DESIGN & OPERATIONAL EXPERIENCE OF THE NUHOMS®-24P SPENT FUEL STORAGE SYSTEM

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ABSTRACT

The NUHOMS®-24P Spent Fuel Storage System began commercial operation at Duke Power's Oconee Nuclear Station in July, 1990. The system was designed and licensed in accordance with requirements of 10 CFR 72. Initial operating experience was gained during the loading of the first few dry shielded canisters in the areas of occupational exposure, task performance times, and storage module shielding performance. Comparisons were made of the Oconee NUHOMS®-24P initial loading results with those from the NUHOMS® demonstration program which was conducted in 1989 at the H. B. Robinson plant.

INTRODUCTION

The NUHOMS® Spent Fuel Storage System provides a safe and economical method for the dry storage of spent fuel assemblies either at an at-reactor Independent Spent Fuel Storage Installation (ISFSI) or at a centralized away-from-reactor (AFR) storage facility. The system consists of three major safety related components: a dry shielded canister (DSC) which provides a high integrity containment boundary and a controlled storage environment for the fuel; a reinforced concrete horizontal storage module (HSM) which houses the stored DSC and provides radiation shielding, protection against natural phenomena, and an efficient means for decay heat removal; and a transfer cask which provides for the safe shielded transfer of the DSC from the plant spent fuel pool to the HSM. The NUHOMS® system is designed and licensed to the requirements of 10 CFR 72 and ANS/ANSI 57.9 for ISFSIs.

The NUHOMS® concept was developed in the early 1980s and it was selected to be part of a cooperative demonstration program amongthe U.S. Department of Energy, the Electric Power Research Institute, Carolina Power and Light, and NUTECH. The design was reviewed by the USNRC and the NUHOMS®-07P Topical Report was approved in March 1986. The demonstration program was conducted at Carolina Power & Light's H.B. Robinson Plant (1). The results of the demonstration, design, and testing program are documented in Refs. 2 and 3.

In 1987, a larger version of the NUHOMS®system was developed and selected by Duke Power for use at their Oconee Nuclear Station near Seneca, South Carolina. The NUHOMS®-24P system has also been chosen by Baltimore Gas & Electric for use at their Calvert Cliffs Nuclear Plant in early 1992. A NUHOMS®-24P Topical Report was approved by the USNRC in April 1989 and the Oconee Site License was issued to Duke Power by the USNRC in January 1990. After preoperational testing, fuel loading commenced at Oconee in July 1990. Four NUHOMS®-24P canisters were loaded by the end of 1990 with additional canisters to be loaded in future years. Presented in this paper are the design features of the NUHOMS®-24P system together with a summary of the initial operational experience gained at Oconee.

SYSTEM DESCRIPTION

The major components of the NUHOMS® system are shown in Fig. 1. The individual components and their functions are described below.

Dry Shielded Canister (DSC) - The dry shielded canister (Fig. 2) is a cylindrical stainless steel pressure retaining component which contains an internal basket assembly to maintain the spent fuel assemblies in a safe geometry during loading, transfer, storage, and postulated cask drop events. The dimensions of the NUHOMS®-24P DSC are shown in Table I. The canister is equipped with shielded end plugs which maintain low contact radiological dose rates to facilitate DSC sealing operations. The canister also provides for the confinement of an inert environment of helium during storage to prevent long term fuel oxidation.

TABLE I

NUHOMS® Dry Shielded Canister Design Characteristics

Length	4.72 m (186.0 in.)
Diameter	1.71 m (67.25 in.)
Wall Thickness	16 mm (0.625 in.)
Capacity	24 PWR
	52 PWR (w/channels)
Weight (max.)	36,290 Kg (80,000 lbs.)

The DSC is designed for optimum structural performance, criticality control, and decay heat removal capacity. The NRC approved criticality design basis relies on credit for dissolved boron in the flooded canister during wet loading and unloading operations, thus eliminating the need for additional neutron absorbing materials.

Horizontal Storage Module (HSM) - The horizontal storage module is a steel reinforced concrete structure (Fig. 3). The HSM may be constructed in-place at the ISFSI location or it may be prefabricated off-site and positioned on a reinforced concrete pad at the ISFSI. The principal

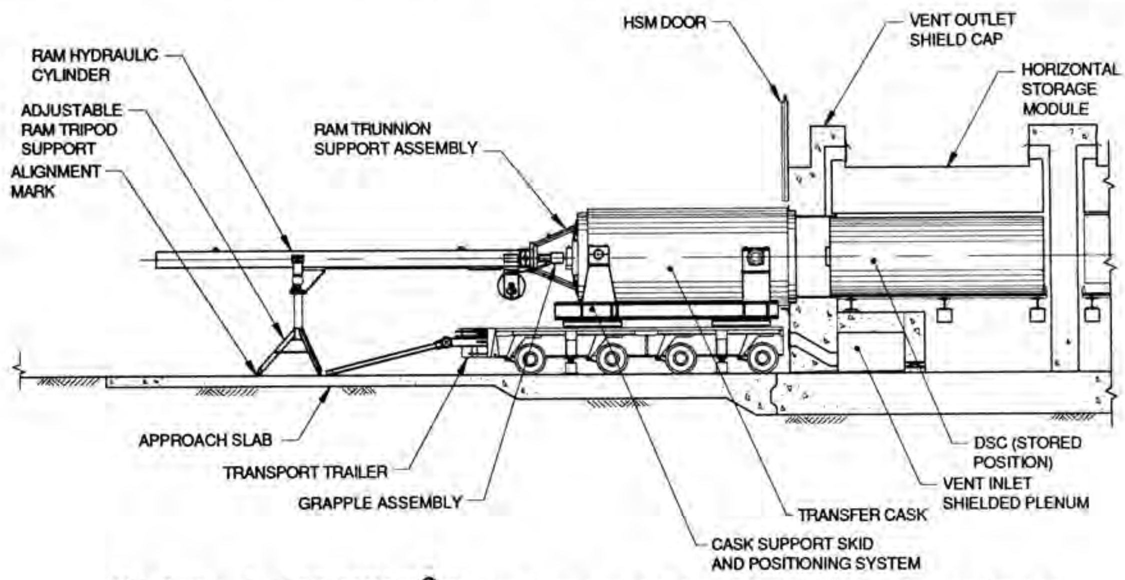


Fig. 1. Standard NUHOMS® System components, structures, and transfer equipment.

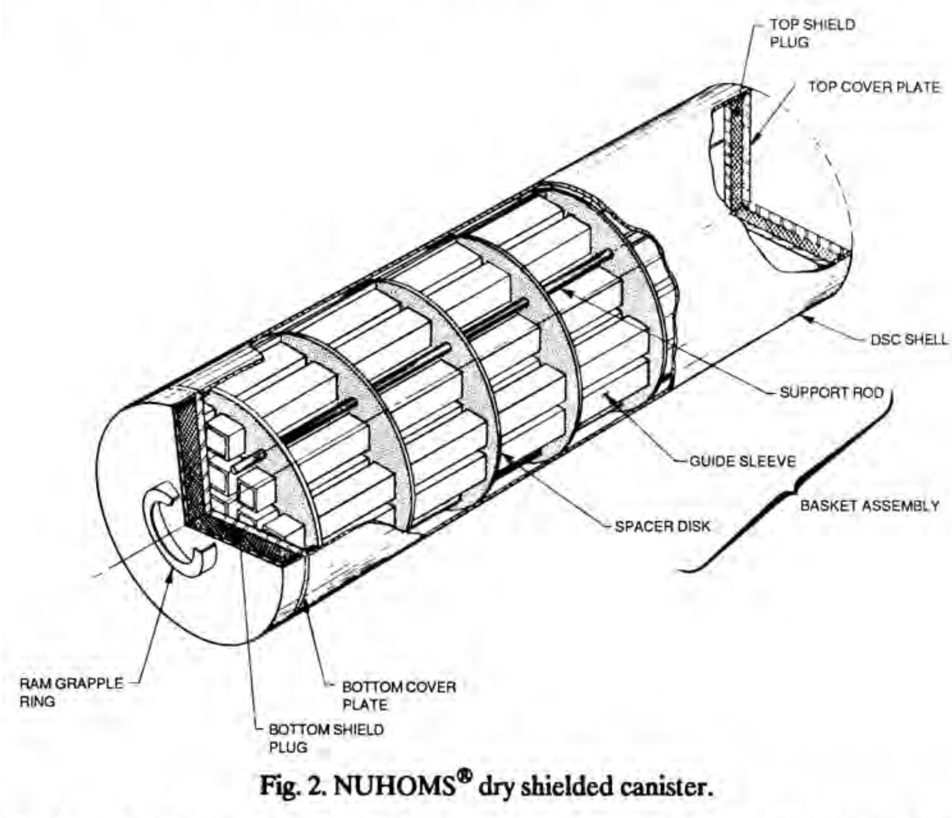


Fig. 2. NUHOMS® dry shielded canister.

design functions of the HSM are to provide radiation shielding for the fuel/DSC during storage and to provide a passive mechanism for the removal of decay heat by natural circulation of ambient air. The massive structure also provides an effective means of protecting the stored canisters from postulated natural phenomena such as earthquakes or tornado missiles. The DSC is supported inside the HSM by a support system of steel rails. Air inlet vents on the lower front of the module and multiple air outlet vents on the roof of the HSM provide for the natural convective removal of decay heat from the spent fuel stored in the DSC.

One DSC is stored in each HSM. A multiple array of various sizes may be constructed to meet the long term storage needs at the site. Life-of-plant storage needs for a twin reactor plant usually require 80-120 modules/canisters. Since the system is totally modular, additional HSMs can be

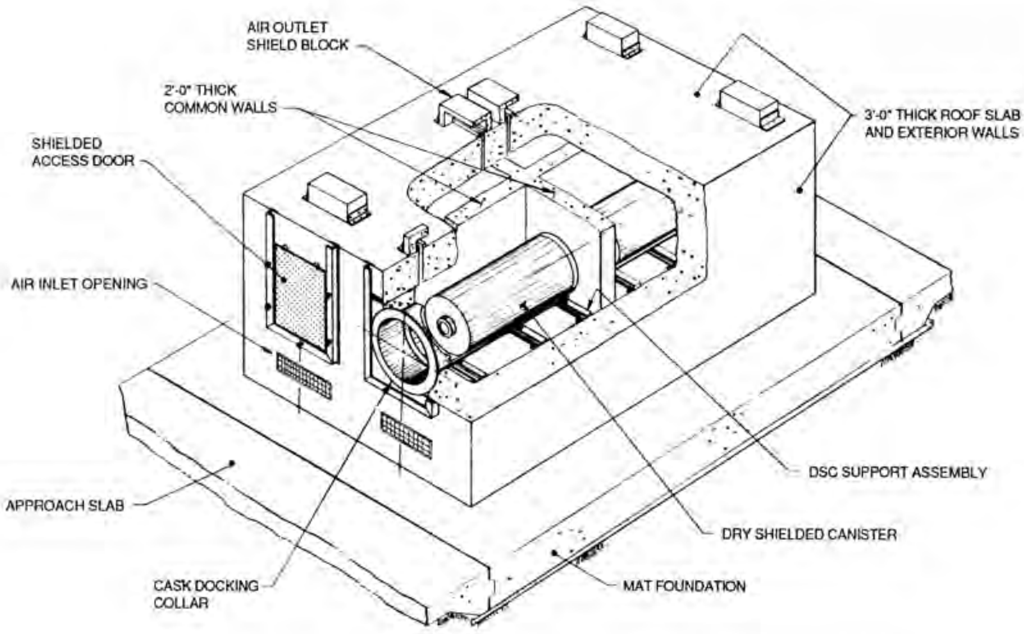


Fig. 3. The NUHOMS® horizontal storage module with stored DSC.

constructed to match the projected additional fuel storage needs.

Transfer Cask - The purpose of the on-site transfer cask is to provide the means to safely transport the DSC from the spent fuel pool building to the HSM. The cask provides the necessary radiological shielding during DSC sealing operations within the fuel building and also during transfer operations. In addition, the cask provides physical protection for the DSC containment boundary for a range of postulated cask drop accidents. The cask provides for the efficient heat transfer of spent fuel decay heat during the sealing and transfer operations.

NUHOMS® OPERATIONS

A schematic of the fuel loading, sealing, transport and storage operations is shown in Fig. 4. The following steps describe the operational features of NUHOMS®.

The DSC is initially placed in the transfer cask, and an inflatable seal is placed in the annular space between the DSC and the transfer cask cavity inner wall to prevent any contaminated pool water from contaminating the exterior of the DSC. The DSC is filled with fuel pool (borated) water and the annulus is filled with demineralized water. Both components are lowered into the spent fuel pool. Twenty-four PWR or fifty-two BWR aged fuel assemblies are loaded into the DSC/cask using the plant fuel handling equipment. The spent fuel design characteristics for the NUHOMS® system are shown in Table II.

TABLE II

NUHOMS® Spent Fuel Design Characteristics

	PWR	BWR
Initial Enrichment (w/o)	4.0	4.0
Burnup (MWD/MtU)	40,000	35,000
Cooling Time (years)	8-10	8-10
Decay Heat (Kw/Assy.)	.66	.30
Decay Heat (Kw/DSC)	16	16

While still submerged, a shielded end plug is lowered into the top of the canister. The loaded DSC/cask is then lifted from the fuel pool to the cask decontamination area in preparation for the DSC draining, drying, and sealing operations. The water levels in the DSC and cask annulus are lowered slightly and the DSC shielded end plug is welded to the DSC wall using remote automatic welding equipment. The remaining water is removed from the DSC through special fittings, and the DSC is subsequently vacuum dried. Following vacuum drying, helium is backfilled into the DSC, the fittings are sealed, and helium leak checks are performed. The DSC top cover plate is then lowered into position and it is welded in place, thus, together with the shield plug weld, forming a redundant weld configuration for the DSC. The cask lid is subsequently bolted in place and the cask/DSC is lowered onto the transfer trailer for the short journey to the horizontal storage modules at the ISFSI location.

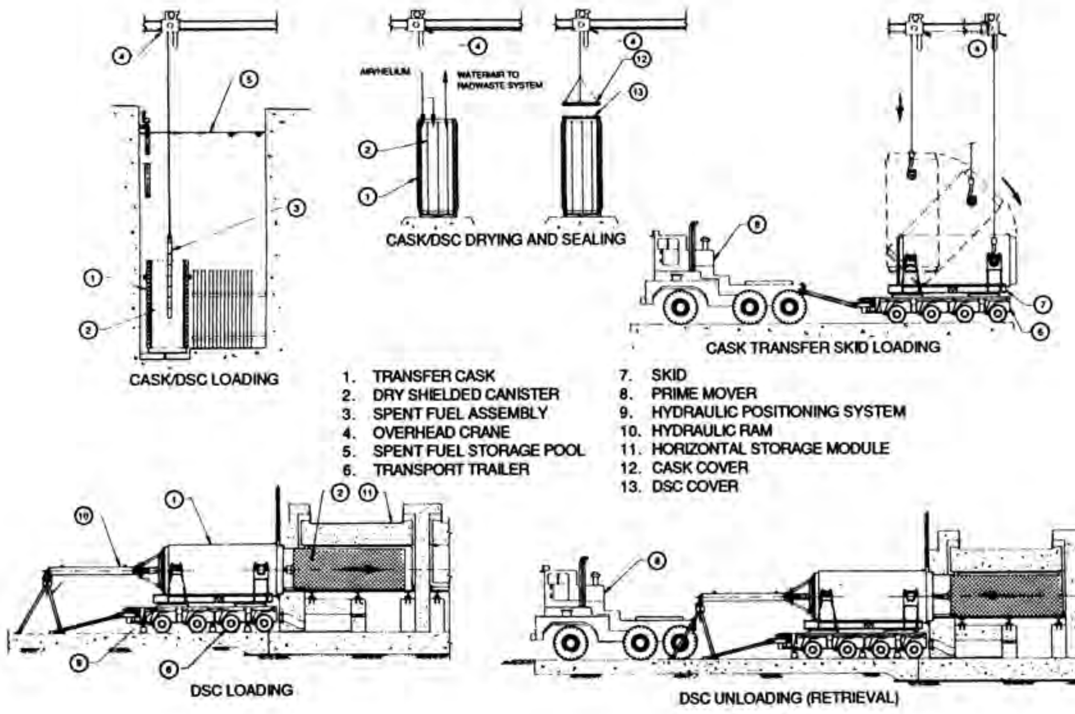


Fig. 4. NUHOMS® system operations.

At the HSM the cask lid is removed and the cask is aligned with the module. A hydraulic ram is used to transfer the DSC horizontally into the HSM. (A ram access port in the bottom of the cask allows the ram to make the transfer). The HSM door is lowered into position and tack welded, thereby completing the transfer operation. If retrieval of the DSC ever becomes necessary, the same operational steps are followed in reverse order.

OCONEE LOADING EXPERIENCE

Duke Power received a 10 CFR 72 site license from the USNRC in January, 1990. The license is valid for the storage of fuel in the NUHOMS®-24P system at Oconee in as many as 88 horizontal storage modules. The system can accommodate life-of-plant storage of spent fuel at Oconee. A picture of the Oconee ISFSI is shown in Fig. 5. Site construction of the ISFSI commenced in late 1988, immediately following the USNRC review and approval of the Environmental Report. Construction of 20 modules (220 MtU) was undertaken in the first phase and the facility was complete in early 1990. Fabrication of the initial canisters was initiated in late 1988 and delivery of the first canister occurred in late 1989 (Fig. 6). Delivery of the transfer cask occurred in February 1990, and following minor repairs of in-transit damage, the NUHOMS® equipment was ready for preoperational testing in May 1990. The preoperational testing included welding qualification testing, DSC transfer operations at the HSMs, and spent fuel pool cask handling operations. The vacuum drying system was also tested.

In late July 1990 fuel loading operations commenced. Twenty-four aged Oconee fuel assemblies were loaded into the first DSC. The entire loading, sealing, and transfer operations lasted for approximately six days. A breakdown of the various task times is shown in Fig. 7. A picture of the loaded transfer cask just prior to DSC transfer at the HSM is shown in Fig. 8. Although the storage capacity of the canister is more than tripled, the task times were similar to the times experienced in the earlier NUHOMS® demonstration program at Carolina Power & Light's H. B. Robinson plant. Occupational exposures for the first three canisters are shown in Fig. 9. A breakdown of the occupational exposure is shown in Fig. 10.

Module dose rates (preliminary) are shown in Fig. 11. Like the NUHOMS® demonstration program at H.B. Robinson, the Oconee module dose rates showed significant margin to the licensed limits.

Duke Power plans to load additional canisters in 1991. Approximately 5 DSCs/year will be loaded in future years.

CURRENT DEVELOPMENTS

The NUHOMS® design was submitted to the NRC in late 1990 for certification under the new General License Rule (Subparts K and L to 10 CFR 72). When approved, a

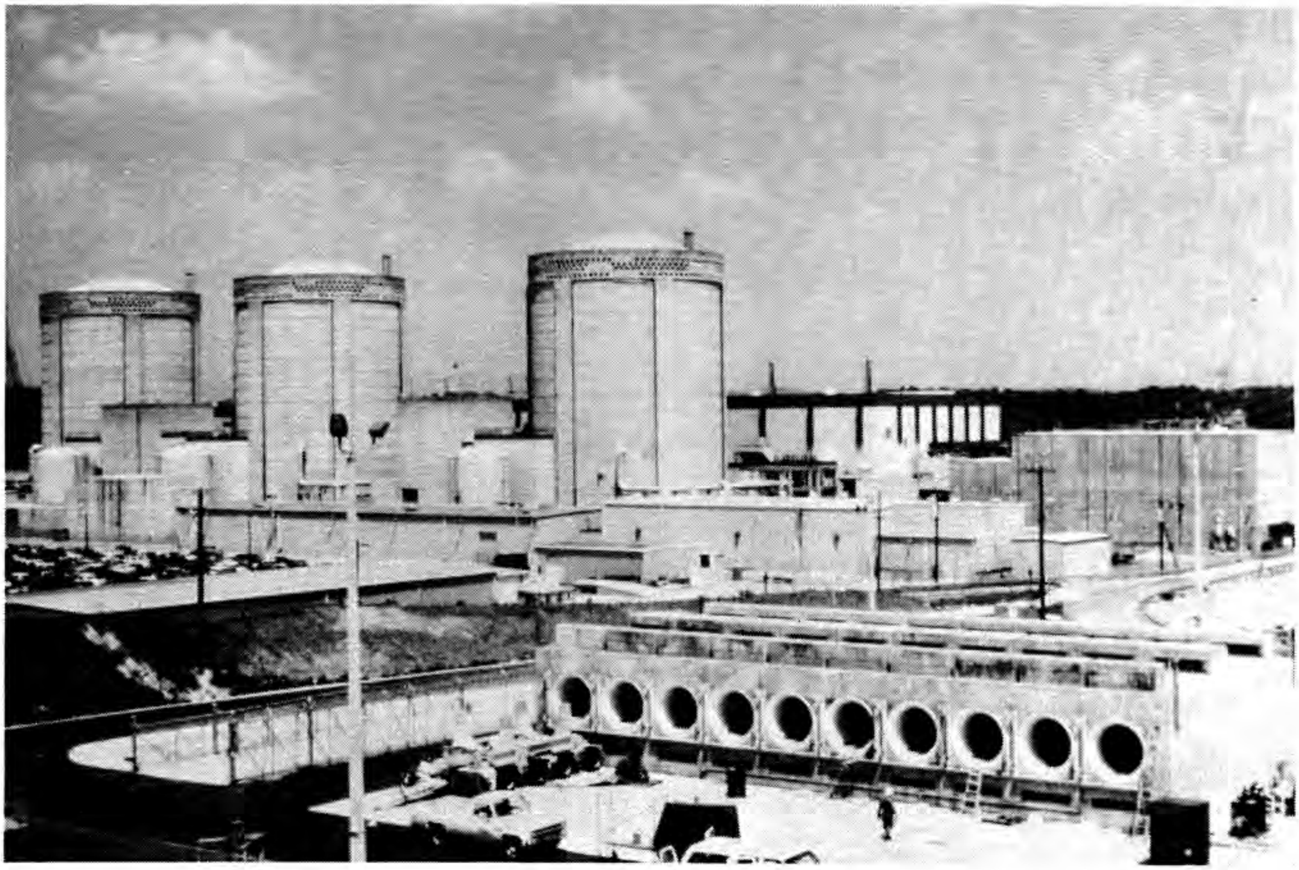


Fig. 5. Duke Oconee NUHOMS®-24P storage installation.

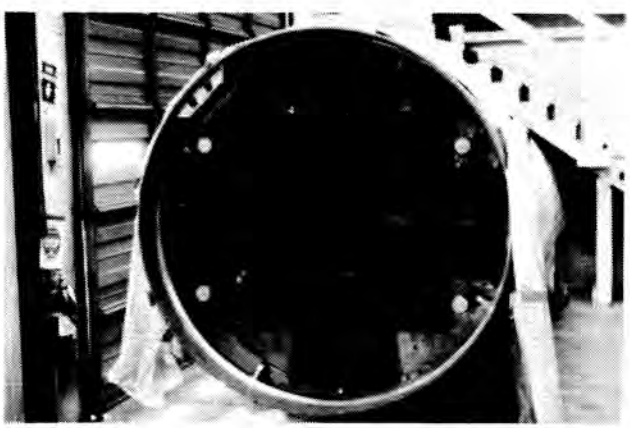


Fig. 6. NUHOMS®-24P dry shielded canister.

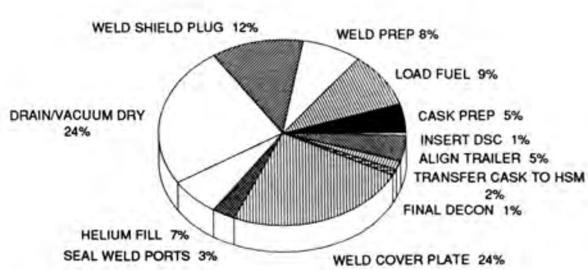


Fig. 7. Typical DSC loading cycle-task times.

specific NUHOMS® site license application is not required, thus streamlining the licensing process for NUHOMS® ISFSIs in the United States.

The NUHOMS® DSC will also be reviewed by the NRC for future transportation (10 CFR 71). When approved, the fuel/DSC may be shipped off-site with a compatible shipping cask directly to either a monitored retrievable storage facility (MRS) or a geologic repository, without returning to the plant spent fuel pool. The direct transfer is desirable to minimize the rehandling of the fuel and its

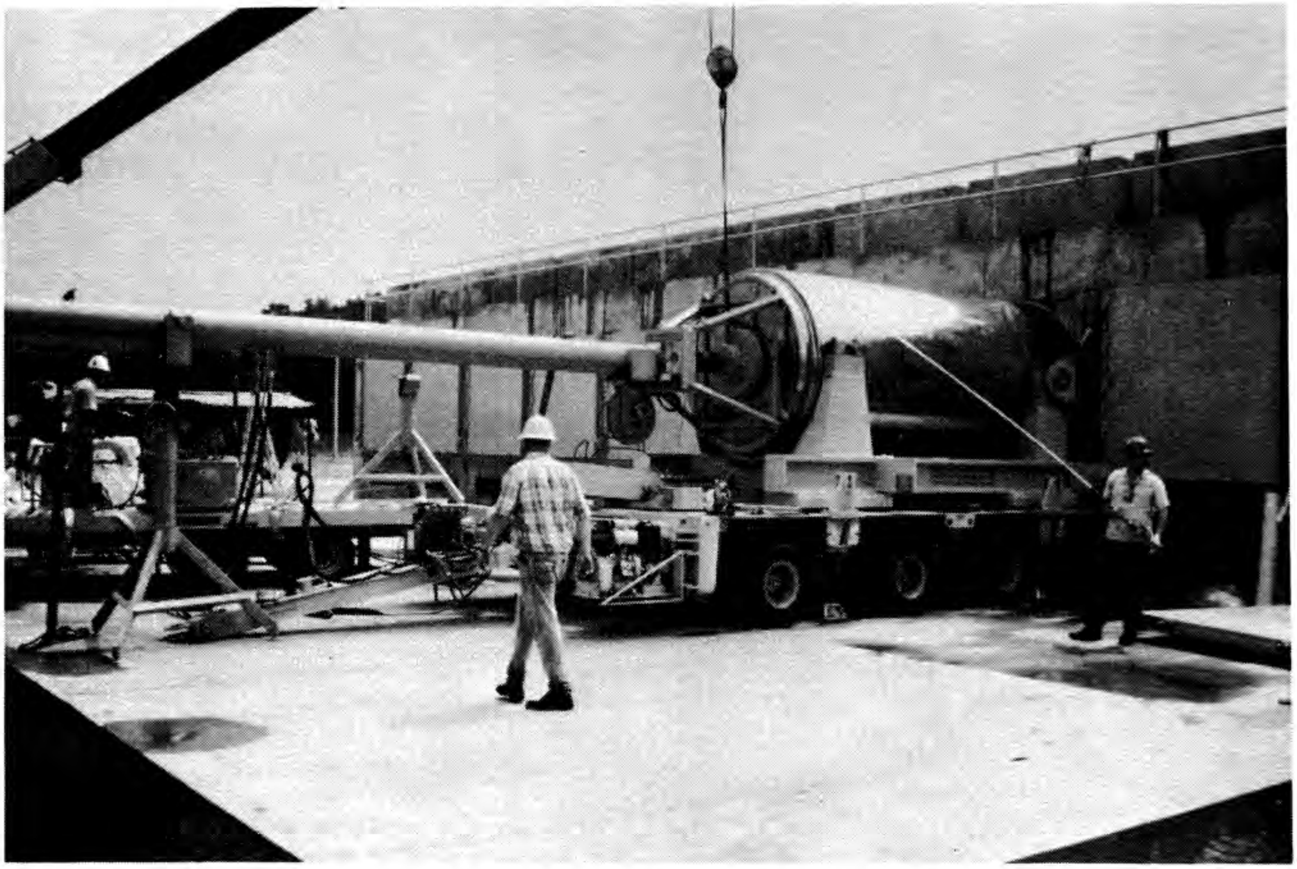


Fig. 8. Transfer cask at HSM just prior to DSC transfer.

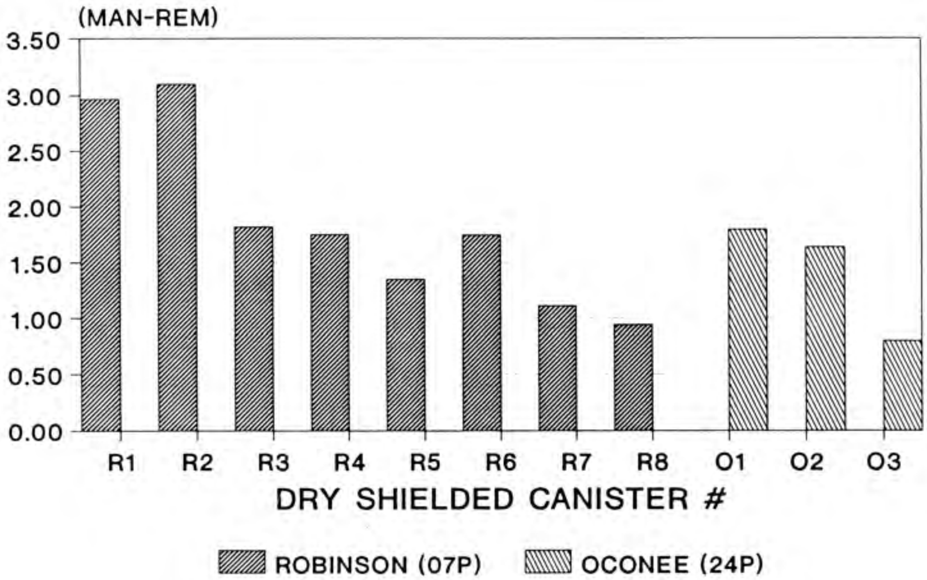


Fig. 9. Occupational Exposure comparison.

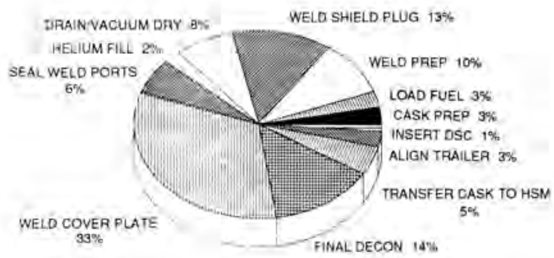
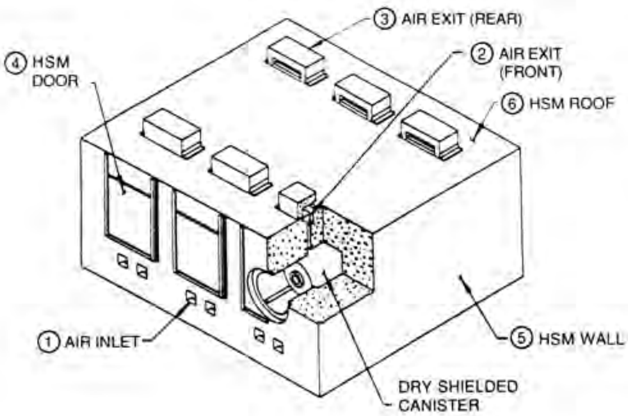


Fig. 10. Typical DSC loading cycle-occupational exposure.



MAXIMUM SURFACE DOSE RATES

	ACTUAL* NEUTRON	ACTUAL* GAMMA	LICENSE LIMIT
① AIR INLET	1.0	28	200 MR/HR
② AIR EXIT (FRONT)	2.5	22	125 MR/HR
③ AIR EXIT (REAR)	2.5	10	125 MR/HR
④ HSM DOOR	**	**	100 MR/HR
⑤ HSM WALL	N/A	N/A	20 MR/HR
⑥ HSM ROOF	1.5	2	20 MR/HR

* PRELIMINARY (HSM #2) ** NOT AVAILABLE

Fig. 11. Oconee NUHOMS®-24P actual measured dose rates vs. licensed contact dose rates.

associated risk. A description of an integrated storage and transportation system using NUHOMS® is provided in Ref. 4.

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