4. INSTALLATION DESIGN

4.1 Summary Description

This chapter provides a more detailed description of the NUHOMS® system including the HSM, DSC, and on-site transfer cask.

4.1.1 Location and Layout of Installation

The details of a NUHOMS® ISFSI layout with proximity to other plant features to be determined by the licensee is site specific. The following guidelines are provided for ISFSI site layout as a means of providing a basis for generic analysis of the anticipated HSM arrangements:

A. Prefabricated HSMs may be arranged in side-by-side arrays as a single module row ranging in size from a single stand alone HSM to a 1x10 array of HSMs or larger, as shown in Figure 1.3-12 Adjacent HSMs have a 6" inch space between them to permit ventilation air flow. The side walls of the HSM base units are 1'-6" thick. The outside end walls of the HSM array are shielded by 2'-0" thick shield walls. The rear walls of a single module row HSM array are also shielded by 2'-0" thick shield walls. Detailed requirements for the arrangement of HSMs in a single module row are defined on the Appendix E drawings.

B. Prefabricated HSMs may be arranged in side-by-side back-to-back arrays as a double module row ranging in size from a 2x1 array to a maximum array size of 2x10 HSMs or larger, as shown in Figure 1.3-11. Adjacent HSMs have a 6" inch space between them to permit ventilation air flow.

C. The outside end walls of an HSM array are shielded by 2'-0" thick shield walls. Detailed requirements for the arrangement of HSMs in a double module row are defined on the Appendix E drawings.

D. Combinations of the single module row and double module row arrangements are also permissible as shown in Figure 1.3-13.

E. A concrete basemat and approach slab with access space in front of the HSMs is needed which varies in size depending on the site specific ISFSI layout. Examples of these are shown in Figures 1.3-11 through 1.3-13.

Guidelines for selection of a suitable ISFSI site are provided in Section 1.2.6 and Chapter 2.

4.1.2 Principal Features

The principal features of a NUHOMS® ISFSI installation are described in Sections 1.2 and 1.3. The location of the ISFSI with respect to the plant site boundary and the associated emergency planning zone are site specific and are to be addressed by the licensee. The controlled access area for some typical NUHOMS® ISFSIs is illustrated in Figures 1.3-11 through 1.3-13. There are no utility systems, other than those required for the temperature monitoring system, required during storage conditions with a NUHOMS® ISFSI. Low voltage electrical power is needed to operate hydraulic pumps during DSC insertion and withdrawal operations, and for ISFSI lighting and security systems. The existing plant paging system may be extended to the ISFSI to provide telephone and paging information. There are no water or sewer systems necessary, nor are there any holding ponds, chemical and gas storage systems or open air tankage utilized for a NUHOMS® ISFSI. A NUHOMS® ISFSI has no stacks.

4.2 Storage Structures

4.2.1 Structural Specifications

The design bases for the NUHOMS® ISFSI are described in Chapter 3. Fabrication and construction specifications will be utilized in accordance with 10CFR72 (4.1) and industry codes and standards. The codes and standards used for fabrication and construction the NUHOMS® components, equipment, and structures are identified throughout the SAR. They are summarized as follows:

Component, Equipment, Structure	Code of Construction
DSC	ASME Code, Section III, Division 1, 1983 Edition with Winter 1985 Addenda (4.5) Subsection NB, Subsection NF, and Appendix F with exceptions as noted in Section 4.8 of this SAR.
Transfer Cask	ASME Code, Section III, Division 1, 1983 Edition with Winter 1985 Addenda (4.5) Subsection NC as applicable for non-pressure retaining vessels, with exceptions as noted in Section 4.9 of this SAR.
HSM	ACI-318-83 Code (4.10)
DSC Supports	AISC Specification, 1990, Ninth Edition (4.11)
Transfer Equipment	AISC, ANSI, AWS and/or other applicable Standards

The ASME Code boundaries for the DSC and the transfer cask are identified on the corresponding Appendix E drawings. The code boundary for the NUHOMS®-61BT and –24PT2 DSC are provided in Appendices K and L, respectively.

4.2.2 Installation Layout

The specific layout of the ISFSI will be developed by the licensee in accordance with the requirements of 10CFR72. Layouts for typical NUHOMS® ISFSIs are shown in Figures 1.3-11 through 1.3-13. The functional features of the NUHOMS® storage structures are shown on the Appendix E drawings. Radioactive particulate matter and gaseous fission products are confined within the DSC as discussed in Sections 1.2 and 1.3.

4.2.3 Individual Unit Description

4.2.3.1 Dry Shielded Canister

The following description is applicable to the 24P and 52B DSC designs. The 61BT DSC design description is included in Appendix K and the 24PT2 DSC design description is included in Appendix L. The DSC is a high integrity stainless steel welded pressure vessel that provides confinement of radioactive materials, encapsulates the fuel in a helium atmosphere, and, when placed in the transfer cask, provides biological shielding during DSC closure and transfer operations. With the exceptions noted in Section 4.8, the DSC shell assembly and associated subcomponents conform to the requirements of the ASME B&PV Code Section III, Division 1, Subsection NB while the DSC basket assembly conforms to Subsection NF. The NUHOMS® DSC design is illustrated in Figures 1.3-1 through 1.3-3. Drawings for the standardized DSC are contained in Appendix E.

The DSC cylindrical shell is fabricated from rolled and butt-welded stainless steel plate material as shown in Figure 4.2-1. Stainless steel cover plates and thick carbon steel or lead encased in steel shielding material form the DSC top and bottom end assemblies. The cover plates are double seal welded to the DSC shell to form the containment pressure boundary.

The DSC shell, and top and bottom end assemblies enclose a non-pressure retaining basket assembly which serves as the structural support for the SFAs as shown in Figure 4.2-2 and Figure 4.2-3. The primary components of the basket assembly are the spacer discs, which maintain cross sectional spacing of (and provide lateral support to) the fuel assemblies within the DSC, and the support rods, which hold the spacer discs in place and maintain longitudinal separation of the spacer discs during a postulated cask drop accident.

The PWR NUHOMS-24P fuel basket assembly consists of 24 stainless steel guide sleeves, eight carbon steel spacer discs and four Type XM-19 stainless steel support rods. The inner guidesleeves in the assembly are equipped with stainless steel oversleeves placed at both ends of the basket assembly between the two top and bottom spacer discs. No connection exists between the spacer discs and the guidesleeves. Guidesleeve stops fabricated from stainless steel plate strips and plug welded to the sides of the guidesleeves prevent removal of the guidesleeves from the basket if a fuel assembly becomes stuck during insertion or removal. Criticality control is achieved by use of water with dissolved boron in the DSC cavity as described in Section 3.3.

The BWR NUHOMS-52B basket assembly uses nine spacer discs to maintain fuel position within the DSC. Axial position of the discs is maintained by preloaded spacer sleeves. There are six spacer sleeves locations around the periphery of each disc with 10 spans per location, from the bottom end to the top end of the basket assembly. The spacer sleeves are preloaded by support rods which span the full length of the basket assembly within the spacer sleeves and discs. The basket includes fixed neutron absorbing plates ("poison sheets") to provide criticality control for BWR fuel assemblies in non-borated water. The axial support of the poison sheets at the top disc is accomplished by bolting of the sheets to a support bar which is welded to the bottom of the top disc. The top spacer disc is constructed of SA-537 Grade 2 carbon steel. The remaining spacer discs are constructed of SA-516, Grade 70 carbon steel. The spacer sleeves and support rods are constructed of SA-564, Type 630 precipitation hardened steel. The poison plates are constructed of A-887, Type 304B3 borated stainless steel and the poison plate support bars are constructed of A36 carbon steel.

The shield plugs at each end of the DSC provide biological shielding when the DSC is in the transfer cask or in the HSM. The top shield plug is captured between the supporting ring and the top cover plates, which provide a redundant pressure retaining function. The bottom shield plug and cover plates, the internal basket assembly, the shell and support ring, and the grapple ring are shop fabricated assemblies. The top shield plug and top cover plate assemblies are installed at the plant after the fuel assemblies have been loaded into the DSC internal basket. A small diametral gap is provided between the top shield plug and the DSC shell. The minimum radial gap at any point on the circumference of the top shield plug/DSC shell annulus is controlled during fabrication. This gap is adequate to allow the plug to be freely inserted or removed from the DSC shell assembly with the DSC submerged in the fuel pool. The design of the DSC is intended to allow for differential thermal expansion between the DSC shell assembly and basket assembly components.

A "Strongback Device" is placed over the inner top cover plate of the DSC and attached to the transfer cask (TC) during draining, backfilling, and leak testing. The strongback is used to prevent deflection of the cover plate during these operations which involve significant DSC pressurization.

The inner top cover plate is welded to the DSC shell to form the inner pressure boundary at the top end of the DSC as shown in Figure 4.2-4 and Figure 4.2-5. The outer pressure boundary is provided by the outer top cover plate which is also welded to the DSC shell. All closure welds are multiple-layer welds. This effectively eliminates any pinhole leak which might occur in a single- layer weld, since the chance of pinholes being in alignment on successive weld layers is negligibly small. The circumferential and longitudinal shell plate weld seams are fabricated using multi-layer full penetration butt welds. The butt weld joints are fully radiographed and inspected according to the requirements of Section V of the ASME Boiler and Pressure Vessel Code, to insure that the integrity of the welded joint is as sound as the parent metal itself. Any exceptions to the ASME Code are discussed in Section 4.8.

These stringent design and fabrication requirements insure that the containment pressure retaining function of the DSC is maintained. It should be noted that pressure monitoring instrumentation is not used since penetration of the pressure boundary would be required. The penetration itself would then become a potential leakage path and, by its presence, compromise the leak tightness of the DSC design.

The top shield plug support ring assembly includes siphon and vent ports. The design incorporates two small diameter tubing penetrations into the DSC cavity for draining and filling operations. One penetration, the vent port, is terminated at the bottom of the shield plug assembly. The other port is attached to a siphon tube, which continues to the bottom of the DSC cavity. The siphon and vent port includes a two plane, dog-leg type offset to prevent radiation streaming. The siphon and vent ports terminate in normally closed quick-connect fittings. Both ports are used to remove water from the DSC during the drying and sealing operations.

The drying and sealing operations are described in Section 4.7.3. Transfer of the DSC to the HSM by the hydraulic ram is done by grappling the ring plate assembly welded to the bottom cover plate of the DSC. This assembly prevents significant deformation and bending stresses in the DSC during handling. When the DSC is transferred by the hydraulic ram, the load is sustained by this cover plate.

Four lifting lug plates are provided on the interior of the DSC shell to facilitate placement of the empty DSC into the transfer cask prior to fuel loading. The DSC is lowered into the transfer cask cavity using the fuel/reactor building crane or other suitable crane at the utility's option. Shackles and rope slings are used to rig the DSC lifting lugs to the crane hook.

The DSC azimuthal orientation during insertion into the transfer cask is achieved by alignment of match marks on the DSC and the cask top ends. In addition, a key-way detail is used for the DSC basket assembly to ensure that the fuel matrix orientation with the DSC shell and transfer cask is maintained.

Frictional loads during DSC transfer are reduced by the application of a dry film lubricant to the support rails inside the HSM and the transfer cask which are in contact with the DSC shell during horizontal DSC transfer. The lubricant chosen for this application is a tightly adhering inorganic lubricant with an inorganic binder. The dry film lubricant provides a thin, clean, dry, layer of lubricating solids that is intended to reduce wear, and prevent galling in metals. It is applied as a thin sprayed coating, like paint, using a carefully controlled process. The lubricant is not affected by water and is designed to be highly resistant to aggressive chemicals such as fuming nitric acid and hydrazine and to maintain its lubricity when exposed to these chemical agents. This product is designed for radiation service and has a low coefficient of sliding friction against stainless steel.

Pressure and leak tests of the DSC confinement boundary welds are performed according to the requirements of the ASME Code to the extent practical with exceptions as discussed in Section 4.8

The principal materials of construction for the NUHOMS® DSC are stainless and carbon steel. All structural component parts of the DSC are fabricated from these materials. Carbon steel is used for the DSC internals excluding the 24P guide sleeves, oversleeves, and support rods and the 52B spacer sleeves, support rods, and poison plates which are stainless steel. The DSC cylindrical shell and the cover plates which form the DSC containment pressure boundary are stainless steel. Lead is used as a shielding material in the long-cavity PWR canister shield plugs.

4.2.3.2 The Horizontal Storage Module

The design of the prefabricated NUHOMS® HSM has been developed in accordance with the applicable codes and a quality assurance program suitable for design of structures important to safety, as documented in Chapter 3. The design of the prefabricated NUHOMS® HSM has been performed using techniques similar to those reviewed and approved by the NRC for the NUHOMS®-24P design (4.13). The width and height of the HSM cavity and effective shielding thicknesses are the same.

The HSM is a massive reinforced concrete structure that provides protection for the DSC against tornado missiles and other potentially adverse natural phenomena. The HSM also serves as the principal biological shield for the spent fuel during storage. The NUHOMS® HSM design is illustrated in Figures 1.2-2 and 1.3-4. Drawings for the HSM are contained in Appendix E. Details for the standardized HSM are depicted in the illustrations and drawings referred to herein.

The HSM contains four shielded air inlet openings in the lower side walls of the structure to admit ambient ventilation air into the HSM as shown in Figure 4.2-6 and Figure 4.2-7. The air inlet and outlet openings in HSM Model 102 are lined with 1½ inch thick steel plates for improved shielding. The cooling ventilation air flows around the DSC (see Figure 1.3-5) to the top of the HSM. Air warmed by the DSC is exhausted through four shielded vent openings near the HSM roof slab. Adjacent modules are spaced to provide adequate ventilation flow and shielding. This passive system provides an effective means for spent fuel decay heat removal. A heat shield is provided between the DSC and HSM concrete to mitigate concrete temperatures.

The DSC rests on a frame structure with support rails in the cavity of the HSM, which is anchored to the HSM floor slab, side wall and front wall opening. The DSC support structure is fabricated from structural steel as shown in Figure 4.2-8. The DSC support structure member sizes and connection details are shown on the Appendix E drawings. The support structure is leveled and bolted to the HSM floor slab and side wall during module assembly. The support rails extend into the HSM front wall access opening, which is slightly larger in diameter than the DSC. The HSM access opening has a stepped flange sized to facilitate docking of the transfer cask, as shown in Figure 4.2-9. This configuration minimizes streaming of radiation through the HSM opening during DSC transfer.

The DSC support rails are set parallel and leveled, then welded to embedded plates in the HSM opening. Thermal expansion of the support rails is accommodated by the DSC support system design. The top surfaces of the rails, on which the DSC slides, are coated with a dry film lubricant (see previous discussion for DSC) which is suitable for a radiation environment. The support rail sliding surfaces consist of hardened stainless steel cover plates for corrosion protection and added lubricity. Inside the HSM, the heat rejected from the DSC has a drying effect. Thus, the HSM atmosphere is benign in terms of corrosion, decay heat warms the air, thus preventing the accumulation or condensation of moisture inside the HSM.

The DSC is prevented from sliding along the support rails during a postulated seismic event by rail stops attached to the back ends of the DSC support rails, and a retainer located in the front access door of the HSM. The DSC axial retainer design is shown in Figure 4.2-9.

Clearance between the axial retainer and the DSC is designed for the maximum DSC thermal growth which occurs during the postulated HSM blocked vent case, as discussed in Section 8.2-7. During normal storage there is a small gap which may allow movement of the DSC relative to the HSM. This motion would produce a small increase in the DSC axial force due to seismic loads if these forces were sufficient to overcome friction between the rails and DSC. For conservatism, these effects have been included in the design analysis.

The HSM wall and roof thicknesses are primarily dictated by shielding requirements. The massive walls adequately protect the DSC against tornado missiles and other adverse natural phenomena. The tornado generated missile effects are considered to bound any other reasonable impact-type accident. The HSM wall thickness for individual modules and HSM arrays are specified on the Appendix E drawings and discussed in Section 4.1.2.

The entrance to the HSM Model 80 is covered by a thick steel door which provides shielding and protection against tornado missiles. The door assembly includes a solid concrete core which acts as a combined gamma and neutron shield. For security purposes, the HSM door may be welded to the HSM access opening docking collar, in addition to the bolted brackets which attach the door to the docking collar. The door is attached to the front wall using four bolted clamps.

For increased shielding, the entrance to HSM Model 102 is provided with a 2-foot thick reinforced concrete door with ½ inch thick steel liner at the rear. The door is attached to the front wall by four 1½ inch diameter bolts.

During DSC insertion/withdrawal operations, the transfer cask is docked with the HSM docking flange and mechanically secured to embedments provided in the front wall of the HSM. The cask restraints used for this purpose are shown in Figure 4.2-13. The embedments are equally spaced on either side of the HSM access opening. The HSM embedments are designed in accordance with the requirements of ACI 349 Code (4.14). The transfer cask restraint system is designed for loads which occur during normal DSC transfer operations and during an off-normal jammed DSC event.

The HSM gap between modules is covered with stainless steel wire bird screen to prevent pests or foreign material from entering the HSM. Periodic surveillance constitutes the only required maintenance activity for the NUHOMS® ISFSI.

It is expected that during the installation and loading of an HSM array there will be empty modules. Vacant HSMs can occur due to: partial filling of a complete construction phase of HSMs, or a partial filling of a phase of HSMs which will be expanded at a future date. The following issues have been evaluated for both cases: Normal Operation Issues, Construction Issues, and Accident Condition Issues. During installation of an additional HSM(s), or for other reasons, shield wall(s) may be removed for a period of time. However, compensatory measures shall be considered for radiation shielding and for missile protection, if necessary.

The design flexibility of the HSMs permits a licensee to choose the most economical arrangement of HSMs which best meets plant specific conditions and requirements. This SAR presents a detailed analysis for a single stand-alone module as this is the governing design case for the postulated environmental loads such as earthquake, flooding, and tornado loads. Thermal loads also provide significant loadings for the HSM structural design for the free-standing prefabricated HSM.

A typical reinforcing steel layout for the HSM floor, walls, and roof is shown in Figure 8.1-19. The reinforcement sizing and placement specified is used for HSM array configurations ranging in size from a single stand alone module to a 2x10 array of HSMs or larger. Licensing details, such as concrete joint and reinforcing bar lap splice requirements, are shown on the Appendix E drawings.

The HSM design documented in this SAR is constructed of 5,000 psi (minimum) compressive strength, normal weight (145 pounds per cubic foot minimum density) concrete with Type II Portland cement meeting the requirements of ASTM C150 (4.6). The concrete aggregate meets the specifications of ASTM C33 (4.6). The concrete is reinforced by ASTM A615 or A706 Grade 60 (4.7) deformed bars placed vertically and horizontally at each face of the walls, roof and floor.

The aggregate used in the concrete mix of the HSM roof slab and base unit must meet additional requirements, as listed below, due to the elevated temperatures that these HSM components may experience. The aggregate used in the concrete mix for the HSM base unit and roof slab also has to meet certain thermal expansion requirements. These requirements depend on design temperatures that the HSM components may experience during service. These requirements are not applicable to the concrete mix used for the shield walls or any non-structural concrete such as the shielded door fill:

1) PWR and BWR Base Unit and BWR Roof Slab:

These components have a maximum normal temperature not greater than 200°F and a maximum off-normal temperature not greater than 225°F. Accordingly, the following requirements for aggregates must be satisfied:

- Have a demonstrated coefficient of thermal expansion no greater than 6×10^{-6} in/in/°F measured in accordance with ASTM E831 or E228 in a temperature range of 70°F to 100°F. Testing for the coefficient of thermal expansion of the coarse aggregates shall be performed directly on a sample of the aggregate. However, testing the fine aggregates may be performed on either some larger size pieces of the aggregate, or a controlled matrix of cement and fine aggregates. If the latter is followed, the coefficient of thermal expansion for the fine aggregates is then calculated by removing the effect of cement based on its percentage volume in the matrix.

OR

- The coarse aggregates to be one or a mix of the following aggregates: limestone, dolomite, marble, basalt, granite, rhyolite, gabbro, and the fine aggregates to be one or a mix of limestone, dolomite, marble, basalt, granite, rhyolite, gabbro, quartz, or sandstone. ASTM C294 (4.6) provides descriptions of the constituents of the above mineral aggregates. Classification of the aggregates shall be obtained by petrographic examination performed in accordance with ASTM C295 (4.6) on each source of aggregates used. Natural mineral aggregates as they occur in nature contain some impurities. The impact of such impurities in the matrix of the aggregates on the coefficient of thermal expansion for the aggregate will be evaluated based on either the percentage volume of the impurities in the matrix, or their established coefficient of thermal expansion (4.20), or both.

2) PWR Roof Slabs:

The PWR roof slab has a maximum normal temperature greater than 200°F but not greater than 300°F, and a maximum off-normal temperature greater than 225°F but not greater than 300°F. Therefore, the following requirements for aggregates must be satisfied:

- Have a demonstrated coefficient of thermal expansion no greater than 6×10^{-6} in/in/°F in a temperature range of 70°F to 100°F. Testing shall be in accordance with ASTM E831 or E228 as described above.

OR

- The coarse and fine aggregates to be one or a mix of the following: limestone, dolomite, marble, basalt, granite, rhyolite, gabbro. Determination of the aggregate constituents shall be done in accordance with the same methods described above.

For all PWR and BWR HSM components the above aggregate requirements can be waived if the criteria established by Appendix D for strength reduction is further validated by strength tests performed on the actual concrete mix to be used for construction subjected to elevated temperatures established by the design. Alternatively the minimum compressive strength requirements for the concrete may be increased to account for an appropriate reduction in concrete strength. This approach removes the need to reevaluate the HSM design analyses.

4.2.3.3 On-Site Transfer Cask

The on-site transfer cask is a nonpressure-retaining cylindrical vessel with a welded bottom assembly and bolted top cover plate. The transfer cask is designed for on-site transport of the DSC to and from the plant's spent fuel pool and the ISFSI as shown in Figure 4.2-10 and Figure 4.2-11. The transfer cask provides the principal biological shielding and heat rejection mechanism for the DSC and SFAs during handling in the fuel/reactor building, DSC closure operations, transport to the ISFSI, and transfer to the HSM. The transfer cask also provides primary protection for the loaded DSC during off-normal and drop accident events postulated to occur during the transport operations. The NUHOMS® transfer cask is illustrated in Figure 1.3-6. Drawings of the transfer cask are contained in Appendix E.

The transfer cask may be fitted with a shielded collar to extend the cask cavity length to accommodate the longer NUHOMS®-52B DSC as shown in Figure 4.2-12. The collar is a heavy forged steel ring with a bolt circle to match that of the transfer cask top flange and cover plate. Alternatively, a NUHOMS® transfer cask with a longer cavity length may be used for DSCs with PWR (with cask spacer) or BWR fuel.

The transfer cask to be used by a utility may be any one of the designs documented in Appendix E, including the standardized cask, OS197 or OS197H. The licensee may also use any other previously NRC reviewed and approved design such as the transfer cask designs documented in the NUHOMS®-24P Topical Report [4.13], the Oconee Nuclear Station ISFSI Safety Analysis Report [4.16], and the Calvert Cliffs ISFSI Safety Analysis Report [4.17], provided it is demonstrated prior to use that the limiting conditions of use as described in CoC 1004 can be met.

The transfer cask is constructed from three concentric cylindrical shells to form an inner and outer annulus. These are filled with lead and a neutron absorbing material. The two inner shells are welded to heavy forged ring assemblies at the top and bottom ends of the cask as shown in Figure 1.3-6. Rails fabricated from a hardened, non-galling, wear resistant material coated with a high contact pressure dry film lubricant are provided to facilitate DSC transfer. All surfaces exposed to fuel pool water are stainless steel. The transfer cask structural shell and the bolted top cover plate may be fabricated from carbon or stainless steel. The transfer cask carbon steel structural shell and top cover plate are coated with a durable epoxy paint which is shop applied in accordance with the manufacturer's standards. This coating system is suitable for immersion service with a continuous temperature of 250°F with intermittent temperatures to 400°F.

The method used to cast the transfer cask lead shielding will vary between fabricators. Only one transfer cask need be utilized for each ISFSI. Transfer casks for different ISFSIs may be supplied by different fabricators. Each fabricator is required to submit detailed procedures for the lead pour consistent with the requirements delineated on the Appendix E drawings. These procedures include specific locations and sealing of pour holes, temporary bracing, and controlled cooling methods for the lead, all of which must meet the applicable codes and standards.

The transfer cask neutron shield cavity is fabricated as a pressure vessel since it is desirable to have this cavity remain leak tight to prevent intrusion of contaminated spent fuel pool water. Also, the support members for the outer shell of the solid neutron shield are angled at 45° with respect to the transfer cask structural shell to further enhance shielding and decay heat removal. Solid neutron shielding materials are also incorporated into the top and bottom end closures to provide effective radiological protection.

Two trunnion assemblies are provided in the upper region of the cask for lifting of the transfer cask and DSC inside the plant's fuel/reactor building, and for supporting the cask on the skid for transport to and from the ISFSI. An additional pair of trunnions in the lower region of the cask are used to position the cask on the support skid, serve as the rotation axis during down-ending of the cask, and provide support for the bottom end of the cask during transport operations. There are no testing requirements per the ASME Code for the transfer cask trunnions. Neither the transfer cask nor the trunnions are special lifting devices per ANSI N14.6. Nonetheless, for transfer casks fabricated under the General License, a one-time pre-service load test of the trunnions is performed at a load equal to 150% of the design load followed by an examination of all accessible trunnion welds. Trunnion testing is neither applicable nor required for existing NUHOMS® transfer casks previously licensed for site specific use (e.g., Calvert Cliffs and Oconee plants).

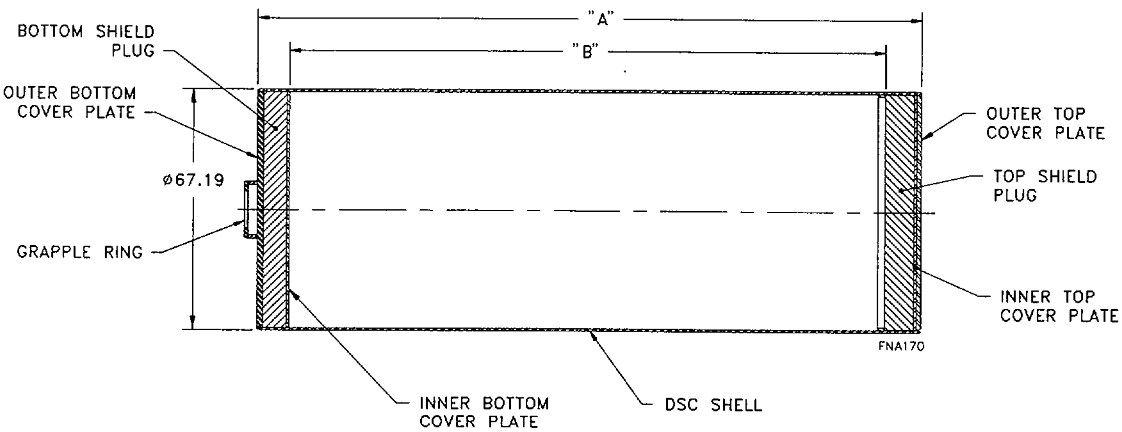
The cask bottom ram penetration cover plate is a water tight closure used during fuel loading in the fuel pool, during DSC closure operations in the cask decon area, and during cask handling operations in the fuel/reactor building. The circular projection on the transfer cask bottom cover plate is dimensioned to ensure that the DSC does not contact any surface of the bottom cover plate assembly. Prior to cask transport from the plant's fuel/reactor building to the HSM, the bottom cover plate of the cask is removed and a temporary neutron/gamma shield plug is attached (the temporary shield plug is not utilized with the integral ram transfer trailer/skid). An illustration of the temporary shield plug design is shown in Figure 4.2-14. The temporary shield plug is a two piece construction with a center cover which is removed for ram insertion. The temporary shield plug is designed such that the contact dose rate is ALARA. The temporary shield plug may be deleted based on an ALARA evaluation.

Alignment of the DSC with the transfer cask is achieved by the use of permanent alignment marks on the DSC and transfer cask top surfaces. These marks facilitate orienting the DSC to the required azimuthal tolerances for fuel loading using the plant's fuel handling machine.

The yoke design used for cask handling is a non-redundant two point lifting device with a single pinned connection to the crane hook as shown in Figure 4.2-15. Thus, the yoke balances the cask weight between the two trunnions and has sufficient margin for any minor eccentricities in the cask vertical center of gravity which may occur. The yoke and other lifting devices are designed and fabricated to meet the requirements of ANSI N14.6 (4.9). The test load for the yoke and other lifting devices is 300% of the design load, with annual dimensional and liquid penetrant or magnetic particle inspection, to meet ANSI N14.6 requirements.

As shown in Figure 4.2-16, the cask upper flange is designed to allow an inflatable seal to be inserted between the cask liner and the DSC. The seal is fabricated from reinforced elastomeric material rated for temperatures well above boiling. The seal is placed after the DSC is located in the cask and serves to isolate the clean water in the annulus from the contaminated water in the spent fuel pool. After installation, the seal is inflated to prevent contamination of the DSC exterior surfaces by waterborne particulates.

The structural materials and licensing requirements for the NUHOMS® transfer cask are delineated on the Appendix E drawings. In general, these requirements are in accordance with the applicable portions of the ASME Code, Section III, Division 1, Subsection NC for Class 2 vessels with exceptions as discussed in Section 4.9. The cask is designated as an atmospheric pressure vessel and therefore a pressure test is not required. The cask is not N-stamped. The upper lifting trunnions and trunnion sleeves are conservatively designed in accordance with the ANSI N14.6 (4.9) stress allowable requirements for a non-redundant lifting device. All structural welds are ultrasonically or radiographically examined or tested by the dye penetrant method as appropriate for the weld joint configuration. These stringent design and fabrication requirements ensure the structural integrity of the transfer cask and performance of its intended safety function.



SCHEDULE		
FUEL TYPE	CANISTER LENGTH "A"	CAVITY LENGTH "B"
PWR (LONG CAVITY)	186.00	173.00
PWR (STANDARD CAVITY)	186.00	167.00
BWR	196.00	177.50

Figure 4.2-1
Standardized NUHOMS® Canister Shell Assembly

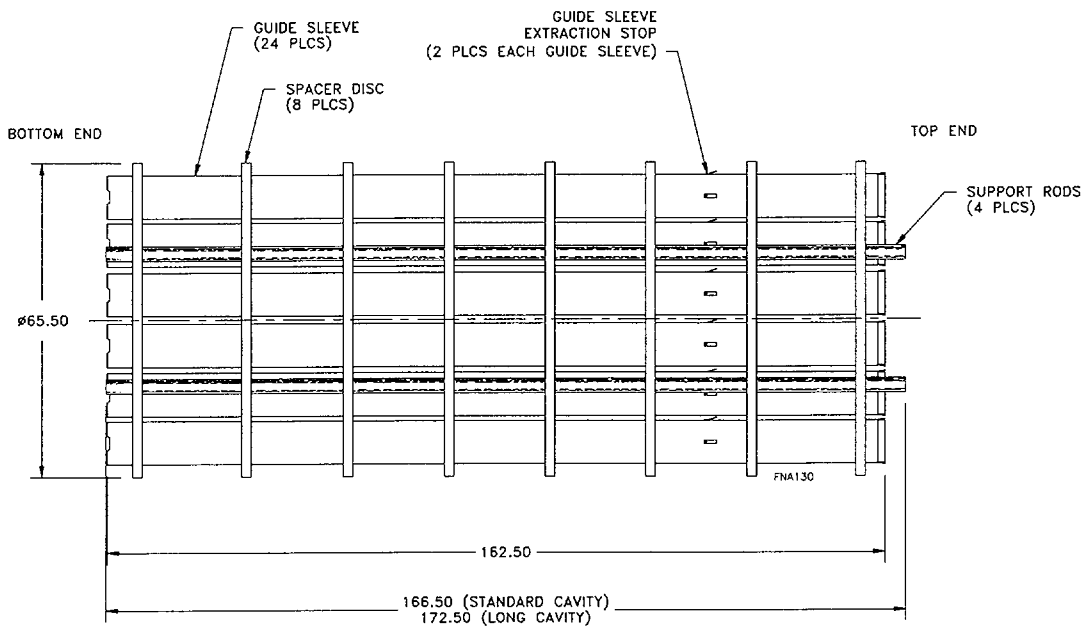


Figure 4.2-2
Standardized NUHOMS®-24P Canister Basket

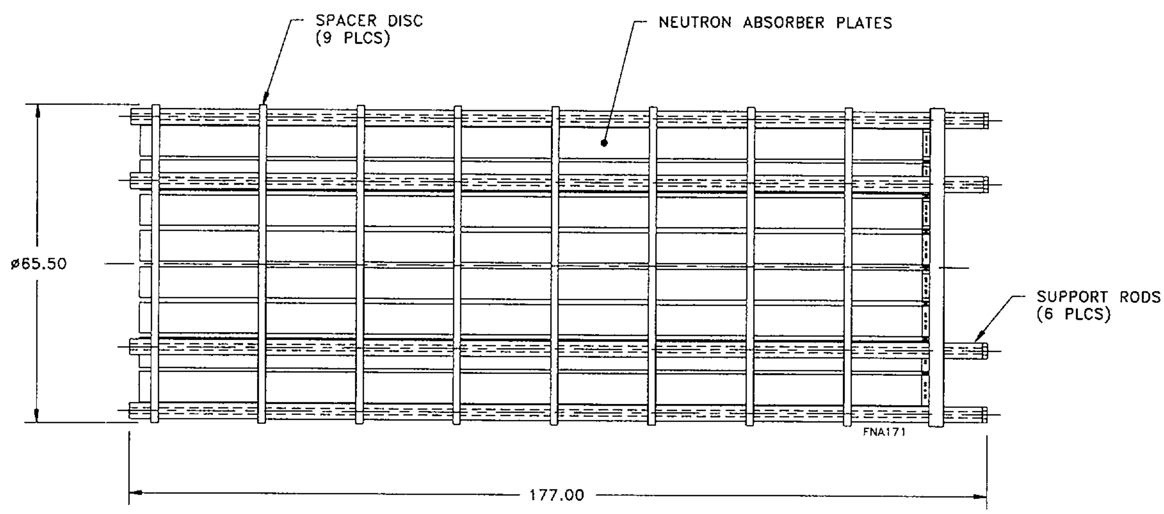


Figure 4.2-3
Standardized NUHOMS®-52B Canister Basket

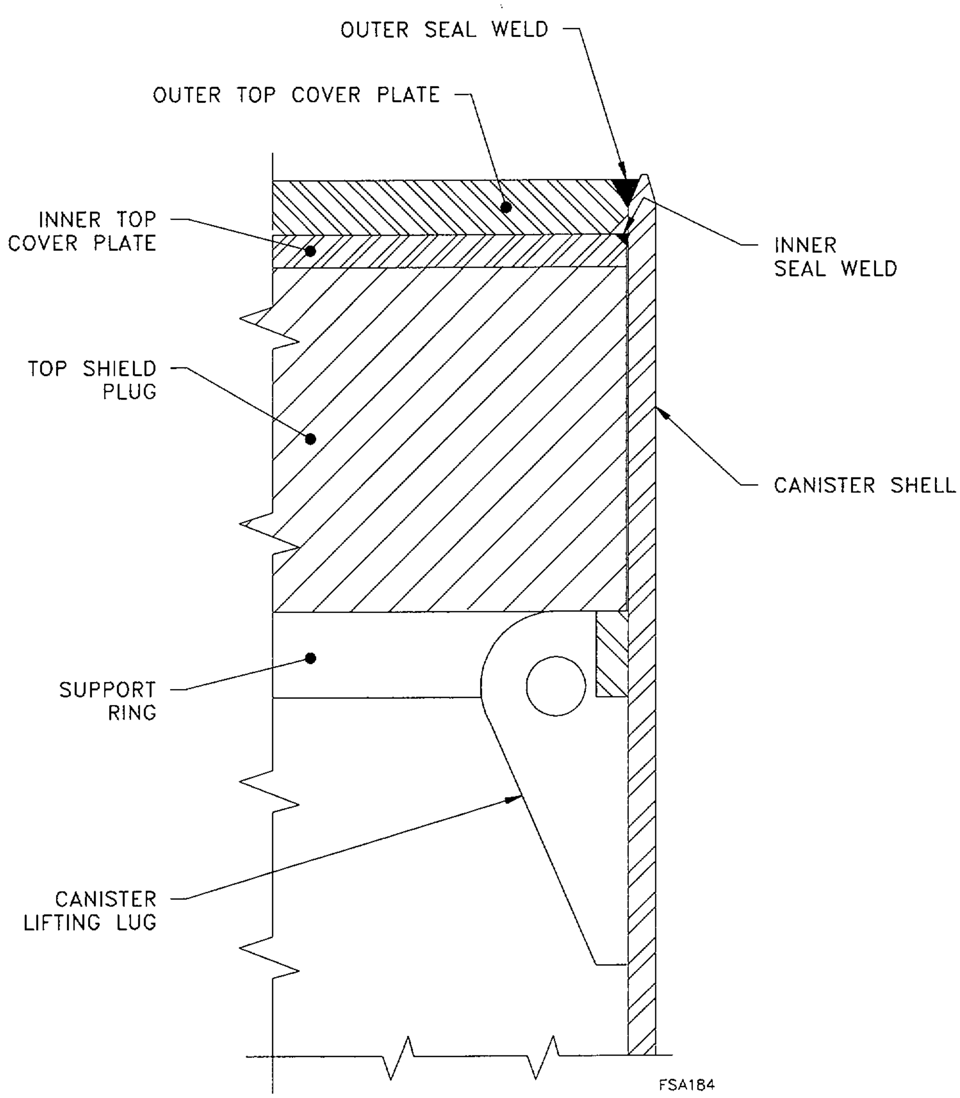


Figure 4.2-4
DSC Top Shield Plug and Cover Plate Closure Welds

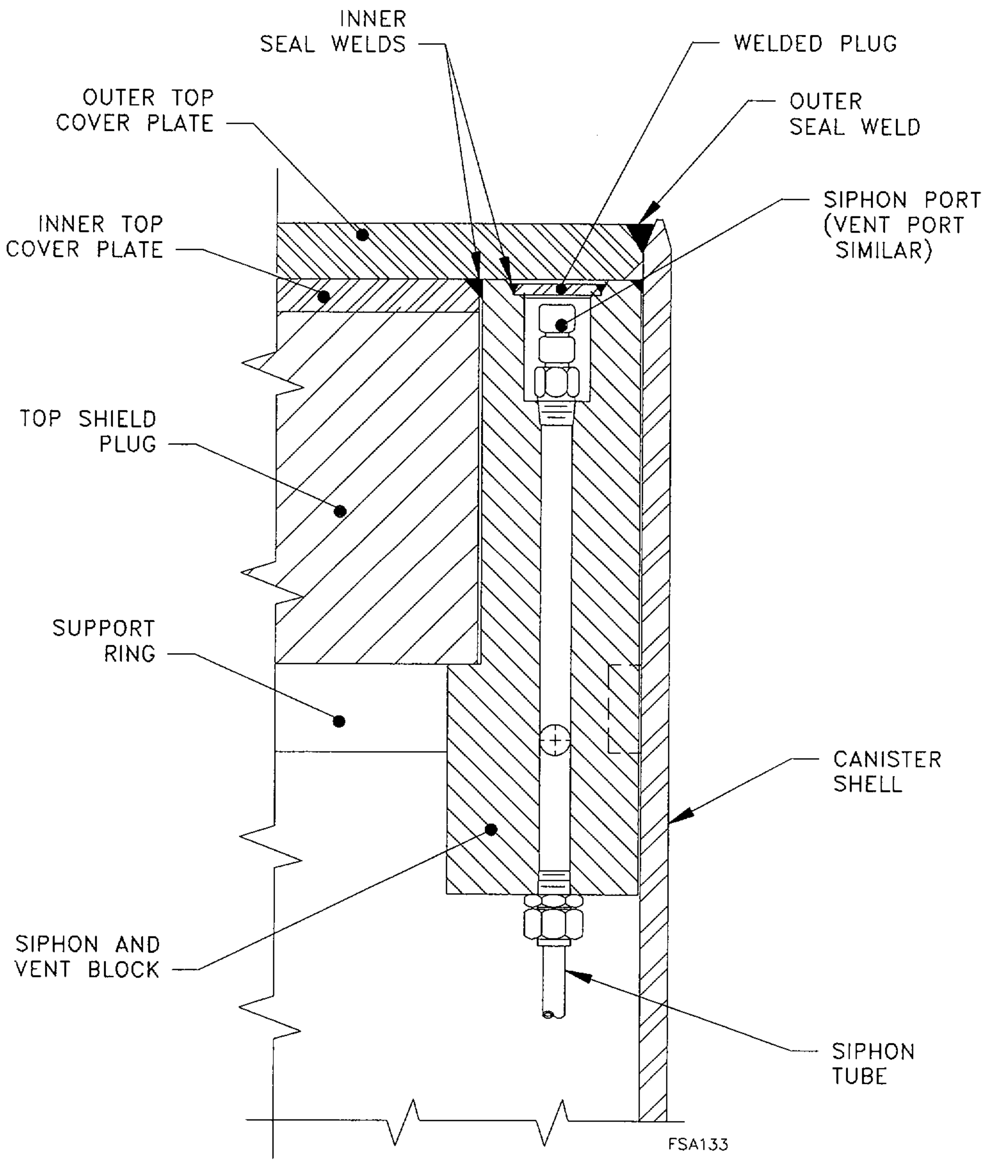
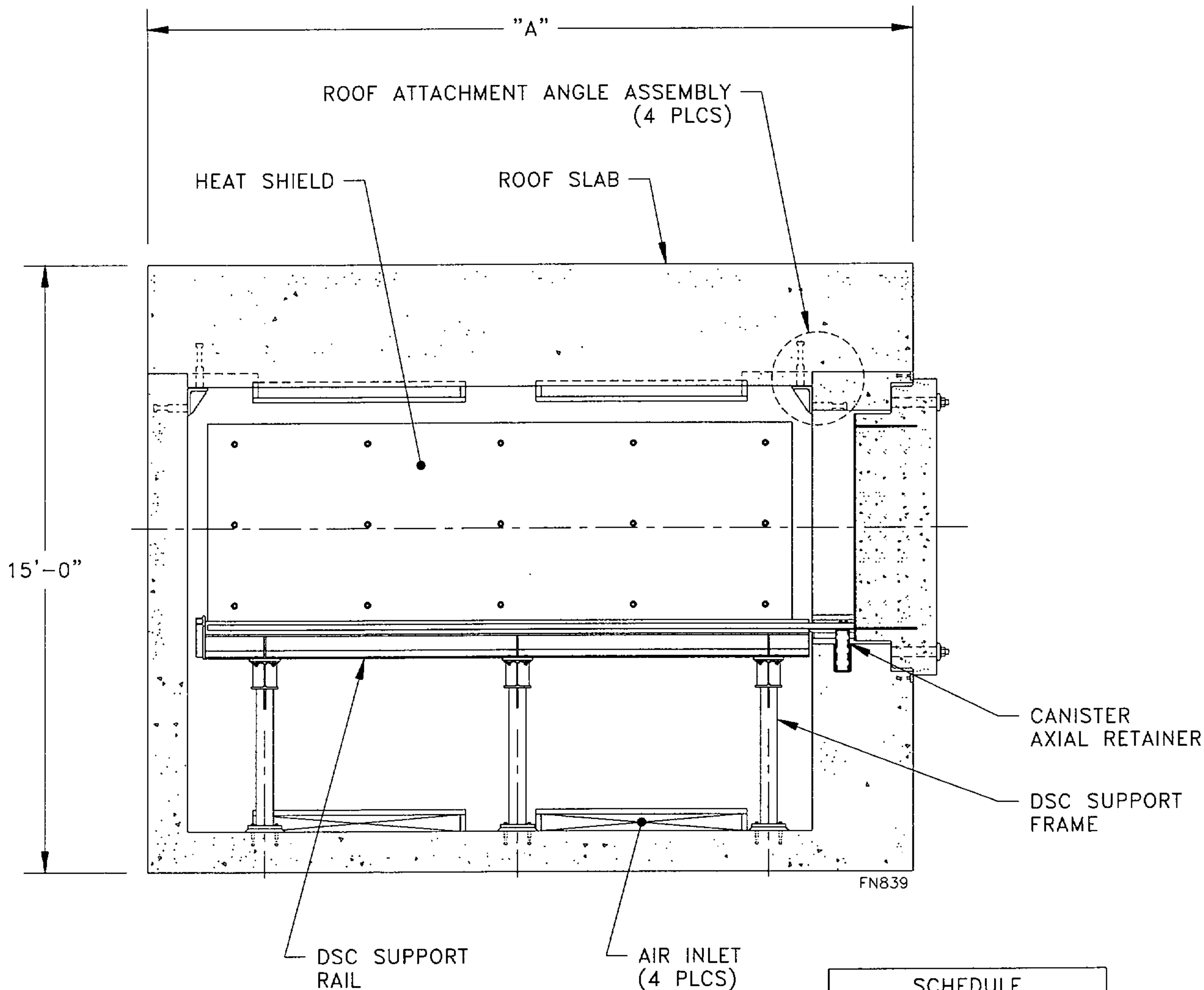


Figure 4.2-5
DSC Siphon and Vent Port Closure Welds



SCHEDULE	
FUEL TYPE	DIMENSION "A" MODULE LENGTH
PWR	19'-0"
BWR	19'-10"

Figure 4.2-6
Prefabricated NUHOMS® HSM (Model 102) Longitudinal Section

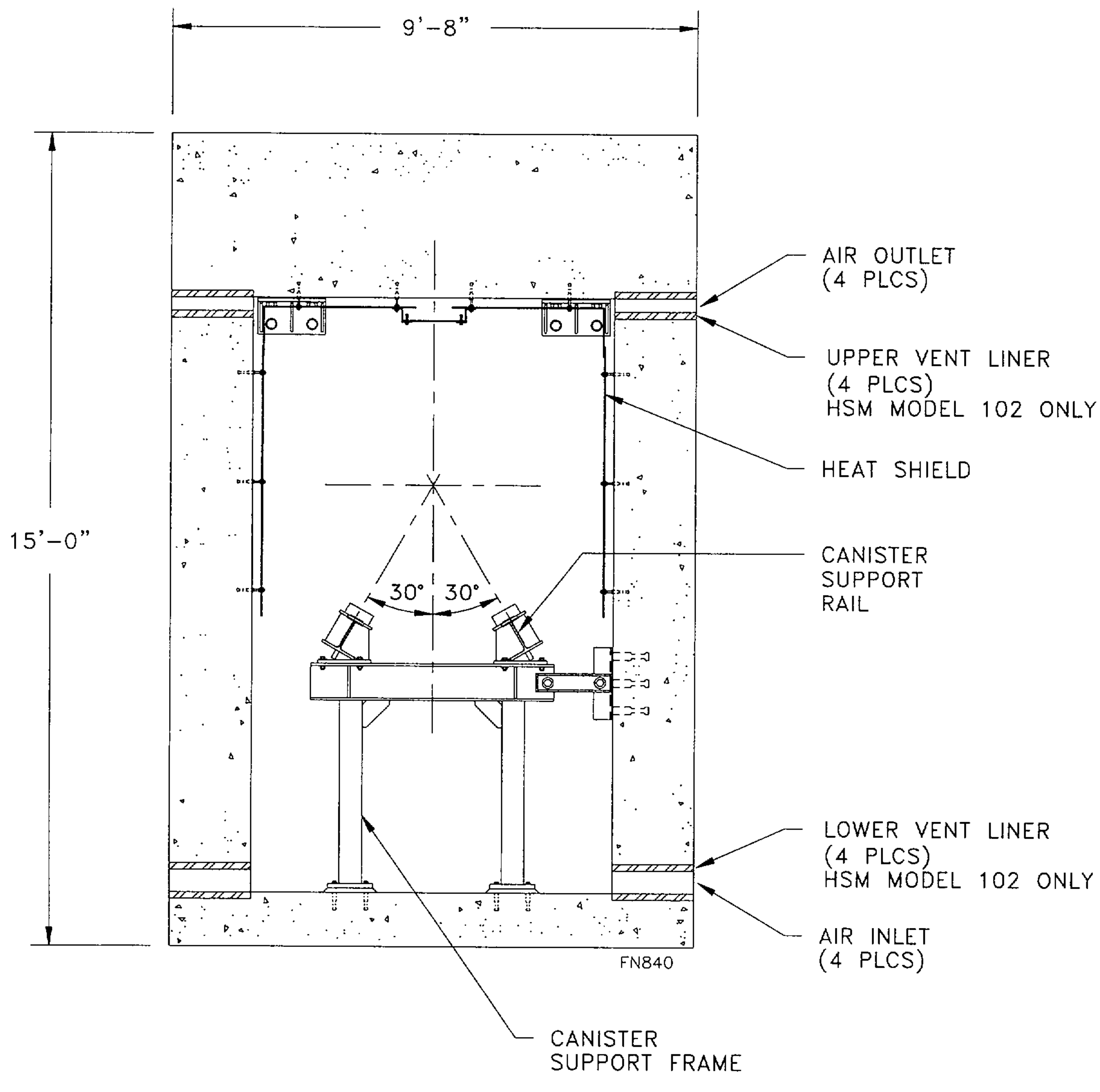


Figure 4.2-7
Prefabricated NUHOMS® HSM (Model 102) Cross-Section

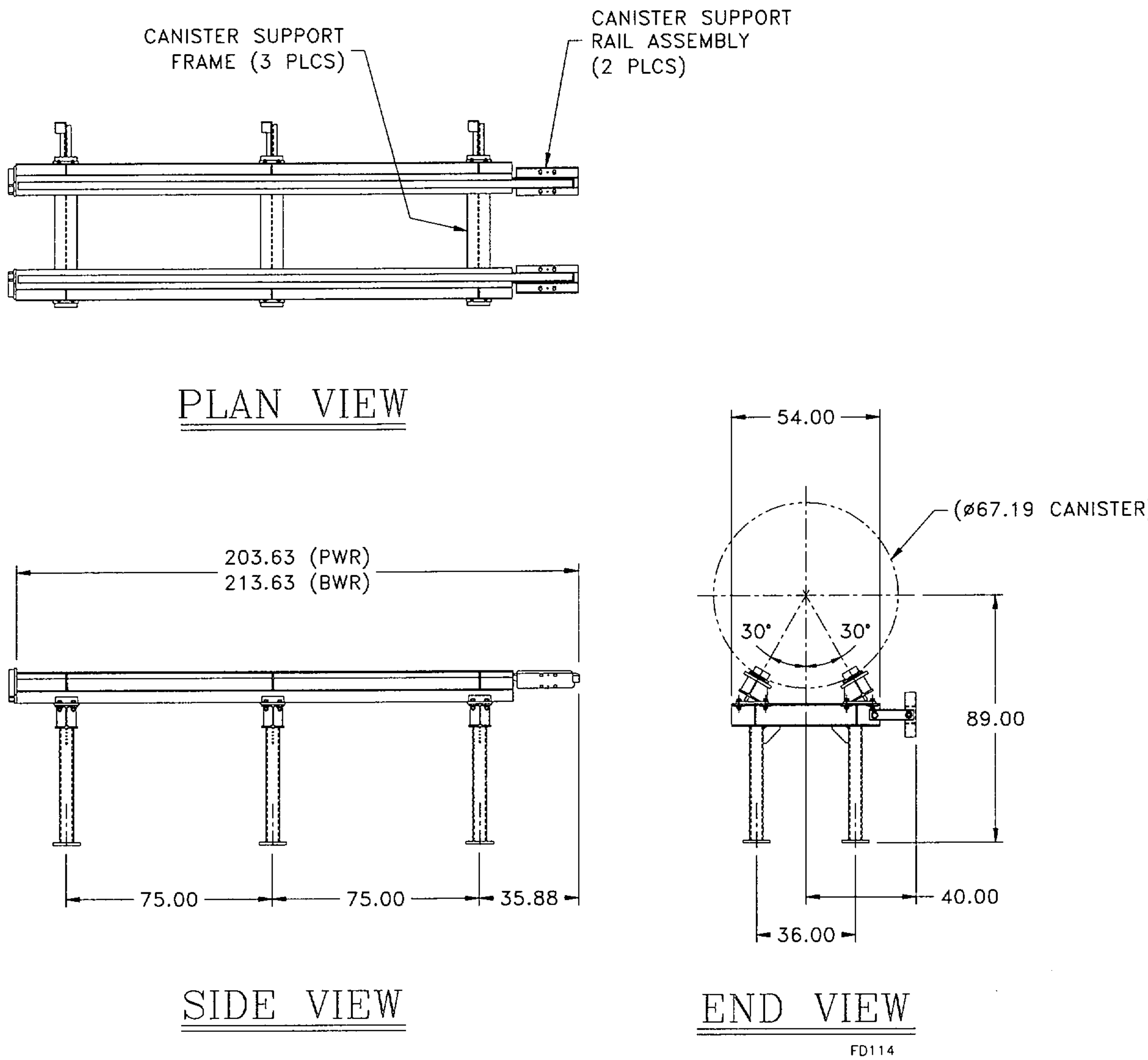


Figure 4.2-8
DSC Support Structure

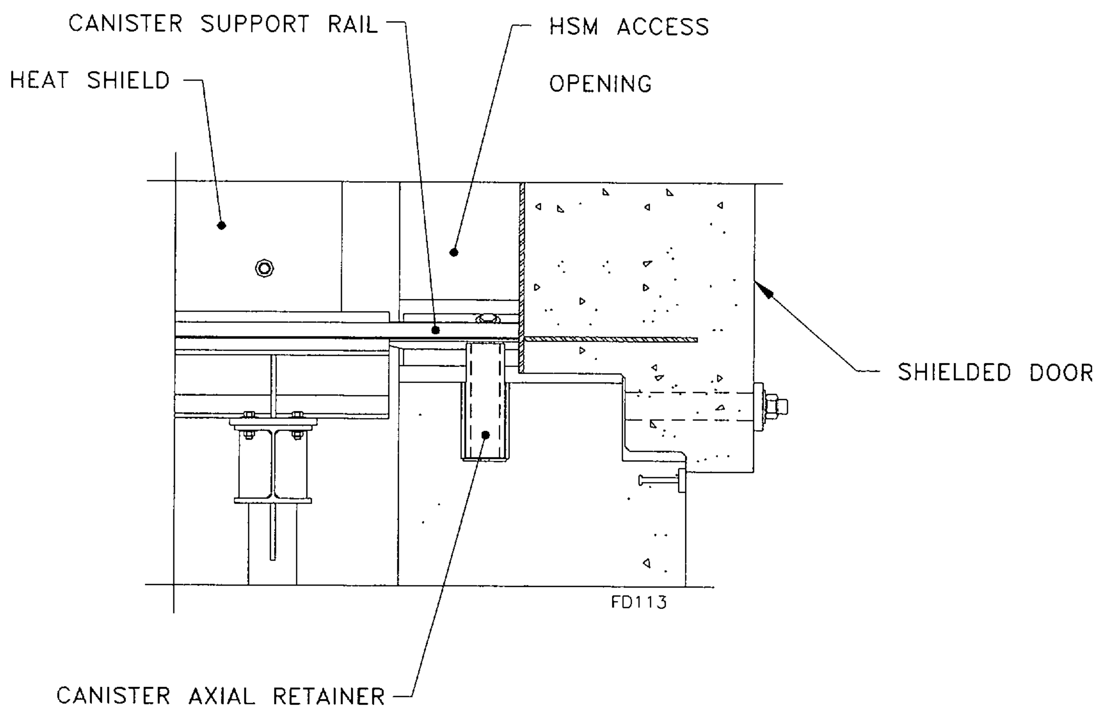


Figure 4.2-9
DSC Axial Retainer

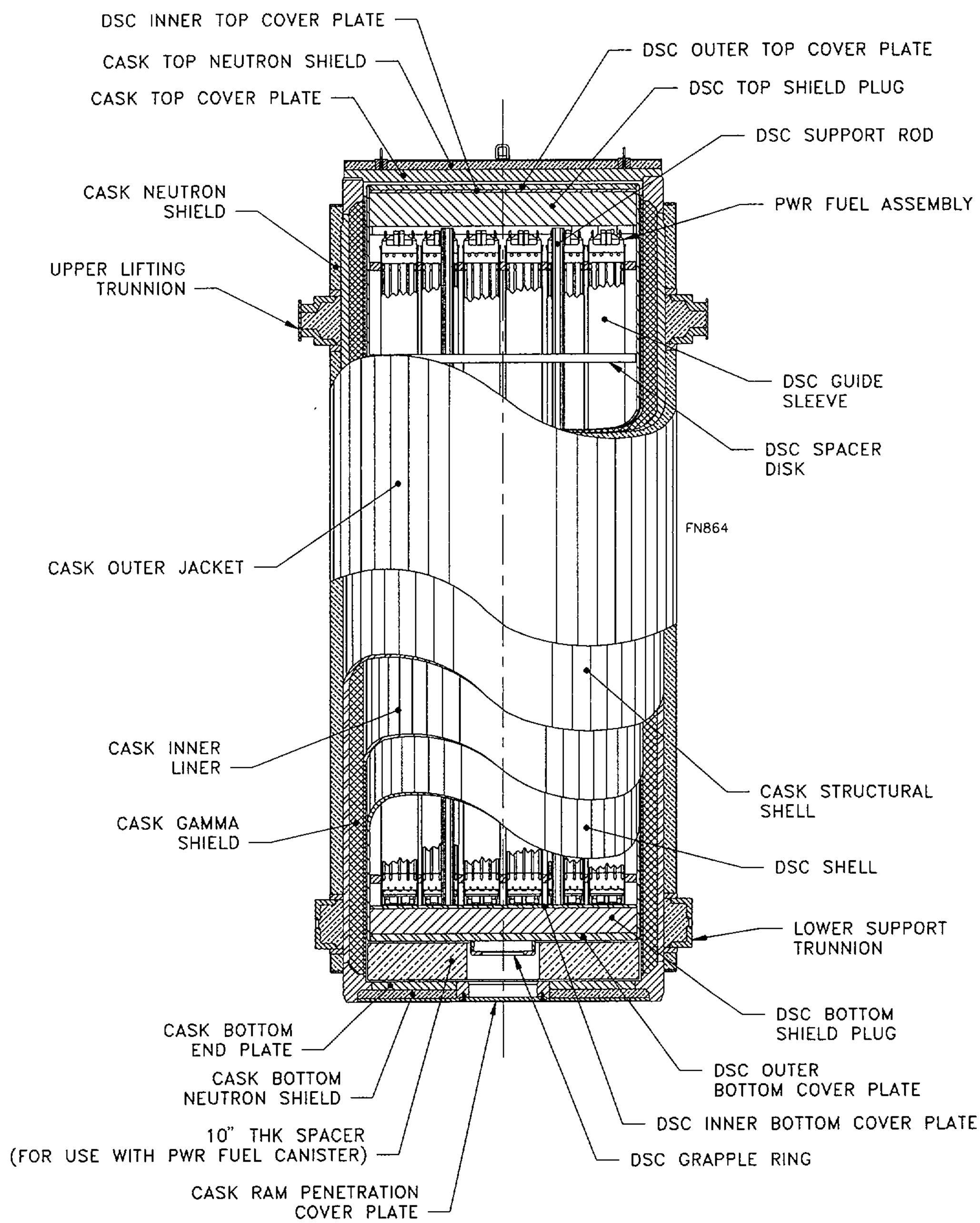


Figure 4.2-10
Composite View of NUHOMS® Transfer Cask and NUHOMS®-24P DSC with Spent PWR Fuel

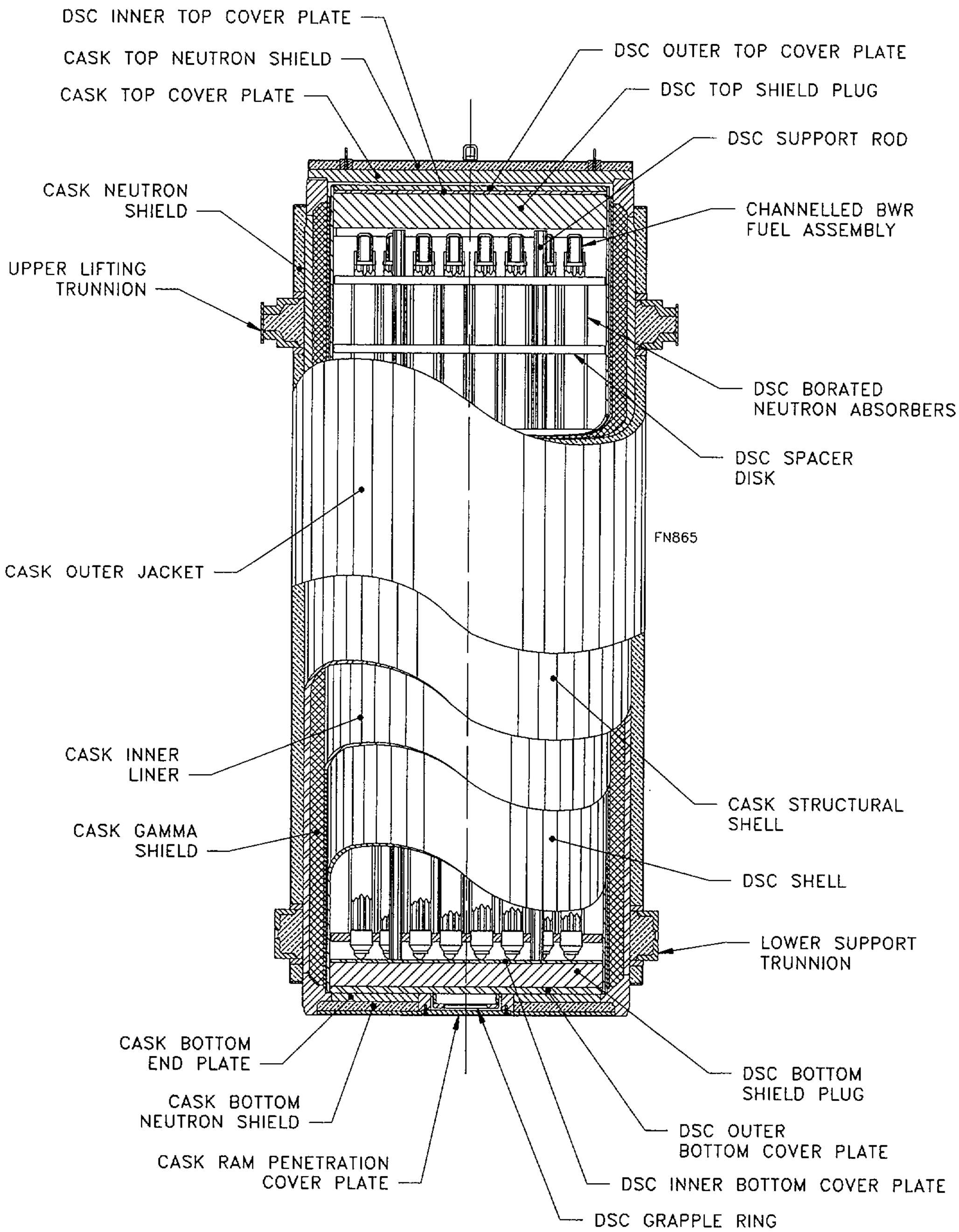
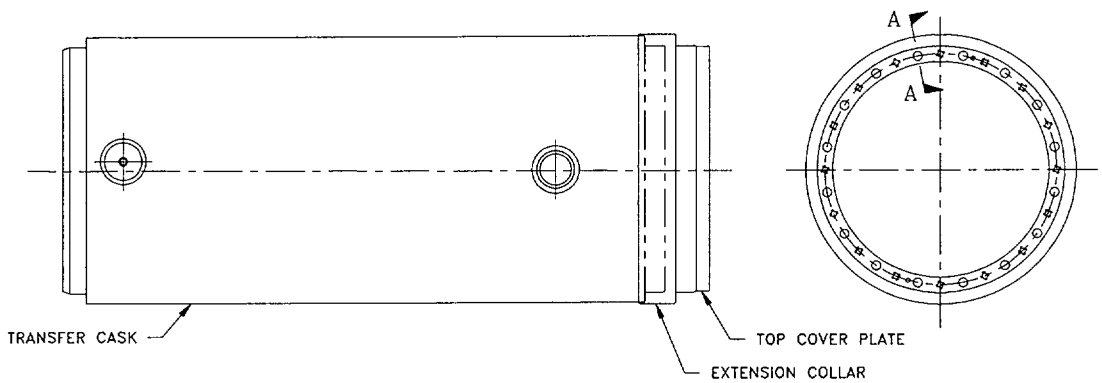
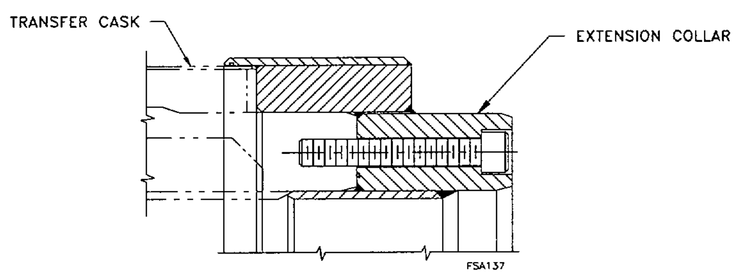


Figure 4.2-11
Composite View of NUHOMS® Transfer Cask and NUHOMS®-52B DSC with Spent BWR Fuel





SECTION A–A

Figure 4.2-12
NUHOMS® On-Site Transfer Cask with BWR Extension Collar

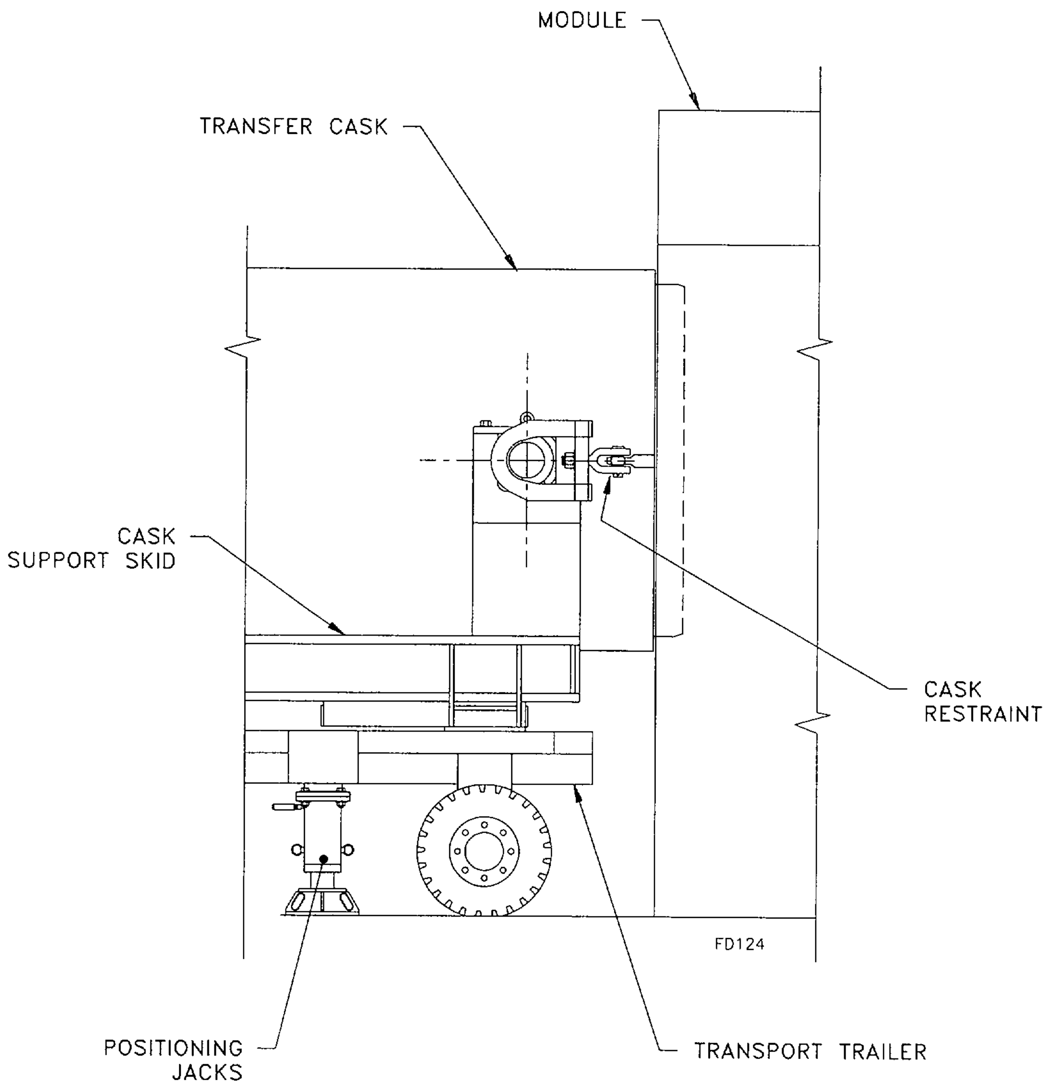


Figure 4.2-13
Elevation View of Transfer Cask Restraint

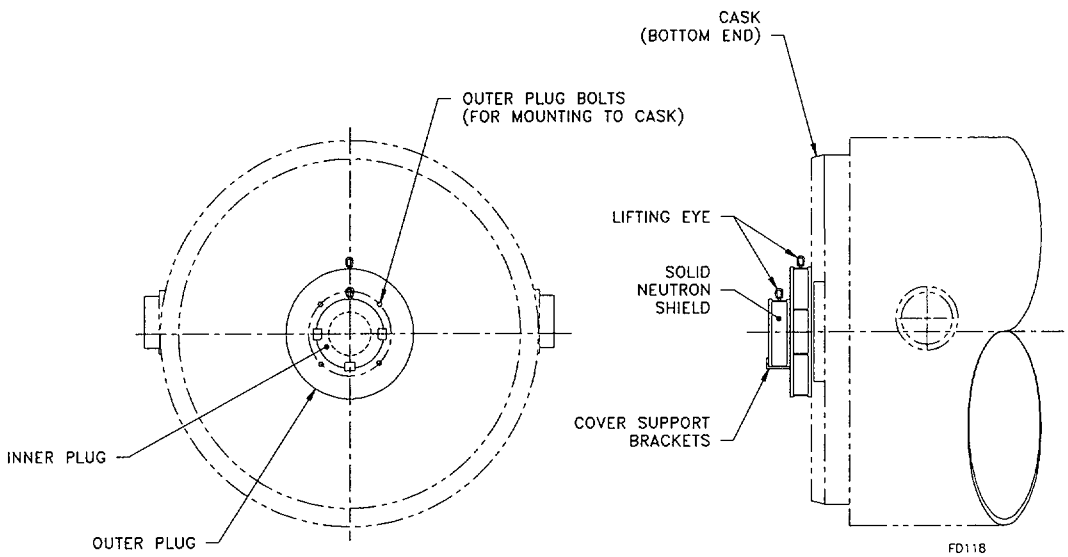


Figure 4.2-14
Transfer Cask Temporary Shield Plug

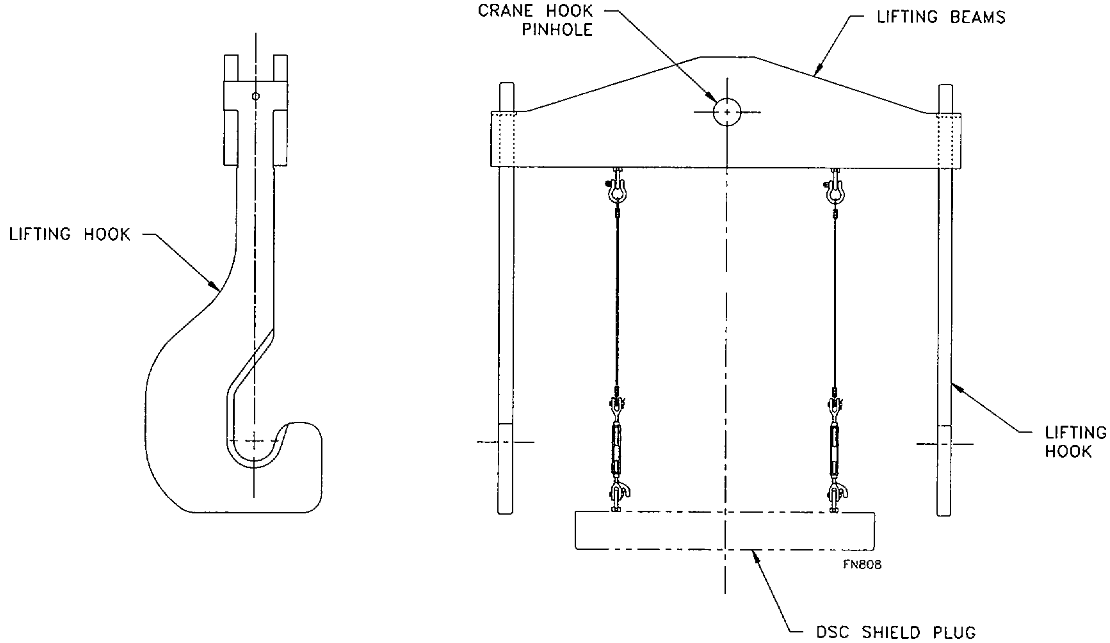


Figure 4.2-15
NUHOMS® Transfer Cask Lifting Yoke

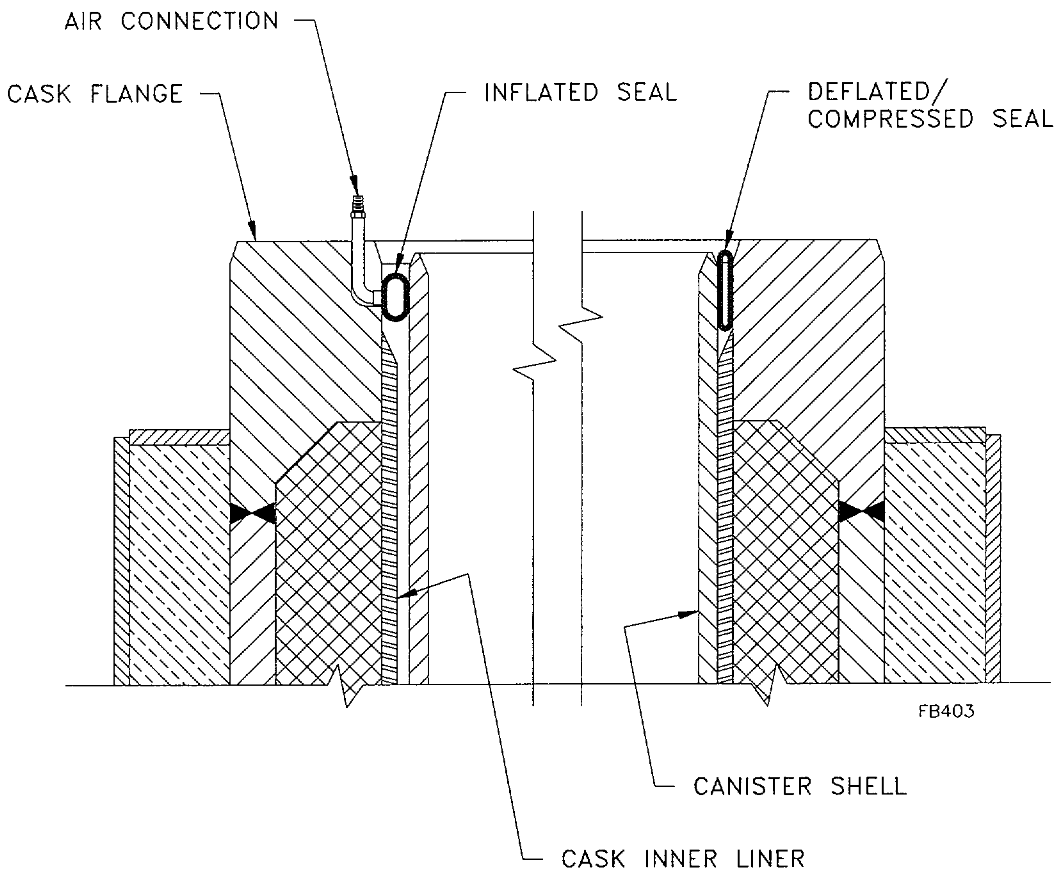


Figure 4.2-16
DSC/Transfer Cask Annulus Seal Detail

4.3 Auxiliary Systems

The NUHOMS® ISFSI is a self-contained, passive storage facility which requires no auxiliary systems.

4.3.1 Ventilation Systems

Spent fuel confined in the NUHOMS® DSC is cooled by conduction and radiation within the DSC; and by conduction, convection and radiation from the DSC surface. Air inlets near the bottom of the HSM side walls and outlets near the HSM roof allow convective cooling by natural circulation. The driving force for this ventilation process is thermal buoyancy. The analysis of the HSM ventilation system is described in Section 8.1.3. No auxiliary ventilation is used or required at the ISFSI. Fuel loading/unloading and DSC closure/opening operations take place in the plant's fuel/reactor building which utilize the existing ventilation system in that facility.

4.3.1.1 Off-Gas Systems

There are no off-gas systems required for a NUHOMS® ISFSI. Any off-gas systems required during the DSC drying and backfilling operations utilize existing plant systems.

4.3.2 Electrical Systems

No electrical systems are required for the HSM or DSC during storage conditions other than for lighting and security system power except for the HSM temperature monitoring. Nonessential electrical power is used during DSC closure operations and during DSC transfer operations to the HSM. The required electrical power in the fuel/reactor building is obtained from existing plant systems. Power at the ISFSI is generally supplied from a retail source.

4.3.3 Air Supply System

An air supply system may be used to force water from the DSC during closure operations.

4.3.4 Steam Supply and Distribution System

There are no steam systems utilized.

4.3.5 Water Supply System

The NUHOMS® system for loading of PWR fuel requires borated water for the DSC cavity compatible with the plant's existing fuel pool and technical specification limits.

(Borated water may be supplied from the plant's spent fuel pool for this purpose.) Demineralized water or spent fuel pool water is used for the DSC cavity during loading of BWR fuel. Demineralized water is also needed for filling the DSC/cask annulus and for transfer cask and lifting yoke washdown operations. This water is supplied by existing plant systems.

4.3.6 Sewage Treatment System

There are no sewage treatment systems required for a NUHOMS® ISFSI.

4.3.7 Communications and Alarm System

No communication systems are required for the safe operation of a NUHOMS® ISFSI. The existing plant paging and telephone system is generally extended to the ISFSI for convenience during transfer operations. The ISFSI security alarm system is to be described in the ISFSI Security Plan prepared by the licensee.

4.3.8 Fire Protection System

No fire detection or suppression system is required for a NUHOMS® ISFSI. The HSM contains no combustible materials. The potential for fire hazards near the ISFSI should be addressed by the licensee. The provisions needed for fire response should be provided consistent with existing plant requirements.

4.3.9 Maintenance Systems

The NUHOMS® system is designed to be totally passive with minimal maintenance requirements. During fuel storage, the system requires only periodic inspection of the air inlets and outlets to ensure that no blockage has occurred.

The transfer cask is designed to require only minimal maintenance. Transfer cask maintenance is limited to periodic inspection of critical components and replacement of damaged or nonfunctioning components. A discussion of these requirements is provided in Section 4.5.

4.3.10 Cold Chemical Systems

There are no cold chemical systems for a NUHOMS® ISFSI.

4.3.11 Air Sampling System

No air sampling systems are required for a NUHOMS® ISFSI. Any airborne activity which may occur during fuel loading/unloading and DSC closure/opening operations is monitored by the existing fuel/reactor building ventilation and radiological detection systems.

4.3.12 Instrumentation

As required by the specifications in Chapter 10, a 'Not Important to Safety' Temperature Monitoring System shall be installed on the HSM.

4.4 Decontamination System

4.4.1 Equipment Decontamination

No decontamination equipment is required at a NUHOMS® ISFSI. The principal decontamination activity performed in the plant's fuel/reactor building is the removal of contamination from the outside surfaces of the transfer cask, lifting yoke, and upper end of the DSC shell. Such contamination is due to immersion in the spent fuel pool. To prevent contamination of the DSC exterior surface and the transfer cask cavity by pool water, the annulus between the DSC and cask is filled with clean demineralized water prior to insertion into the pool. The annulus is then sealed closed with an inflatable seal.

Upon withdrawal from the fuel pool, the exterior surfaces of the transfer cask, lifting yoke, and upper end of the DSC are sprayed with a high pressure hose and subsequently decontaminated to levels consistent with existing plant technical specifications prior to proceeding with transfer operations to the ISFSI. Decontamination operations are generally performed in the fuel/reactor building's cask washdown pit using detergent and wiping cloths.

As part of DSC closure operations, the seal is removed and the water in the cask/DSC annulus drained by means of the cask drain. The DSC exterior surface is checked for smearable contamination to a depth of about one foot below the top surface to verify that neither the exterior of the DSC nor the transfer cask cavity has become contaminated. If no smearable contamination has penetrated to this depth, the DSC exterior is presumed to be clean throughout its length. If smearable contamination exceeds technical specification limits, then the annulus is flushed with clean demineralized water until acceptable smearable contamination levels are obtained.

4.4.2 Personnel Decontamination

No personnel decontamination facilities are needed for a NUHOMS® ISFSI. Personnel decontamination in the plant's fuel/reactor building, if necessary, utilize existing plant equipment and procedure.

4.5 Transfer Cask and Lifting Hardware Repair and Maintenance

(for information only)

The transfer cask is designed to minimize maintenance and repair requirements. These operations may be performed at existing plant maintenance facilities or any suitable location since transfer cask contamination levels are maintained below transportable limits.

4.5.1 Routine Inspection

The following inspections should be performed prior to each use of the transfer cask and lifting hardware:

A. Visual inspection of the cask exterior for cracks, dents, gouges, tears, or damaged bearing surfaces. Particular attention should be paid to the cask trunnions and lifting yoke.

B. Visually inspect all threaded parts and bolts for burrs, chafing, distortion or other damage.

C. Check all quick-connect fittings to ensure their proper operation.

D. Visually inspect the interior surface of the cask for any indications of excessive wear to bearing surfaces.

E. Visual inspection of neutron shield jacket.

4.5.2 Annual Inspection

The following inspections and tests shall be performed on an annual basis:

A. Test the cask cavity quick-connect fittings and ram penetration seal for leak tightness.

B. Examine the cask trunnions and cask lifting yoke.

Any parts which fail these tests shall be repaired or replaced as appropriate.

Any indications of damage, failure to operate, or excessive wear should be evaluated to ensure that the safe operation of the cask is not impaired. Damage which impairs the ability of the cask to properly function should be repaired or replaced. This work may be performed on site, depending upon the capabilities of the site resources, or at an approved vendor's facility. Repairs should be performed in accordance with the manufacturer's or cask designer's recommendations.

4.6 Cathodic Protection

The NUHOMS® ISFSI is dry and above ground so that cathodic protection in the form of impressed current is not required. The normal operating environment for all metallic components is well above ambient air temperatures so that there is no opportunity for condensation on those surfaces.

The austenitic stainless steel DSC requires no corrosion protection for any foreseeable event. The carbon steel basket in the DSC is protected from corrosion by a metallic coating. This coating protects the basket for the duration between fabrication and fuel loading. After the DSC is sealed, dried, and backfilled with helium, the basket is maintained in an inert environment and is not subject to corrosion.

The DSC support structure in the HSM is coated carbon steel and requires no additional protection against the expected environment. The HSM heat shield is galvanized for corrosion protection.

Any carbon steel used in the transfer cask is protected from corrosion by suitable coatings. Although the transfer cask top cover plate is not exposed to pool water, it is also protected by a suitable coating, if carbon steel.

4.7 Fuel Handling Operation Systems

Fuel handling for a NUHOMS® ISFSI is performed in two general locations. Individual fuel assemblies are loaded into the DSC in the plant's fuel/reactor building. Once confined in the DSC, the fuel is transported to the ISFSI and the DSC is inserted into the HSM. Fuel handling activities inside the fuel/reactor building are performed under the plant's 10CFR50 license. Fuel handling operations outside the fuel/reactor building are performed under the 10CFR72 license as described in this SAR. Fuel handling systems utilized in the fuel/reactor building include:

A. Cask handling crane

B. Spent fuel handling machine

C. Transfer cask and lifting devices

The fuel handling systems utilized outside the fuel/reactor building include the equipment required to transport the DSC to the HSM and insert the DSC into the HSM. These are the:

A. Transfer Cask

B. Transport Trailer and Skid

C. Skid Positioning System

D. Hydraulic Ram System

4.7.1 Structural Specifications

The cask handling crane and spent fuel handling machine are described in the plant's 10CFR50 SAR. The codes and standards for the transfer cask and transfer equipment are described in Section 4.7.4.

4.7.2 Installation Layout

The layout of the fuel/reactor building is shown in the plant's 10CFR50 SAR. The layout of a NUHOMS® ISFSI is discussed in Section 4.1. General layout criteria for the ISFSI site (such as fence location, distance to site boundary, distance to personnel, work areas, etc.) which have radiological dose impact are to be addressed by the licensee.

4.7.2.1 Building Plans

Plans for a typical NUHOMS® ISFSI are provided in Figures 1.3-11 through 1.3-13. The building plans for an individual plant ISFSI are site specific and are to be prepared by the licensee in accordance with industry codes and standards.

4.7.2.2 Building Sections

Sections for a typical NUHOMS® ISFSI are provided in Appendix E. The building plans for an individual plant ISFSI are site specific and are to be prepared by the licensee in accordance with industry codes and standards.

4.7.2.3 Confinement Features

The confinement features of the NUHOMS® system are described in Section 3.3.2.

4.7.3 Individual Unit Descriptions

4.7.3.1 Fuel/Reactor Building Equipment

The cask handling crane is used for all DSC and transfer cask movements within the fuel/reactor building. The spent fuel handling machine is used to load spent fuel assemblies into the DSC.

Records of the SFAs which are candidates for dry storage are to be reviewed to ensure conformance with the required fuel characteristics delineated in Chapter 10, and to ensure mechanical and structural integrity prior to placement in the DSC. If plant records indicate that the structural integrity of the fuel assemblies is adequate, inspection of the fuel assembly may not be required. The fuel assembly identification number must always be visible and recorded prior to placement into the DSC in order to maintain fuel accountability.

The SFAs are placed into the DSC while the DSC is resting in the cask cavity in the spent fuel pool. The general layout of the spent fuel pool area is shown in the plant's 10CFR50 SAR. Each time a DSC containing spent fuel is moved or handled, the DSC resides inside the cavity of the transfer cask.

Prior to placement of the DSC into the fuel pool, the top shield plug is rigged for fit-up with the DSC shell as follows:

A. The shield plug is rigged and placed on the DSC to recheck proper fit-up with the DSC shell assembly. During the fit-up operation the shield plug lifting cables, attached to the cask lifting yoke, may require adjustment or tensioning to ensure that the plug fits squarely into the DSC shell assembly when suspended from its rigging. Once the rigging has been adjusted, the plug should fit true in subsequent lift and placement operations in the pool.

B. At many plants, the cask decontamination area and fuel pool are not in the same area/building. By moving the shield plug and DSC/transfer cask in one movement, the need for a number of crane movements is minimized and the fuel loading process is expedited. In addition, at some plants, because of space limitations in the areas surrounding the fuel pool, the cask lid or shield plug and cask yoke may be left in the pool during the fuel loading process.

Placement of the top shield plug into the DSC in the fuel pool following completion of the fuel loading is performed in gradual movements to ensure that misalignment or damage to components does not occur. Because of the extremely slow speed of the crane hoist during shield plug placement, the water flow rate out of the cask is not excessive. A gap exists between the top shield plug and DSC shell which permits unrestricted flow of the displaced water out of the DSC. The vent and siphon ports may be left open for this operation, although it is not necessary.

With reference to the generic operating procedures outlines in Chapter 5, the following description is provided to illustrate how the top shield plug installation operation can be accomplished. Detailed operating procedures are to be developed by the licensee on a site specific basis.

After the spent fuel assemblies have been placed into the DSC, install the shield plug as follows:

A. Position the shield plug over the DSC so that the shield plug aligns with the DSC. Tag lines may be used to assist in precise positioning. An underwater viewing box or CCTV cameras may be used to verify correct installation.

B. Lower the crane hook until the shield plug is seated on the DSC and sufficient slack exists in the lifting cables to permit attachment of the yoke to the cask.

C. During placement of the shield plug, the following observations should be made to ascertain that the shield plug is seated properly:

    1. Observe the shield plug and DSC to ensure that the shield plug is seated with the DSC shell uniformly.

    2. Ascertain that all shield plug lifting cables slacken simultaneously.

    3. After shield plug placement, an underwater television camera, periscope, or other method may be used to inspect the height of the DSC shell above the shield plug to make sure that it is uniform and that the DSC siphon and vent port is flush with the shield plug.

D. Corrective action which may be taken if the top shield plug is cocked:

1. Slowly raise the shield plug from the DSC. When it clears the DSC shell, laterally move the crane trolley toward the low side of the cocked shield plug.

2. Re-seat the shield plug and inspect for correct placement. Repeat this operation if necessary, making slight lateral adjustments to the crane trolley.

3. If this fails, it may be necessary to adjust the shield plug rigging. This is accomplished by bringing the shield plug out of the pool and placing it on a stand or the floor. Adjust the length of the cables as necessary.

During the draining and drying operation, the water in the DSC cavity is removed by supplying compressed air, nitrogen or helium through the vent port, forcing water out through the siphon port. The inlets to the siphon and vent ports have quick release connections (Figure 4.7-1). The quick-release connections remain closed unless a connection is made. These quick-release valves insure that no accidental release of radioactive material occurs through the siphon or vent ports.

The basic configuration for both the siphon and vent ports used during the drying process consists of a hose with a valve on each end and a quick release connection to the DSC. One of the valves is connected to the siphon or vent port. This valve is designated as Valve No. 1 of the draining and drying system (see Figure 4.7-1). The valve at the other end of the hose is designated as Valve No. 2 of the draining and drying system. All auxiliary equipment and radioactive waste systems are connected to Valve No. 2. The type or method of connection is dependent on the equipment used at the plant and will be selected by the licensee.

Valve No. 1 for both the vent and the siphon ports remains open during most of the drying operation. The flow is regulated with Valve No. 2. Valve No. 1 acts as a redundant valve and is only used if Valve No. 2 should fail or a leak in the hose should develop. By using Valve No. 2 as the flow regulator as well as the connection point between the auxiliary system and the DSC, the amount of time which personnel are exposed to radiation is minimized. Once the connection between Valve No. 1 and the siphon or vent tube is made, additional shielding may be placed over the shield plug to further reduce personnel radiation exposure.

All discharges from the DSC cavity, whether gas or water, are routed to the plant's existing radioactive waste system or spent fuel pool. Water from the DSC cavity may be routed back to the plant's fuel pool as appropriate. Therefore, all radioactive materials or particles are confined within a closed controlled system.

Once all the water has been forced out of the DSC cavity with compressed air, nitrogen or helium, the remaining moisture contained within the cavity is removed with a vacuum drying system. The vacuum drying system evacuates the DSC cavity and lowers the moisture content to an acceptable level.

The suction line of the vacuum drying system is connected to the DSC vent and siphon ports. A hose is connected from the discharge outlet of the vacuum drying system to the plant's radioactive waste system or spent fuel pool. A particle filter is located on the suction side of the vacuum drying system. The filter is used to capture any radioactive particles that may be entrained within the gas thereby preventing contamination of the vacuum drying system. A drain in the vacuum suction line allows any liquid water remaining in the DSC cavity to be routed directly to the plant's radioactive waste system or spent fuel pool. The vacuum drying system is completely closed so that all radioactive material is confined within a controlled system.

During the drying and final sealing operations of the DSC, the inner seal weld confines any radioactive particles in the DSC cavity. The pressure boundary is formed by welding the inner top cover plate to the DSC shell using remote automatic welding equipment (see Figure 4.7-2). The vent port remains open and vented at atmosphere pressure to the plant's radwaste system during welding of the inner top cover plate. Fabricated plugs are placed over the siphon and vent port openings and welded into place. Once the DSC has been dried and backfilled with helium, the outer top cover plate is lowered onto the DSC. Again, using remote automatic welding equipment, the outer top cover plate is welded in place. These welded joints act as barriers for confining all radioactive material within the DSC throughout the service life of the DSC.

The canister Automatic Welding System consists of two major components, the welding machine itself as shown in Figure 4.7-2, and the control panel/power supply which is not shown. The control panel and power supply, along with the purge gas bottle, can be located at any convenient position for the operator within the range of the umbilical cables, usually about 50 feet. The use of an automatic welding machine is considered essential for ALARA operations in routine use. Manual welding of any of the closure welds is permissible, but is recommended only for purposes of weld repair or as a recovery procedure if the machine becomes non-operational during the closure process. Small weldments such as the vent and siphon port plug seals may be made manually as part of routine operations because of the short stay time required for the small weld volume.

4.7.3.2 Transfer Cask

The transfer cask is a cylindrical vessel with a bottom end closure assembly and a bolted top cover plate as shown in Figure 1.3-6. The cask's cylindrical walls are formed from three concentric steel shells with lead poured between the inner liner and the structural shell to provide gamma shielding during DSC transfer operations. The outer shell forms an annular vessel with a neutron absorbing material placed between the structural shell and outer shell to provide neutron shielding during DSC transfer operations.

The cask bottom end assembly is welded to the cylindrical shell assembly and includes two closure assemblies for the ram grapple access penetration. A water tight bolted cover plate is used for transfer operation within the plant's fuel/reactor building. The bolted ram access penetration cover plate assembly may be replaced by a two piece neutron shield plug assembly for transport operations from the plant's fuel/reactor building to the ISFSI as shown in Figure 4.2-14. Transport trailers with an integral ram will not utilize a shield plug assembly. At the ISFSI site, the inner shield plug of the neutron shield plug assembly is removed to provide access for the ram and grapple to push the DSC into the HSM.

The top cover plate is bolted to the top flange of the cask during transport from the plant's fuel/reactor building to the ISFSI. The top cover plate assembly consists of a thick structural plate with a thin shell encapsulating solid neutron shielding material. Two upper lifting trunnions are located near the top of the cask for downending/uprighting and lifting of the cask in the fuel/reactor building. Two lower trunnions, located near the base of the cask, serve as the axis of rotation during downending/uprighting operations and as supports during transport to the ISFSI.

The material selected for use as a solid neutron shield material is a cementitious shop castable, fire resistant material with a high hydrogen content which is designed for use in shielding doors, hatches, plugs, and other nuclear applications. The solid neutron shielding material used in the cask outer annular cavity, top and bottom covers, produces water vapor and a small quantity of non-condensible gases when heated above 212°F. The off-gassing produces an internal pressure which increases with temperature. As the temperature is reduced, the off-gas products are reabsorbed into the matrix, and the pressure returns to atmospheric. The maximum steady state temperature of the material is calculated conservatively for an extreme ambient day with a design basis decay heat load. This temperature, assumed to exist throughout the entire shield, results in an internal cavity pressure. This pressure is well within the design allowable value for the neutron shield cavity. The release of off-gas products (water vapor) does not affect the predicted neutron doses since the hydrogen content assumed in the shielding analysis is conservative. This is exceeded by the manufacturer's guaranteed minimum hydrogen content and actual test sample values of as-delivered product.

The material selected for the liquid neutron shield material is water. Precautionary measures shall be taken to ensure that the water does not freeze during cold weather operations.

Although the loss of the neutron shield is highly unlikely, the loss of neutron shield accident case is analyzed in Section 8.2.5.3. The transfer cask is designed to provide adequate shielding to maintain the maximum radiation surface dose to less than 5 R/hr combined gamma and neutron for a cask drop accident event assuming a complete loss of neutron shielding.

The transfer cask is designated important to safety since it provides biological shielding and structural protection for the DSC from impact loads. The codes and standards used to design and fabricate the transport cask are presented in Section 4.7.4.

4.7.3.3 Transport Cask Lifting Yoke

The lifting yoke is a special lifting device which provides the means for performing all cask handling operations within the plant's fuel/reactor building. It is designed to support a loaded transfer cask. A lifting pin connects the fuel/reactor building cask handling crane hook and the lifting yoke. The lifting yoke is shown in Figure 4.2-15.

The lifting yoke is a passive, open hook design with two parallel lifting beams fabricated from thick, high-strength carbon steel plate material, with a decontaminable coating. It is designed to be compatible with the fuel/reactor building crane hook and load block. The lifting yoke engages the outer shoulder of the transfer cask lifting trunnions. To facilitate ease of shipment and maintenance, all yoke subcomponent structural connections are bolted.

The lifting yoke is designated "safety related" since it is in the direct load path of the cask. The codes and standards used to design and fabricate the lifting yoke are presented in Section 4.7.4.

4.7.3.4 Transport Trailer

The transport trailer is designed for use with the NUHOMS® transfer equipment. Its function is to move the cask and cask support skid from the fuel/reactor building to the ISFSI location. Once there, the trailer is raised and remains passive during the transfer for the DSC into the HSM.

The trailer is a commercial grade item of the type commonly used to haul very heavy loads such as transformers, boilers, and construction equipment. An illustration of the trailer is shown in Figure 4.7-3. The codes and standards governing the design and construction of the trailer are provided in Section 4.7.4.

The loading sequence for the cask is shown in Figure 4.7-4 where it is illustrated that the cask is never lifted above the maximum drop height of 80 inches after it is loaded onto the cask support skid. The transport trailer and other transfer equipment is shown in its configuration at the HSM in Figure 1.1-2. The trailer itself is considered not important to safety since its failure would not result in a cask drop exceeding the cases evaluated in Chapter 8.

The trailer is typically configured as a 4x2 dolly. Eight hydraulic suspensions carry four pneumatic tires each and are located in four axle lines. Hydraulic suspensions enable coupled steering of all axles around a common point, thus minimizing tire scuffing and the resulting damage to pavement and tires. The suspensions also allow other advantages, such as adjustable deck height, in-situ lockout or repair of failed suspensions or tires, and automatic compensation for road surface irregularities. The trailer has multi-wheel braking using industrial grade air/spring brakes. The brakes automatically lock on loss of air pressure from the tractor.

4.7.3.5 Skid Positioning System

The functions of the skid positioning system (SPS) are to hold the cask support skid stationary (with respect to the transport trailer) during cask loading and transport, and to provide alignment between the transfer cask and the HSM prior to insertion or withdrawal of the DSC. It is composed of tie down or travel lock brackets and bolts, three hydraulically powered horizontal positioning modules, four hydraulic lifting jacks, and a hydraulic supply and control skid. The SPS hardware which is located on the transport trailer is illustrated in Figure 4.7-5.

The codes and standards governing the design and construction of the SPS are provided in Section 4.7.4. The SPS is considered not important to safety since its failure would not result in a cask drop as severe as the cases evaluated in Chapter 8.

The skid tie down brackets are shown in Figure 4.7-6. The brackets are designed to withstand the design basis loads for the skid which are described in Chapter 8.

The hydraulic jacks are designed to support the loaded cask, skid, and trailer and the loads applied to them during HSM loading and unloading. They are utilized at two locations: in the fuel/reactor building during cask downending, and at the ISFSI during cask alignment and DSC transfer. At both locations, their purpose is to provide a solid support for the trailer frame and skid. Three measures are taken to avoid accidental lowering of the trailer payload: the hydraulic pump is de-energized after the skid has been aligned (the jacks are also hydraulically locked out during operation of the horizontal cylinders); there are mechanical locking collars on the cylinders; and pilot-operated check valves are located on each jack assembly to prevent fluid loss in the event of a broken hydraulic line.

Three hydraulic positioning modules provide the motive force to horizontally align the skid and cask with the HSM prior to insertion or retrieval of the DSC. The positioning modules controls are manually operated and hydraulically powered. The system is designed to provide the capability to align the cask to within the specified alignment tolerance.

Anti-friction pads constructed from woven teflon pads and steel are used to reduce the force required to align the cask. These pads are commonly used as bearings for bridges, tank supports, and hydro/electric gates. Four pads are mounted to the trailer frame. Steel bearing plates mounted on the bottom of the skid longitudinal beams slide on the teflon surfaces and protect them from the weather. The travel of the skid is restricted by the stroke of the hydraulic positioning cylinders. In the event of cylinder failure, travel stops surrounding the bearing plates prevent the skid from excessive travel.

The hydraulic power supply and controls for the SPS may be included as a part of the transfer trailer hydraulics or, as an option, can be located on a separate skid. The hydraulic pump is powered by an electric motor. Directional metering valves are used to allow precise control of cylinder motions. The SPS is manually operated and has three operational modes: simultaneous actuation of the four vertical jacks or any pair of jacks, actuation of any single vertical jack, or actuation of any one of the three horizontal actuators. Simultaneous operation of the vertical jacks and the horizontal actuators is not possible. Fourteen small hydraulic quick connect lines provide power to the seven SPS hydraulic cylinders.

4.7.3.6 Hydraulic Ram System

The Hydraulic Ram System (HRS) provides the motive force for transferring the DSC between the HSM and the transfer cask. Since operation of the HRS cannot result in damage to the fuel inside the DSC, it is considered not important to safety. The HRS is illustrated in Figure 1.3-9. The codes and standards used in design of the HRS are listed in Section 4.7.4.

The HRS includes the following main subcomponents: one double-acting hydraulic cylinder; one grapple assembly; one hydraulic power unit; hydraulic hoses and fittings; one hose reel; and all necessary appurtenances, pressure limiting devices and controls for the system operation.

The HRS is designed to grapple, push or pull the DSC at any point in the extent of its horizontal travel between the cask and the HSM. The HRS and all other components of the transfer system are conservatively designed for and can apply pushing and pulling forces of up to 80,000 pounds, if necessary to complete the transfer.

The ram hydraulic cylinder is provided with a support and alignment system which provides for the range of vertical and lateral motion necessary for alignment with the DSC, cask and HSM.

The ram hydraulic power unit and controls are designed to provide the range of flows and pressures as required to push or pull the DSC under normal to maximum load conditions at safe design speeds. All controls are mounted in one control panel. Features are included in the control system to prevent the inadvertent operation of the HRS, limit the speed and force of the ram cylinder, as well as to provide an emergency means of stopping the ram motion.

The equipment safety concerns are addressed using a relatively simple control system and comprehensive operational procedure. All controls are manually operated. Pre-set pressure and flow control devices ensure that the maximum design forces and speeds of the hydraulic ram are not exceeded. System pressure gauges are provided to monitor the insertion operation and to verify that design force limits are not exceeded.

4.7.3.7 Ram Support Assembly

The ram hydraulic cylinder may be permanently mounted on the cask transfer trailer using a steel support assembly, or it may be installed on an adjustable tripod as shown in Figure 1.3-9 and attached to the cask by a steel support frame. In either case, the hydraulic ram push loads are transmitted through the support assembly to the transfer cask, through the cask to the cask restraints and into the HSM front wall embedments.

4.7.3.8 Cask Support Skid

The cask support skid is a structural steel frame fabricated from standard wide flange members, built up box beam cross members and trunnion support towers. The cask support skid, shown in Figure 1.3-8, is designed according to the AISC code for its operating loads. During cask loading and trailer towing operations, the cask support skid is rigidly attached to the transfer trailer by four bolted brackets. During cask alignment, the bolts are removed, and the alignment system is used to move the cask support skid into position. For this operation, the skid is supported by the skid positioning system bearing pads located on the trailer frame cross members. The transfer cask is supported on the front and rear trunnion support tower pillow blocks. For cask downending, the lower trunnions are engaged into the front pillow blocks, and the top section of the blocks installed. The cask lifting yoke and fuel/reactor building crane are then used to lower the upper trunnions into the rear trunnion supports. The yoke is then removed and the upper trunnion capture plates are installed.

4.7.4 Transfer Equipment

Applicable sections of the following codes and standards are specified for the design, construction, and testing of the NUHOMS® ISFSI transfer equipment components.

4.7.4.1 Transfer Cask and Lifting Yoke

A. ASME Boiler and Pressure Vessel Code, Section III, Division 1, Subsection NC, "Class 2 Components", 1983 Edition through Winter 1985 Addenda, used as a guide for design and fabrication.

B. ASME Boiler and Pressure Vessel Code, Section III, Division 1, Appendices.

C. ANSI N14.6 - 1993, "Special Lifting Devices for Shipping Containers Weighing 10,000 lbs. or more."

D. ANSI Y14.5 - 1982, "Dimensioning and Tolerancing."

E. ANSI 57.9 - 1984, "Design Criteria for an Independent Spent Fuel Storage Installation (Dry Storage Type)."

F. ANSI N45.2 - 1977, "Quality Assurance Requirements for Nuclear Power Plants."

G. AWS D1.1-88, "Structural Welding Code - Steel."

H. Steel Structures Painting Council (Standards).

I. EPRI NP-4830, "Comparison of Pad Hardness Study with Drop Test Results."

J. Crane Manufacturers' Association of America (CMAA) Specification No. 70-1983, "Specifications for Electric Overhead Traveling Cranes."

4.7.4.2 Transfer System Equipment

A. American Institute of Steel Construction, "Manual of Steel Construction."

B. National Electrical Code.

C. National Fluid Power Association (Standards).

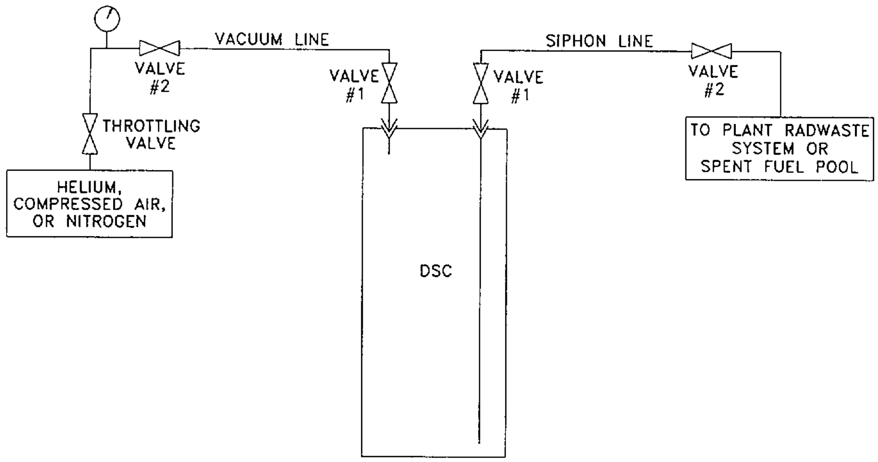
D. National Electrical Manufacturer's Association (Standards).

E. American Society for Testing and Materials (Standards).

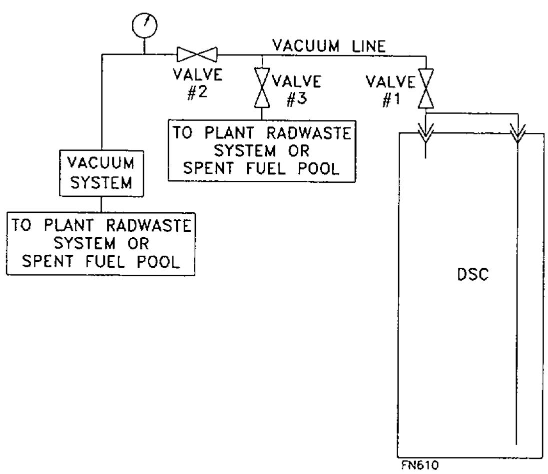
F. Steel Structures Painting Council (Standards).

G. American National Standards Institute (Standards).

H. American Welding Society, AWS D1.1, "Structural Welding Code-Steel."



CONFIGURATION FOR
DSC DRAINING



CONFIGURATION FOR
DSC VACUUM DRYING

Figure 4.7-1
Typical DSC Draining and Drying System

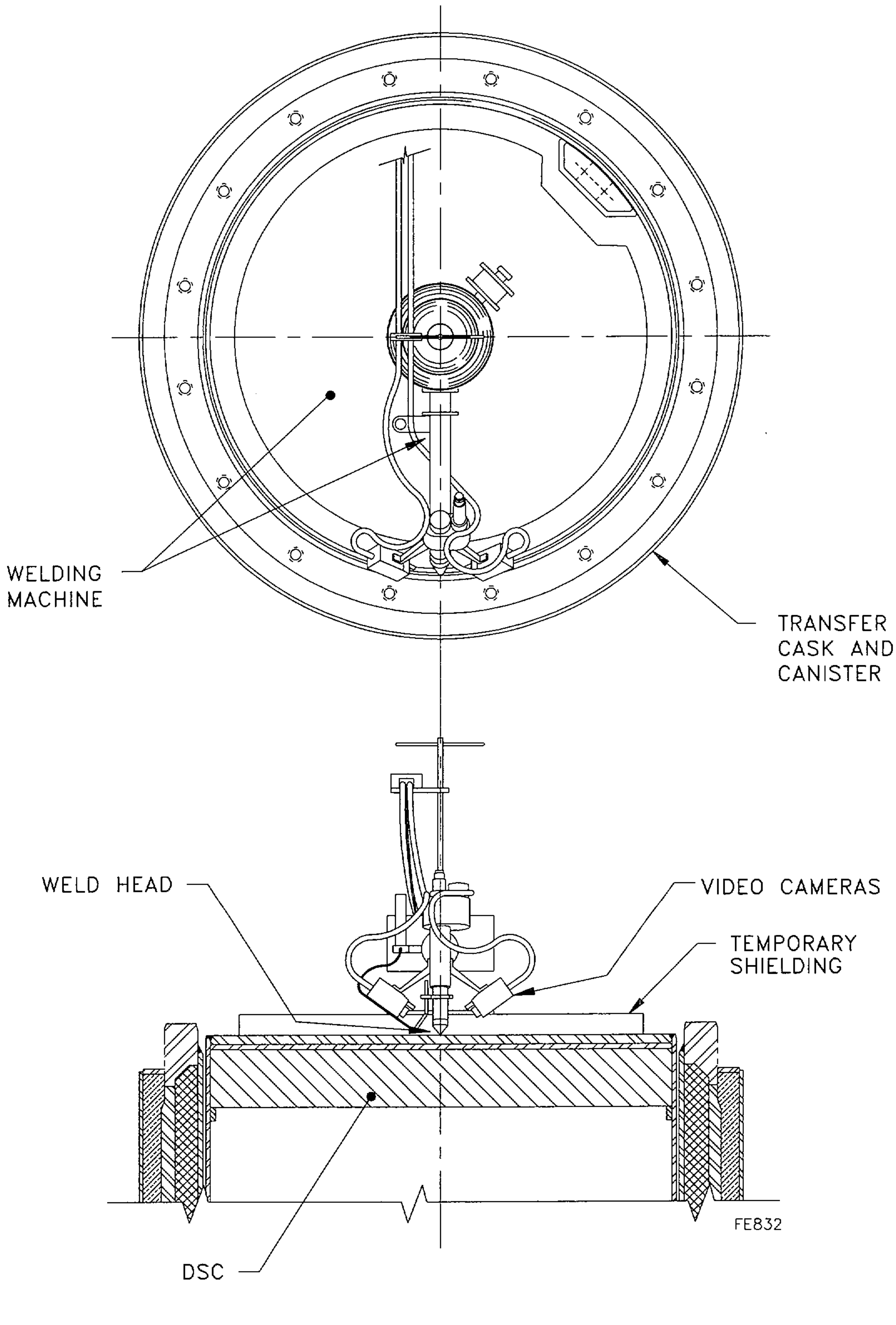


Figure 4.7-2
DSC Automatic Welding System

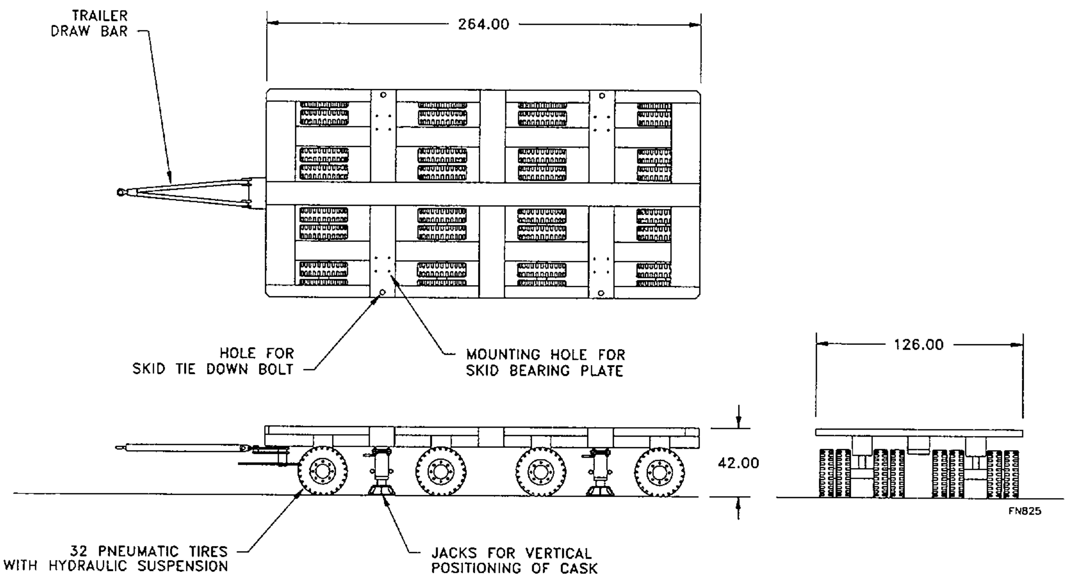


Figure 4.7-3
Typical NUHOMS® Transport Trailer

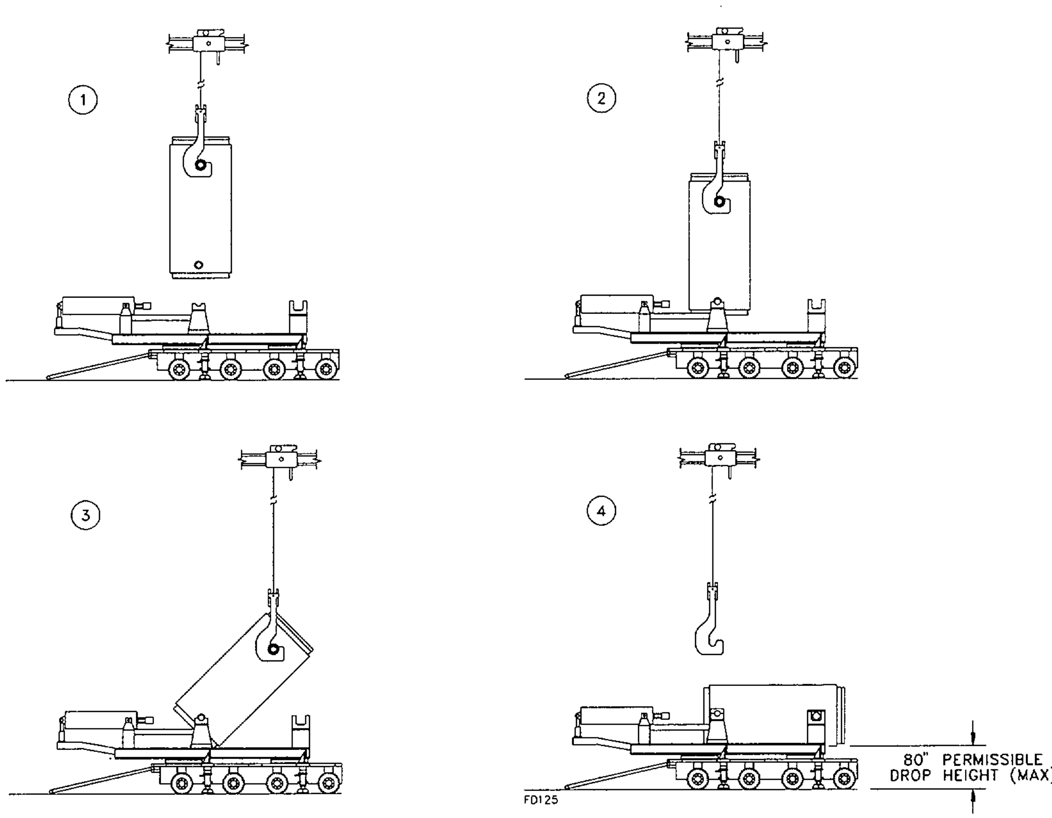


Figure 4.7-4
NUHOMS® Transport Cask Downending Sequence

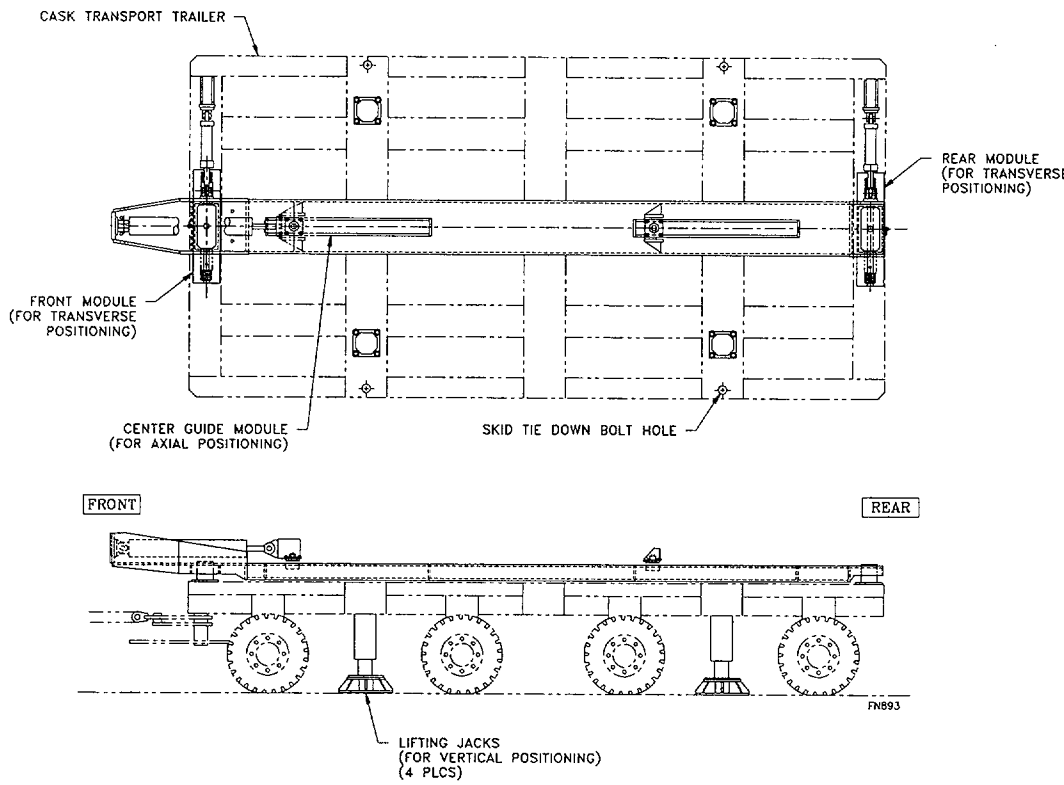


Figure 4.7-5
NUHOMS® Skid Positioning System (SPS)

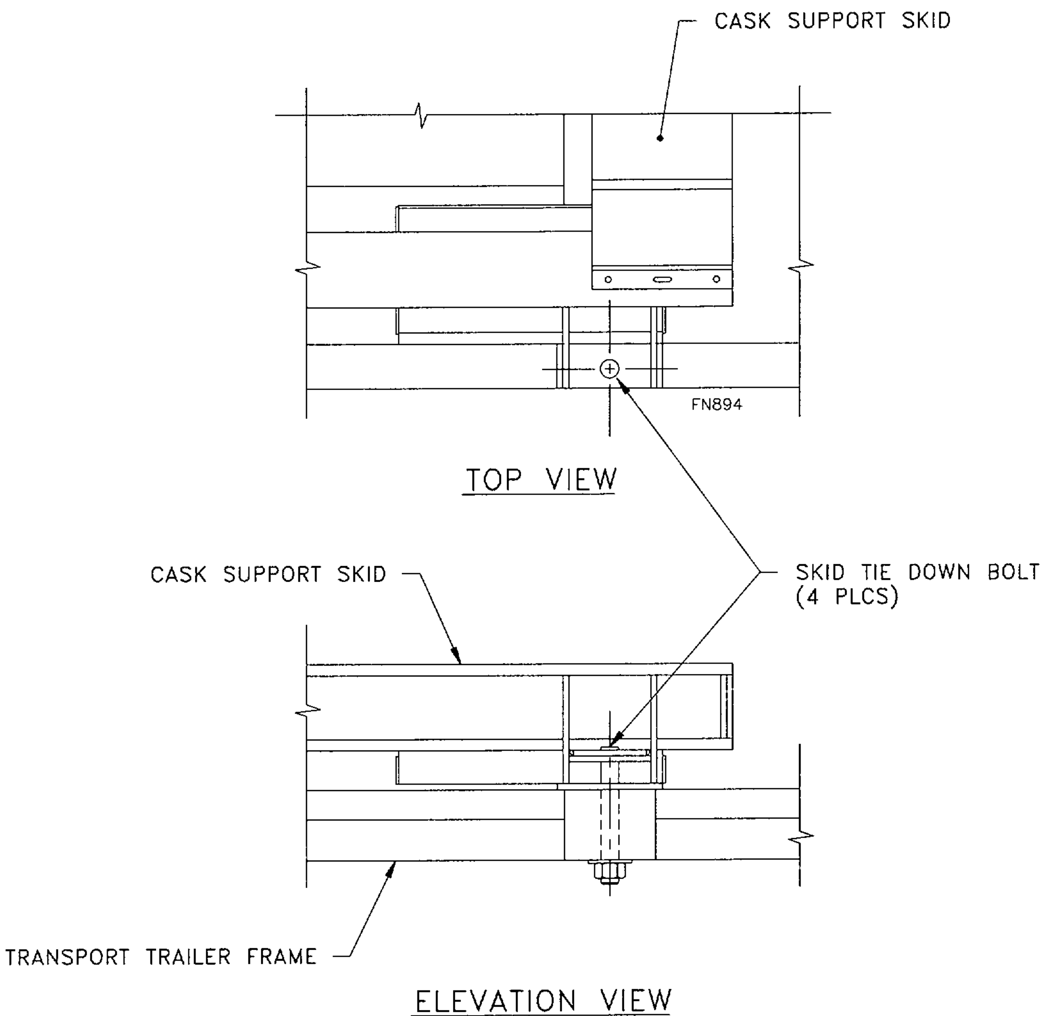


Figure 4.7-6
NUHOMS® Cask Support Skid Tie-Down Bracket

4.8 ASME Code Exceptions List[1] for the NUHOMS®-24P, (Standard and Long Cavity), 24PT2 and 52B DSC

This Code exception report is prepared to document and provide justifications for all deviations from the ASME Boiler and Pressure Vessel Code (hereinafter referred to as the Code).

The technical requirements for the 24P (standard and long cavity) and 52B DSCs are based on the following sections of the Code.

- Section II for materials.
- Section III for materials, design, fabrication, testing, inspection, and over pressure protection.
- Section V for non-destructive examination.
- Section IX for welder and procedure qualifications.

Code Exceptions

Exceptions made to the Code for the DSCs are grouped into four areas as follows:

- Administration of the Code
- Design
- Fabrication
- Inspection/Examination/Testing

Each of these areas are interrelated; however, each section is governed by different authorities.

Administration of the Code

Administration of the Code is generally covered in Section III, Division 1, Subsection NCA and is controlled by the type of contract placed for the design and fabrication of the component. The 52B and 24P (standard and long cavity) DSCs are procured according to the requirements of 10CFR72 and the applicable technical requirements of the Code. Many of the administrative items that would allow the vessels to receive an N-stamp are not formally in place. These administrative items include the following:

[1] For NUHOMS®-61BT DSC, see Appendix K.

- Design Specification certified by a professional engineer
- Formal Over Pressurization report
- Design performed by a firm(s) holding an N-stamp
- Fabrication performed by a firm(s) holding an N-stamp
- No Authorized Nuclear Inspector (ANI) certified inspector sign-off

These items have little affect on the functionality of the component DSCs but directly affect its ability to comply with the requirements of the ASME Code. The qualifications of the firms and personnel, procedures used to develop the design reports and fabrication specifications, and the lack of an N stamped vendor are all exceptions to the requirements of Subsection NCA. Technically, wherever the Code requires the Certificate Holder to perform some function, neither the designer nor the fabricator can comply since they are not formally functioning as the Certificate Holder. Hence Subsection NCA does not apply.

Technical Compliance

Technical compliance is compliance with the design rules, material specifications, fabrication processes, joint configurations, etc. that would allow the DSCs to comply with the Code. Tables 4.8-1 and 4.8-2 provide a discussion of exceptions made to the technical requirements of the Code for materials, fabrication, examination, and testing. Most of the exceptions occur because the DSC configuration is different from the classical pressure vessel addressed by the Code. If an Owner generated, certified ASME Design Specification had been available, then in accordance with the Code, each of these exceptions could be evaluated and possibly accepted. This Design Specification acceptance constitutes a Code interpretation by the certifying professional engineer and could permit stamping of the DSCs.

Fabrication and Inspection of Components

Permitting a non ASME Code certified fabricator to build the DSCs is an exception made to the Inspection of Components section of the Code. Neither an ANI nor a Code certified shop is required by the procurement documents to fabricate or inspect these components or by 10CFR72 and associated NUREG's. Therefore, the role of the Certificate Holder is missing from the fabrication and inspection process. These exceptions are provided in Table 4.8-1and Table 4.8-2.

Table 4.8-1
ASME Code Exceptions List for NUHOMS®-24P (Standard and Long Cavity), 24PT2 and 52B DSC Pressure Boundary Components

Reference ASME Code Section/Article	Code Requirement	Exception, Justification and Compensatory Measures
NB-1100	Requirements for Code Stamping of Components	The 24P (standard and long cavity) and 52B, DSC shell assemblies are designed and fabricated in accordance with the ASME Code, Section III, Subsection NB to the maximum extent practical as described in here, but Code Stamping is not required. Therefore, Code Stamping is not required, the fabricator is not required to hold an ASME N or NPT stamp or be ASME Certified.
NB-2130	Material must be supplied by ASME approved material suppliers	All DSC pressure boundary sub-components designated as ASME on Appendix E DSC drawings are obtained from TN West approved suppliers with Certified Material Test Reports (CMTR's). Material is certified to meet all ASME code criteria but is not eligible for certification or code stamping if a non-ASME fabricator is used. Since the fabricator is not required to be ASME certified, material certification to NB-2130 is not possible.
NB-4121	Material Certification by Certificate Holder	Material traceability and certification are maintained in accordance with TN West's approved QA program
NB-4240 NB-5230	Full penetration welds are required for pressure boundary closure joints Weld examination shall be UT or RT with surface PT	DSC Pressure Boundary Welds: The joint details at the top and bottom end of the DSCs are not full penetration welds and thus do not comply with the requirements of figure NB-4243-1 for Category C flat head closure pressure and containment boundary welds. Volumetric weld inspection (RT or UT) is not practical due to the DSC geometry at the top and bottom closures and due to high radiation at the top closure after fuel loading (ALARA consideration). The inner and outer cover plate closure welds provide redundant closure welds, which are required by the 10CFR72 license. These welds are partial penetration welds that have been designed using a conservative "weld efficiency" factor of 0.6. Breach of the DSC confinement barriers due to an undetected flaw in any single weld layer is implausible due to the requirement for multi-layer welds. The top and bottom outer cover plate to shell welds and the inner bottom cover plate to shell weld receive a root and final PT. The top inner cover plate to shell weld, which is leak tested, has a final PT only. The final assurance against containment breach is that the normal operating pressure inside the DSC is low (approx. 5 psig compared to over 60 psig for the worst case accident pressure) (See Chapter 8 for the normal and accident pressures). The SER states in Section 3.2.1 that the normal operating pressure is closer to 1 psig. Thus, low pressure stresses result during normal operating conditions.

Table 4.8-1
ASME Code Exceptions List for NUHOMS®-24P (Standard and Long Cavity), 24PT2 and 52B DSC Pressure Boundary Components

(continued)

Reference ASME Code Section/Article	Code Requirement	Exception, Justification and Compensatory Measures
NB-6111	All completed pressure retaining systems shall be pressure tested	The pressure retaining system of the DSC consists of the following components: shell, bottom inner and outer cover plates, siphon and vent block, and top inner and outer cover plates. The bottom cover plates are welded to the shell in the fabricator shop, whereas the top cover plates are field welded to the shell in the nuclear power plant following the loading of irradiated nuclear fuel. All other welds made to the pressure boundary, such as the support ring to shell weld are not part of the pressure boundary and thus are not pressure tested. DSC Shell and Bottom Cover Plate Welds: The DSC Shell and inner bottom cover plate are pressure tested during fabrication to the requirements of NB-6000. A helium leak test is performed to demonstrate leakage integrity of this boundary. Since the outer bottom cover plate is installed after the inner bottom cover plate is installed, it cannot be pressure tested. DSC Top Cover Plates Closure Welds: The top closure welds are not completed until the DSC is loaded with irradiated nuclear fuel; therefore, a pressure test is not performed. Multi-layer welds are used for these joints to eliminate potential leakage paths. The inner and outer top containment boundary welds are tested as follows: Inner Top Containment Boundary Welds: The inner top containment boundary welds include the following: (1) field weld of inner cover plate to shell weld (including inner top cover plate to vent and siphon block), (2) top of siphon and vent block to shell weld, and (3) field weld of siphon and vent port cover plates to vent and siphon block ports. Weld (1) is helium leak tested in the field. Weld (2) is made in the fabricator shop under controlled conditions and receives a final PT. A pressure test and helium leak test are not practical because of its location. A field leak test of weld (2) is not performed because the current 10CFR72 license does not require it. Weld (3) is performed in the field with a final PT and without a leak test. A helium leak test cannot be performed on these welds because the vent and siphon ports are covered by the plates. Pressurization would require cutting a hole in the DSC creating a potential leakage point for the long-term storage canister. Outer Top Containment Boundary Weld: The outer top cover plate to shell weld receives a root and final PT. It is not leak tested because it is installed following the inner top cover plate.

Table 4.8-1
ASME Code Exceptions List for NUHOMS®-24P (Standard and Long Cavity), 24PT2 and 52B DSC Pressure Boundary Components

(continued)

Reference ASME Code Section/Article	Code Requirement	Exception, Justification and Compensatory Measures
NB-7000	Vessels are required to have overpressure protection	No overpressure protection is provided for the DSCs. The function of the DSC is to contain radioactive materials under normal, off normal and hypothetical accident conditions of storage. The DSCs are designed to withstand the maximum credible internal pressure at the maximum accident temperature and remain with ASME Code Level D allowable stresses. (See Section 8.2.9)
NB-8000	Requirements for nameplates, stamping and reports per NCA-8000	The DSC stamping provides the appropriate information required by 10CFR72; however, code stamping is not required. QA Data Packages are prepared in accordance with 10CFR72 and TN West's approved QA program.

Table 4.8-2
ASME Code Exceptions List for NUHOMS®-24P (Standard and Long Cavity), 24PT2 and 52B DSC Basket Assembly

Reference ASME Code Section/Article	Code Requirement	Exception, Justification and Compensatory Measures
NF-2130	Material must be supplied by ASME approved material suppliers	All DSC Basket Assembly sub-components designated as ASME on Appendix E DSC drawings are obtained from TN West approved suppliers with Certified Material Test Reports (CMTR's). The DSC basket subcomponents listed below have been designated as non-Code. • Guide Sleeves, Oversleeves, and extraction stops (PWR only) • Neutron Absorber Plates and misc. hardware, such as anti-rotation pin, screws and locknuts, (BWR Only) • Coating for Spacer Discs
NF-4121	Material Certification by Certificate Holder	Material traceability and certification are maintained in accordance with TN West's NRC approved QA program
NF-8000	Requirements for nameplates, stamping and reports per NCA-8000	The DSC stamping provides the appropriate information required by 10CFR72; however, code stamping is not required. QA Data Packages are prepared in accordance with 10CFR72 and TN West's approved QA program.

4.9 ASME Code Exceptions List for the Transfer Cask

The transfer cask is a nonpressure retaining component that is conservatively designed and fabricated, where practicable and appropriate, in accordance with ASME Code Section III, Subsection NC requirements for a pressure retaining component. The following discussion documents and provides justification for deviations from these ASME Code requirements.

The technical requirements for the transfer cask are based on the following sections of the ASME Code:

- Section II for materials.
- Section III for materials, design, fabrication, testing, inspection, and over pressure protection.
- Section V for non-destructive examination.
- Section IX for welder and procedure qualifications.

Code Exceptions

The areas of possible exceptions to the ASME Code can be broken down into four basic areas. These are:

- Administration of the Code
- Technical design
- Fabrication of the components
- Inspection/Examination of the components

Although each of these areas is interrelated, each section is governed by different authorities.

Administration of the Code

This is generally covered in Section III, Division 1, Subsection NCA and is controlled by the type of contract placed for the design and fabrication of the component. The transfer cask was procured under the premise of following the technical requirements of the Code without requiring the use of an ANI and not applying an N stamp. Hence, many of the administrative items that would allow the cask to be stamped are not formally in place. This includes such things as a Design Specification certified by a professional engineer and a formal Over Pressurization report; and design and fabrication work being done by a firm(s) holding an N-stamp. These items have little effect on the functionality of the component but directly affect its ability to comply with the requirements of the ASME Code. The qualifications of the firms and personnel, procedures used to develop the design reports and fabrication specifications, and the lack of an N stamped vendor are all exceptions to the requirements of Subsection NCA. Technically, wherever the Code requires the Certificate Holder to perform some function, neither the designer nor the fabricator can comply since they are not formally functioning as the Certificate Holder. Hence, Subsection NCA does not apply.

Technical Compliance

Technical compliance is compliance with the design rules and specification of materials, processes, joint configurations, etc. that allow the transfer cask to comply with the Code. The design is based on compliance with Section III of the ASME Code as modified by 10CFR72, NRC Regulatory Guides and NUREGs as discussed in the Chapters 3 and 8. Table 4.9-1 provides a discussion of technical exceptions to the written Code provisions for the materials, fabrication, examination, and testing. The majority of these exceptions are caused by the deviations in configuration of the cask from the classical pressure vessel addressed by the Code. If an Owner generated, certified ASME Design Specification had been available, then in accordance with the Code, each of these exceptions could be evaluated and possibly accepted. This Design Specification acceptance constitutes a Code interpretation by the certifying professional engineer and could permit stamping of the cask.

Fabrication and Inspection of Components

An exception to the Code is the use of a non-ASME Code certified fabricator for the fabrication of the transfer cask. Neither an ANI nor a Code certified shop is required by the procurement documents or 10CFR72 and associated NUREGs to fabricate or inspect the cask. Therefore, the role of the Certificate Holder is missing from the fabrication and inspection process.

Table 4.9-1
ASME Code Exceptions List for the Transfer Cask (Applies to Cask Structural Components Only, Lead Shielding, Neutron Shielding, and Neutron Shield Jacket of the Cask is Not Addressed by this Table)

Reference ASME Code Section/Article	Code Requirement	Exception, Justification and Compensatory Measures
NC-1100	Requirements for Code Stamping of Components	As described in Chapters 3 and 8, the cask is designed and fabricated to the requirements of Subsection NC, to the maximum extent practical. However, the transfer cask does not have a Code stamp. Code Stamping is not required by 10CFR72 regulation. Therefore, the fabricator is not required to be ASME Certified.
NC-2000	ASME Code Materials are to be used	The Cask bottom ram access cover plate is made of ASTM A240, a non-ASME material. This cover plate is a water tight closure used during fuel loading/unloading operations in the fuel/reactor building only. This is not a pressure boundary component, and its failure does not result in any public safety concerns.
NC-2130	Material must be supplied by ASME approved material suppliers	Materials designated as ASME on the Appendix E drawings are obtained by TN West approved suppliers with Certified Material Test Reports (CMTR's). Material is certified to meet all ASME Code criteria but is not eligible for Certification or Code Stamping, if a non-ASME fabricator is used. As the fabricator is not required to be ASME certified, material certification to NC-2130 is not possible.
NC-4120	Material Certification by Certificate Holder	Material traceability & certification are maintained in accordance with TN West's NRC approved QA program.
NC-4240	Full penetration welds are required for pressure boundary closure joints.	The joint between the ram access penetration forging and the bottom end plate consists of partial penetration welds, while NC-3200 would require full penetration welds. This cover plate is a water tight closure used during fuel loading/unloading operations in the fuel/reactor building only. This is not a pressure boundary component, and its failure does not result in any public safety concerns.
NC-5250	Category A and B joints shall be fully radiographed.	Appendix E drawing NUH-03-8001 permits weld examination of (a) the circumferential and longitudinal welds for the structural shell and (b) the weld between the bottom end plate and the bottom support ring to be done using radiography (RT) or ultrasound (UT) while NC-5250 allows full penetration welds to be examined by RT only. Since the structural shell is not a pressure boundary, this code exception is acceptable.
NC-6000	All completed pressure retaining systems shall be pressure tested.	With respect to pressure testing requirements, the transfer cask is considered a non pressure retaining component. Therefore, no pressure testing is required. However, the liquid neutron shield cavity, cask bottom neutron shield cavity, and the bottom cover plate assembly are pressure and leak tested.
NC-7000	Overpressure Protection	The transfer cask is considered a non pressure retaining component. Therefore, no overpressure protection is provided for the transfer cask, except that a pressure relief valve is provided for the annular neutron shielding.

Reference ASME Code Section/Article	Code Requirement	Exception, Justification and Compensatory Measures
NC-8000	Requirements for nameplates, stamping & reports per NCA-8000	The transfer cask nameplate provides the information required by 10CFR72. Code stamping is not required for the transfer cask. QA Data packages are prepared in accordance with the requirements of 10CFR72 and TN West's NRC approved QA program.

4.10 References

4.1 U.S. Government, "Licensing Requirements for the Storage of Spent Fuel in an Independent Spent Fuel Storage Installation (ISFSI)," Title 10 Code of Federal Regulations, Part 72, Office of the Federal Register, Washington, D.C.

4.2 Deleted.

4.3 Deleted.

4.4 Deleted.

4.5 American Society of Mechanical Engineers, ASME Boiler and Pressure Vessel Code, Section III, Division 1, 1983 Edition, with Winter 1985 Addenda.

4.6 American Society for Testing and Materials, Annual Book of ASTM Standards, Section 4, Volume 04.02, 1990.

4.7 American Society for Testing and Materials, Annual Book of ASTM Standards, Section 1, Volume 01.04, 1990.

4.8 Deleted.

4.9 "American National Standard for Special Lifting Devices for Shipping Containers Weighing 10,000 Pounds (4500 kg) or More for Nuclear Materials", ANSI N14.6-1993, American National Standards Institute, Inc., New York, New York.

4.10 American Concrete Institute, "Building Code Requirement for Reinforced Concrete," ACI-318, 1983.

4.11 American Institute of Steel Construction, (AISC), "Specification for Structural Steel Buildings," Ninth Edition 1990, Chicago, Illinois.

4.12 American National Standards Institute, "American National Standard for Radioactive Materials - Leakage Tests on Packages for Shipment," ANSI N14.5, 1977.

4.13 U.S. Nuclear Regulatory Commission, Office of Nuclear Materials Safety and Safeguards, "Safety Evaluation Report Related to the Topical Report for the NUTECH Horizontal Modular Storage System for Irradiated Nuclear Fuel NUHOMS®-24P Submitted by NUTECH Engineers Inc.," NUH-002, Revision 1A, April 1989.

4.14 American Concrete Institute, Code Requirements for Nuclear Safety Related Concrete Structures and Commentary, ACI 349-85 and ACI 349R-85, American Concrete Institute, Detroit, Michigan (1985).

4.15 U.S. Nuclear Regulatory Commission, "Safety Evaluation Report for Pacific Sierra Nuclear Topical Report on the Ventilated Storage Cask System for Irradiated Fuel, Revision 2," March 29, 1991.

4.16 U.S. Nuclear Regulatory Commission, "Safety Evaluation Report for a Design Change to the Transfer Cask for the Duke Power Company's Independent Spent Fuel Storage Installation," February 1990.

4.17 U.S. Nuclear Regulatory Commission, "Safety Evaluation Report for the Baltimore Gas and Electric Company's Safety Analysis Report for an Independent Spent Fuel Storage Installation at Calvert Cliffs," November, 1992.

4.18 VECTRA Letter, VF-95-042, to Director, Office of Nuclear Material Safety and Safeguards, USNRC, VECTRA Supplemental Response to Confirmatory Action Letter, dated September 22, 1995.

4.19 USNRC Letter to VECTRA, Confirmatory Action Letter, dated October 12, 1995, Docket Nos. 72-1004 and 72-14.

4.20 ACI Publication SP 25, Effect of Temperature on Concrete, presented at the ACI Fall Meeting, Nov. 1968, and other industry published thermal expansion data.

5. OPERATION SYSTEMS

This Chapter presents the operating procedures for the standardized NUHOMS® system described in previous chapters and shown on the drawings in Appendix E for the 24P and 52B systems. The 61BT system operating procedures are described in Appendix K and the 24PT2 system operating procedures are described in Appendix L. The procedures include preparation of the DSC and fuel loading, closure of the DSC, transport to the ISFSI, DSC transfer into the HSM, monitoring operations, and DSC retrieval from the HSM. The standardized NUHOMS® transfer equipment, and the existing plant systems and equipment are used to accomplish these operations. Procedures are delineated here to describe how these operations are to be performed and are not intended to be limiting. Standard fuel and cask handling operations performed under the plant's 10CFR50 operating license are described in less detail. Existing operational procedures may be revised by the licensee and new ones may be developed according to the requirements of the plant, provided that the limiting conditions of operation specified in Technical Specifications, Functional and Operating Limits of the NUHOMS® CoC (5.6) are not exceeded.

5.1 Operation Description

The following sections outline the typical operating procedures for the standardized NUHOMS® system. These generic NUHOMS® procedures have been developed to minimize the amount of time required to complete the subject operations, to minimize personnel exposure, and to assure that all operations required for DSC loading, closure, transfer, and storage are performed safely. Plant specific ISFSI procedures are to be developed by each licensee in accordance with the requirements of 10CFR72.24 (h) and the guidance of Regulatory Guide 3.61 (5.7). The generic procedures presented here are provided as a guide for the preparation of plant specific procedures and serve to point out how the NUHOMS® system operations are to be accomplished. They are not intended to be limiting, in that the licensee may judge that alternate acceptable means are available to accomplish the same operational objective.

The generic operating procedures presented herein also do not address the use of auxiliary equipment which is optional or represents a level of detail which a licensee may choose to implement based on licensee preference. Examples of such auxiliary items are the Neutron Shield Overflow Tank (used with OS197 or OS197H Cask only), TC/DSC Annulus Pressurization Tank, and the Shield Plug Restraints.

5.1.1 Narrative Description

The following steps describe the recommended generic operating procedures for the standardized NUHOMS® system. Flowcharts of NUHOMS® system loading and retrieval operations are provided in Figure 5.1-1 and Figure 5.1-2, respectively.

5.1.1.1 Preparation of the Transfer Cask and DSC

1. Prior to placement in dry storage, the candidate fuel assemblies are to be visually examined to insure that no known or suspected gross cladding breaches exist. Pinholes and hairline cracks are acceptable. Verification of fuel integrity may also be accomplished using suitable existing plant records. The assemblies shall be evaluated (by plant records or other means) to verify that they meet the physical, thermal and radiological criteria specified in Technical Specification 1.2.1.

2. Prior to being placed in service, the transfer cask is to be cleaned or decontaminated as necessary to insure a surface contamination level of less than those specified in Technical Specification 1.2.12.

3. Place the transfer cask in the vertical position in the cask decon area using the cask handling crane and the transfer cask lifting yoke.

4. Place scaffolding around the cask so that the top cover plate and surface of the cask are easily accessible to personnel.

5. Remove the transfer cask top cover plate and examine the cask cavity for any physical damage and ready the cask for service.

6. Examine the DSC for any physical damage which might have occurred since the receipt inspection was performed. The DSC is to be cleaned and any loose debris removed.

7. Using a crane, lower the DSC into the cask cavity by the internal lifting lugs and rotate the DSC to match the cask and DSC alignment marks.

8. Fill the cask-DSC annulus with clean, demineralized water. Place the inflatable seal into the upper cask liner recess and seal the cask-DSC annulus by pressurizing the seal with compressed air.

9. Fill the DSC cavity with water from the fuel pool or an equivalent source which meets the requirements of Technical Specification 1.2.15. For PWR fuel, the

water must be borated to the specified minimum concentration. For BWR fuel, demineralized water may be used. Fill liquid neutron shield, if applicable.

10. Using the fuel/reactor building main hook and the cask lifting yoke, position the cask lifting yoke above the DSC top shield plug and attach the four designated cable assemblies between the yoke and the DSC top shield plug. Adjust the turnbuckles on the cable assemblies as necessary to level the shield plug. If not already done, test fit the DSC top shield plug onto the DSC.

11. Place the DSC top shield plug, with the cable assemblies attached and disconnect from the yoke. Position the cask lifting yoke above the transfer cask and engage the cask lifting trunnions.

12. Visually inspect the yoke lifting hooks to insure that they are properly positioned and engaged on the cask lifting trunnions.

13. Move the scaffolding away from the cask as necessary.

14. Lift the cask just far enough to allow the weight of the cask to be distributed onto the yoke lifting hooks. Reinspect the lifting hooks to insure that they are properly positioned on the cask trunnions.

15. Optionally, secure a sheet of suitable material to the bottom of the transfer cask to minimize the potential for ground-in contamination. This may also be done prior to initial placement of the cask in the decon area.

16. Prior to the cask being lifted into the fuel pool, the water level in the pool should be adjusted as necessary to accommodate the cask/DSC volume. If the water placed in the DSC cavity was obtained from the fuel pool, a level adjustment may not be necessary.

5.1.1.2 DSC Fuel Loading

1. Lift the cask/DSC and position it over the cask loading area of the spent fuel pool in accordance with the plant's 10CFR50 cask handling procedures.

2. Lower the cask into the fuel pool until the bottom of the cask is at the height of the fuel pool surface. As the cask is lowered into the pool, spray the exterior surface of the cask with demineralized water.

3. Place the cask in the location of the fuel pool designated as the cask loading area.

4. Disengage the lifting yoke from the cask lifting trunnions and remove the yoke from the fuel pool. Spray the lifting yoke with clean demineralized water as it is raised out of the fuel pool.

5. Move a candidate fuel assembly from a fuel rack in accordance with the plant's 10CFR50 fuel handling procedures.

6. Prior to insertion of a spent fuel assembly into the DSC, the identity of the assembly is to be verified by two individuals using an underwater video camera or other means. Read and record the fuel assembly identification number from the fuel assembly and check this identification number against the DSC loading plan which indicates which fuel assemblies are acceptable for dry storage.

7. Position the fuel assembly for insertion into the selected DSC storage cell and load the fuel assembly. Repeat Steps 5 through 7 for each SFA loaded into the DSC. After the DSC has been fully loaded, check and record the identity and location of each fuel assembly in the DSC.

8. After all the SFAs have been placed into the DSC and their identities verified, reconnect the yoke to the previously staged DSC shield plug/cable assemblies and re-verify shield plug is level. Position the lifting yoke and the top shield plug above the fuel pool and lower the shield plug onto the DSC.

   CAUTION: Verify that all the lifting height restrictions as a function of temperature specified in Technical Specification 1.2.13 can be met in the following steps which involve lifting of the transfer cask.

9. Visually verify that the top shield plug is properly seated onto the DSC.

10. Position the lifting yoke with the cask trunnions and verify that it is properly engaged.

11. Raise the transfer cask to the pool surface. Prior to raising the top of the cask above the water surface, stop vertical movement.

12. Inspect the top shield plug to verify that it is properly seated onto the DSC. If not, lower the cask and reposition the top shield plug. Repeat Steps 11 and 12 as necessary.

13. Continue to raise the cask from the pool and spray the exposed portion of the cask with demineralized water until the top region of the cask is accessible.

14. Drain any excess water from the top of the DSC shield plug back to the fuel pool.

15. Lift the cask from the fuel pool. As the cask is raised from the pool, continue to spray the cask with demineralized water.

16. Move the transfer cask with loaded DSC to the cask decon area.

17. Install TC seismic restraints if required by Technical Specification 1.2.16 (required only on plant-specific basis).

5.1.1.3 DSC Drying and Backfilling

1. Check the radiation levels along the perimeter of the cask. The cask exterior surface should be decontaminated as necessary in accordance with the limits specified in Technical Specification 1.2.12. Temporary shielding may be installed as necessary to minimize personnel exposure. Fill neutron shield if empty.

2. Place scaffolding around the cask so that any point on the surface of the cask is easily accessible to personnel.

3. Disengage the rigging cables from the top shield plug and remove the eyebolts. Disengage the lifting yoke from the trunnions and move it clear of the cask.

4. Decontaminate the exposed surfaces of the DSC shell perimeter and remove the inflatable cask/DSC annulus seal.

5. Connect the cask drain line to the cask, open the cask cavity drain port and allow water from the annulus to drain out until the water level is approximately twelve inches below the top edge of the DSC shell. Take swipes around the outer surface of the DSC shell and check for smearable contamination in accordance with the Technical Specification 1.2.12 limits.

6. Install the automated welding machine onto the inner top cover plate and place the inner top cover plate with the automated welding machine onto the DSC. Verify proper fit-up of the inner top cover plate with the DSC shell.

7. Check radiation levels along surface of the inner top cover plate. Temporary shielding may be installed as necessary to minimize personnel exposure.

8. Connect the vacuum drying system (VDS) to the DSC and use the liquid pump to drain approximately 60 gallons from the DSC to the fuel pool. This will lower the water level about four inches below the bottom of the shield plug.

9. Disconnect the VDS from the DSC.

CAUTION: For DSCs with spacer discs which have been coated with aluminum, an additional step is required to address Bulletin 96-04 concerns (5.5). This step provides for continuous hydrogen monitoring during the welding of the top inner cover plate as described in step 11 (5.4). Insert a ¼ inch tygon tubing of sufficient length through the vent port such that it terminates just below the DSC shield plug. Connect the tygon tubing to a hydrogen monitor to allow continuous monitoring of the hydrogen atmosphere in the DSC cavity during welding of the inner cover plate. Hydrogen monitoring is optional for DSCs with spacer discs which have been coated with electroless nickel. Regardless of whether hydrogen monitoring is performed, the licensee shall ensure that the DSC internal pressure remains atmospheric during welding of the inner top closure plate.

10. Cover the cask/DSC annulus to prevent debris and weld splatter from entering the annulus.

11. Ready the automated welding machine and tack weld the inner top cover plate to the DSC shell. Complete the inner top cover plate weldment and remove the automated welding machine.

CAUTION: For DSCs with spacer discs coated with aluminum, continuously monitor the hydrogen concentration in the DSC cavity using the tygon tube arrangement described in step 9 during the inner top cover plate cutting/welding operations. Verify that the measured hydrogen concentration does not exceed a safety limit of 2.4% (5.4). If this limit is exceeded, stop all welding operations and purge the DSC cavity with 2-3 psig helium (or any other inert medium) via the ¼" tygon tubing to reduce the hydrogen concentration safely below the 2.4% limit. This step is optional for DSCs with spacer discs which have been coated with electroless nickel.

12. Perform dye penetrant weld examination of the inner top cover plate weld in accordance with the Technical Specification 1.2.5 requirements.

13. Place the strongback so that it sits on the inner top cover plate and is oriented such that:

- the DSC siphon and vent ports are accessible
- the strongback stud holes line up with the TC lid bolt holes.

14. Lubricate the studs and, using a crossing pattern, adjust the strongback studs to snug tight ensuring approximately even pressure on the cover plate.

15. Connect the VDS to the DSC siphon and vent ports.

16. Install temporary shielding to minimize personnel exposure throughout the subsequent operations as required.

17. Engage the compressed air, nitrogen or helium supply and open the valve on the vent port and allow compressed gas to force the water from the DSC cavity through the siphon port.

18. Once the water stops flowing from the DSC, close the DSC siphon port and disengage the gas source.

19. Open the cask drain port valve and remove the remaining water from the cask/DSC annulus. (This step may be performed after completion of the vacuum drying procedure or after the DSC sealing operations.)

20. Connect the hose from the vent port and the siphon port to the intake of the vacuum pump. Connect a hose from the discharge side of the VDS to the plant's radioactive waste system or spent fuel pool. Connect the VDS to a helium source.

21. Open the valve on the suction side of the pump, start the VDS and draw a vacuum on the DSC cavity. The cavity pressure should be reduced in steps of approximately 100 torr, 50 torr, 25 torr, 15 torr, 10 torr, 5 torr, and 3 torr. After pumping down to each level, the pump is valved off and the cavity pressure monitored. The cavity pressure will rise as water and other volatiles in the cavity evaporate. When the cavity pressure stabilizes, the pump is valved in to complete the vacuum drying process. It may be necessary to repeat some steps, depending on the rate and extent of the pressure increase. Vacuum drying is complete when the pressure stabilizes for a minimum of 30 minutes at 3 torr or less as specified in Technical Specification 1.2.2.

22. Open the valve to the vent port and allow the helium to flow into the DSC cavity.

23. Pressurize the DSC with helium to about 24 psia not to exceed 34 psia.

24. Helium leak test the inner top cover plate weld for leakage in accordance with the Technical Specification 1.2.4 limits.

25. If a leak is found, repair the weld, repressurize the DSC and repeat the helium leak test.

26. Once no leaks are detected, depressurize the DSC cavity by releasing the helium through the VDS to the plant's spent fuel pool or radioactive waste system.

27. Re-evacuate the DSC cavity using the VDS. The cavity pressure should be reduced in steps of approximately 10 torr, 5 torr, and 3 torr. After pumping down to each level, the pump is valved off and the cavity pressure is monitored. When the cavity pressure stabilizes, the pump is valved in to continue the vacuum drying process. Vacuum drying is complete when the pressure stabilizes for a minimum of 30 minutes at 3 torr or less in accordance with Technical Specification 1.2.2 limits.

28. Open the valve on the vent port and allow helium to flow into the DSC cavity to pressurize the DSC to about 17.2 psia in accordance with Technical Specification 1.2.3 limits.

29. Close the valves on the helium source.

30. Remove the Strongback, decontaminate as necessary, and store.

5.1.1.4 DSC Sealing Operations

1. Disconnect the VDS from the DSC. Seal weld the prefabricated plugs over the vent and siphon ports and perform a dye penetrant weld examination in accordance with the Technical Specification 1.2.5 requirements.

2. Install the automated welding machine onto the outer top cover plate and place the outer top cover plate with the automated welding system onto the DSC. Verify proper fit up of the outer top cover plate with the DSC shell.

3. Tack weld the outer top cover plate to the DSC shell. Complete the outer top cover plate weld root pass. Perform dye penetrant examination of the root pass weld. Weld out the outer top cover plate to the DSC shell and perform dye penetrant examination on the weld surface in accordance with the Technical Specification 1.2.5 requirements.

4. Remove the automated welding machine from the DSC. Rig the cask top cover plate and lower the cover plate onto the transfer cask.

5. Bolt the cask cover plate into place, tightening the bolts to the required torque in a star pattern.

5.1.1.5 Transfer Cask Downending and Transport to ISFSI

NOTE:

Alternate Procedure for Downending of Transfer Cask: Some plants have limited floor hatch openings above the cask/trailer/skid, which limit crane travel (within the hatch opening) that would be needed in order to downend the TC with the trailer/skid in a stationary position. For these situations, alternate procedures are to be developed on a plant-specific basis, with detailed steps for downending.

1. Verify neutron shield is filled. Re-attach the transfer cask lifting yoke to the crane hook, as necessary. Ready the transport trailer and cask support skid for service.

2. Move the scaffolding away from the cask as necessary. Engage the lifting yoke and lift the cask over the cask support skid on the transport trailer.

3. The transport trailer should be positioned so that cask support skid is accessible to the crane with the trailer supported on the vertical jacks.

4. Position the cask lower trunnions onto the support skid lower trunnion pillow blocks.

5. Move the crane forward while simultaneously lowering the cask until the cask upper trunnions are just above the support skid upper trunnion pillow blocks.

6. Inspect the positioning of the cask to insure that the cask and trunnion pillow blocks are properly aligned.

7. Lower the cask onto the skid until the weight of the cask is distributed to the trunnion pillow blocks.

8. Inspect the trunnions to insure that they are properly seated onto the skid and install the trunnion tower closure plates.

9. Remove the bottom ram access cover plate from the cask. Install the two-piece temporary neutron/gamma shield plug to cover the bottom ram access. Install the ram trunnion support frame on the bottom of the transfer cask. (When using the integral ram/trailer, the temporary shield plug and ram trunnion support frame are not required, and this step is therefore optional.)

5.1.1.6 DSC Transfer to the HSM

1. Prior to transporting the cask to the ISFSI, or prior to positioning the transfer cask at the HSM designated for storage, remove the HSM door using a porta-crane, inspect the cavity of the HSM, removing any debris and ready the HSM to receive a DSC. The doors on adjacent HSMs should remain in place.

2. Inspect the HSM air inlet and outlets to ensure that they are clear of debris. Inspect the screens on the air inlet and outlets for damage.

   CAUTION: Verify that the requirements of Technical Specification 1.2.14, "TC/DSC Transfer Operations at High Ambient Temperatures" are met prior to next step.

3. Using a suitable heavy haul tractor, transport the cask from the plant's fuel/reactor building to the ISFSI along the designated transfer route.

4. Once at the ISFSI, position the transport trailer to within a few feet of the HSM.

5. Check the position of the trailer to ensure the centerline of the HSM and cask approximately coincide. If the trailer is not properly oriented, reposition the trailer, as necessary.

6. Back the cask to within a few inches of the HSM, set the trailer brakes and disengage the tractor. Drive the tractor clear of the trailer. Extend the transfer trailer vertical jacks.

7. Using a porta-crane, unbolt and remove the cask top cover plate.

8. Connect the skid positioning system hydraulic power unit to the positioning system via the hose connector panel on the trailer, and power it up. Remove the skid tie-down bolts and use the skid positioning system to bring the cask into approximate vertical and horizontal alignment with the HSM. Using optical survey equipment and the alignment marks on the cask and the HSM, adjust the position of the cask until it is properly aligned with the HSM.

9. Using the skid positioning system, fully insert the cask into the HSM access opening docking flange.

10. Secure the cask trunnions to the front wall embedments of the HSM using the cask restraints.

11. After the cask is docked with the HSM, verify the alignment of the transfer cask using the optical survey equipment.

12. Position the hydraulic ram behind the cask in approximate horizontal alignment with the cask and align the ram. Remove either the bottom ram access cover plate or the outer plug of the two-piece temporary shield plug. Power up the ram hydraulic power supply and extend the ram through the bottom cask opening into the DSC grapple ring.

13. Activate the hydraulic cylinder on the ram grapple and engage the grapple arms with the DSC grapple ring.

14. Recheck all alignment marks in accordance with the Technical Specification 1.2.9 limits and ready all systems for DSC transfer.

15. Activate the hydraulic ram to initiate insertion of the DSC into the HSM. Stop the ram when the DSC reaches the support rail stops at the back of the module.

16. Disengage the ram grapple mechanism so that the grapple is retracted away from the DSC grapple ring.

17. Retract and disengage the hydraulic ram system from the cask and move it clear of the cask. Remove the cask restraints from the HSM.

18. Using the skid positioning system, disengage the cask from the HSM access opening. Insert DSC axial retainer.

19. Install the HSM door using a portable crane and secure it in place.

20. Replace the transfer cask top cover plate (optional, may be done later away from the ISFSI). Secure the skid to the trailer, retract the vertical jacks and disconnect the skid positioning system.

21. Tow the trailer and cask to the designated equipment storage area. Return the remaining transfer equipment to the storage area.

22. Close and lock the ISFSI access gate and activate the ISFSI security measures.

<u>5.1.1.7 Monitoring Operations</u>

1. Perform routine security surveillance in accordance with the licensee's ISFSI security plan.

2. Perform a daily visual surveillance of the HSM air inlets and outlets (end wall and roof birdscreens) to insure that no debris is obstructing the HSM vents in accordance with Technical Specification 1.3.1 requirements.

3. Perform a temperature measurement of the thermal performance, for each HSM, on a daily basis in accordance with Technical Specification 1.3.2 requirements.

5.1.1.8 DSC Retrieval from the HSM

1. Ready the transfer cask, transport trailer, and support skid for service and tow the trailer to the HSM.

2. Back the trailer to within a few inches of the HSM, remove the cask top cover plate. Remove the HSM door using a porta-crane. Remove the DSC axial retainer.

3. Using the skid positioning system align the cask with the HSM and position the skid until the cask is docked with the HSM access opening.

4. Using optical survey equipment verify alignment of the cask with respect to the HSM. Install the cask restraints.

5. Install and align the hydraulic ram with the cask.

6. Extend the ram through the cask into the HSM until it is inserted in the DSC grapple ring.

7. Activate the arms on the ram grapple mechanism with the DSC grapple ring.

8. Retract ram and pull the DSC into the cask.

9. Retract the ram grapple arms.

10. Disengage the ram from the cask.

11. Remove the cask restraints.

12. Using the skid positioning system, disengage the cask from the HSM.

13. Install the cask top cover plate and ready the trailer for transport.

14. Replace the door on the HSM.

5.1.1.9 Removal of Fuel from the DSC

When the DSC has been removed from the HSM, there are several potential options for off-site shipment of the fuel. It is preferred to ship the DSC intact to a reprocessing facility, monitored retrievable storage facility or permanent geologic repository in a compatible shipping cask licensed under 10CFR71.

If it becomes necessary to remove fuel from the DSC prior to off-site shipment, there are two basic options available at the ISFSI or reactor site. The fuel assemblies could be removed and reloaded into a shipping cask using dry transfer techniques, or if the applicant so desires, the initial fuel loading sequence could be reversed and the plant's spent fuel pool utilized. Procedures for unloading of the DSC in a fuel pool are presented here, however wet or dry unloading procedures are essentially identical to those of DSC loading through the DSC weld removal (beginning of preparation to placement of the cask in the fuel pool). Prior to opening the DSC, the following operations are to be performed.

1. The cask may now be transported to the cask handling area inside the plant's fuel/reactor building.

2. Position and ready the trailer for access by the crane and install the ram access penetration cover plate, if not already installed.

3. Attach the lifting yoke to the crane hook.

4. Engage the lifting yoke with the trunnions of the cask.

5. Visually inspect the yoke lifting hooks to insure that they are properly aligned and engaged onto the cask trunnions.

6. Lift the cask approximately one inch off the trunnion supports. Visually inspect the yoke lifting hooks to insure that they are properly positioned on the trunnions.

7. Move the crane backward in a horizontal motion while simultaneously raising the crane hook vertically and lift the cask off the trailer. Move the cask to the cask decon area.

8. Lower the cask into the cask decon area in the vertical position.

9. Wash the cask to remove any dirt which may have accumulated on the cask during the DSC loading and transfer operations.

10. Place scaffolding around the cask so that any point on the surface of the cask is easily accessible to handling personnel.

11. Unbolt the cask top cover plate.

12. Connect the rigging cables to the cask top cover plate and lift the cover plate from the cask. Set the cask cover plate aside and disconnect the lid lifting cables.

13. Install temporary shielding to reduce personnel exposure as required. Fill the cask/DSC annulus with clean demineralized water and seal the annulus.

The process of DSC unloading is similar to that used for DSC loading. DSC opening operations described below are to be carefully controlled in accordance with plant procedures. This operation is to be performed under the site's standard health physics guidelines for welding, grinding, and handling of potentially highly contaminated equipment. These are to include the use of prudent housekeeping measures and monitoring of airborne particulates. Procedures may require personnel to perform the work using respirators or supplied air.

If fuel needs to be removed from the DSC, either at the end of service life or for inspection after an accident, precautions must be taken against the potential for the presence of damaged or oxidized fuel and to prevent radiological exposure to personnel during this operation. A sampling of the atmosphere within the DSC will be taken prior to inspection or removal of fuel.

If the work is performed outside the fuel/reactor building, a tent may be constructed over the work area which may be kept under a negative pressure to control airborne particulates. Any radioactive gas release will be Kr-85, which is not readily captured. Whether the krypton is vented through the plant stack or allowed to be released directly depends on the plant operating requirements.

Following opening of the DSC, the cask and DSC are filled with water prior to the placement in the fuel pool to prevent a sudden inrush of pool water. Cask placement into the pool is performed in the usual manner. Fuel unloading procedures will be governed by the plant operating license under 10CFR50. The generic procedures for these operations are as follows:

14. Locate the DSC siphon and vent port using the indications on the top cover plate. Place a portable drill press on the top of the DSC. Position the drill with the siphon port.

15. Place an exhaust hood or tent over the DSC, if necessary. The exhaust should be filtered or routed to the site radwaste system.

16. Drill hole(s) through the DSC top cover plate to expose the siphon and vent port quick connects.

17. Drill holes through the siphon and vent port cover plates to expose the siphon and vent port quick connects.

18. Obtain a sample of the DSC atmosphere, if necessary (e.g., at the end of service life). Fill the DSC with water from the fuel pool (and meeting the requirements of Technical Specification 1.2.15, if required) through the siphon port with the vent port open and routed to the plant's off-gas system.

    CAUTION:

    (a) The water fill rate must be regulated during this reflooding operation to ensure that the DSC vent pressure does not exceed 20.0 psig.

    (b) To address Bulletin 96-04 concerns (5.5), for DSCs with spacer discs coated with aluminum, provide for continuous hydrogen monitoring of the DSC cavity atmosphere (Reference step 5.1.1.3.9) during all subsequent cutting operations to ensure that a safety limit of 2.4% hydrogen concentration is not exceeded (5.4). Purge with 2-3 psig helium (or any other inert medium) as necessary to maintain the hydrogen concentration safely below this limit. This requirement is optional for DSCs with spacer discs which are coated with electroless nickel.

19. Place welding blankets around the cask and scaffolding.

20. Using plasma arc-gouging, a mechanical cutting system or other suitable means, remove the seal weld from the outer top cover plate and DSC shell. A fire watch should be placed on the scaffolding with the welder, as appropriate. The exhaust system should be operating at all times.

21. The material or waste from the cutting or grinding process should be treated and handled in accordance with the plant's low level waste procedures unless determined otherwise.

22. Remove the top of the tent, if necessary.

23. Remove the exhaust hood, if necessary.

24. Remove the DSC outer top cover plate.

25. Reinstall tent and temporary shielding, as required. Remove the seal weld from the inner top cover plate to the DSC shell in the same manner as the top cover plate. Remove the inner top cover plate. Remove any remaining excess material on the inside shell surface by grinding.

26. Clean the cask surface of dirt and any debris which may be on the cask surface as a result of the weld removal operation. Any other procedures which are required for the operation of the cask should take place at this point as necessary.

27. Engage the yoke onto the trunnions, install eyebolts into the top shield plug and connect the rigging cables to the eyebolts.

28. Visually inspect the lifting hooks or the yoke to insure that they are properly positioned on the trunnions.

29. The cask should be lifted just far enough to allow the weight of the transfer cask to be distributed onto the yoke lifting hooks. Inspect the lifting hooks to insure that they are properly positioned on the trunnions.

30. Install suitable protective material onto the bottom of the transfer cask to minimize cask contamination. Move the cask to the fuel pool.

31. Prior to lowering the cask into the pool, adjust the pool water level, if necessary, to accommodate the volume of water which will be displaced by the cask during the operation.

32. Lower the cask into the fuel pool.

33. Position the cask over the cask loading area in the fuel pool.

34. Lower the cask into the pool. As the cask is being lowered, the exterior surface of the cask should be sprayed with clean demineralized water.

35. Disengage the lifting yoke from the cask and lift the top shield plug from the DSC.

36. Remove the fuel from the DSC and place the fuel into the spent fuel racks.

37. Lower the top shield plug onto the DSC.

38. Visually verify that the top shield plug is properly positioned onto the DSC.

39. Engage the lifting yoke onto the cask trunnions.

40. Visually verify that the yoke lifting hooks are properly engaged with the cask trunnions.

41. Lift the cask by a small amount and verify that the lifting hooks are properly engaged with the trunnions.

42. Lift the cask to the pool surface. Prior to raising the top of the cask to the water surface, stop vertical movement and inspect the top shield plug to ensure that it is properly positioned.

43. Spray the exposed portion of the cask with demineralized water.

44. Visually inspect the top shield plug of the DSC to insure that it is properly seated onto the cask. If the top shield plug is not properly seated, lower the cask back to the fuel pool and reposition the plug.

45. Drain any excess water from the top of the top shield plug into the fuel pool.

46. Lift the cask from the pool. As the cask is rising out of the pool, spray the cask with demineralized water.

47. Move the cask to the cask decon area.

48. Check radiation levels around the perimeter of the cask. The cask exterior surface should be decontaminated if necessary.

49. Place scaffolding around the cask so that any point along the surface of the cask is easily accessible to personnel.

50. Ready the DSC vacuum drying system (VDS).

51. Connect the VDS to the vent port with the system open to atmosphere. Also connect the VDS to the siphon port and connect the other end of the system to the liquid pump. The pump discharge should be routed to the plant radwaste system or the spent fuel pool.

52. Open the valves on the vent port and siphon port of the VDS.

53. Activate the liquid pump.

54. Once the water stops flowing out of the DSC, deactivate the pump.

55. Close the valves on the VDS.

56. Disconnect the VDS from the vent and siphon ports.

57. The top cover plates may be welded into place as required.

58. Decontaminate the DSC, as necessary, and handle in accordance with low-level waste procedures. Alternatively, the DSC may be repaired for reuse.

5.1.2 Process Flow Diagram

Process flow diagrams for the NUHOMS® system operation are presented Figure 5.1-1 and Figure 5.1-2. The location of the various operations may vary with individual plant requirements.

5.1.3 Identification of Subjects for Safety Analysis

5.1.3.1 Criticality Control

Criticality safety for the NUHOMS® system is assured through a combination of geometrical separation of the fuel assemblies, the neutron absorbing capability of the internal basket assembly, and administrative controls for the selection and identification of the fuel assemblies to be stored as delineated in Technical Specification 1.2.1. In addition, to maintain criticality safety during DSC wet loading and unloading operations for storage of PWR fuel, the DSC is flooded with borated water having a minimum concentration as specified in Technical Specification 1.2.15. The DSC is flooded with demineralized water during wet loading and unloading operations for storage of BWR fuel. The criticality analysis for the standardized NUHOMS® system is described in Section 3.3.4.

5.1.3.2 Chemical Safety

There are no hazardous chemicals used in the NUHOMS® system that require special precautions.

5.1.3.3 Operation Shutdown Modes

NUHOMS® is a totally passive system and has no operational shutdown modes.

5.1.3.4 Instrumentation

Table 5.1-1 shows the typical instruments which might be used to measure conditions or control the operations during the DSC loading, closure and transfer operations. The instruments are standard industry equipment readily available to the plant.

5.1.3.5 Maintenance Techniques

NUHOMS® is a totally passive system and therefore does not require maintenance. However, to insure that the ventilation airflow is not interrupted, the HSM is periodically inspected to insure that no debris is in the airflow inlet or outlet openings.

Table 5.1-1
Instrumentation Used During NUHOMS® System Loading Operations

	Instruments	Function
1.	Gross Gamma/Beta/Neutron Detectors	Measure doses at DSC top shield plug and cover plates, transfer cask and HSM.
2.	Pressure and Vacuum Gauges	Measure helium, air, water and vacuum pressures inside DSC
3.	Hydraulic Pressure Gauges and Ram Pressure Relief Valves	Measure and limit hydraulic ram force applied to DSC
4.	Optical Survey Equipment	Align cask and ram with HSM

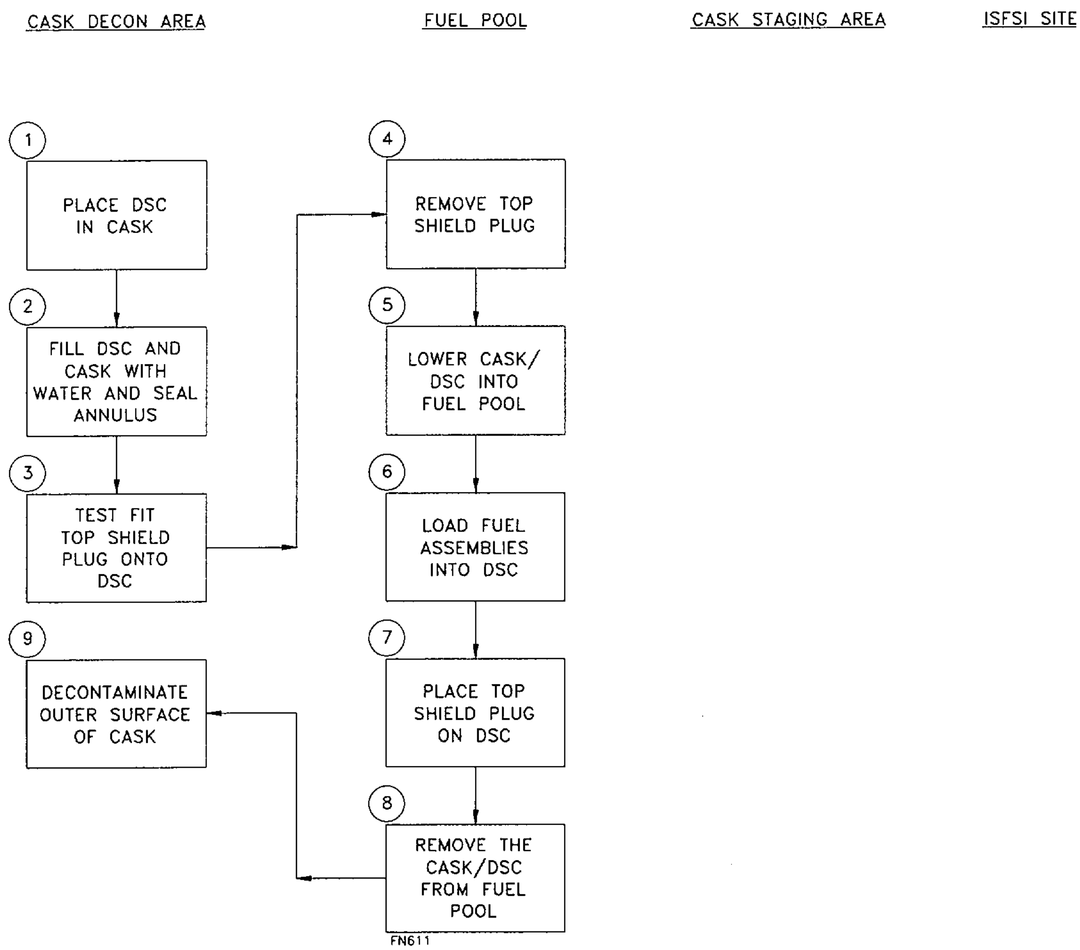


Figure 5.1-1
NUHOMS® System Loading Operations Flow Chart

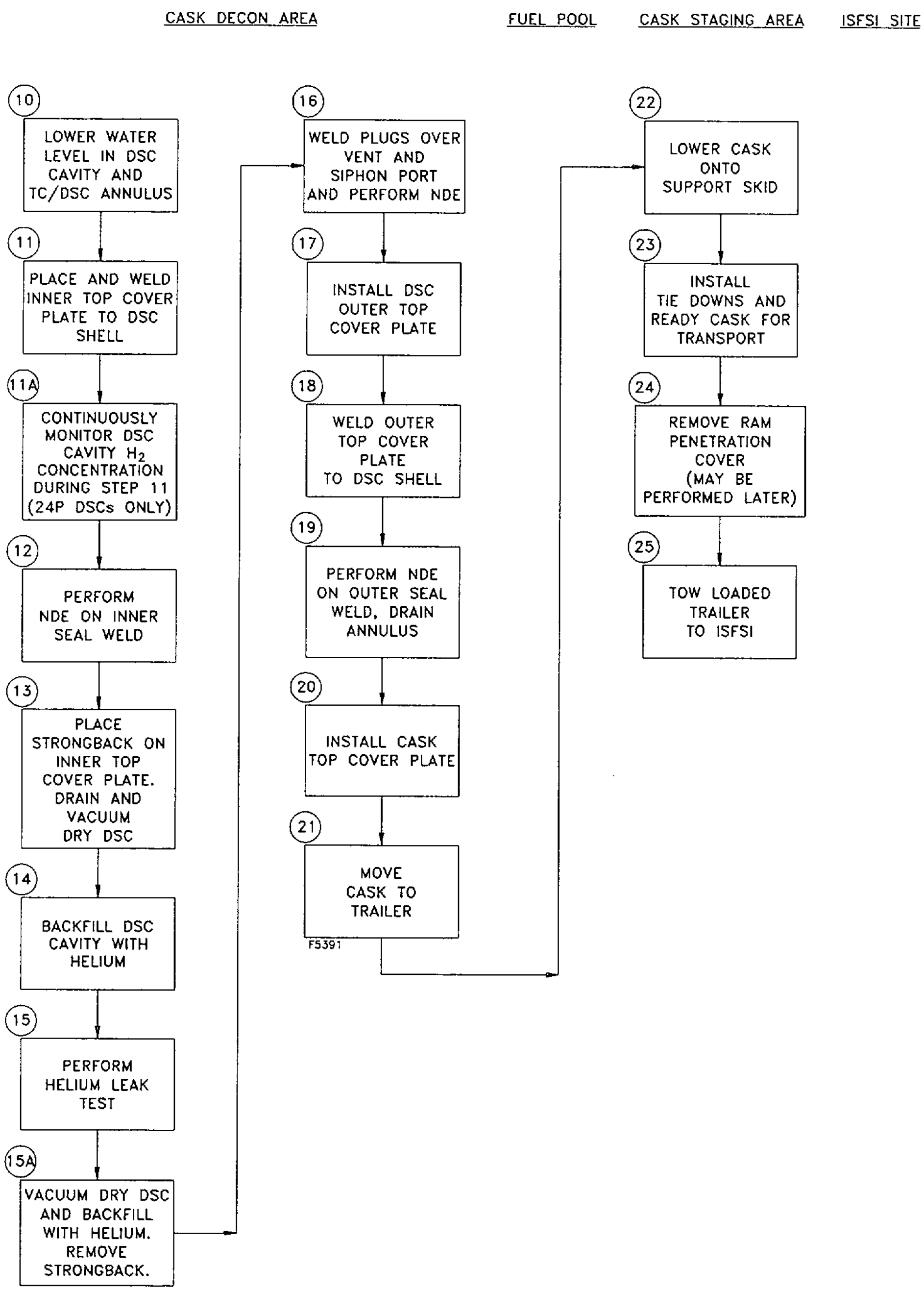


Figure 5.1-1
NUHOMS® System Loading Operations Flow Chart
(continued)

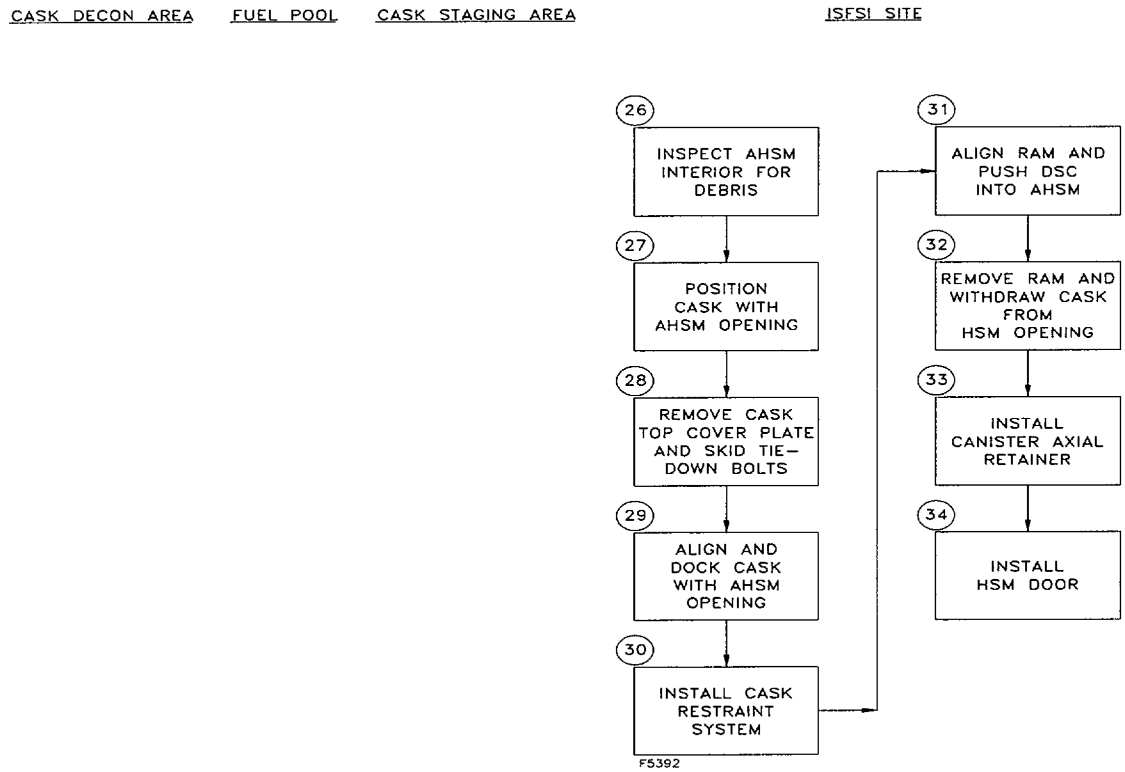


Figure 5.1-1
NUHOMS® System Loading Operations Flow Chart
(concluded)

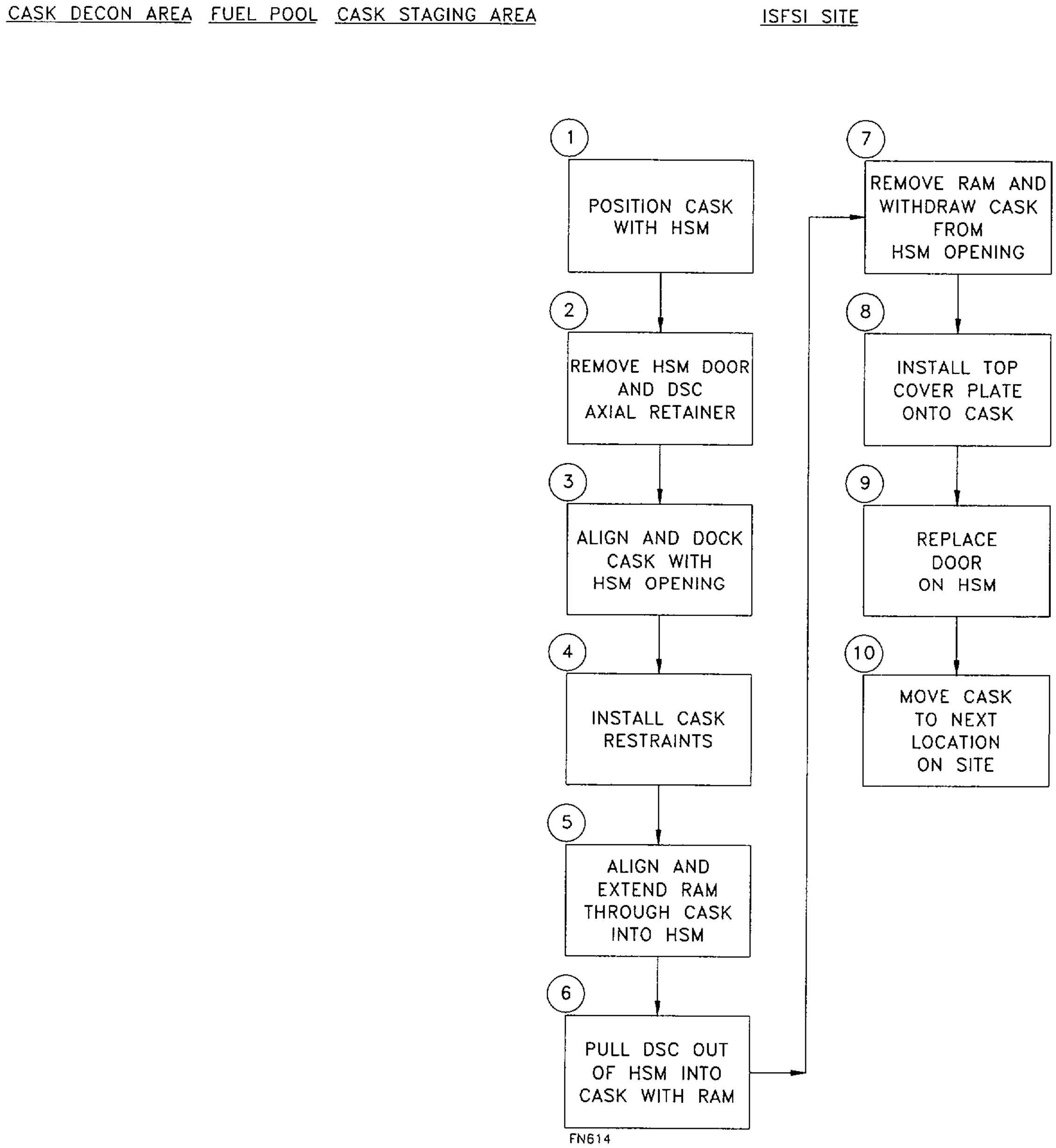


Figure 5.1-2
NUHOMS® System Retrieval Operations Flow Chart

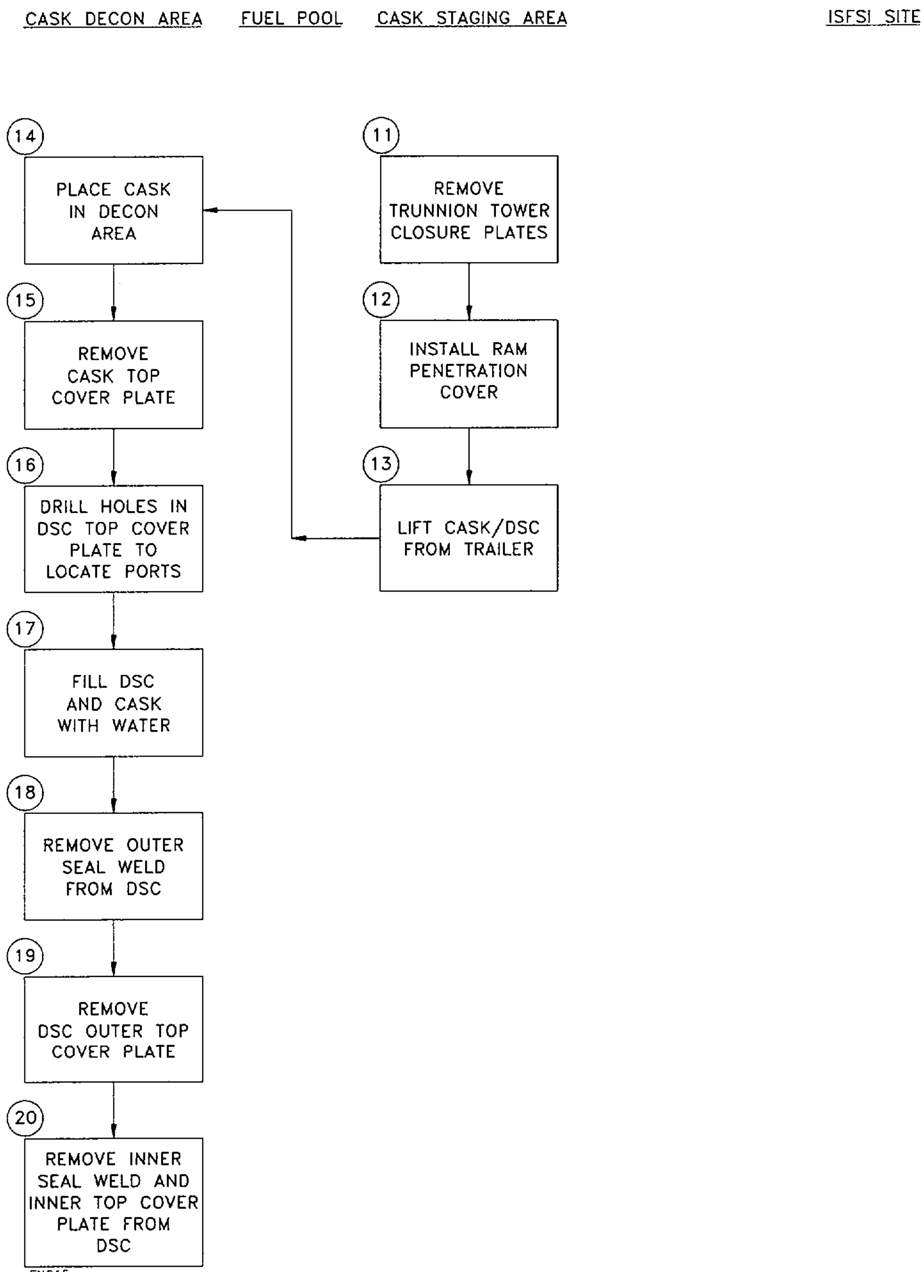


Figure 5.1-2
NUHOMS® System Retrieval Operations Flow Chart
(continued)

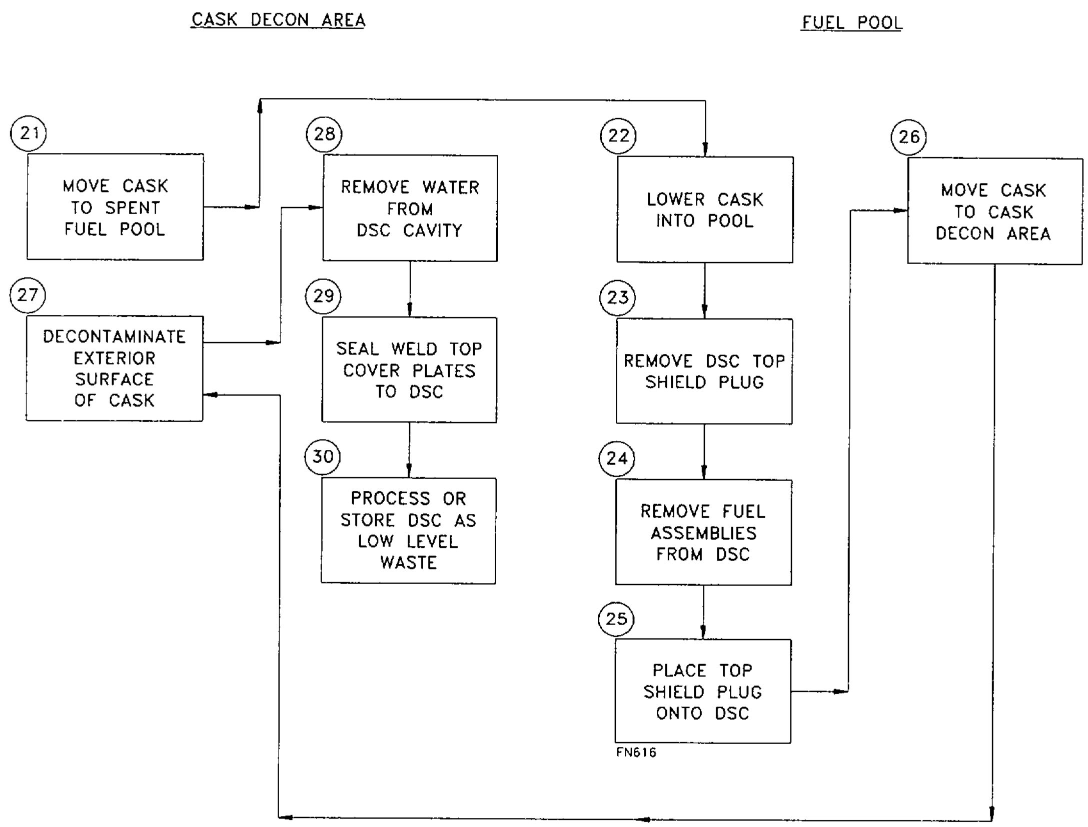


Figure 5.1-2
NUHOMS® System Retrieval Operations Flow Chart
(concluded)

5.2 Fuel Handling Systems

5.2.1 Spent Fuel Handling and Transfer

NUHOMS® is a modular storage system which provides for the dry storage of spent fuel in a horizontal orientation. NUHOMS® is a system designed to be installed at any licensed reactor site or other licensed independent site. It utilizes the existing plant systems for handling spent fuel and casks. This section describes the spent fuel handling systems that are unique to NUHOMS® and used during the DSC loading, closure, and transfer operations. The standardized transfer system is described in this section to illustrate the hardware and procedures required for operation of the NUHOMS® system.

5.2.1.1 Function Description

Figure 5.2-1 illustrates the DSC loading, closure, and transfer operations.

Transfer System The transfer system is composed of the NUHOMS® on-site transfer cask, lifting yoke, support skid, skid positioning system, transport trailer, hydraulic ram, and auxiliary equipment as described in Section 1.3.1.

Transfer Cask The NUHOMS® transfer cask is used to transfer a loaded DSC to and from the HSM as shown in Figure 4.2-10 and 4.2-13. The cask provides biological shielding during the transfer, loading, and retrieval operations. During transfer of the DSC to the HSM, the top end of the cask is docked within the HSM access opening sleeve. A description of the NUHOMS® transfer cask design criteria and capabilities are provided in Chapters 3, 4, and 8.

Cask Support Skid The purpose of the cask support skid shown in Figure 1.3-8, is to transport the cask, in a horizontal position, to the ISFSI and maintain the cask alignment during the loading and retrieval operations. The skid is mounted on bearing plates and secured to the transport trailer during transport. These bearing plates permit the skid to align the DSC with the DSC support structure inside the HSM, using the skid positioning system (Figure 4.7-5). Section 3.1.2.2 establishes the criteria for design of the cask support skid.

Transport Trailer The function of the transport trailer is two-fold, 1) to transport the loaded cask in the horizontal position to the ISFSI and 2) to approximately align the cask with the HSM opening. The trailer shown in Figure 1.3-7 is a standard heavy haul trailer capable of handling a 125 ton payload.

Optical Survey Equipment After the loaded trailer has been backed up to the HSM, the cask is aligned with the HSM. Alignment is achieved using a transit level and optical alignment marks on the cask and HSM as shown in Figure 5.2-2. Once the cask is aligned with the HSM, the trailer jacks and cask restraints insure that alignment is maintained throughout the DSC transfer or retrieval operations.

Jack Support System The tires on the trailer are pneumatic. As the DSC is being transferred into or out of the HSM, the transfer of the load may cause the alignment to be altered or cause the DSC to bind in the cask or HSM. To ensure that the alignment is maintained throughout the DSC transfer or retrieval operations, jacks at four locations on the trailer are used as shown in Figure 4.7-3. The design criteria for the jack support system are established in Section 3.1.2.

Cask Restraints During the DSC transfer or retrieval operations, the resistance of the DSC could cause the cask to move in its axial direction. This motion could cause the alignment to be altered or shielding by the HSM and cask to be jeopardized. To insure that the cask does not move in the axial direction, cask restraints join the HSM front wall embedments to the cask lifting trunnions as shown in Figure 4.2-7.

Ram and Grappling Apparatus The ram is a hydraulic cylinder which extends from the back of the cask through the length of the cask as shown in Figure 1.3-9. The grappling apparatus is mounted on the front of the ram as shown in Figure 1.3-9. The hydraulics for the grappling apparatus are activated causing the arms to engage the DSC grapple ring. Once the arms are engaged, the ram is extended, pushing the DSC out of the cask and into the HSM. For retrieval of the cask the process is reversed. The DSC slides along the cask inner liner rails and onto the support rails inside the HSM.

DSC Support Rails During the transfer operation, the DSC slides out of the cask on hard surfaced rails and onto the support rails inside the HSM as shown in Figure 4.2-8. The support rails in the HSM serve as both the sliding surfaces during the transfer operation as well as supports during DSC storage. The surface of the support rails which comes in contact with the surface of the DSC is coated with a solid film lubricant.

5.2.1.2 Safety Features

Except for the transfer of the DSC from the cask to the HSM, the loaded DSC is always seated inside the cask cavity. The safety features used in handling the cask in the fuel/reactor building are unique to the plant and governed by the plant's 10CFR50 operating license.

To ensure that the minimum amount of force is applied to the DSC during the transfer operation, the cask cavity rails and the support rails in the HSM which are in contact with the DSC are coated with a dry film lubricant. A low coefficient of friction minimizes the amount of force applied to the DSC, thus minimizing the possibility of damage to the DSC.

If the motion of the DSC is impeded during the transfer operation and the ram continues to travel, the force exerted by the ram on the DSC will increase. To indicate the occurrence of such an event, the amount of force which the ram may exert is limited by the ram control system and monitored by the operator. The stresses which develop in the DSC due to the maximum loading force are less than the allowable limits of the DSC material and therefore, the integrity of the canister shell and closure welds is not jeopardized.

5.2.2 Spent Fuel Storage

Descriptions of the operations used for the transfer and retrieval of the DSC from the HSM are presented in Section 5.1.

5.2.2.1 Safety Features

The features, systems and special techniques which provide for safe loading and retrieval operations are described in Section 5.2.1.2.

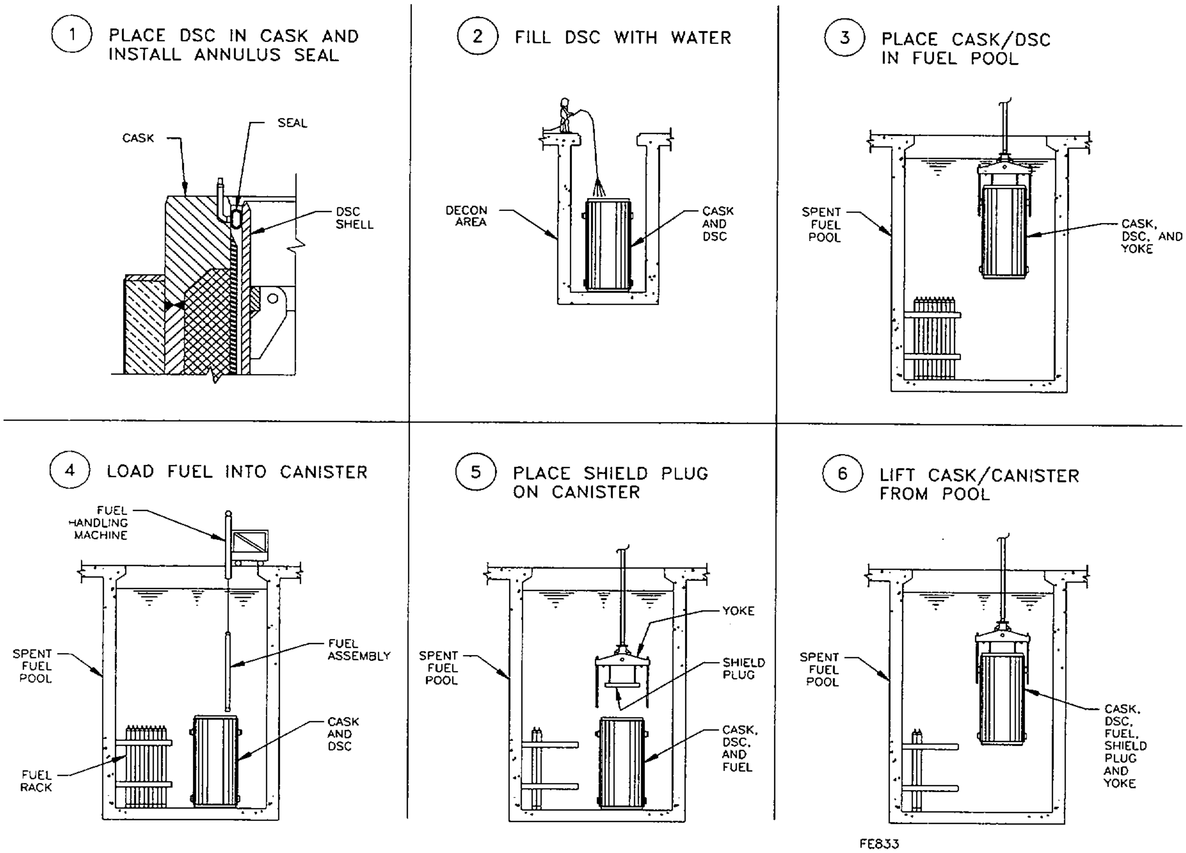


Figure 5.2-1
Primary Operations for the NUHOMS® System

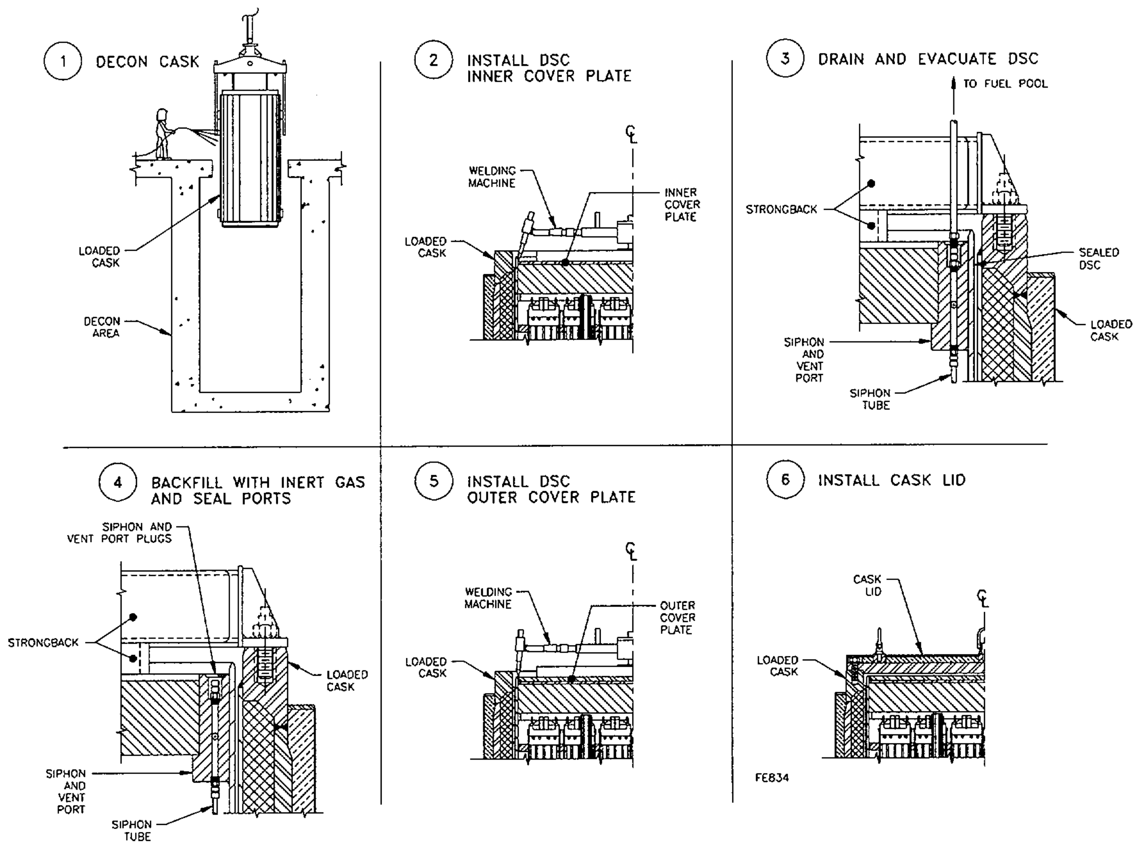


Figure 5.2-1
Primary Operations for the NUHOMS® System
(continued)

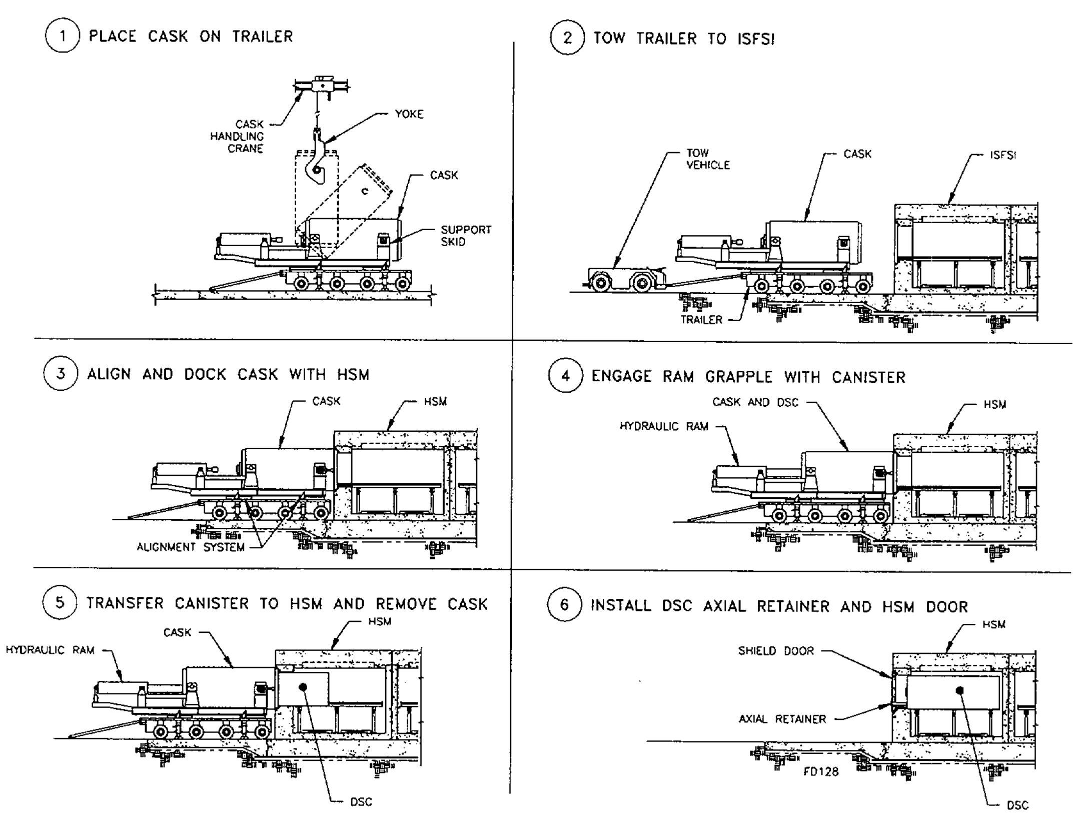


Figure 5.2-1
Primary Operations for the NUHOMS® System
(concluded)

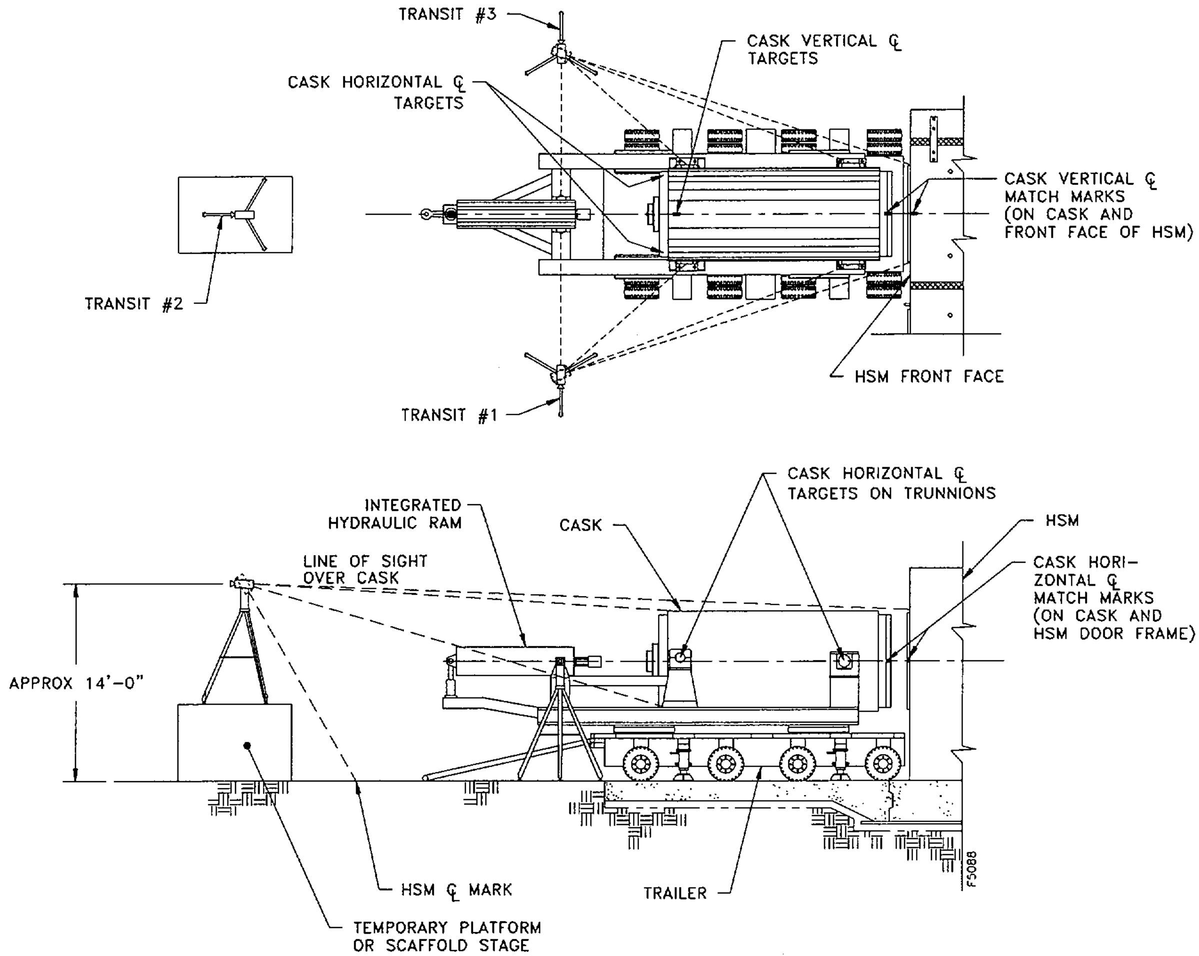


Figure 5.2-2
NUHOMS® Cask/HSM Alignment Verification

5.3 Other Operating Systems

5.3.1 Operating System

NUHOMS® is a passive storage system and requires no operating systems other than those systems used in transferring the DSC to and from the HSM.

5.3.2 Component/Equipment Spares

As discussed in Section 8.2, the standardized NUHOMS® ISFSI is designed to withstand all postulated design basis events. Therefore, no storage component or equipment spares are required for the standardized NUHOMS® system.

5.4 Operation Support System

NUHOMS® is a self contained passive system and requires no effluent processing systems during storage conditions.

5.4.1 Instrumentation and Control System

There are no instrumentation and control systems used during storage conditions, except for the HSM temperature monitoring required by NUHOMS® Technical Specification 1.3.2. The instrumentation and controls necessary during DSC loading, closure and transfer are described in Section 5.1.3.4.

5.4.2 System and Component Spares

Other than spares for the HSM temperature monitoring, there are no instrumentation or control systems used during storage conditions; thus, no other system and component spare parts are required.

5.5 Control Room and/or Control Areas

There are no control room or control areas for the NUHOMS® system.

5.6 Analytical Sampling

The only analytical sampling used with the NUHOMS® system is the continuous monitoring (5.4) of the hydrogen concentration in the DSC cavity during welding of the DSC inner top cover plate. This hydrogen-monitoring requirement only applies to the DSCs with spacer discs or shield plugs coated with aluminum.

5.7 References

5.1 Deleted

5.2 Deleted

5.3 Deleted

5.4 U. S. Nuclear Regulatory Commission, Office of the Nuclear Material Safety and Safeguards, "Safety Evaluation of VECTRA Technologies' Response to Nuclear Regulatory Commission Bulletin 96-04 for the NUHOMS®-24P and NUHOMS®-7P Dry Spent Fuel Storage Systems, November 1997 (Dockets 72-1004, 72-3, 72-4, 72-8 and 72-14).

5.5 U. S. Nuclear Regulatory Commission Bulletin 96-04, "Chemical, Galvanic or Other Reactions in Spent Fuel Storage and Transportation Casks," July 5, 1996.

5.6 NUHOMS® Certificate of Compliance for Dry Spent Fuel Storage Casks, Certificate Number 1004 (Docket 72-1004).

5.7 U.S. Nuclear Regulatory Commission, "Standard Format and Content for a Topical Safety Analysis Report for a Spent Fuel Dry Storage Cask, Regulatory Guide 3.61 (Task 306-4), February 1989.

6. WASTE CONFINEMENT AND MANAGEMENT

6.1 Waste Sources

There are no radioactive wastes generated by the storage of spent fuel in a NUHOMS® ISFSI. The radioactive wastes generated in the plant's fuel/reactor building during DSC loading and closure operations are handled and processed using existing plant facilities and procedures.

6.2 Offgas Treatment and Ventilation

There is no radioactive offgas generated by the storage of spent fuel in a NUHOMS® ISFSI. Potentially contaminated air and helium purged from the DSC during evacuation operations are redirected and processed using existing plant facilities and procedures. These may include routing of offgas to the spent fuel pool.

6.3 Liquid Waste Treatment and Retention

There are no liquid wastes generated by the storage of spent fuel in a NUHOMS® ISFSI. The contaminated water purged from the DSC during closure operations may be drained back to the spent fuel pool with no additional processing. A small amount of liquid waste, estimated to be <15 cubic feet, results from decontamination of the transfer cask outer surface following removal from the spent fuel pool. This normally includes a small amount of detergent mixed with demineralized water which is collected in the cask decon area and subsequently processed using existing plant facilities and procedures.

6.4 Solid Wastes

There are no solid wastes generated by the storage of spent fuel in a NUHOMS® ISFSI. A small quantity of low level solid waste, estimated to be less than two cubic feet, consisting of disposable Anti-C garments, tape, decon clothes, etc., are generated during DSC closure operations. Solid low level wastes are handled and processed utilizing existing plant facilities and procedures.

6.5 Radiological Impact of Normal Operations - Summary

There are no gaseous, liquid effluents or solid wastes generated by the storage of spent fuel in a NUHOMS® ISFSI. The small volumes of these wastes generated during DSC loading and closure operations in the plant's fuel/reactor building have no significant impact on the ability of existing plant facilities to handle and process them.

7. RADIATION PROTECTION

The analysis presented in this Chapter is specifically applicable to the NUHOMS®-24P and –52B systems. Appendices J, K and L provide a similar evaluation for the NUHOMS®-24P long cavity, -61BT and -24PT2 systems, respectively.

7.1 Ensuring That Occupational Radiation Exposures Are As-Low-As-Reasonably-Achievable (ALARA)

7.1.1 Policy Considerations

The licensee's existing radiation safety and ALARA policies for the plant should be applied to the ISFSI. The ALARA program should follow the general guidelines of Regulatory Guides 1.8, 8.8, 8.10 and 10CFR20. ISFSI personnel should be trained and updated on ALARA practices and dose reduction techniques. Implementation of ISFSI systems and equipment procedures should be reviewed by the licensee to ensure ALARA exposure during all phases of operations, maintenance and surveillance.

7.1.2 Design Considerations

The design of the NUHOMS® DSC and HSM comply with 10CFR72 ALARA requirements. Features of the NUHOMS® system design that are directed toward ensuring ALARA are:

A. Thick concrete walls and roof on the HSM to minimize the on-site and off-site dose contribution from the ISFSI.

B. A thick shield plug on each end of the DSC to reduce the dose to plant workers performing drying and sealing operations, and during transfer and storage of the DSC in the HSM.

C. Use of a heavy shielded transfer cask for DSC handling and transfer operations to ensure that the dose to plant and ISFSI workers is minimized.

D. Fuel loading procedures which follow accepted practice and build on existing experience.

E. A recess in the HSM access opening to dock and secure the transfer cask during DSC transfer so as to reduce direct and scattered radiation exposure.

F. Double seal welds on each end of DSC to provide redundant containment of radioactive material.

G. Placement of demineralized water in the transfer cask/DSC annulus, then sealing the annulus to minimize contamination of the DSC exterior and the transfer cask interior surfaces during loading and unloading operations in the fuel pool.

H. Use of a heavy shielded door for the HSM to minimize direct and scattered radiation exposure.

I. Use of a passive system design for long term storage that requires minimal maintenance.

J. Use of proven procedures and experience to control contamination during canister handling and transfer operations.

K. Use of water in the DSC cavity during placement of the DSC inner seal weld to minimize direct and scattered radiation exposure.

L. Use of water in the transfer cask/DSC annulus during DSC closure operations to reduce radiation streaming through the annulus.

M. Use of temporary shielding during DSC draining, drying, inerting and closure operations as necessary to further reduce the direct and scattered dose.

Further ALARA measures may be implemented, as necessary, by the licensee.

7.1.3 Operational Considerations

Consistent with the licensee's overall commitment to keep occupational radiation exposures ALARA, specific plans and procedures should be followed by ISFSI personnel to ensure that ALARA goals are achieved consistent with the intent of Section C.1 of Regulatory Guides 8.8 and 8.10. Since the ISFSI is a passive system, no maintenance is expected on a normal basis. Maintenance operations on the transfer cask, transfer equipment and other auxiliary equipment is generally performed in a very low dose environment during periods when fuel movement is not occurring. Maintenance activities that could involve significant radiation exposure of personnel should be carefully planned. They should utilize previous operating experience, and be carried out using well trained personnel and proper equipment. Where applicable, formal ALARA reviews should be prepared which specify radiation exposure reduction techniques, such as those set out in Regulatory Guide 8.8.

7.2 Radiation Sources

7.2.1 Characterization of Sources

This section describes the design basis radiation source strengths and source geometries used for the standardized NUHOMS® 24P and 52B systems shielding design calculations. Appendices K and L describe the same for the NUHOMS®-61BT and –24PT2 systems respectively.

The neutron and gamma radiation sources include the design basis PWR and BWR spent fuel, activated portions of the fuel assembly, and secondary gammas. All sources, except secondary gammas, are considered physically bound in the source region. Secondary gammas are produced by neutrons passing through shielding regions.

The design basis PWR spent fuel for the NUHOMS®-24P system has been subjected to an average fuel burnup of 40,000 MWD/MTU. The maximum initial enrichment is 4.0 weight percent U-235 and a post-irradiation cooling time equivalent to five years is assumed. Similarly, the design basis BWR spent fuel for the NUHOMS®-52B system has been subjected to an average fuel burnup of 35,000 MWD/MTU with a maximum initial enrichment of 4.0 weight percent U-235 and a cooling time of five years. Spent fuel assemblies which meet these criteria are bounded by the source strengths used in this analysis.

Neutron sources are based on spontaneous fission contributions from six nuclides (predominantly Cm-242, Cm-244, and Cm-246 isotopes), and (α,n) reactions due almost entirely to eight alpha emitters, (predominantly Pu-238, Cm-242, and Cm-244). The fission spectrum used in shielding calculations is a weighted combination of the principal contributors. The total neutron source strength for PWR fuel is 2.23E8 neutrons per second per assembly. Similarly, the total neutron source strength for BWR fuel is 1.01E8 neutrons per second per fuel assembly. The neutron energy spectrum and flux-to-dose conversion factors are presented in Table 7.2-1 and Table 7.2-2.

Gamma radiation sources include 70 principal fission product nuclides within the spent fuel, and several activation products and actinide elements present in the spent fuel and fuel assemblies. The gamma energy spectrum includes contributions from each source isotope as determined by ORIGEN calculations for the design basis spent fuel. The total gamma source strength for PWR fuel is 5.81E15 MeV/s/MTHM. Similarly the total gamma source strength for BWR fuel is 4.86E15 MeV/s/MTHM. The gamma energy spectrum and flux-to-dose conversion factors are presented in Table 7.2-3 and Table 7.2-4. The gamma source due to control components, which represents less than 10% of the fuel source, is addressed in Appendix H.

The source geometries for neutron shielding calculations are either cylindrical or slab, depending on whether neutron dose rates are required in the radial or axial direction around the DSC, respectively. Section 7.3.2 contains detailed descriptions of the neutron source model geometries.

The gamma shielding calculations are based on cylindrical source models. A source mesh is defined for each shielding model with increasingly finer mesh spacing near detectors. Symmetry is taken advantage of wherever possible to facilitate the use of more mesh points. Section 7.3.2 further describes the gamma source models.

7.2.2 Airborne Radioactive Material Sources

The release of airborne radioactive material is addressed for three phases of system operation: fuel handling in the spent fuel pool, drying and sealing of the DSC, and DSC transfer and storage. Potential airborne releases from irradiated fuel assemblies in the spent fuel pool are discussed in the plant's existing 10CFR50 license.

DSC drying and sealing operations are performed using procedures which prohibit airborne leakage. During these operations, all vent lines are routed to the plant's existing radwaste systems. Once the DSC is dried and sealed, there are no design basis accidents which could result in a breach of the DSC and the airborne release of radioactivity. Design provisions to preclude the release of gaseous fission products as a result of accident conditions are discussed in Section 8.2.8.

During transfer of the sealed DSC and subsequent storage in the HSM, the only postulated mechanism for the release of airborne radioactive material is the dispersion of non-fixed surface contamination on the DSC exterior. By filling the cask/DSC annulus with demineralized water, placing an inflatable seal over the annulus, and utilizing procedures which require examination of the annulus surfaces for smearable contamination, the contamination limits on the DSC can be kept below the permissible level for off-site shipments of fuel. Therefore, there is no possibility of significant radionuclide release from the DSC exterior surface during transfer or storage.

Table 7.2-1
Neutron Energy Spectrum and Flux-to-Dose Conversion Factors for PWR Spent Fuel

Upper Energy Level (MeV)	Group Fraction[2] (unitless)	Flux-to-Dose Conversion Factor[1] (mrem/hr per neutron/cm²-sec)
14.92	1.255e-04	1.945e-01
12.20	1.067e-03	1.597e-01
10.00	2.935e-03	1.471e-01
8.18	1.463e-02	1.477e-01
6.36	3.705e-02	1.534e-01
4.96	4.900e-02	1.506e-01
4.06	1.230e-01	1.389e-01
3.01	1.007e-01	1.284e-01
2.46	2.461e-02	1.253e-01
2.35	1.271e-01	1.263e-01
1.83	2.265e-01	1.289e-01
1.11	2.008e-01	1.169e-01
5.50e-01	9.252e-02	6.521e-02
1.11e-01	3.986e-06	9.188e-03
3.35e-03	0.000	3.713e-03
5.83e-04	0.000	4.009e-03
1.01e-04	0.000	4.295e-03
2.90e-05	0.000	4.476e-03
1.01e-05	0.000	4.567e-03
3.06e-06	0.000	4.536e-03
1.12e-06	0.000	4.370e-03
4.14e-07	0.000	3.714e-03

(1) Data obtained from Reference 7.12.

(2) Typical neutron spectrum used for design calculations. Neutron dose rates will not vary substantially due to spectral differences for any candidate fuel assemblies.

Table 7.2-2
Neutron Energy Spectrum and Flux-to-Dose Conversion Factors for BWR Spent Fuel

Upper Energy Level (MeV)	Group Fraction[2] (unitless)	Flux-to-Dose Conversion Factor[1] (mrem/hr per neutron/cm²-sec)
14.92	1.255e-04	1.945e-01
12.20	1.067e-03	1.597e-01
10.00	2.935e-03	1.471e-01
8.18	1.463e-02	1.477e-01
6.36	3.705e-02	1.534e-01
4.96	4.900e-02	1.506e-01
4.06	1.230e-01	1.389e-01
3.01	1.007e-01	1.284e-01
2.46	2.461e-02	1.253e-01
2.35	1.271e-01	1.263e-01
1.83	2.265e-01	1.289e-01
1.11	2.008e-01	1.169e-01
5.50e-01	9.252e-02	6.521e-02
1.11e-01	3.986e-06	9.188e-03
3.35e-03	0.000	3.713e-03
5.83e-04	0.000	4.009e-03
1.01e-04	0.000	4.295e-03
2.90e-05	0.000	4.476e-03
1.01e-05	0.000	4.567e-03
3.06e-06	0.000	4.536e-03
1.12e-06	0.000	4.370e-03
4.14e-07	0.000	3.714e-03

(1) Data obtained from Reference 7.12

(2) Typical neutron spectrum used for design calculations. Neutron dose rates will not vary substantially due to spectral differences for any candidate fuel assemblies.

Table 7.2-3
Gamma Energy Spectrum and Flux-to-Dose Conversion Factors for PWR Fuel

Mean Energy (MeV)	Group Fraction (unitless)	Flux-to-Dose Conversion Factor[1] (mrem/hr per Photon/cm²-sec)
9.50	2.190e-11	9.142e-03
7.00	1.905e-10	7.294e-03
5.00	1.653e-09	5.800e-03
3.50	1.138e-06	4.627e-03
2.75	8.919e-06	3.961e-03
2.25	2.888e-04	3.471e-03
1.75	5.809e-04	2.930e-03
1.25	3.563e-02	2.320e-03
0.85	8.698e-02	1.759e-03
0.575	3.854e-01	1.315e-03
0.375	1.453e-02	9.332e-04
0.225	2.500e-02	5.658e-04
0.125	3.043e-02	3.261e-04
0.085	2.991e-02	2.646e-04
0.058	4.619e-02	2.687e-04
0.038	5.892e-02	3.940e-04
0.025	5.445e-02	8.002e-04
0.010	2.317e-01	3.960e-03

(1) Data obtained from Reference 7.12

Table 7.2-4
Gamma Energy Spectra and Flux-to-Dose Conversion Factors for BWR Fuel

Mean Energy (MeV)	Group Fraction (unitless)	Flux-to-Dose Conversion Factor[1] (mrem/hr per Photon/cm²-sec)
9.50	2.205e-11	9.142e-03
7.00	1.918e-10	7.294e-03
5.00	1.661e-09	5.800e-03
3.50	1.291e-06	4.627e-03
2.75	1.004e-05	3.961e-03
2.25	2.597e-04	3.471e-03
1.75	6.561e-04	2.930e-03
1.25	2.831e-02	2.320e-03
0.85	8.834e-02	1.759e-03
0.575	3.964e-01	1.315e-03
0.375	1.503e-02	9.332e-04
0.225	2.469e-02	5.658e-04
0.125	3.096e-02	3.261e-04
0.085	2.945e-02	2.646e-04
0.058	4.538e-02	2.687e-04
0.038	5.950e-02	3.940e-04
0.025	5.451e-02	8.002e-04
0.010	2.265e-01	3.960e-03

(1) Data obtained from Reference 7.12

7.3 Radiation Protection Design Features

7.3.1 Installation Design Features

The design considerations listed in Section 7.1.2 ensure that occupational exposures to radiation are ALARA and that a high degree of integrity is achieved through the confinement of radioactive materials inside the DSC. Applicable portions of Regulatory Position 2 of Regulatory Guide 8.8 (7.5) have been used as guidance.

A. Access control to radiation areas should utilize the licensee's existing plant procedures.

B. Radiation shielding substantially reduces the exposure of personnel during system operations and storage.

C. The NUHOMS® system is a passive storage system; no process instrumentation or controls are necessary during storage. The only required instrumentation is the HSM temperature monitoring required by the Certificate conditions of use.

D. Airborne contaminants and gaseous radiation sources are confined by the high integrity double seal welded DSC assembly.

E. No crud is produced by the NUHOMS® system.

F. The necessity for decontamination is reduced by maintaining the cleanliness of the DSC and transfer cask during fuel loading and unloading operations (see Section 5.1); the DSC and transfer cask surfaces are smooth, nonporous, and are generally free of crevices, cracks, and sharp corners.

G. No radiation monitoring system is required during storage.

H. No resin or sludge is produced by the NUHOMS® system.

The NUHOMS® system is a passive storage system which uses ambient air for decay heat removal. Each HSM is capable of providing sufficient ventilation and natural circulation to assure adequate cooling of the DSC and its contents so that fuel cladding integrity is maintained. The convective cooling system is completely passive and requires no filtration system.

7.3.2 Shielding

7.3.2.1 Radiation Shielding Design Features

Radiation shielding is an integral part of both the DSC and HSM designs. The features described in this section assure that doses to personnel and the public are ALARA.

The DSC is a cylindrical pressure vessel constructed from stainless steel with carbon steel internals. Details of the DSC and relevant dimensions can be found in Chapter 4 and on the drawings in Appendix E. A thick steel or composite lead/steel plug and two stainless steel cover plates provide axial shielding at each end of the DSC. During DSC handling operations, additional shielding is provided by the on-site transfer cask.

Two small penetrations in the top shield plug provide a means for draining water, vacuum drying and helium backfilling the DSC. The penetrations are located on the perimeter of the DSC away from fuel assemblies and contain sharp bends to minimize radiation streaming. Appendix A shows the relevant dimensions of the shielding materials located at the top and bottom ends of the DSC. Figure 1.3-1 shows the physical arrangements of the DSC shield plug assemblies.

The HSM provides substantial shielding during storage of the DSC. Details of the HSM and relevant dimensions can be found in Chapter 4 and on the drawings in Appendix E. Thick reinforced concrete walls and a roof slab provide neutron and gamma shielding. The HSM's access opening is covered by a thick concrete door (HSM Model 102), or an alternate composite door (HSM Model 80) which includes a heavy steel plate with a concrete core.

Penetrations in the HSM allow convective air cooling of the DSC and HSM internals. The inlet vents located in the lower side walls of the HSM draw air into the HSM. The HSM outlet vents are located in the upper side walls of the HSM. There are no penetrations or openings in occupiable areas surrounding the HSM. The features of the HSM design are illustrated in Figure 1.3-4.

The on-site transfer cask is a cylindrical shielded vessel constructed from steel and various shielding materials. Details of the transfer cask and relevant dimensions can be found on the drawings in Appendix E. Radial gamma shielding is principally provided by a stainless steel inner liner, a lead shield, and a carbon or stainless steel structural shell. Neutron shielding in the radial direction is provided by an outer metal jacket which forms an annulus with the cask structural shell. The annulus is filled with a neutron absorbing material to provide neutron dose attenuation. The steel transfer cask top and bottom cover plates with integral solid neutron shielding material provide additional shielding in the axial direction to that of the DSC shield plugs. Figure 1.3-6 shows the physical arrangement of the transfer cask top and bottom end assembly.

Additional portable shielding during DSC handling, transport and transfer operations may be utilized by the licensee, if desired. Section 7.4 conservatively provides an assessment of design basis on-site doses without the use of portable shielding.

7.3.2.2 Shielding Analysis

This section describes the radiation shielding analytical methods and assumptions used in calculating NUHOMS® 24P and 52B systems dose rates during the handling and storage operations. Appendices K and L describe the same for the NUHOMS®-61BT and -24PT2 systems, respectively. The dose rates of interest are calculated at the locations listed in Table 7.3-2 for 5 year cooled design basis PWR fuel. Table 7.3-3 shows the dose rates for 10 year cooled PWR fuel which are included for information only. Figure 7.3-3 shows these locations on the HSM, DSC and transfer cask. The dose rates reported in Tables 7.3-2 and 7.3-3 for the DSC with the HSM are for HSM Model 80 which bounds the dose rates for HSM Model 102. The computer codes used for analysis are described below, each with a brief description of the input parameters generic to its use. Descriptions of the individual analytical models used in the analysis are also provided. Consistent with the relative design basis source strengths, the shielding analysis results for the NUHOMS®-24P envelop those of the NUHOMS®-52B systems, except on the bottom of the DSC. The bottom of the NUHOMS®-52B canister has 0.5" less steel shielding. The effect of this difference on the dose rates at the bottom surface of the transfer cask and the HSM with and without the door are provided in Tables 7.3-4 and 7.3-5 for 5 and 10 year cooled BWR fuel, respectively.

A. Computer Codes ANISN (7.1), a one-dimensional, discrete ordinates transport computer code, is used to obtain neutron and gamma dose rates at the outer HSM walls, and at the outside surface of the loaded transfer cask in the radial direction. ANISN is also used to obtain the axial neutron dose rates at the shield plugs of the DSC, the transfer cask, and outside the HSM access door. The CASK cross section library, which contains 22 neutron energy groups and 18 gamma energy groups, is applied in an S_8P_3 approximation for cylindrical or an $S_{16}P_3$ approximation for slab geometry, respectively (7.7). Calculated radiation fluxes are multiplied by flux-to-dose conversion factors (Table 7.2-1, Table 7.2-2, Table 7.2-3, and Table 7.2-4) to obtain final dose rates. The ANISN calculations use the coupled neutron and gamma libraries. Therefore, dose rates from both primary and secondary gammas are calculated in each run.

QAD-CGGP (7.2), a three-dimensional point-kernel code, is used for the axial gamma shielding analysis of the HSM access door, the DSC and cask end assemblies, the DSC-cask annular gap, and the HSM air vent penetrations. Mass attenuation and buildup factors are obtained from QAD-CGGP's internal library. The gamma energy spectrum is taken directly from ORIGEN.

Since QAD-CGGP calculates dose rates from primary gammas only, the primary gamma source strength in the active fuel region is increased for calculations in the axial direction of the DSC. This is done as a way to include the dose rate effect due to secondary gammas primarily generated in the shield plug material of the DSC and additional activation products located in the fuel assembly end fittings. Previous licensing calculations indicate that secondary gammas contribute only one percent of the total gamma radiation dose rate in the HSM concrete. Therefore, these effects are neglected for the QAD-CGGP analysis for the HSM concrete.

In order to substantiate increasing the primary gamma source strength when using QAD-CGGP for axial calculations, a set of benchmarking runs are performed. For this calibration analysis, QAD-CGGP is used to model an actual metal storage cask containing spent PWR fuel where the geometry of the cask and the contained fuel is similar to that of NUHOMS® and actual measured dose rates at the cask ends are available (7.10). As a result, it is concluded that increasing the primary gamma source strength in the active fuel region for the QAD-CGGP runs resulted in the maximum calculated dose rates at the cask ends meeting or slightly exceeding the maximum measured dose rates (average calculated dose rates exceeded average measured dose rates across the entire cask ends). Therefore, increasing the gamma source strength in the active fuel region when using QAD-CGGP for estimating gamma dose rates in the DSC axial direction results in conservative values.

Manual albedo calculations are used in conjunction with the fluxes calculated by QAD-CGGP and ANISN to provide upper bounds on the reflected dose rate at the HSM front wall and roof vent screens and the DSC/cask annular gap. The albedo method used is described in References 7.8 and 7.9.

<u>B. HSM Surface Dose Rates</u> The ANISN analytical model used to determine neutron and gamma dose rates outside the thick HSM walls (or roof) is presented in Appendix A. The DSC/HSM is represented by a cylindrical model which includes a homogenized, isotropic, self-shielding source region, the HSM heat shield, an air gap between the DSC and the thick concrete wall or roof. The effective radius of the source region is chosen to be the inside radius of the DSC. The mesh size in each material region is chosen to be on the order of one mean free path of neutrons through that material. A buckling factor correction for the infinite length model is made to estimate the dose rates at the active fuel region midplane.

<u>C. Cask and HSM Axial Dose Rates</u> An ANISN model of an infinite slab is also used to calculate the neutron dose rates in the axial direction (e.g., at the DSC top and bottom cover plate surfaces).

Appendix A illustrates the analytical QAD-CGGP models for the top and bottom axial dose rate calculations, respectively. A simple 3-D slab shield geometry and cylindrical source mesh are constructed. The results are extended to include the dose rate outside the thick HSM access door.

D. HSM Front Wall and Roof Bird Screen Dose Rates The total dose rate along the HSM roof and front bird screens is assumed to consist of direct and reflected components of both neutron and gamma radiation.

The direct radiation component is calculated similar to the nominal roof or side wall dose rates using QAD-CGGP for gamma rays and ANISN for neutrons.

The reflected radiation component is treated by a combination of computer and manual calculations since neither QAD-CGGP nor ANISN can directly model scattered reflection. The methodology used for both types of radiation are described below.

It is assumed that the primary scattering surface is the entire HSM side wall surface. Incident dose rates on the scattering surface are determined using QAD-CGGP or ANISN. In order to simplify calculations, a monoenergetic incident particles assumption is made for both neutrons and gamma rays. Gamma radiation is assumed to be entirely 1 MeV energy particles since the 1 MeV energy group contributes the most to the HSM exterior dose. Neutrons are assumed to be thermal for the same reason.

For neutrons, a simple normally incident, broad beam assumption is made. This is considered sufficient since the problem is significantly dominated by gamma radiation. For gammas, a more accurate modeling approach is used. Incident dose rate data is taken from the QAD-CGGP run for a very large number of detectors along the scattering surface. The detector mesh is sufficiently small to properly represent the streaming paths through the vents. For each detector point, it is assumed that the most likely incident angle is from the nearest point on the active fuel zone to the detector. This incident angle is then used to accurately compute the albedo factor.

To calculate the amount of radiation leaving the scattering surface in the direction of interest, albedo factors are calculated. Albedo factors for neutrons are calculated based on the data in Reference 7.9. Gammas are calculated by using a unique albedo factor for each of the QAD-CGGP detector points. Empirical differential dose albedo data for concrete (7.8 and 7.9) are used. A single scatter approximation is used. This process is repeated for several points along the bird screens in order to develop a dose rate profile.

The QAD-CGGP analytical model is shown in Appendix A. All the gamma sources are modelled in the active fuel region to obtain the gamma dose rate profile. The secondary gamma source is found to have a negligible effect on the penetration dose rates due to the large size of the primary gamma source and so it is not included.

E. Cask-DSC Annular Gap Dose Rate The exact annulus size depends on the position of the DSC within the transfer cask. An evaluation of radiation streaming through a bounding annular gap (maximum possible) between the DSC and the transfer cask is performed. Manual albedo calculations are performed to assess the annular gap streaming. Neutron and gamma fluxes, as determined by ANISN outside the DSC at the fuel midplane, are assumed to be constant over the cask inner wall surface. The worst-case scenario is examined where the DSC is placed off-center in the cask resulting in no clearance on one side and the maximum gap on the other. The results are given in Table 7.3-2 and Table 7.3-3 for the NUHOMS®-24P system. Tables 7.3-4 and 7.3-5 present the results for the NUHOMS®-52B system.

F. Transfer Cask Surface Dose Rates The ANISN model used to determine combined radiation dose rates on and away from the transfer cask surface during handling operations is shown in Appendix A. The analytical modelling methodology is similar to the ANISN model of the HSM previously described.

7.3.2.3 Shielding Provided by Lead Shield Plug

As an alternative to the solid steel shield plugs used in the analyses, shield plugs consisting of lead encased in steel can be used. The total thickness of these plugs is less than that of the solid steel shield plugs, which results in a longer canister cavity. However, the overall shielding effectiveness is equivalent, due to lead's higher density. This design is currently in use at Oconee Nuclear Station and licensed in the NUHOMS®-24P Topical Report/Safety Evaluation Report (7.13). A detailed discussion of this shield plug design and its effectiveness is provided in Appendix J.

7.3.3 Ventilation

The HSM has a ventilation system to provide for natural circulation cooling of the DSC. No off-gas treatment system is required due to the low exterior contamination level permitted for the DSC (see Sections 3.3.7 and 4.3.1).

The NUHOMS® system is designed to prevent the release of radioactive material during normal storage of the DSC in an HSM. No additional design features or equipment would result in a significant reduction in a postulated release of radioactive materials. Furthermore, no credible site accident would result in a release of radioactive materials to the environment due to the key features of the NUHOMS® system design. These include:

A. The use of a high integrity DSC with redundant seal welds at each end,

B. The passive nature of the system such as the HSM natural convection cooling system which ensures that fuel cladding integrity is maintained, and

C. The operational limits and controls placed on DSC loading and closure and transfer operations.

7.3.4 Area Radiation and Airborne Radioactivity Monitoring Instrumentation

As indicated in Section 3.3.5, area radiation and airborne radioactivity monitors are not needed for a NUHOMS® ISFSI. Thermoluminescent dosimeters (TLDs) may be used to record dose rates along the ISFSI fence, however. The licensees environmental monitoring program should be expanded to include the ISFSI.

Table 7.3-1

Deleted

Table 7.3-2

Shielding Analysis Results for 5 Year Cooled Fuel NUHOMS®-24P System(5) (w/o BPRAs)

Location	Neutron Dose Rate (mrem/hr.)		Gamma Dose Rate (mrem/hr) Primary and Secondary		Total Dose Rate (mrem/hr.)
	Direct	Reflected	Direct	Reflected	
DSC in HSM					
1. HSM Surface					
1.1 HSM Wall or Roof	0.4	(1)	48.2	(1)	48.6
1.2 HSM Front Bird Screen	0.8	15.7	75.2	234.2	325.9
1.3 HSM Roof Bird Screen	0.8	35.2	103.6	427.8	567.4
1.4 Center of Door (exterior)	28.2	(1)	22.2	(1)	62.3(4)
1.5 Center of Door Opening (door removed)	966.1	(1)	1135.2	(1)	2329(4)
DSC IN CASK					
1. Centerline Top Shield Plug(2)	0.4	(1)	79.4	(1)	79.8
2. Top Cover Plate (cavity drained with water in annulus and 3 inches of temporary neutron and 1" of gamma shielding)					
2.1 Centerline	10.2	(1)	31.1	(1)	41.3
2.2 Outer Edge(3)	8.1	(1)	24.9	349.0	382.0

(1) The reflected dose at these locations is negligible.

(2) The DSC/cask annulus is filled with water and additional neutron shielding material is utilized as required. In addition, the DSC inner cavity is assumed to be filled with water for this operation.

(3) The same gap dose rate applies for cases where only the top shield plug is in place. The dose rates reported are with water in the DSC/cask annulus (however, no water is assumed to be in the DSC).

(4) Represents the greatest total dose rate calculated for fuel assemblies suitable for storage per Table 1.2a from Attachment A of CoC 1004. Analysis was performed conservatively for fuel assemblies with burnups up to 50 GWD/MTU.

(5) Shielding Analysis Results for storing fuel with BPRAs into NUHOMS ®-24P System are presented in Appendix J.

Table 7.3-2
Shielding Analysis Results for 5 Year Cooled Fuel NUHOMS®-24P System (w/o BPRAs)

(Concluded)

Location	Neutron Dose Rate (mrem/hr.)		Gamma Dose Rate (mrem/hr) Primary and Secondary		Total Dose Rate (mrem/hr.)
	Direct	Reflected	Direct	Reflected	
DSC IN CASK (continued)					
3. Transfer Cask					
3.1 Radial	163.9	(1)	427.9	(1)	591.8
a. Surface	75.4	(1)	211.8	(1)	287.2
b. 3 Ft. from Surface					
3.2 Top axial	16.8	(1)	4.4	(1)	33.3(4)
3.3 Bottom axial	28.3	(1)	39.1	(1)	69.8(4)

Table 7.3-3
Shielding Analysis Results for 10 Year Cooled Fuel NUHOMS®-24P System[(2)]

Location	Neutron Dose Rate (mrem/hr.)		Gamma Dose Rate (mrem/hr) Primary and Secondary		Total Dose Rate (mrem/hr.)
	Direct	Reflected	Direct	Reflected	
DSC in HSM					
1. HSM Surface					
1.1 HSM Wall or Roof	0.3	(1)	17.5	(1)	17.8
1.2 HSM Front Bird Screen	0.6	11.2	31.0	102.6	145.4
1.3 HSM Roof Bird Screen	0.6	25.0	42.2	190.1	257.9
1.4 Center of Door (exterior)	19.6	(1)	8.3	(1)	27.9
1.5 Center of Door Opening (door removed)	670.6	(1)	477.4	(1)	1148.0
DSC IN CASK					
1. Transfer Cask	113.7	(1)	144.6	(1)	258.3
1.1 Radial	52.3	(1)	70.5	(1)	122.8
a. Surface					
b. 3 Ft. from Surface					
1.2 Top axial	11.7	(1)	1.5	(1)	13.2
1.3 Bottom axial	19.6	(1)	15.0	(1)	34.6

(1) The reflected dose at these locations is negligible.

(2) The 10 year cooled fuel doses are for information only.

Table 7.3-4
Shielding Analysis Results for 5 Year Cooled Fuel NUHOMS®-52B System

Location	Neutron Dose Rate (mrem/hr.)		Gamma Dose Rate (mrem/hr) Primary and Secondary		Total Dose Rate (mrem/hr.)
	Direct	Reflected	Direct	Reflected	
DSC in HSM					
1. HSM Surface					
1.1 HSM Wall or Roof	(1)	(2)	(1)	(2)	(1)
1.2 HSM Front Bird Screen	(1)	(1)	(1)	(1)	(1)
1.3 HSM Roof Bird Screen	(1)	(1)	(1)	(1)	(1)
1.4 Center of Door (exterior)	30.7	(2)	24.4	(2)	55.1
1.5 Center of Door Opening (door removed)	1035.7	(2)	1310.0	(2)	2345.7
DSC IN CASK					
1. Centerline Top Shield Plug[(3)]	(1)	(2)	(1)	(2)	(1)
2. Top Cover Plate (cavity drained with water in annulus and 3 inches of temporary neutron and 1" of gamma shielding)					
2.1 Centerline	(1)	(2)	(1)	(2)	(1)
2.2 Outer Edge[(4)]	(1)	(2)	(1)	(1)	(1)

(1) These results are bounded by the corresponding 24P results shown in Table 7.3-2.

(2) The reflected dose at these locations is negligible.

(3) The DSC/cask annulus is filled with water and additional neutron shielding material is utilized as required. In addition, all but the top six inches of the DSC inner cavity is assumed to be filled with water for this operation.

(4) The same gap dose rate applies for cases where only the top shield plug is in place. The dose rates reported are with water in the DSC/cask annulus (however, no water is assumed to be in the DSC).

Table 7.3-4
Shielding Analysis Results for 5 Year Cooled Fuel NUHOMS®-52B System

(Concluded)

Location	Neutron Dose Rate (mrem/hr.) Direct	Neutron Dose Rate (mrem/hr.) Reflected	Gamma Dose Rate (mrem/hr) Primary and Secondary Direct	Gamma Dose Rate (mrem/hr) Primary and Secondary Reflected	Total Dose Rate (mrem/hr.)
DSC IN CASK (continued)					
3. Transfer Cask					
3.1 Radial					
a. Surface	(1)	(2)	(1)	(2)	(1)
b. 3 Ft. from Surface	(1)	(2)	(1)	(2)	(1)
3.2 Top axial	(1)	(2)	(1)	(2)	(1)
3.3 Bottom axial	30.7	(2)	43.1	(2)	73.8

Table 7.3-5
Shielding Analysis Results for 10 Year Cooled Fuel NUHOMS®-52B System

Location	Neutron Dose Rate (mrem/hr.)		Gamma Dose Rate (mrem/hr) Primary and Secondary		Total Dose Rate (mrem/hr.)
	Direct	Reflected	Direct	Reflected	
DSC in HSM					
1. HSM Surface					
1.1 HSM Wall or Roof	(1)	(2)	(1)	(2)	(1)
1.2 HSM Front Bird Screen	(1)	(1)	(1)	(1)	(1)
1.3 HSM Roof Bird Screen	(1)	(1)	(1)	(1)	(1)
1.4 Center of Door (exterior)	25.47	(2)	9.26	(2)	34.73
1.5 Center of Door Opening (door removed)	860.3	(2)	550.8	(2)	1411.1
DSC IN CASK					
1. Transfer Cask					
1.1 Radial					
a. Surface	(1)	(2)	(1)	(2)	(1)
b. 3 Ft. from Surface	(1)	(2)	(1)	(2)	(1)
1.2 Top axial	(1)	(2)	(1)	(2)	(1)
1.3 Bottom axial	25.5	(2)	16.7	(2)	42.2

(1) These results are bounded by the corresponding 24P results shown in Table 7.3-3.

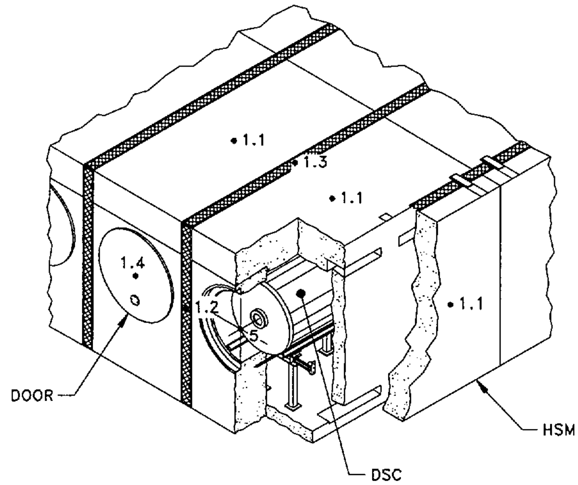
(2) The reflected dose at these locations is negligible.

Figure 7.3-1

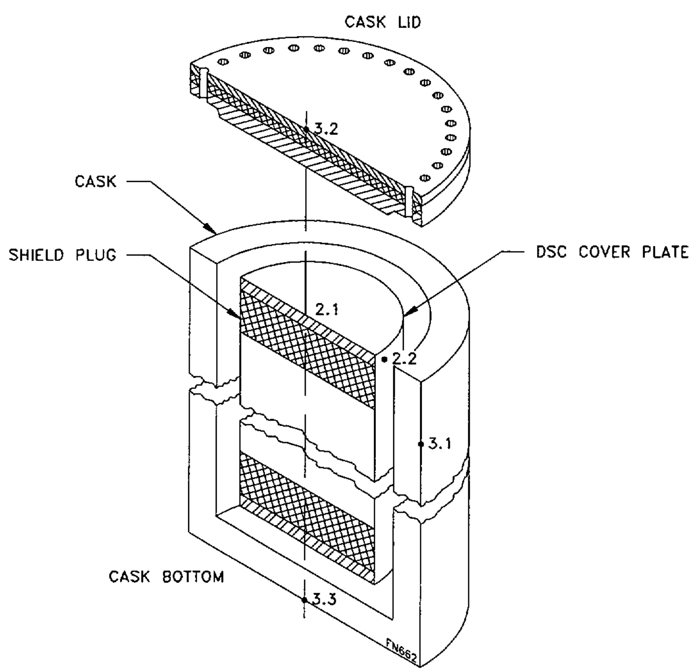
Deleted

Figure 7.3-2

Deleted



DSC IN HSM DOSE RATE CALCULATION LOCATIONS



DSC IN CASK DOSE RATE CALCULATION LOCATIONS

Figure 7.3-3

Locations of Reported Dose Rates for Tables 7.3-2 and 7.3-3

Figure 7.3-4

Included in Appendix A

Figure 7.3-5

Deleted

Figure 7.3-6

Deleted

Figure 7.3-7

Deleted

Figure 7.3-8

Included in Appendix A

Figure 7.3-9

Deleted

Figure 7.3-10

Deleted

Figure 7.3-11

Included in Appendix A

7.4 Estimated On-Site Collective Dose Assessment

7.4.1 Operational Dose Assessment

This SAR section establishes the anticipated cumulative dose exposure to site personnel during the fuel handling and transfer activities associated with utilizing one NUHOMS® HSM for storage of one DSC. Chapter 5 describes in detail the NUHOMS® operational procedures, a number of which involve potential radiation exposure to personnel.

A summary of the operational procedures which result in radiation exposure to personnel is given in Table 7.4-1. The cumulative dose can be calculated by estimating the number of individuals performing each task and the amount of time associated with the operation. The resulting man-hour figures can then be multiplied by appropriate dose rates near the transfer cask surface, the exposed DSC top surface, or the HSM front wall. Dose rates can be obtained from the Section 7.3 results of dose rate versus distance from the cask side, DSC top end (with and without the top cover plate and cask lid in place) and HSM front wall for the 24P and 52B DSCs. Similar results with the NUHOMS®-61BT DSC and 24PT2 DSC are provided in Appendices K and L.

Every operational aspect of the NUHOMS® system, from canister loading through drying, sealing, transport, and transfer is designed to assure that exposure to occupational personnel is as low as reasonably achievable (ALARA). In addition, many engineered design features are incorporated into the NUHOMS® system which minimize occupational exposure to plant personnel during placement of fuel in dry storage as well as off-site dose to the nearest neighbor during long-term storage. The resulting dose at the ISFSI site boundary is to be within the limits specified by 10CFR72 and 40CFR190.

Based on the experience for an operating NUHOMS® system, the occupational dose for placing a canister of spent fuel into dry storage for the operational steps listed in Table 7.4-1 is less than 1.2[1] man-rem. With the use of effective procedures and experienced ISFSI personnel, the total accumulated dose can be reduced further below one man-rem per canister.

7.4.2 Site Dose Assessment

Dose rate maps are constructed from the shielding analysis described in the previous sections. Direct neutron and gamma flux, as well as the air-scattered radiation from the module surfaces are considered. Figure 7.4-2 and Figure 7.4-3 provide a dose rate map in the general vicinity of a 2x10 array and two 1x10 arrays containing ten year cooled fuel.

[1] The expected small additional occupational dose when loading PWR fuel with BPRAs into a NUHOMS® Long Cavity DSC is presented in Appendix J of the SAR.

Ten year fuel is shown since it is a physical impossibility for a utility to have a facility full of five year fuel. In fact, given the average age of fuel in U.S. storage pools, and the most probable NUHOMS® loading schedules, filled NUHOMS® ISFSIs should have substantially older fuel than indicated in the Figures.

The surface radiation sources used for the direct and air scattered dose calculations are shown in Figure 7.4-5 and Figure 7.4-6. The energy distribution of the neutron and gamma fluxes is taken from the applicable calculation as described in the previous sections. Air-scattered dose rates are determined with the computer code Micro SKYSHINE (7.4); direct dose rates are calculated using the computer code MICROSHIELD (7.11). No credit is taken for shielding by nearby structures or terrain. Initial loading of all HSMs with the ten year cooled fuel is assumed. Dose rates for the PWR DSC are provided since these values bound the BWR DSC dose rates.

The ISFSI is generally surrounded by a large open area for operational and security purposes. Access to the storage modules is restricted such that during storage, no access is allowed except for security and surveillance inspection purposes. There are generally no work areas close to the ISFSI. Additional dose to plant workers due to exposure from the ISFSI is negligible. Inspection of the HSM air vents can be maintained ALARA by keeping inspection personnel back from the HSM front wall a distance which permits adequate inspection.

Since the site dose for an ISFSI is highly site specific, each licensee should perform a dose analysis in accordance with 10CFR72.212. The analysis should consider existing plant conditions, the site specific arrangement of the ISFSI, the characteristics of the spent fuel to be placed in dry storage, and relevant empirical data as appropriate. The on-site dose analysis should demonstrate compliance with the 10CFR20.105 limits for normal conditions and 10CFR72.106 and 10CFR100 for accident conditions.

Table 7.4-1
NUHOMS® System Operations Enveloping Time
for Occupational Dose Calculations
(for information only)

	Number of Workers	Completion Time[3] (hours)
Location: Auxiliary Building and Fuel Pool		
Ready the DSC and Transfer Cask for Service	2	4.0
Place the DSC into the Transfer Cask	3	1.0
Fill the Cask/DSC Annulus with Clean Water and Install the Inflatable Seal	2	2.0
Fill the DSC Cavity with Water (borated for PWRs)[1]	1	6.0
Place the Cask Containing the DSC in the Fuel Pool	5	1.0
Verify and Load the Candidate Fuel Assemblies into the DSC	3	8.0
Place the Top Shield Plug on the DSC	3	1.0
Remove the Cask/DSC from the Fuel Pool and Place them in the Decon Area	5	2.0
Location: Cask Decon Area		
Decontaminate the Outer Surface of the Cask[2]	7	1.0
Drain Water Above DSC Shield Plug	3	1.0
Decon the Top Region of the Cask and DSC	2	1.0
Remove a Small Volume of Water from the DSC Cavity[2]	2	0.5
Remove the Cask/DSC Annulus Seal and Set-up Welder	2	1.5
Weld the Inner Top Cover to the DSC Shell and Perform NDE (PT)[1]	2	6.0
Drain the Cask/DSC Annulus and the DSC Cavity[1]	2	3.0
Vacuum Dry and Backfill the DSC with Helium[1]	2	16.0
Helium Leak Test the Shield Plug Weld	2	1.0
Seal Weld the Prefabricated Plugs to the Vent and Siphon Port and Perform NDE (PT)	2	1.5
Fit-up the DSC Top Cover Plate	2	1.0
Weld the Outer Top Cover Plate to DSC Shell and Perform NDE (PT)[1]	2	16.0
Install the Cask Lid	2	1.0

Table 7.4-1
NUHOMS® System Operations Enveloping Time for Occupational Dose Calculations
(for information only)

(continued)

	Number of Workers	Completion Time[3] (hours)
Location: Reactor /Fuel Building Bay		
Ready the Cask Support Skid and Transport Trailer for Service[2]	2	2.0
Place the Cask onto the Skid and Trailer	3	0.5
Remove the RAM Access Cover Plate	2	1.0
Secure the Cask to the Skid	2	1.0
Location: ISFSI Site		
Ready the HSM and Hydraulic Ram System for Service[2]	2	2.0
Transport the Cask to the ISFSI	6	1.0
Position the Cask in Close Proximity with the HSM	3	1.0
Remove the Cask Lid	3	1.0
Align and Dock the Cask with the HSM	3	2.0
Position and Align Ram with Cask	3	1.0
Transfer the DSC from the Cask to the HSM	3	0.5
Lift the Ram Back onto the Trailer and Un-Dock the Cask from the HSM	3	1.0
Install the HSM Access Door	3	1.0
Total		90.5[3]

(1) Monitoring operation - personnel may leave the radiation work area.
(2) Operation may be performed in parallel with other activities.
(3) Time shown for each operation is enveloping. Actual times for similar operations have been considerably less.

Figure 7.4-1

Deleted

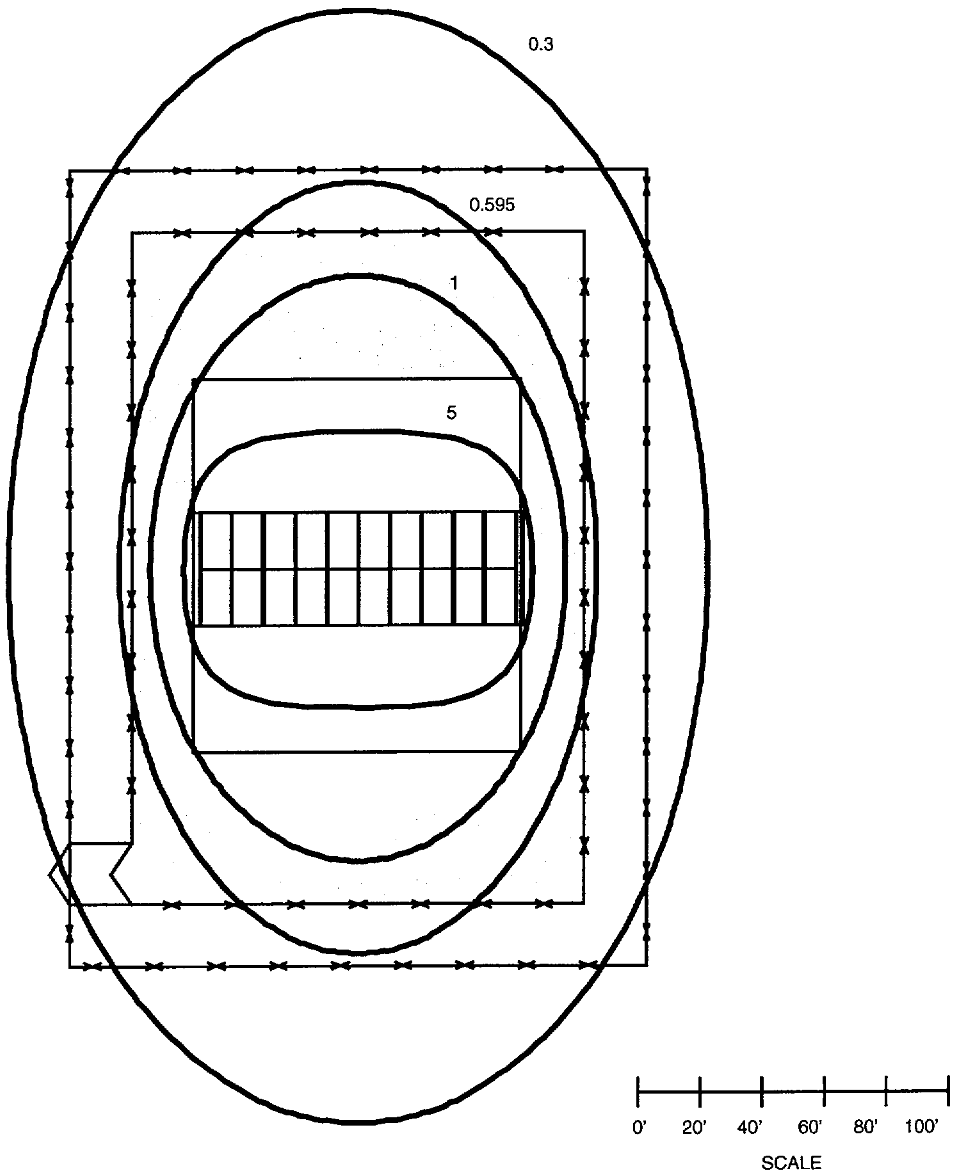


Figure 7.4-2
On-Site Dose Map Around 2x10 Array of Standard HSMs Containing 10 Year Cooled Fuel (mrem/hr)

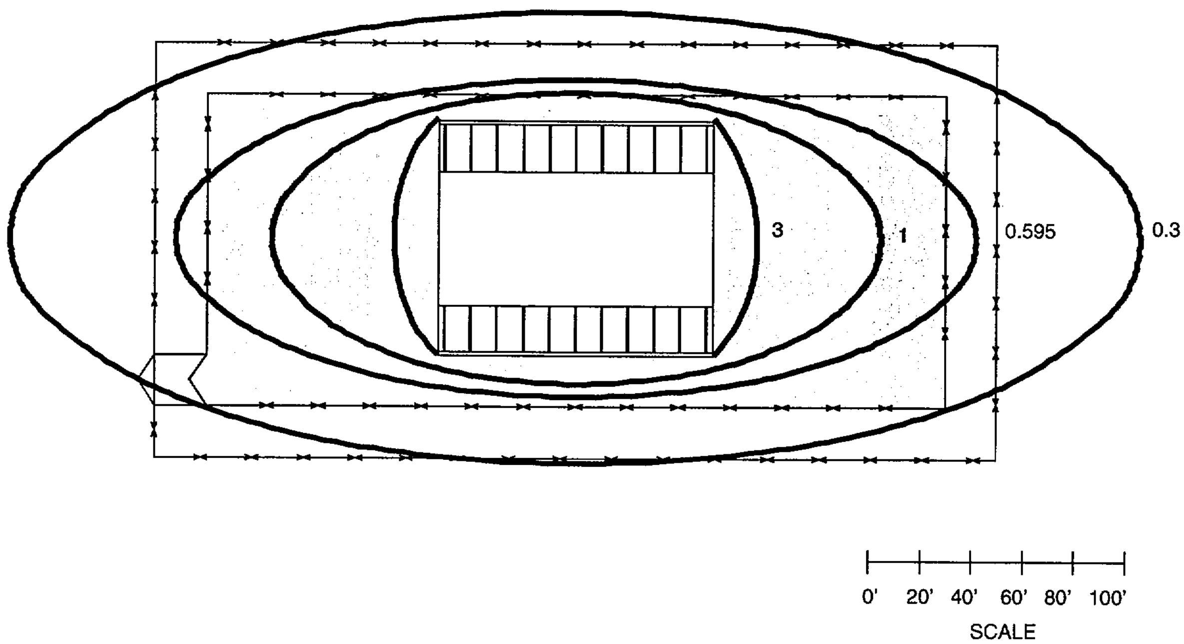
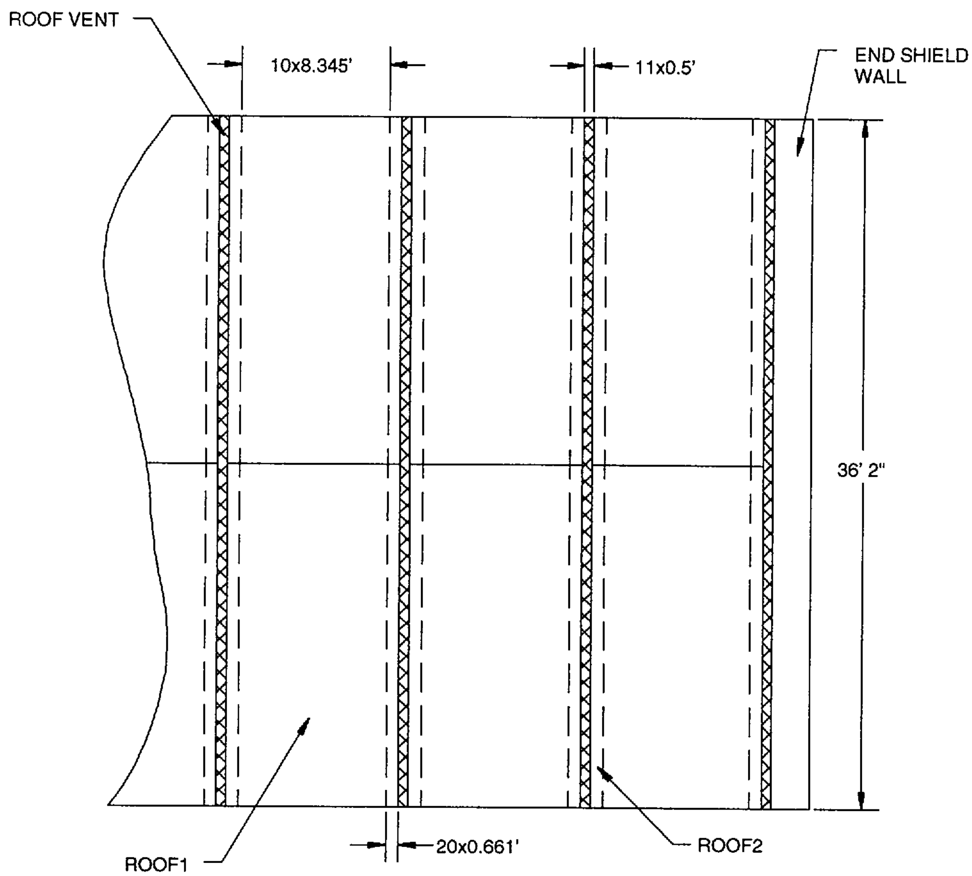


Figure 7.4-3
On-Site Dose Map Around 2-1x10 Arrays of Standard HSMs Containing 10 Year Cooled Fuel (mrem/hr)

Figure 7.4-4

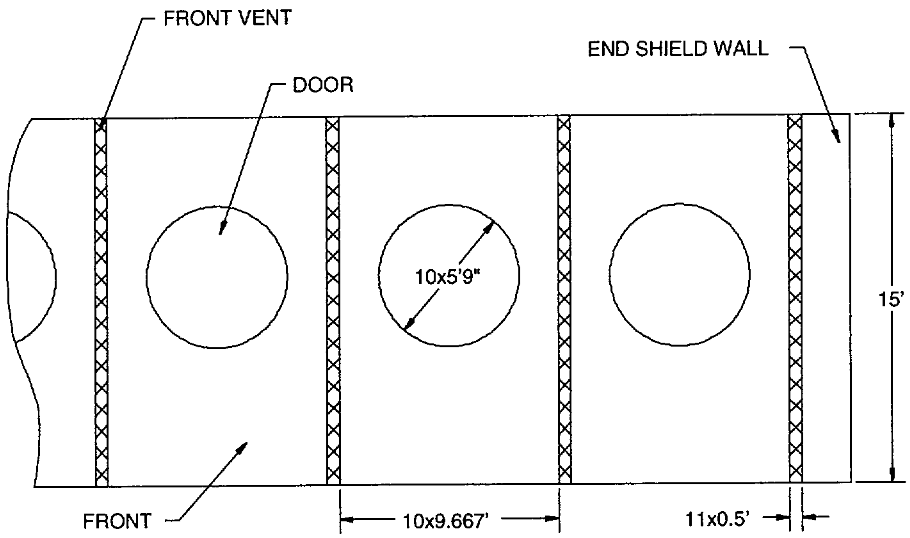
<u>Deleted</u>



Location	Area (ft^2)	Neutron Dose Rate (mrem/hr)	Gamma Dose Rate (mrem/hr)	Total Dose Rate (mrem/hr)
ROOF1	3,018	0.27	17.53	17.80
ROOF2	478	0.27	23.83	24.10
ROOF VENT	199	25.60	139.73	165.33
AREA WEIGHTED AVERAGE		1.63	24.92	26.56

Notes:
1. Basis for averaging is the 2x10 configuration for 10 year cooled PWR fuel.
2. Dose rates are averages and include direct and scattered components.
3. End shield walls are 0.06/2.1 mrem/hr neutron/gamma.

Figure 7.4-5
HSM Roof Average Dose Rate - 10 Year Fuel



Location	Area (ft^2)	Neutron Dose Rate (mrem/hr)	Gamma Dose Rate (mrem/hr)	Total Dose Rate (mrem/hr)
FRONT	1,190	0.27	17.53	17.80
DOOR	260	19.57	8.34	27.91
FRONT VENT	83	11.80	77.63	89.43
AREA WEIGHTED AVERAGE		4.16	19.21	23.37

Notes:

1. Basis for averaging is the 2x10 configuration for 10 year cooled PWR fuel.
2. Dose rates are averages and include direct and scattered components.
3. End shield walls are 0.06/2.1 mrem/hr neutron/gamma.

Figure 7.4-6
HSM Front Wall Average Dose Rate - 10 Year Fuel

Figure 7.4-7

Deleted

Figure 7.4-8

<u>Deleted</u>

7.5 Health Physics Program

Since the ISFSI is located within the owner controlled area for the plant, the licensees existing health physics program is generally extended to incorporate the ISFSI.

7.6 Estimated Off-Site Collective Doses

7.6.1 Effluent and Environmental Monitoring Program

No effluents are released from the NUHOMS® ISFSI during storage conditions. Effluents released during DSC loading are treated using existing power plant systems as described in Chapter 6. Since no effluents are released from the ISFSI, no monitoring program is required.

The only off-site dose due to the NUHOMS® ISFSI is from direct and skyshine radiation. Figure 7.4-2 and Figure 7.4-3 show the radiation dose rates in the vicinities of typical HSM arrays. The collective off-site dose is a function of the number and arrangement of the HSMs on the ISFSI site, the proximity of the ISFSI to the site boundary and nearest neighbor, and other plant specific considerations which are to be addressed by the licensee in accordance with 10CFR72.212.

7.6.2 Analysis of Multiple Contribution

An analysis of multiple contributions should be performed by the licensee in accordance with 10CFR72.212 to determine the additional radiological impact that the ISFSI may impose on the population surrounding the plant site. This impact, added to the contributions made by other uranium fuel cycle operations in the vicinity, should be compared to the natural background radiation and the regulatory requirements of 10CFR72.104 and 40CFR190. The maximally exposed member of the public should be assumed to have continuous occupancy in the nearest residence to the ISFSI.

7.6.3 Estimated Dose Equivalents

Since no liquid or airborne effluents are postulated to emanate from a NUHOMS® ISFSI, the direct and air-scattered radiation exposure discussed in previous sections comprises the total radiation exposure to the public. No estimation of effluent dose equivalents is necessary.

7.6.4 Liquid Release

No liquids are released from a NUHOMS® ISFSI.

7.7 References

7.1 Oak Ridge National Laboratory, "ANISN/PC - Multigroup One-Dimensional Discrete Ordinates Transport Code System with Anisotropic Scattering," CCC-514 MICRO, Oak Ridge National Laboratory (1977).

7.2 Oak Ridge National Laboratory, "QAD-CGGP, "A Combinatorial Geometry Version of QAD-P5A, A Point Kernel Using the GP Buildup Factor," CCC-493, Oak Ridge National Laboratory (1986).

7.3 Electric Power Research Institute, "NUHOMS® Modular Spent-Fuel Storage System: Performance Testing," Final Report, EPRI NP-6941, PNL-7327, September 1990.

7.4 Grove Engineering, Inc., "Micro Skyshine Manual," Ver. 1.15, 1987.

7.5 U. S. Nuclear Regulatory Commission, "Information Relevant to Ensuring that Occupational Radiation Exposures at Nuclear Power Stations Will be As Low As Reasonably Achievable," Regulatory Guide 8.8, Revision 3, (1978).

7.6 SCALE-3: A Modular Code System for Performing Standardized Computer Analysis for Licensing Evaluation, ORNL, Revision 3, December 1984.

7.7 Radiation Shielding Information Center, "CASK81 22 Neutron, 18 Gamma Ray Group, P3 Cross-Sections for Shipping Cask Analysis," DLC-23, June 1987.

7.8 American Nuclear Society Standards Committee Working Group ANS-6.4, "American National Standard Guidelines on the Nuclear Analysis and Design of Concrete Radiation Shielding for Nuclear Power Plants," ANSI/ANS-6.4-1977, American Nuclear Society, 1978.

7.9 W. E. Selph, "Neutron and Gamma-Ray Albedos," ORNL-RSIC-21, Radiation Shielding Information Center, Oak Ridge National Laboratory, February 1968.

7.10 Electric Power Research Institute, "The TN-24P PWR Spent-Fuel Storage Cask: Testing and Analysis," EPRI NP-5128, April 1987.

7.11 Grove Engineering, Inc., "Microshield User's Manual, A Program for Analyzing Gamma Radiation Shielding," Ver. 2.0, 1985.

7.12 American Nuclear Society Standards Committee Working Group ANS-6.1.1, "American National Standard Neutron and Gamma-Ray Flux-to-Dose-Rate Factors" ANSI/ANS-6.1.1-1977, American Nuclear Society, 1977.

7.13 U.S. Nuclear Regulatory Commission, Office of Nuclear Materials Safety and Safeguards, "Safety Evaluation Report Related to the Topical Report for the NUTECH Horizontal Modular Storage System for Irradiated Nuclear Fuel NUHOMS®-24P Submitted by NUTECH Engineers, Inc.," NUH-002, Revision 2A, San Jose, California.