ADVANCED NUHOMS® SYSTEM
Solution For Spent Fuel Storage At High Seismic Activity ISFSI Sites

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ABSTRACT

The standard NUHOMS® System licensed under Certificate of Compliance (CoC) 72-1004, stores PWR and BWR spent fuel assemblies in sealed canisters within concrete horizontal storage modules (HSMs) at seven U. S. sites. The Advanced NUHOMS® System consists of an advanced HSM (AHSM), NUHOMS® 24PT transportable canister, and NUHOMS® on-site transfer and off-site transport casks. This paper describes the design of the Advanced NUHOMS® System.

Sites with high seismic spectra and/or requirements for a significant reduction in site-boundary dose are well suited to the AHSM design. The Advanced NUHOMS® System seismic criteria use the standard response spectrum shape in NRC Regulatory Guide 1.60 anchored at 1.50g ZPA for the horizontal direction. The vertical design spectra are set at two-thirds of the horizontal direction over the entire frequency range. At an Interim Spent Fuel Storage Installation (ISFSI), AHSMs are arranged in arrays to minimize space and maximize self-shielding. Keys and ties between adjacent AHSMs provide maximum resistance to extreme environmental conditions including high seismic loads. The NUHOMS® 24PT canister is laterally and longitudinally restrained within the AHSM to prevent movement during seismic events. AHSM arrays are fully expandable to permit modular expansion of an ISFSI in support of an operating plant's storage needs.

The NUHOMS® -24PT canister is a modification of the existing NUHOMS® 24P transportable canister design with additional provisions for storage and transport of intact and damaged fuel assemblies along with control components in the same canister.

The existing NUHOMS® OS-197 transfer cask is used to transfer the 24PT canisters to the AHSMs. The Advanced NUHOMS® System uses the existing NUHOMS® MP187 or the new NUHOMS® MP197 transport cask for transport of 24PT canisters off-site.

INTRODUCTION

NUHOMS® storage systems have been in operation for more than 15 years. Over 140 NUHOMS® storage systems have been successfully loaded with spent fuel assemblies from PWR and BWR reactors. A number of power plants needing to store spent fuel on-site have severe restrictions with regard to earthquake levels, shielding requirements, and space available for an ISFSI. Transnuclear has designed and is currently in the process of obtaining a new general license for storage (CoC 72-1029) and amending its existing transportation license (CoC 71-9255) to include the Advanced NUHOMS® system that can be operated under these severe restrictions. Additionally, the Advanced NUHOMS® System design takes advantage of lessons learned from previous Transnuclear designs and is completely compatible with the proven operational features of the licensed NUHOMS® system storage and transport equipment.

The Advanced NUHOMS® System is designed to meet the requirements of 10CFR71[1] and 10CFR72 [2]. The system is designed to operate in high seismic areas while providing the most compact ISFSI footprint with the lowest dose rates in the U.S. spent fuel storage industry.

DESIGN DESCRIPTION

The Advanced NUHOMS® System provides for the horizontal, dry storage of canisterized spent fuel assemblies in concrete overpacks. The storage system components consist of a reinforced concrete AHSM and a stainless steel NUHOMS® 24PT Dry Shielded Canister (DSC) confinement vessel that stores up to 24 spent fuel assemblies. In addition, the Advanced NUHOMS® System also utilizes the existing NUHOMS® transfer system to move the DSCs from the plant's fuel/reactor building, where they are loaded with spent fuel assemblies and readied for storage, to the ISFSI AHSMs where they are stored. This transfer system consists of a transfer cask, a lifting yoke, hydraulic ram system, a transfer trailer and tractor, a cask support skid, and skid positioning system.

Of all the important design features of the Advanced NUHOMS® System, the two that are unique in the industry are the method of transferring the canister into and out of the overpack and the design of the overpack itself. The typical NUHOMS® HSM (overpack) design already provides a compact ISFSI footprint, stability under seismic loads, and the highest shielding performance compared to any other system offered in the industry. The AHSM design significantly improves system performance in each of these areas. A description of the operational features of the Advanced NUHOMS® System, presented later in this paper, demonstrates that the Advanced NUHOMS® System operation is completely compatible with that used to load the more than 140 NUHOMS® Systems already installed.

Design Features

The Advanced NUHOMS® DSC and AHSM are shown in Figure 1. The AHSM design is based on the patented design of the Standard NUHOMS® HSM. The AHSM is a reinforced concrete structure designed to shield and support the DSC while providing passive heat removal during storage. The AHSM consists of two main prefabricated segments: a base storage segment where the DSC is stored and a top (roof) shield block segment. Ambient air enters the AHSM through the inlet vent in the front of the base segment, circulates around the DSC, and exits through the outlet vent at the top of the AHSM. The AHSM is designed to protect the DSC from extreme environmental and geological conditions including tornadoes, earthquakes, and floods.

The AHSM design uses passive natural convection heat transfer for removal of spent fuel decay heat from the canister. The AHSM ventilation system has a heat removal capacity of 24 kilowatts per canister, and is qualified using bounding thermal analyses for extreme ambient temperatures ranging from –40°F to 117°F. Each AHSM has a stainless steel heat shield installed on the inside of the AHSM to minimize the temperatures in the AHSM concrete.

Each AHSM includes hard-faced steel support rails that allow the horizontal sliding insertion and retrieval of the canister. Stop plates are installed on the support rails at the rear of the AHSM and seismic restraints are provided at the front end of the AHSM. The canister transfer operations at existing ISFSIs have been highly successful in demonstrating the safety and simplicity of the horizontal sliding transfer technology patented by Transnuclear.

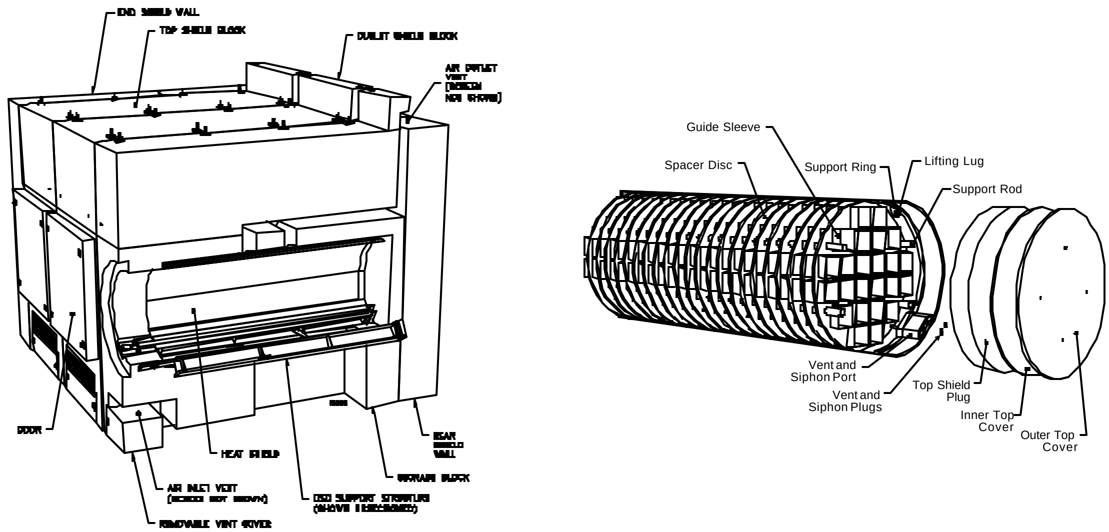

Figure 1 Advanced NUHOMS® AHSM And 24PT DSC

Each AHSM is 19 feet 7 inches long, 8 feet 5 inches wide, 20 feet 7 inches high. The nominal thickness of the AHSM roof is five feet for maintaining dose rates as low as reasonably achievable (ALARA). Separate shield walls at the end of an AHSM array, in conjunction with the AHSM wall, provide a minimum thickness of four feet for maintaining dose rates ALARA. Similarly, an additional shield wall is used at the rear of the AHSM if the ISFSI is configured as a single AHSM array. A typical ISFSI layout showing both single and double (back-to-back) AHSM arrays and the associated shielding is shown in Figure 2. The empty weight of the storage AHSM is approximately 320,000 pounds. The weigh of a AHSM with a canister is approximately 400,000 pounds.

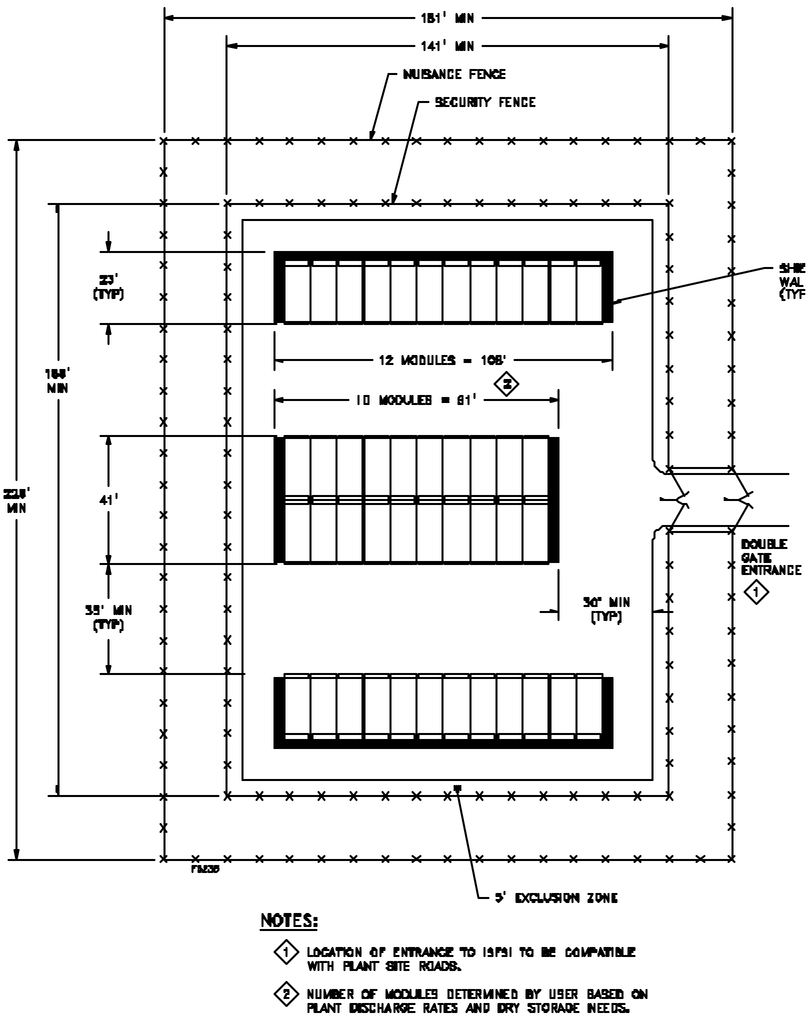

Figure 2 Typical Combined Single and Double AHSM Arrays
Advanced NUHOMS® System ISFSI Layout

Seismic Design Features

Seismic design criteria are dependent on the specific site location of the ISFSI. These criteria are established based on the general requirements stated in 10CFR Part 72.102 [2]. The design earthquake (DE) for the AHSMs must be equivalent or larger than the safe shutdown earthquake (SSE) for a colocated nuclear power plant, the site of which has been evaluated under the criteria of 10CFR Part 100, Appendix A [3].

To provide a system which bounds all high seismic sites in the United States, the design basis response spectra of the Advanced NUHOMS® System design are based on the standard spectrum shape in NRC

Regularoty Guide 1.60 [4] anchored at 1.5g ZPA for the horizontal direction. The vertical design spectrum is set at two-thirds of the horizontal direction over the entire frequency range. The horizontal and vertical spectra are specified at the top of the basemat. The design response spectra are shown in Figures 3 and 4.

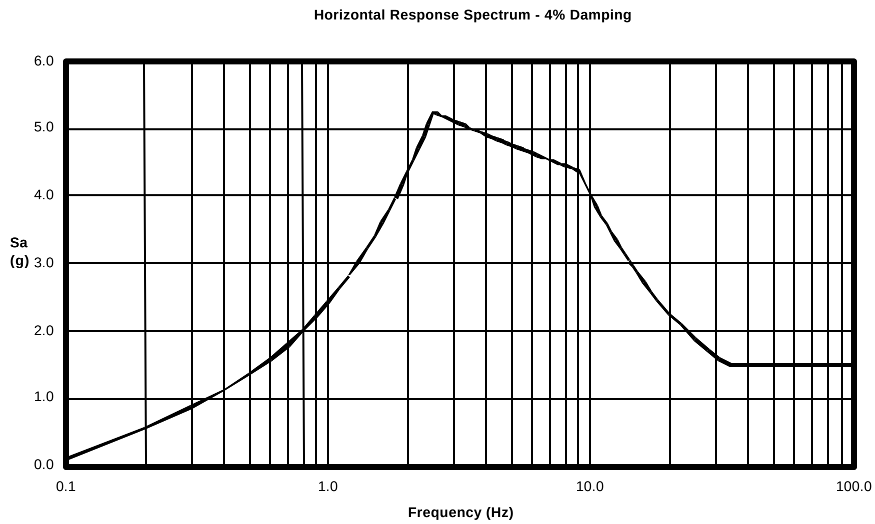

Figure 3 AHSM Base Input Horizontal Response Spectra for 1.5g ZPA

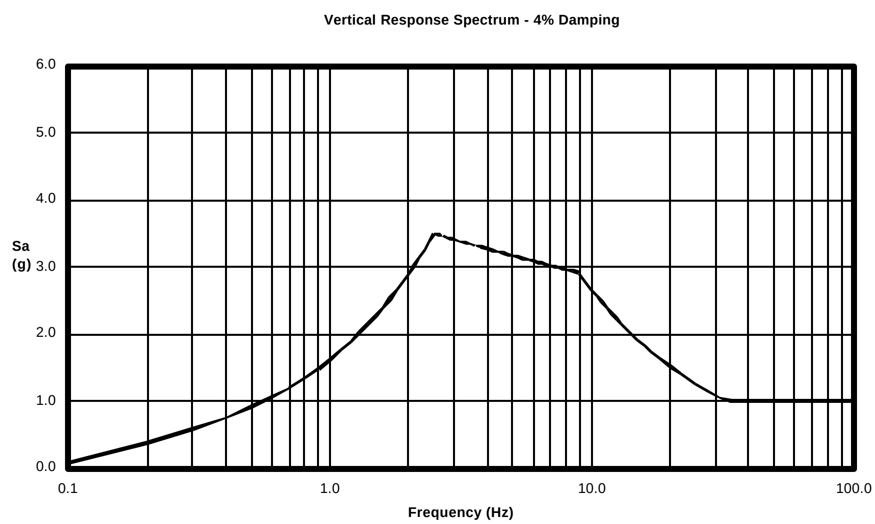

Figure 4 AHSM Base Input Vertical Response Spectra for 1.0g ZPA

The Advanced NUHOMS® System is qualified for these seismic excitations using linear and non-linear analysis methods to determine the maximum seismic responses. Linear elastic methods are used for stress qualification. Non-linear analysis methods are used to determine stability response of the AHSM.

The AHSM array maintains a very low aspect ratio on the ISFSI pad, making the NUHOMS® System the most seismically stable system offered to the industry. A minimum array size of three AHSMs is sufficient to provide adequate stability during a design basis seismic event.

Adjacent AHSMs are tied together using tie beams at the top (roof) units and tie rods at the bottom storage units. These ties prevent out-of-phase tipping and AHSM-to-AHSM separation. Horizontal and vertical keys, located on the interface walls between adjacent AHSMs, restrain relative horizontal sliding (front-to-back) and vertical movement (in-phase tipping) between AHSMs. The restrain system is also designated to accommodate a 5% accidental torsional load due to seismic excitation.

The roof attachment to the base storage unit includes interlocking concrete shear keys in two orthogonal directions. In addition to resisting seismic shear, these keys are designed to handle the shear due to missile impact on the front face of the roof. The roof is attached to the base storage unit in the vertical direction.

Construction Considerations

The AHSMs are prefabricated off-site at a qualified concrete fabrication facility. Each AHSM is constructed in three segments, a base storage unit, a top roof unit, and a AHSM door unit, each delivered separately and installed at the ISFSI. By fabricating these components off-site, the Advanced NUHOMS® System minimizes the impact on the power plant facility. By delivering finished segments, thus not requiring any major construction or concrete placements at the ISFSI, each AHSM can be fully erected and completed in approximately one day. The AHSM base unit weighs approximately 172,000 lbs and the roof unit weighs approximately 134,000 lbs. These segments are transported to the ISFSI by any combination of barge, truck or rail.

Operational Considerations

The patented design of the NUHOMS® HSM allows for the safest and simplest canister transfer operation in the industry. The canister is transferred and stored in the HSM without performing a single critical lift at the ISFSI or anywhere outside the protected area. This design eliminates entirely the risk associated with such critical lifts of canisters loaded with spent fuel or the need for a heavy single failure proof crane at the ISFSI.

The simplicity of the Advanced NUHOMS® System basic operational steps is shown in Figure 5. These operational steps have proven to be very efficient and effective in transferring spent fuel to storage. No significant operational problems have occurred during over 140 transfers using the NUHOMS® System.

Retrieval of the NUHOMS® canister from the AHSM for transport is performed following the identical process as loading. The NUHOMS® 24PT canister is a dual-purpose canister and is compatible with the NUHOMS® MP187 Transport Cask. The transport package (MP187 cask containing a 24PT canister) is loaded onto a rail car or truck for transport to the final storage location.

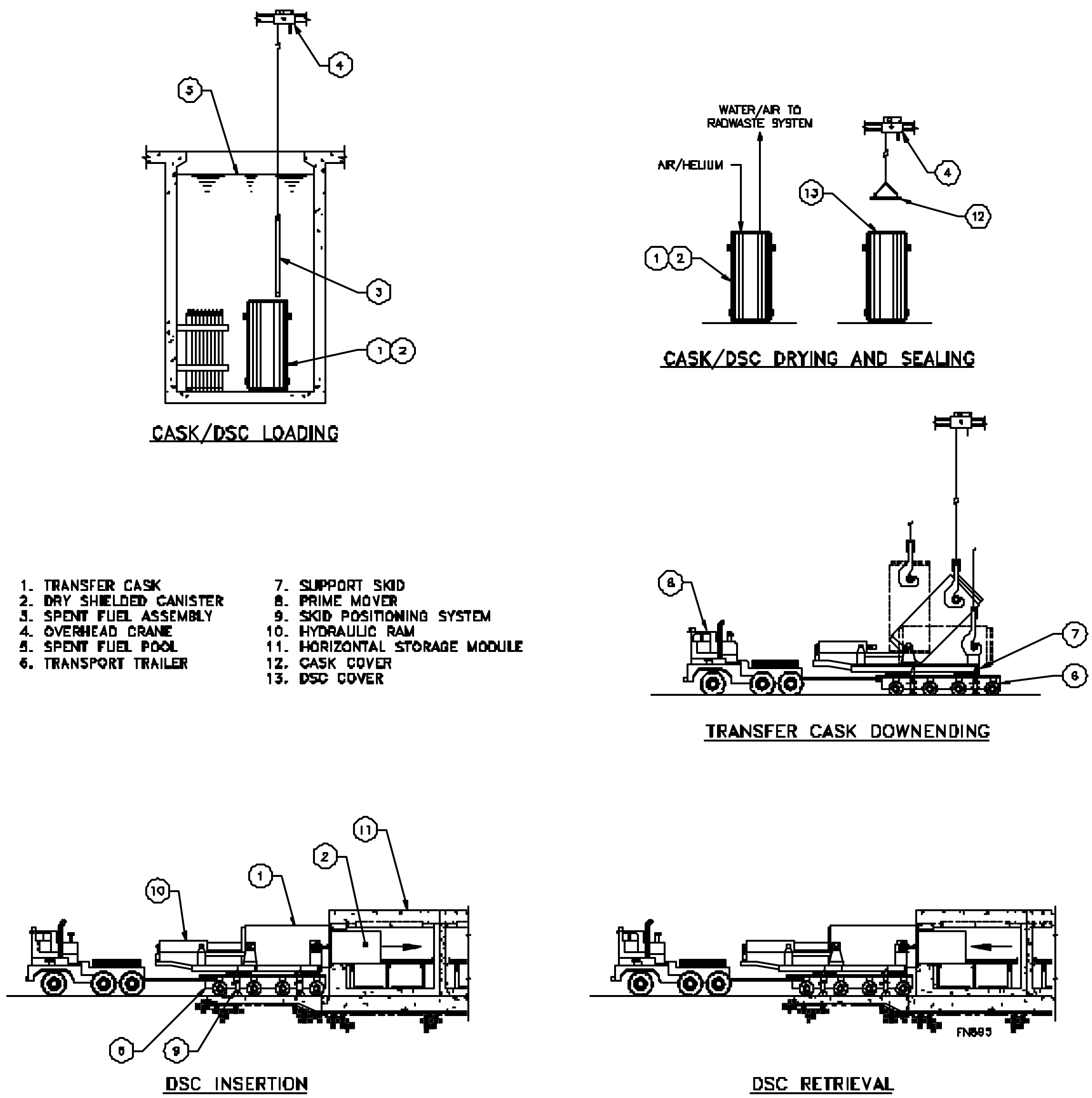

Figure 5 Basic Operational Steps For Horizontal Storage and Transport

LICENSING

Transnuclear has submitted to the NRC an application for a new general license for the Standardized Advanced NUHOMS® Horizontal Modular Storage System For Irradiated Nuclear Fuel. This application was submitted in September 2000 with a NRC scheduled issuance of a preliminary CoC in September 2001. Additionally, a related license amendment application to the Transnuclear transport Certificate of Compliance 71-9255 [6] to add the NUHOMS® 24PT DSC as a payload for the MP187 Transport Cask has been submitted and is currently under review by the NRC. The first use of the Advanced NUHOMS® System will be at the San Onofre Nuclear Generating Station, Unit 1.

CONCLUSIONS

The Advanced NUHOMS® System provides a versatile, cost effect solution to the commercial nuclear power industry to store spent fuel at sites with limited space, very low dose and high seismic requirements. Additionally, the Advanced NUHOMS® System provides for proven operational simplicity and flexibility for effective and efficient use at essentially all commercial power plants. Transnuclear has designed and is currently in the process of obtaining a new general license (72-1029[5]) and amending its existing transportation license (71-9255 [6]) to include the Advanced NUHOMS® System that can be operated under these severe restrictions. The first use of the Advanced NUHOMS® System will be at the San Onofre Nuclear Generating Station, Unit 1.

Transnuclear West Inc., a wholly owned subsidiary of Transnuclear, Inc. with headquarters in Hawthorne, New York, is a member of Cogema's international Transnuclear Group of companies founded by Transnucleaire, SA of Paris, France. The company, which was incorporated in the United States in 1965, and its subsidiaries supply engineering products and services for the transport and storage of radioactive materials.

REFERENCES

1. Title 10, Code of Federal Regulations, Part 71, "Packaging and Transportation of Radioactive

2. Title 10, Code of Federal Regulations, Part 72, "Licensing Requirements for the Storage of Spent Fuel in an Independent Spent Fuel Storage Installation."
3. Title 10, Code of Federal Regulations, Part 100, "Reactor Site Criteria."
4. NRC Regulatory Guide 1.60, "Design Response Spectra for Seismic Design of Nuclear Power

5. TN West, "Standardized Advanced NUHOMS® Horizontal Modular Storage System For Irradiated Nuclear Fuel," ANUH-01.0150, Revision, 0, September 2000, USNRC Docket Number 72-1029.
6. TN West, "Safety Analysis Report for the NUHOMS® MP187 Multi-Purpose Cask," NUH-05-151, Revision 10, September 1998, USNRC Docket Number 71-9255.