NUHOMS® Transportation System Interfaces

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As utilities with nuclear power plants face increasing near term spent fuel storage needs, various systems for dry storage such as the NUTECH Horizontal Modular Storage (NUHOMS®) system are being implemented to augment existing spent fuel pool storage capacities. Since the US Department of Energy (DOE) is tasked with the future responsibility of transporting spent fuel from commercial nuclear power plants, the interfaces between the utilities at-reactor dry storage system and the DOE's away-from-reactor transportation system become important. This paper presents a study of the alternative interfaces between the current at-reactor NUHOMS® system and the future away-from-reactor DOE transportation system being developed under the Office of Civilian Radioactive Waste Management (OCRWM) program.

INTRODUCTION

The NUHOMS® system utilizes a reinforced concrete Horizontal Storage Module (HSM) to store spent nuclear fuel assemblies which are sealed in a Dry Shielded Canister (DSC). The DSC has an internal basket assembly designed to hold 24 PWR or 60 BWR spent fuel assemblies. The HSMs are constructed in interconnected arrays on the utility's reactor site with each HSM holding one DSC. The HSMs and DSCs are the principal components of the Independent Spent Fuel Storage Installation (ISFSI) for which plants are granted a 10CFR72 (1) license by the US Nuclear Regulatory Commission (NRC) for interim dry storage. A complete description of the NUHOMS® system for dry storage of spent fuel and its operation is contained in the NRC approved NUHOMS® Topical Report and related publications (2, 3, 4, 6).

The configuration of the standard NUHOMS®-24P DSC is shown in Figure 1. The DSC provides the primary containment boundary for confinement of radioactive materials during transfer and storage. The DSC can also serve as a secondary containment boundary to that of the transportation cask for future off-site shipment. The DSC has redundant welded end closures, shielded end plugs to minimize occupational dose, and provisions for horizontal transfer utilizing a hydraulic ram. DSC handling and transfer operations between the plant's spent fuel pool and the HSM are performed utilizing a NUHOMS® on-site transfer cask which provides additional shielding and protection against postulated accidents such as a cask drop or extreme natural phenomena. A composite illustration of the DSC, transfer cask, and spent fuel is shown in Figure 2. The standard NUHOMS® system configuration for DSC transfer to or from an HSM is shown in Figure 3.

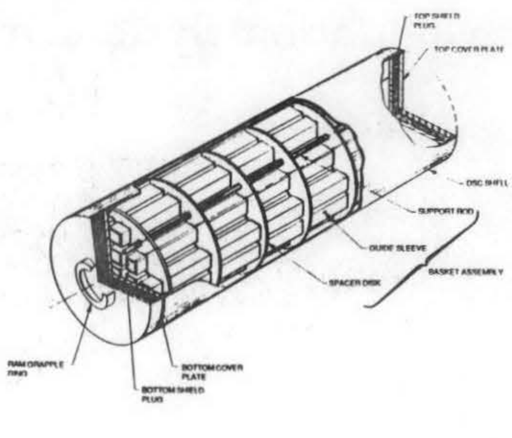

Figure 1 NUHOMS® -24P Dry Shielded Canister

OPTIONS FOR FUEL/ CANISTER SHIPMENT

Following the period of at-reactor dry storage, at the time the DOE begins accepting spent fuel, several alternatives exist for transportation of the spent fuel contained in a NUHOMS® ISFSI to the MRS or geologic repository as depicted in the Figure 4 flow chart. The alternate means available to a particular plant will depend upon the compatibility of the interfaces between the plant and the OCRWM cask, as well as access to rail, barge, or truck transportation systems at or near the reactor site. Rail/barge transportation is the most desirable since the number of fuel assemblies and casks transported for each trip is maximized and the number of trips minimized, thus minimizing the risk to the public and the unit cost of transport. The use of a suitable rail/barge transportation cask also makes possible the shipment of intact DSCs which offers substantial advantages over shipment of non-canisterized spent fuel. These advantages include enhanced safety provided by the second containment boundary to that of the shipping cask, reduced occupational dose since individual spent fuel assemblies are not re-handled at the reactor site, and greater economy since spent fuel pre-packaged in a DSC affords the minimum OCRWM transportation system cycle time.

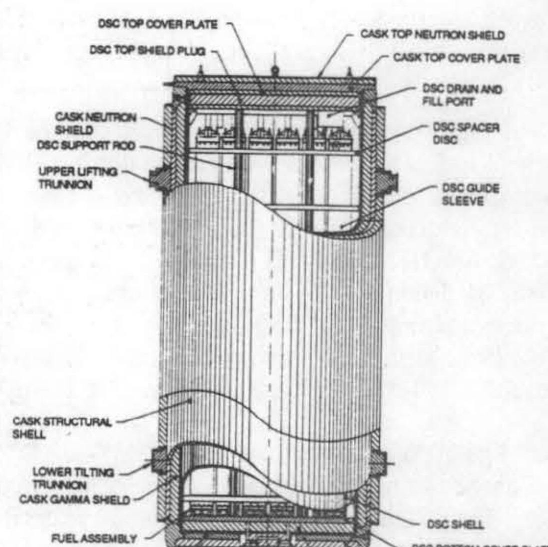

Figure 2 Composite View of NUHOMS® -24P Cask, Canister, and Fuel

CANISTER DESIGN FEATURES AND OCRWM CASK INTERFACES

The NUHOMS® DSC is currently licensed for on-site dry storage applica-

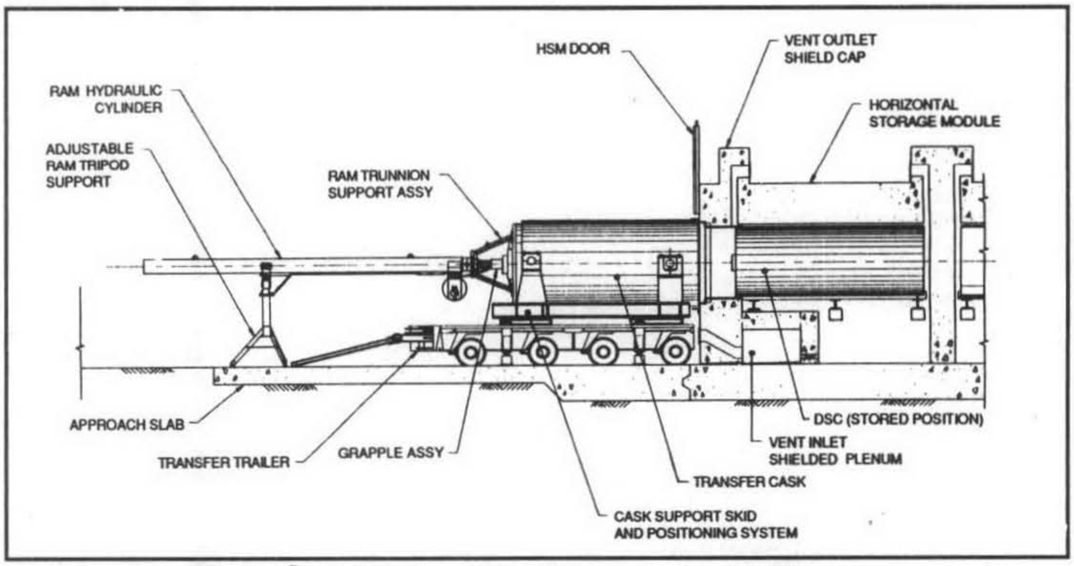

Figure 3 Standard NUHOMS® -24P System Components, Structures, and Transfer Equipment

tions in accordance with the requirements 10CFR72 (1). The standard NUHOMS® DSC design features are summarized in Table I. The DSC internal basket assembly design is customized to suit the physical design and operating histories of the present and future fuel contained in each plant's spent fuel inventory. The outer DSC shell assembly design is standardized such that the physical features and design capacity of the DSCs for all fuel types are the same, providing a standard package with the same characteristic interfaces for transportation considerations.

The shipment of intact DSCs off-site would require qualification and certification of the DSC to the requirements of 10CFR71 (5) for use with a compatible shipping cask. The basic design of the NUHOMS® DSC is suitable for both on-site storage (10CFR72) and off-site shipment (10CFR71). Minor improvements to the basic design of the NUHOMS® DSC are possible to further enhance the compatibility and shipability of the DSC, and to exercise the advantages of shipping canister-

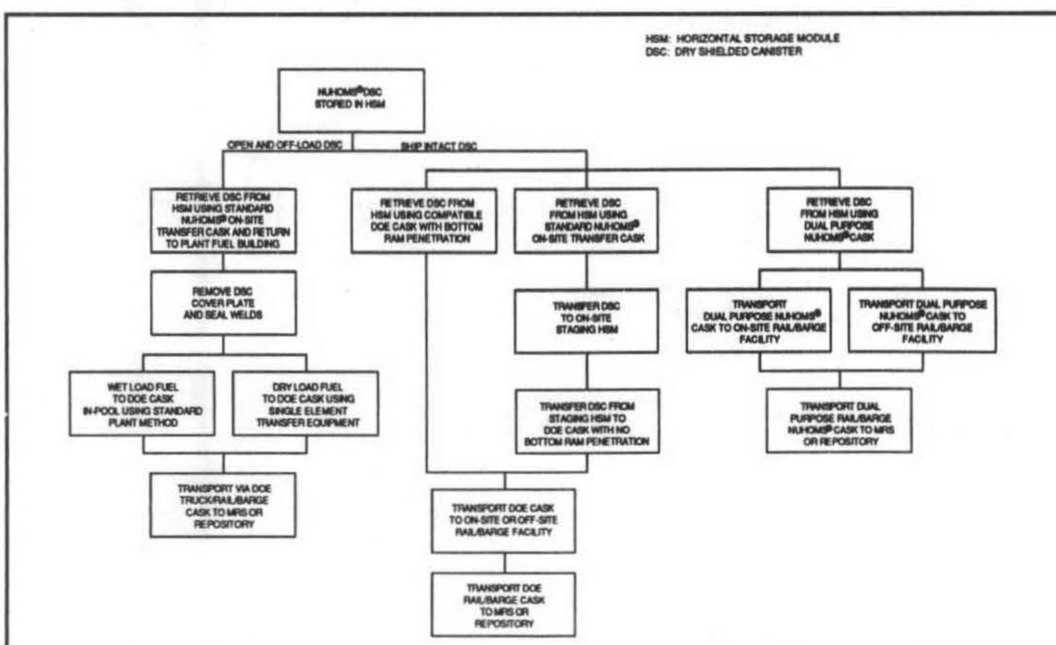

Figure 4 Options for Away-From-Reactor Shipment of Spent Fuel with NUHOMS® System

Table 1
NUHOMS® -24P Standard Shielded Canister Design Features

Physical Parameters:
- Outside Diameter = 1.71m (67.25 in.) - Standard
- Maximum Length PWR Fuel ≤ 1.72m (186 in.)
- Maximum Dry Loaded Weight ≤ 32,660kg (72,000 lbs.)

Criticality Control Capability:
- Credit for Burnup
  - No Poison Basket
  - No Burnable Poisons
  - Nominal Case Keff < 0.95
  - Extreme Case Keff < 0.98
- Governing Conditions
  - Axial Burnup Variation
  - Optimum Moderation
  - Fresh Fuel Misload
  - Combined Effects
- Biases and Uncertainties Included

Radiological and ALARA Provisions:
- Maximum Contact Dose DSC Shield Plug
  - Wet ≤ 100 mrem/hr
  - Dry ≤ 200 mrem/hr
- Smearable Contamination ≤ 22,000 dpm/ 100 cm2

Decay Heat Removal Capacity:
- Spent Fuel Decay Heat Generation
  - 2/3 kW per Fuel Assembly
  - 16 kW per DSC
- Maximum Fuel Cladding Temperature
  - Long Term Storage ≤ 340°C
  - Short Term Conditions ≤ 570°C

Structural Capacity:
- Postulated Cask Drop Accident Decelerations
  - Horizontal Side Drop or Slap Down 75g's
  - Vertical Top or Bottom End Drop 75g's
  - Oblique Corner Drops of 25g's
  - Capacity Exceeds that of Fuel Capability
- Internal Pressure
  - Normal Storage Conditions ≤ 10 psig
  - Worst Case Postulated Accident ≤ 50psig

ized spent fuel to the fullest extent. These enhancements are summarized in Table II.

DIRECT CANISTER TRANSFER TO OCRWM RAIL/BARGE CASK

At-reactor direct transfer of an intact NUHOMS® DSC from an HSM to an OCRWM rail/barge cask requires that the cask have a compatible cavity size, a bottom end penetration for insertion of the hydraulic ram, and a recess for the bottom end DSC grapple ring similar to that of a standard NUHOMS® on-site transfer cask as shown in Figure 2. It may also be feasible to adapt a multi-purpose OCRWM rail/barge cask with a compatible cavity diameter and payload capacity, such as a cask for BWR fuel with a removable basket, by placing an insert in the bottom end of the cask cavity (not shown) designed to support the DSC and to accommodate the DSC grapple ring.

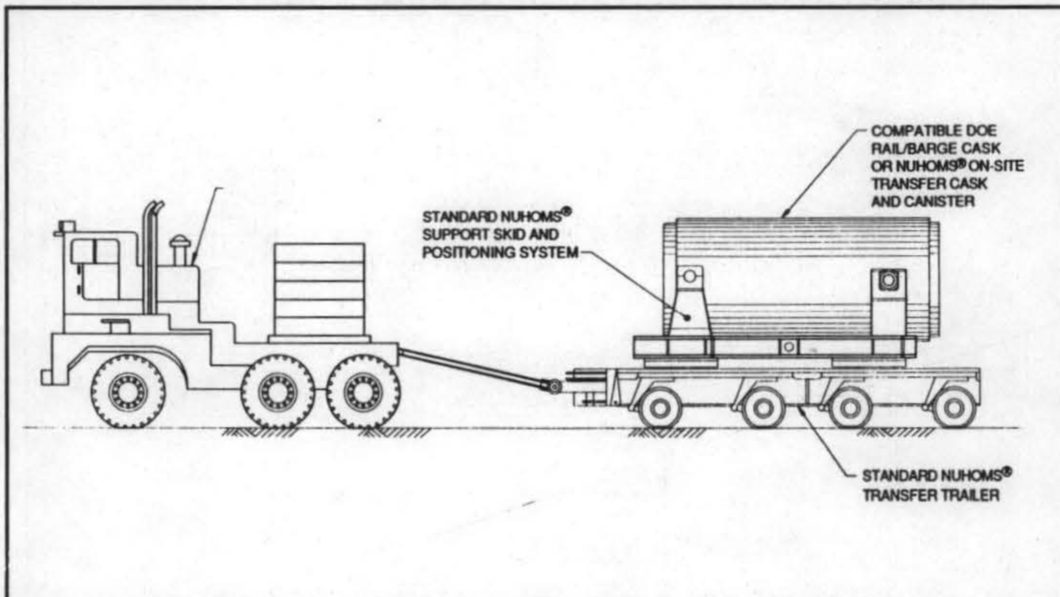

Figure 5 On-Site Transport of Cask/NUHOMS® Canister to Staging Module or Rail/Barge Facility

Table II
NUHOMS®Canister Design Enhancements to Improve Compatibility

Enhancement	Benefits
1. Leak chase between primary and secondary seal welds for DSC top and bottom end closures.	1 Permits helium leak test ot DSC redundant seal welds following initial closure and prior to off-site shipment. All other containment boundary welds are radiographically examined during DSC fabrication.
2. Bolted, removable bottom shield plug and ram grapple ring assembly.	2. Permits shortening of DSC length and use of DOE cask with no bottom penetration. Transfer of DSC to/from DOE cask is performed using staging module.
3. Provisions for lifting, handling, and horizontal transfer of loaded DSC via top cover plate.	3. Permits handling of DSC in hot cell using overhead crane or horizontal transfer to/from staging module for cask with no bottom ram penetration or DSC with a bolt-on bottom shield plug.

Similarly, it may be feasible to place a collar/adapter between the cask top head and the cask body (not shown) to extend the cask cavity length and/or provide a compatible interface for docking of the OCRWM rail/barge cask with the HSM.

Operations for direct transfer of an intact DSC to a compatible OCRWM rail/barge cask would be performed using standard NUHOMS® transfer equipment and transfer techniques as shown in Figure 3, except that the standard NUHOMS® cask support skid would be changed-out or modified to be compatible with the rail/barge cask if necessary. Transport of the OCRWM rail/barge cask to an on-site rail car or barge would proceed using the standard NUHOMS® transport trailer as shown in Figure 6. Once at the on-site rail head or barge facility, the OCRWM rail/barge cask and intact NUHOMS® DSC would be lifted onto the rail car or barge using a suitable crane, or other special purpose handling equipment (not shown) and secured for shipment as shown in Figure 8.

For plants which do not have on-site access to a rail or barge, off-site transport to a nearby rail head or barge facility could be accomplished by adapting the standard NUHOMS® transfer trailer, which is specifically designed for such heavy haul transport on commercial and DOT grade pavement. Additional wheel sets or an entire second trailer with a load spreading device could be

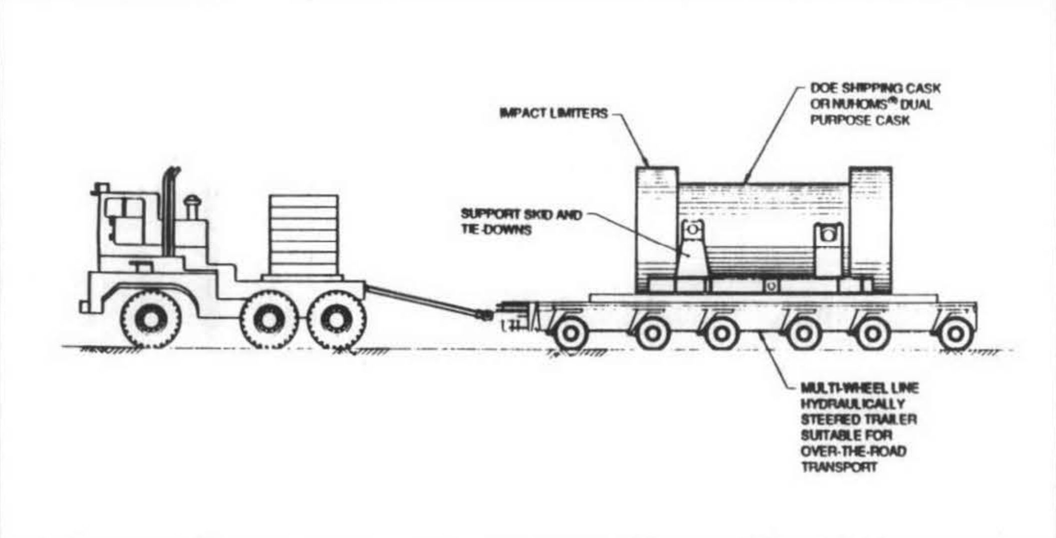

Figure 6 Off-Site Transport of OCRWM or Dual Purpose NUHOMS® Canister to Rail/Barge Facility

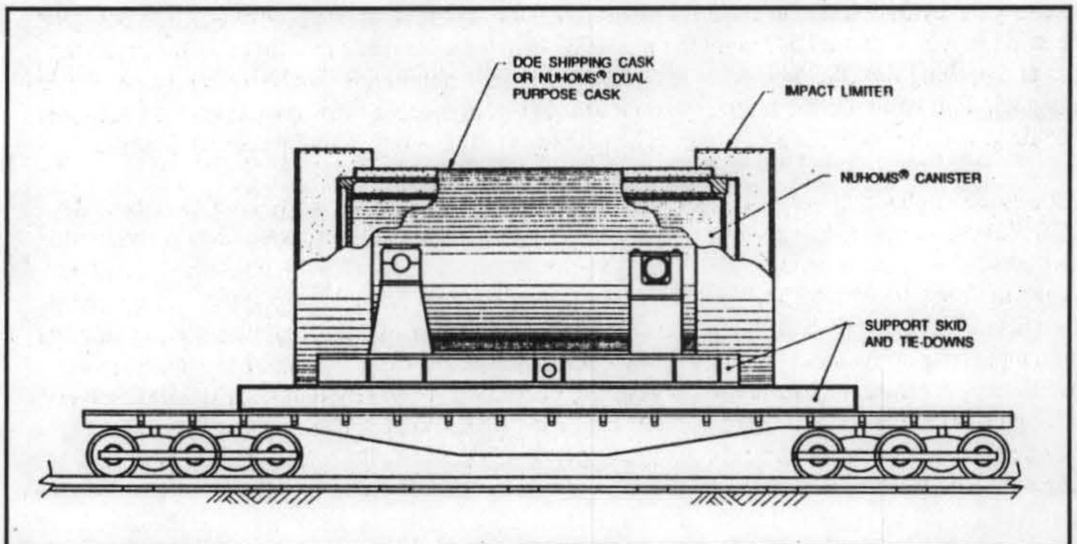

Figure 7 OCRWM Cask or Dual Purpose NUHOMS® Cask and Canister Secured for Shipment on Rail Car

utilized to reduce the maximum wheel loads and to distribute the total load in compliance with local limits for road surfaces and overpasses. Prior to off-site transport, cask impact limiters would be installed and the cask readied for shipment in compliance with the 10CFR71 certification for the cask. The extended transport trailer and cask readied for off-site transport is shown in Figure 7. Once at the nearby rail head or barge facility, the OCRWM rail/barge cask and intact NUHOMS® DSC would be lifted onto a rail car or barge and secured for shipment as shown in Figure 8.

INDIRECT CANISTER TRANSFER TO OCRWM RAIL/BARGE CASK

At-reactor indirect transfer of an intact NUHOMS® DSC to an OCRWM rail/barge cask with a compatible cavity diameter and payload capacity, but without a bottom penetration, can be achieved by first retrieving the DSC from storage in an HSM using the standard NUHOMS® on-site transfer cask, transfer equipment, and transfer techniques. While subsequent transfer of an intact DSC from a NUHOMS® on-site transfer cask directly to a OCRWM rail/barge cask is feasible, this method of transfer is not preferred since the fuel assemblies would be oriented top down and the DSC bottom shield plug and grapple ring assembly would be oriented top up, thus complicating the canister opening and fuel handling process following shipment.

The preferred method of transferring an intact NUHOMS® DSC to an OCRWM rail/barge cask at-reactor following retrieval of the DSC from storage in an HSM using a standard NUHOMS® on-site transfer cask is to first off-load the intact DSC to a NUHOMS® staging module. The single, stand-alone staging module is similar in most respects to a standard NUHOMS® HSM except that the rear wall of the staging module would have a penetration to facilitate use of the hydraulic ram for DSC transfer to a cask with no bottom penetration or use of a DSC with a bolt-on bottom shield plug assembly. The rear penetration module design and ram operation is similar to that first utilized for demonstration of the NUHOMS®-07P system.

At-reactor off-loading of the intact DSC from the NUHOMS® on-site transfer cask to the staging module occurs in a manner similar to that shown in Figure 3 for a standard DSC transfer. As a prerequisite to this operation, the specific interface requirements of the OCRWM rail/barge cask without a bottom-end ram penetration are accommodated. For example, the DSC top end bolt-on grapple ring is installed, following removal of the NUHOMS® on-site transfer cask top cover plate prior to docking the cask with the staging module. The DSC transfer operation proceeds by inserting the hydraulic ram through the on-site transfer cask bottom end penetration and engaging the ram grapple with the DSC grapple ring. DSC transfer takes place by actuating the hydraulic ram and pushing the DSC into the staging module as shown in Figure 3. The hydraulic ram is then retracted. Following DSC transfer, the door to the staging module is lowered to provide adequate shielding, and the NUHOMS® on-site transfer cask is pulled away from the staging module.

Once in the staging module, at-reactor loading of the intact DSC from the staging module to the OCRWM rail/barge cask is achieved. To effect this operation, the rail/barge cask and compatible support skid are placed on the NUHOMS® transfer trailer and docked with the staging module as shown in Figure 9. The hydraulic ram grapple is then inserted through the staging module cavity to engage the previously installed bolt-on DSC top grapple ring and the hydraulic ram actuated to initiate pushing of the intact DSC into the OCRWM rail/barge cask. The rail/barge cask is then pulled away from the staging module and made ready for shipment by removing the DSC top end bolt-on grapple ring and installing the cask top head. Intermediate to these operations, the DSC may be helium leak tested using the pressure ports ready the DSC for shipment in compliance with

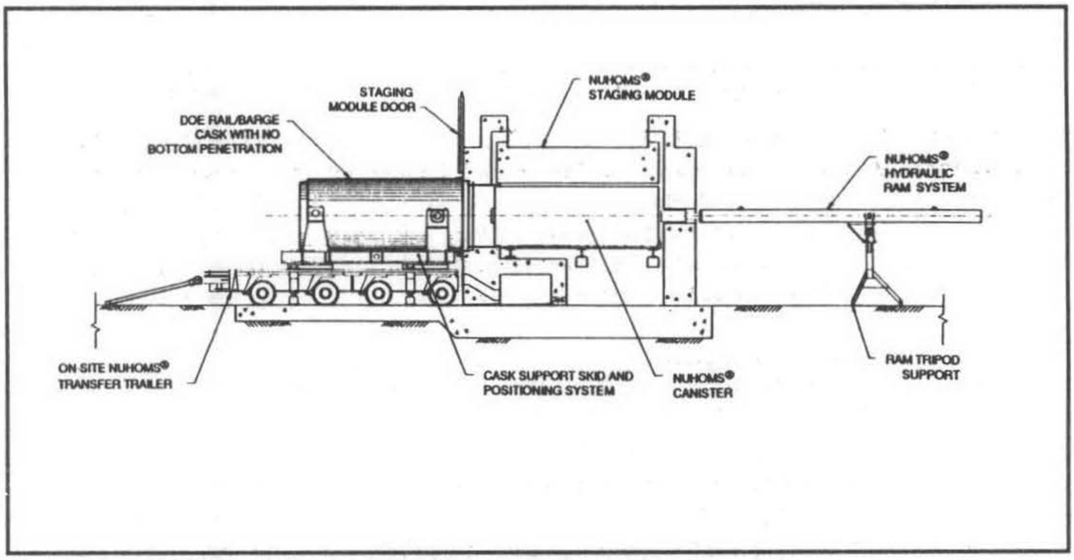

Figure 8 NUHOMS® Canister Transfer From Staging Module to OCRWM Cask

the 10CFR71 certification. The OCRWM rail/barge cask and intact NUHOMS® DSC is then transported to an on-site or nearby off-site rail head or barge facility as shown in Figure 7 for transportation as shown in Figure 8.

DUAL PURPOSE NUHOMS® CASK

In the event that there are no compatible transportation casks available with a cavity size and payload capacity suitable for shipment of an intact NUHOMS® DSC, a NUHOMS® cask which is designed, licensed, and certified for both at-reactor NUHOMS® system storage operations (10CFR72) and away-from-reactor transportation (10CFR71) could be utilized. The design requirements for such a dual purpose NUHOMS® cask are summarized in Table III. The existing 10CFR72 NUHOMS®-24P on-site transfer cask design basis is comparable to that required to meet 10CFR71 (5) with the addition of impact limiters and redundant top cover plate seals. The DSC double seal welds already meet 10CFR71 containment requirements and can be supplemented by the addition of O-ring seals in the top and bottom closure heads of the cask. The puncture, fire and more restrictive radiation dose limits specified for a 10CFR71 cask can also be incorporated into the cask design with minimal changes.

Table III
NUHOMS®-24P Dual Purpose Cask Design Criteria

Operational Capabilities:
- Standard NUHOMS® At-Reactor Dry Storage Operations (10CFR72)
  - Wet Loading of Spent Fuel into DSC
  - Transport DSC to HSM
  - Transfer DSC to/from HSM
- Away-From-Reactor Transport of Intact DSC (10CFR71)
  - Transport to Rail/Barge Facility
  - Load Cask/DSC/Skid onto Rail Car or Barge
  - Transport Cask/DSC to MRS or Repository

Physical Parameters:
- Compatible with Standard NUHOMS®24P DSC
  - Cavity Diameter 1.73m (68 in.)
  - Cavity Length 4.75m (187 in.)
  - Payload Capacity 34,020kg (75,000 lbs.)
- Maximum Cask/DSC Gross Weight < 113mtons (125 tons)

Radiological and ALARA Provisions:
- In Accordance with 10CFR71 Limits
  - Maximum Contact Dose ≤ 200 mrem/hr
  - Dose Versus Distance≤ 10 mrem/hr at 2 meters
  - Smearable Contamination ≤ 20,000 dpm/100 cm^2

Decay Heat Removal Capacity:
- 16 kW per DSC

Postulated Accident Conditions:
- In Accordance with 10CFR71
  - Extreme Environmental Conditions
  - Free Cask Drop onto an Unyielding Surface
  - Crushing Due to Drop of Heavy Object on Cask
  - Puncture Due to Projectile Impact or Cask Drop
  - Exposure to Sustained Fire
  - Deep Submersion in Water

Many of the design features of a dual purpose NUHOMS® cask would be similar to those of a standard NUHOMS® on-site transfer cask shown in Figure 2 and described in the NUHOMS® Topical Report (1). The on-site transfer cask design would be modified to be in compliance with 10CFR71 (5) criteria as discussed above, taking credit for the additional primary containment boundary, axial shielding, and structural capacity provided by the standard NUHOMS®-24P DSC. The at-reactor operations for away-from-reactor shipment of intact DSCs using a dual purpose NUHOMS® cask would be similar to those described above for direct canister transfers to a compatible OCRWM rail/barge cask as shown in Figures 3, 7, and 8.

INTERFACES FOLLOWING CANISTER SHIPMENT TO DOE FACILITY

A conceptualization of a complete transportation cycle utilizing an intact NUHOMS® DSC transported from an at-reactor NUHOMS® ISFSI to an away-from-reactor MRS facility and/or permanent geologic repository is shown in Figure 10. Once at the MRS or repository, the intact DSC could be off-loaded to lag storage consisting of NUHOMS® HSMs using standard NUHOMS® transfer equipment as discussed previously for direct or indirect transfer of NUHOMS® DSCs to/from an OCRWM rail/barge cask or a dual purpose NUHOMS® cask. The inherent economy of such an MRS system is substantial since only the construction of NUHOMS® modules in necessary to implement a fully functional system for storage of spent fuel awaiting a permanent repository.

Alternatively, the intact DSC could be off-loaded to a hot cell and opened using remote mechanical cutting tools to facilitate down-loading of the spent fuel assemblies to short-term rack storage for subsequent processing and packaging for permanent storage in a geologic repository. The emptied DSC could then be decontaminated and re-qualified for use or disposed of as low level waste. It may also be feasible to utilize intact DSCs as the primary container for permanent disposal of spent fuel in the geologic repository with the use of a secondary over-pack container is required.

SUMMARY

The shipment of intact NUHOMS® DSCs appears to offer enhanced safety, flexibility, and economy to the DOE, the utilities, and ultimately the general public, and meets the need for interim at-reactor dry storage utilizing an integrated, compatible system for away-from-reactor

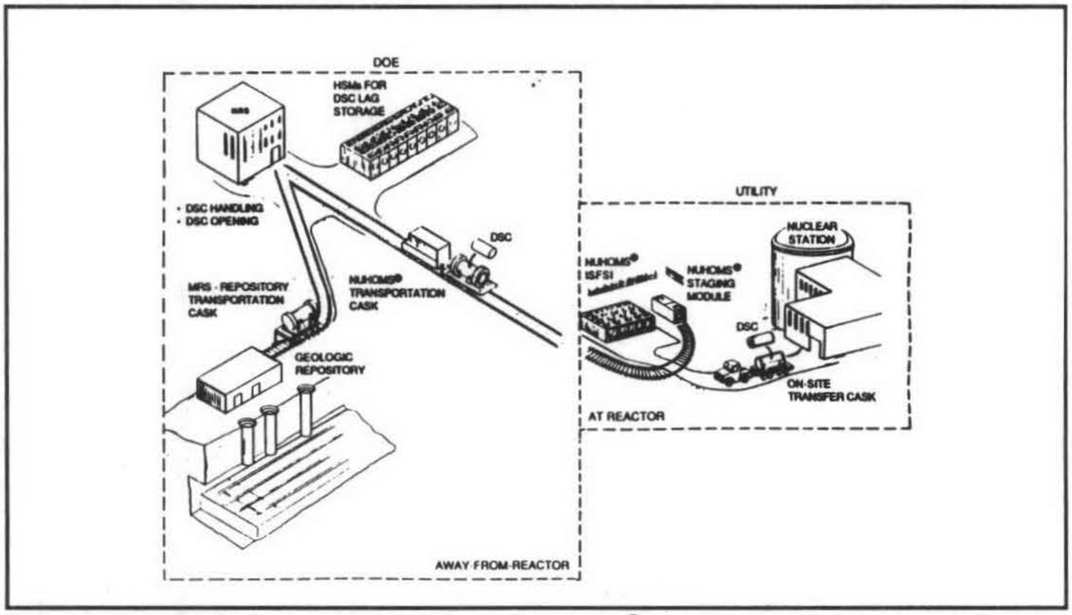

Figure 9 Conceptual Storage Transportation Cycle Using NUHOMS® System

transportation of spent fuel. In addition, the reduced cask loading and unloading time at-reactor and the MRS afforded by shipment of intact canisters may make is possible to utilize a smaller OCRWM cask fleet with the same or greater system capacity than might otherwise be required.

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