in the Figure 1.

Transnuclear, Inc. offers two advanced NUHOMS® solutions for the storage and transportation of high burnup fuel. One includes the NUHOMS® 24PTH system for plants with 90.7 Metric Ton (MT) crane capacity; the other offers the higher capacity NUHOMS® 32PTH system for higher crane capacity. These systems include NUHOMS®-24PTH and -32PTH Transportable Canisters stored in a concrete storage overpack (HSM-H). These canisters are designed to meet all the requirements of both storage and transport regulations. They are designed to be transported off-site either directly from the spent fuel pool or from the storage overpack in a suitable transport cask.

The payload includes PWR fuel assemblies with an assembly average burnup of 62,000 MWD/MTU, 5.0 wt% U235 enrichment and 3 years minimum cooling time. The total heat load at the time of storage is 40.8 kW and 34.8 kW for the -24PTH and -32PTH system respectively. These two NUHOMS® systems by Transnuclear offer the industry a complete solution for storage and transportation of high burnup fuel.

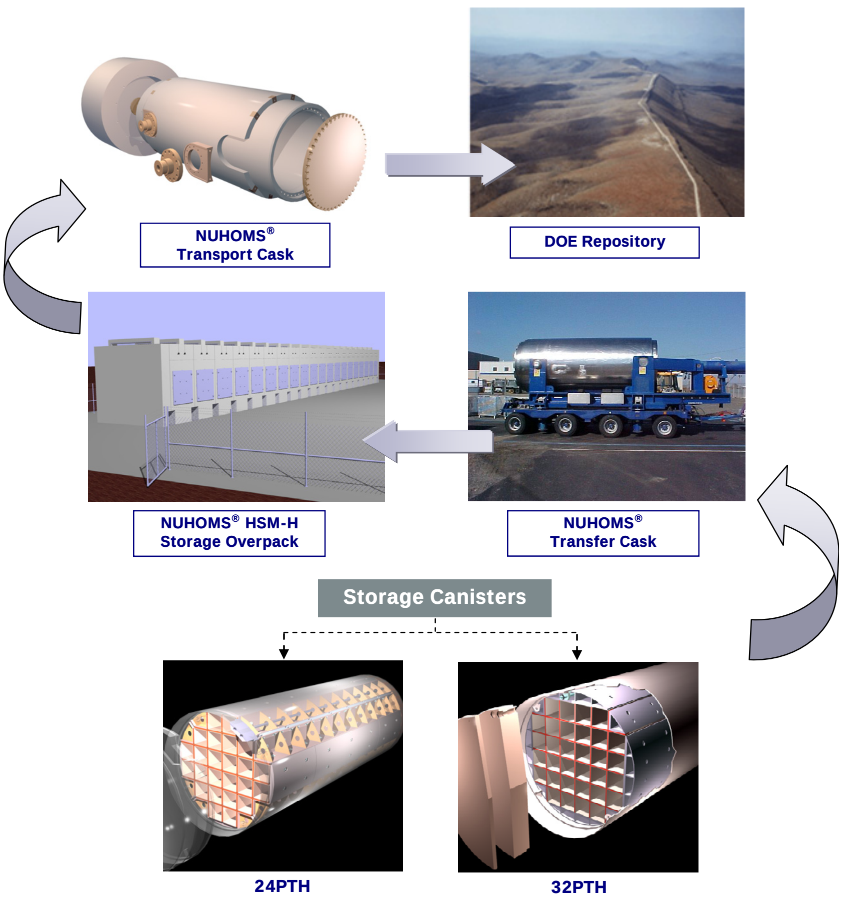

Figure 1: Typical NUHOMS® Solution for Dry Spent Fuel Storage

2.0 NUHOMS® 24PTH CANISTER

The NUHOMS®-24PTH Canister shown in Figure 2 is the latest high decay heat Transportable NUHOMS® Dry Shielded Canister. This canister is optimized for heat while maintaining the full shielding capability of the transfer cask and remaining under 90.7 MT. This canister is made from a stainless steel outer shell, carbon steel top and bottom shield plugs, and two top cover plates. This canister incorporates the same closure weld design as over 200 other safely loaded NUHOMS® canisters.

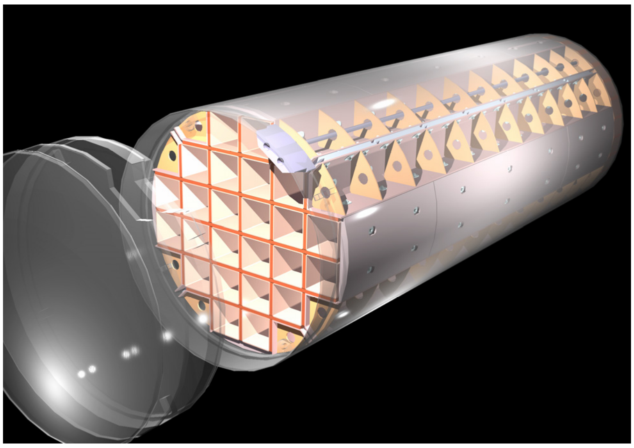

Figure 2: NUHOMS® 24PTH Canister

The NUHOMS® 24PTH Canister incorporates an innovative "egg crate" basket design. The design benefits from the experience gained on several generations of NUHOMS® canisters as well as the TN metal cask product line. This egg crate basket configuration is currently used in our licensed, built and loaded TN68 metal cask line. The basket consists of uninterrupted aluminum heat conducting paths. The slotted aluminum plates are assembled together into a simple "egg crate" configuration, speeding fabrication as shown in Figure 3 . The assembled aluminum crates are stacked axially. The stack is restrained by integral stainless steel bands, which are fusion welded to the stainless steel fuel compartments. The high quality controlled fusion weld process minimizes distortion. The space between the inside diameter of the canister shell and the fuel compartment grid assembly is bridged by "transition rails," which are made from stainless steel and solid aluminum sections connected to the fuel compartment structure. The fuel compartment plates transfer the spent fuel loads to the canister shell, via the transition rails. The transition rails distribute the mechanical loads from the fuel compartment grid to the canister shell, and also provide a thermal conduction path for heat transfer from the basket to the shell, making it efficient in rejecting heat from its payload.

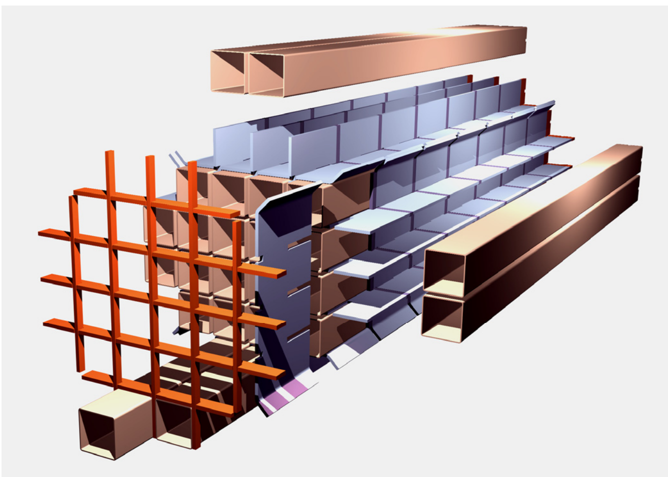

Figure 3: NUHOMS® 24PTH Egg Crate Basket Design

3.0 NUHOMS® 32PTH CANISTER

The NUHOMS® 32PTH Canister shown in Figure 4 is another new generation high heat canister design that offers users the capability to store high burnup short cooled fuel in a high capacity package. While this design is optimized for use in plants with higher crane capacity, this canister can also be used with a light-weight transfer cask to remain under 90.7 MT.

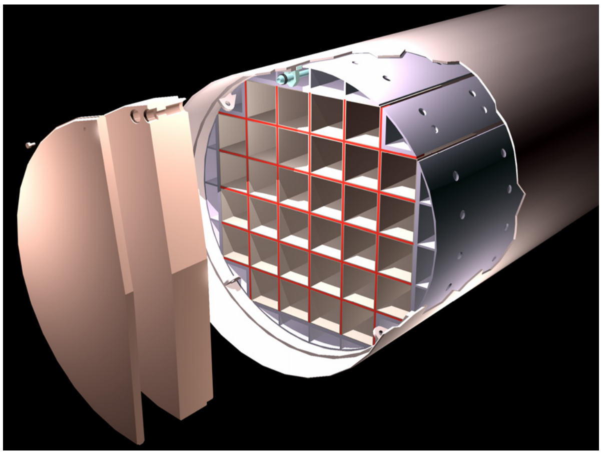

Figure 4: NUHOMS® 32PTH Canister

The 32PTH Canister incorporates a 76.2 mm larger canister diameter than the standard NUHOMS® canisters such as the NUHOMS® 24PTH. The basket geometry is similar to the egg crate basket geometry of the NUHOMS® 24PTH Canister.

This canister incorporates the same closure weld design as the 24PTH canister.

4.0 THE NUHOMS® STORAGE OVERPACK: Horizontal Storage Module (HSM)

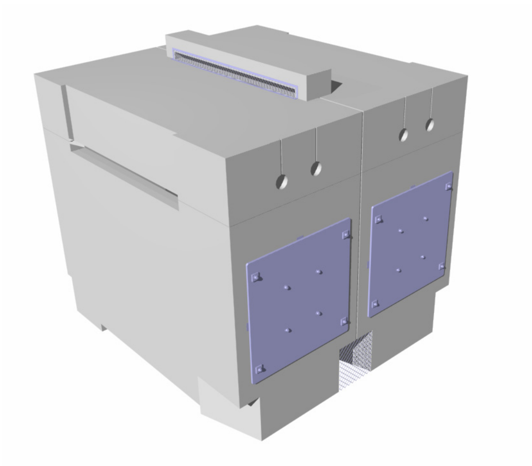

Figure 5: NUHOMS® HSM-H

Of all the important design features of the NUHOMS® System, the one that sets it apart from any other dry storage system offered in the industry is the design of the concrete storage overpack and the method of transferring the canister into and out of the storage overpack.

The HSM Model H (HSM-H) shown in Figure 5, is a new and upgraded design of the standard HSM, currently deployed at a number of Independent Spent Fuel Storage Installation (ISFSI) sites around the country. The Model H offers significant heat rejection capabilities and enhanced shielding performance. These features make the Model H design ideal for dry storage of high burnup fuel.

The patented design of the HSM allows the canister to be transferred and stored without performing a single critical lift at the ISFSI during initial loading or later when unloading to transport to a DOE operating repository. The plants with NUHOMS® System deployed will not require a single failure proof crane at the ISFSI or a cask transfer facility at any stage in these plant's life cycle to unload the modules. Not even after the plants are decommissioned and the existing fuel building cranes are gone. This is an important economic advantage when considering the life cycle cost of dry storage.

The NUHOMS® HSM offers the industry the highest shielding performance of any other system offered in the industry. It accomplishes such performance by surrounding the canister with massive concrete walls and by close packing the modules at the ISFSI allowing adjacent units to shield one another. The fact that NUHOMS® modules are not handled during loading operations allows the system to improve shielding without increasing the weight handled during operations. Therefore, the system weight during transfer operations does not pose a challenge to any of the plant structures or haul routes. Plants implementing dry storage are often faced with severe challenges in attempting to place or move massive components that sometimes weigh well over 181.4 MT on building floors or plant haul routes. The cost associated with reinforcing such structures can be significant. Such challenges and costs are completely avoided with the NUHOMS® system resulting in a lower life cycle cost in implementing dry storage.

A typical HSM-H layout is shown in Figure 6. The highly compact array with back-to-back modules produces the smallest footprint of any system in the industry. The close packing of modules also produces the highest shielding performance and will produce far lower doses than any system offered today. This is a critical advantage for the plants that strictly have high burnup short cooled fuel with significant source terms.

The HSM design uses passive ventilation for the removal of spent fuel decay heat from the canister. The storage module ventilation system has a heat removal capacity of 40.8 kilowatts per canister, and is qualified for extreme ambient temperatures ranging from -40°C to 47.2°C. The top vents are also provided with vent caps, which provide increased shielding.

Each module includes hard-faced steel support rails that allow the horizontal sliding insertion and retrieval of the canister. The canister transfer operations of this new generation NUHOMS® system is similar to what has been used in the operation of over 200 NUHOMS® Canisters loaded. A reinforced concrete pad with a minimum thickness of 457.2 mm is required to adequately support the HSMs. The loaded HSMs do not need to be lifted or moved during loading operations.

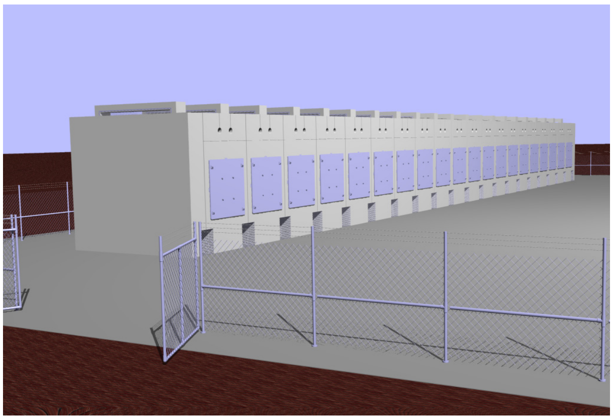

Figure 6: Rendered View of a NUHOMS® ISFSI

The HSMs are prefabricated off-site at a qualified concrete fabrication facility. Each module is constructed out of two segments, a base unit and a roof slab, which are delivered separately and installed at the ISFSI. By fabricating these components off-site, the NUHOMS® System minimizes the impact to plant operations and security. Each NUHOMS® HSM can be fully erected and completed in approximately one day, using a crane and a 5-man crew.

Although the NUHOMS® System is completely passive during operation, the storage CoC 72-1004 requires a daily visual surveillance at the ISFSI of the air inlet and outlet vents or daily thermal monitoring of the concrete temperature. Visual surveillance can be performed manually or using video surveillance equipment. NUHOMS® System does not require continuous monitoring.

5.0 TRANSFER CASK OPTIONS

5.1 Option 1: NUHOMS® OS197 Transfer Cask

This is the cask used by most of the NUHOMS® systems currently in operation. It is capable of transferring both PWR and BWR canisters. It is designed to interface with the standard NUHOMS® canister with up to 1,702 mm outside diameter. The NUHOMS® OS197 transfer cask is made primarily of stainless steel and incorporates gamma and neutron shielding materials. The exterior shell has a highly polished surface finish to facilitate decontamination. The transfer cask has a 5,004 mm long cavity, which allows it to be used for both PWR and BWR canisters. The transfer cask is constructed from two concentric cylindrical steel shells with a bolted top cover plate and a welded bottom end assembly, as shown in Figure 7. The annulus formed by these two shells is filled with cast lead to provide gamma shielding. The transfer cask also includes an outer stainless steel jacket, which is filled with water for neutron shielding. The top and bottom end assemblies incorporate a solid neutron shield material. The transfer cask is designed to provide sufficient shielding to ensure that dose rates are ALARA.

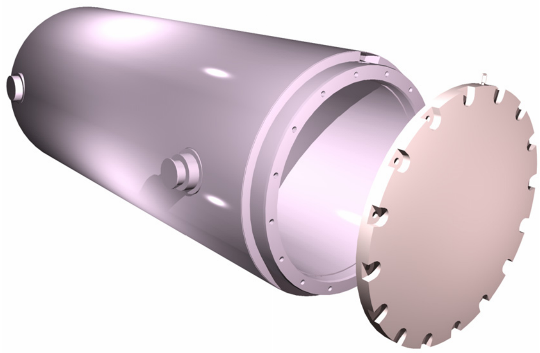

Figure 7: NUHOMS® OS197 Transfer Cask

The shell materials are resistant to corrosion and are not susceptible to galvanic reactions. The NUHOMS® Transfer Cask has been used successfully in PWR and BWR spent fuel pools and has never exhibited an adverse interaction with the spent fuel pool water.

The empty canister is inserted in the transfer cask cavity and the canister/transfer cask is placed vertically in the spent fuel pool. The spent fuel assemblies are loaded in the canister and the canister/cask is then moved from the spent fuel pool to cask handling area. There the canister is drained, dried, and the top cover plates are welded.

The loaded canister and the transfer cask is then moved horizontally from the fuel building to the ISFSI on the transfer skid and transfer trailer, as shown in Figure 8. The canister is then transferred from the transfer cask to the HSM-H for storage.

Figure 8: NUHOMS® OS197 Transfer Cask en Route to ISFSI

5.2 Option 2: OS187-H Transfer Cask

The major differences between this cask and the standard OS197 Transfer Cask is the larger outside and inside diameters which allow it to transfer all the different canister options. This cask is specifically designed to allow the use of the heavier 32PTH canisters without sacrificing any shielding capabilities.

The shielding materials used in the design of this transfer cask are the same as that of the OS197 Transfer cask. The transfer equipments and the transfer operations are also similar to the OS197 transfer cask.

6.0 TRANSPORTATION CASK OPTION

TN is hopeful that with more progress in the DOE repository work, the transportation of high burnup fuel and the effective use of burnup credit and moderator exclusion will be adequately addressed by regulations to allow the industry to effectively deal with transportation of high burnup spent fuel from ISFSI sites to the repository.

6.1 NUHOMS® MP197 Transportation Cask

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. Both are used to secure the top closure lid to the cask body and the ram access closure plate to the bottom of the cask. The body of the cask consists of a 31.8 mm thick, 1,727 mm inside diameter stainless steel inner (containment) shell and a 63.5 mm thick, 2,082.8 mm outside diameter stainless steel structural shell which sandwich the 82.6 mm thick cast lead shielding material. 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 overall external dimensions of the cask are 5,283 mm long and 2,324 mm outer diameter. The weight of the cask body, including the lid and lid bolts, is approximately 67,585 kg , including 4,536 kg of neutron shield material and roughly 27,216 kg of cast lead. The containment boundary consists of a cylindrical shell, bottom end closure plate with a ram access penetration, top end forging ring, bottom and top lids with associated seals and bolts.

There are four trunnion sockets on the cask: two front trunnion sockets, and two rear trunnion sockets. They accommodate removable trunnions for handling, lifting, and rotating of the cask. These trunnion sockets are attached to the structural shell. Two sets of trunnions are provided for the NUHOMS® MP197 transport package lifting. One set of trunnions has double shoulders (non-single failure proof). The other set of trunnions has a single shoulder (single failure proof). Only one set of trunnions will be used depending on site and transfer operation requirements. The trunnions are fabricated and tested in accordance with ANSI N14.6. During transport, four trunnion plugs, containing neutron shielding material, will be bolted to the four trunnion sockets.

When the cask is in the horizontal position, a shear key receptacle on the bottom of the cask reacts the longitudinal tiedown loads. The shear key receptacle is welded to the structural shell and protrudes through the neutron shield. During transport the receptacle interfaces with the shear block attached to the transport skid.

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 an outside diameter of 3,099 mm and a height of 1,543 mm as shown in Figure 9. The inner and outer shells are Type 304 stainless steel joined by radial gussets of the same material. The gussets limit the stresses in the 6.35 mm thick stainless steel outer cylinder and end plates due to pressure differentials caused by elevation and temperature changes during normal transport, and provide wood confinement during impact. 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 NUHOMS® MP197 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.

The MP197 transportation cask is designed to transport loaded canister either directly from the spent fuel pool or from the storage overpack depending upon the heat load in the canister. This unique feature allows the canisters to be transported directly from the storage overpack to the repository without performing a single critical lift at the

ISFSI. When transporting a loaded canister from the HSM-H to the repository, the transport cask will back up to the HSM-H and extract the canister in exactly the same manner of inserting the canister in the HSM-H for storage.

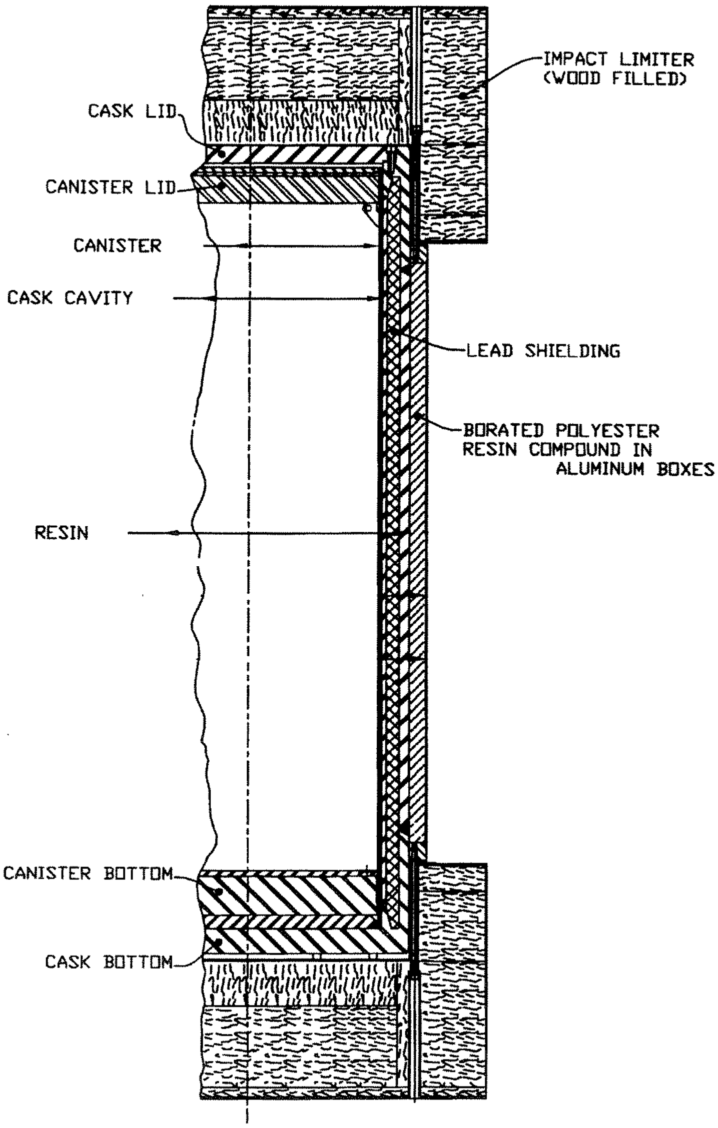

Figure 9: MP197 Transportation Cask

6.2 MP197-H Transportation Cask

The major difference between this cask and the MP197 transportation cask is the larger outside and inside diameters which allow it to transfer all the different canister options. This transportation cask design is currently underway which will allow this cask to be used with a larger diameter canister similar to 32PTH canister. The materials of construction are similar between this cask design and the MP197 transportation cask. The impact limiter design is also based on the impact limiter used for the MP197 transportation cask.

7.0 SUMMARY

The NUHOMS® 24PTH and 32PTH canisters, NUHOMS® HSM-H storage overpack, NUHOMS® OS197 and OS187-H transfer casks, and NUHOMS® MP197 and MP197-H transportation casks offer industry a complete solution for the storage and transportation of high burnup spent fuel.