M.7 Confinement

Confinement of all radioactive materials in the NUHOMS®-32PT system is provided by the NUHOMS®-32PT DSC which is designed and tested to meet the leak tight criteria [7.1].

As discussed in Section 7.2.2, 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 existing radwaste systems of the plant. 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 8.2.9.

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.

M.7.1 Confinement Boundary

Once inside the DSC, the SFAs are confined by the DSC shell and by multiple barriers at each end of the DSC. For intact fuel, the fuel cladding is the first barrier for confinement of radioactive materials. The fuel cladding is protected by maintaining the cladding temperatures during storage below those levels, which may cause degradation of the cladding. In addition, the SFAs are stored in an inert atmosphere to prevent degradation of the fuel, specifically cladding rupture due to oxidation and its resulting volumetric expansion of the fuel. Thus, a helium atmosphere for the DSC is incorporated in the design to protect the fuel cladding integrity by inhibiting the ingress of oxygen into the DSC cavity.

Helium is known to leak through valves, mechanical seals, and escape through very small passages because of its small atomic diameter and because it is an inert element and exists in a monatomic species. Negligible leakage rates can be achieved with careful design of vessel closures. Helium will not, to any practical extent, diffuse through stainless steel. For this reason, the DSC has been designed as a redundant weld-sealed containment pressure vessel with no mechanical or electrical penetrations.

M.7.1.1 Confinement Vessel

The confinement vessel is provided by the NUHOMS®-32PT DSC. The DSC is designed to provide confinement of all radionuclides under normal and accident conditions. The DSC is designed, fabricated and tested in accordance with the applicable requirements of the ASME Boiler and Pressure Vessel Code, Division 1, Section III, Subsection NB [7.2] with exceptions as discussed in Section M.3.1.2.3. The shell and inner and outer bottom cover plates are delivered to the site as an assembly. The shell and the inner bottom cover plate, which provide the confinement boundary as shown in Figure M.3-1, are tested to meet the leak tight criteria as defined in [7.1] at the fabricator. The pneumatic pressure test and leak test are performed on the finished shell and the inner cover plate during fabrication. The outer bottom cover plate provides redundant confinement boundary. The root and final layer closure welds for this redundant boundary are inspected using dye penetrant inspection methods in accordance with requirements of the ASME code [7.2].

Once the fuel assemblies are loaded in the DSC, the heavy shield plug is installed to provide radiation shielding to minimize radiation exposure to workers during DSC closure operations. The inner top cover plate is welded into place along with the vent and siphon port cover plates. These welds represent the first level of closure for the DSC. Finally, the outer top cover plate is welded into place to form the redundant confinement boundary of the DSC. The inner plate is tested using the test port in the outer top cover plate to meet the leak tight criteria [7.1]. The test port plug is then threaded into the outer top cover plate and seal welded in place. The root and final layer closure welds for this redundant boundary are inspected using dye penetrant inspection methods in accordance with requirements of the ASME code [7.2].

M.7.1.2 Confinement Penetrations

The DSC pressure boundary contains two penetrations (vent and siphon ports) for draining, vacuum drying and backfilling the DSC cavity. The vent and siphon ports are closed with welded cover plates and the outer top cover plate provides the redundant closure. The outer cover plate has a single penetration used for leak testing the closure welds. This test port plug is threaded into the outer top cover plate and seal welded in place after testing to complete the redundant closure. The DSC has no bolted closures or mechanical seals. The final confinement boundary contains no external penetrations.

M.7.1.3 Seals and Welds

The DSC cylindrical shell is fabricated from rolled ASME stainless steel plate that is joined with full penetration 100% radiographed welds. All top and bottom end closure welds are multiple-layer welds. This effectively eliminates a pinhole leak which might occur in a single pass weld, since the chance of pinholes being in alignment on successive weld passes is not credible. Furthermore, the DSC cover plates are sealed by separate, redundant closure welds. All the DSC pressure boundary welds are inspected according to the appropriate articles of the ASME Boiler and Pressure Vessel Code, Section III, Division 1, Subsection NB. These criteria insure that the weld filler metal is as sound as the parent metal of the pressure vessel. There are no bolted closures or mechanical seals.

M.7.1.4 Closure

All top end closure welds are multiple-layer welds. This effectively eliminates a pinhole leak which might occur in a single pass weld, since the chance of pinholes being in alignment on successive weld passes is not credible. Furthermore, the DSC cover plates are sealed by separate, redundant closure welds. Finally, the inner closure welds are tested to the leak tight criteria [7.1]. There are no bolted closures or mechanical seals.

M.7.2 Requirements for Normal Conditions of Storage

M.7.2.1 Release of Radioactive Material

The NUHOMS®-32PT DSC is designed, fabricated and tested to meet the leak tight criteria [7.1]. Therefore, there is no release of radioactive material under normal conditions of storage. As noted in acceptance criteria IV-4 of [7.3], a closure monitoring system is not required. The confinement boundary ensures that the inert fill gas does not leak or diffuse through the weld or parent material of the DSC. The continued effectiveness of the confinement boundary is demonstrated by (a) daily visual inspections of the HSM inlets and outlets (b) daily monitoring of the HSM thermal performance (c) and the use of radiation monitors (typically TLDs) on the ISFSI boundary fence. A breach of the confinement boundary would result in an increase in the measured dose at the ISFSI fence. If an increase were detected, steps would be initiated to enable the licensee to take corrective actions to maintain safe storage conditions.

M.7.2.2 Pressurization of Confinement Vessel

The maximum internal pressures in the NUHOMS®-32PT DSC during transfer and storage for normal and off-normal conditions are calculated in Section M.4.4.4 and M.4.5.4. These pressures are below the design pressures of the DSC as shown in Section M.4.4 and M.4.5.

M.7.3 Confinement Requirements for Hypothetical Accident Conditions

M.7.3.1 Fission Gas Products

The analysis presented in Section M.3 demonstrates that the confinement boundary (pressure boundary) is not compromised following hypothetical accident conditions. Therefore, there is no need to calculate the fission gas products available for release.

M.7.3.2 Release of Contents

The NUHOMS®-32PT DSC is designed and tested to meet the leak tight criteria [7.1]. The analysis presented in Section M.11 demonstrates that the confinement boundary (pressure boundary) is not compromised following hypothetical accident conditions. Therefore, there is no release of radioactive material under hypothetical accident conditions of storage.

M.7.4 References

7.1 "American National Standard for Radioactive Materials – Leakage Tests on Packages for Shipment," ANSI N14.5-1997, American National Standards Institute, Inc., New York, New York, 1997.

7.2 ASME Boiler and Pressure Vessel Code, Section III, Division 1, Subsection NB, 1998, including 1999 addenda.

7.3 Interim Staff Guidance (ISG)-5, Revision; Confinement Evaluation.

M.8 Operating Systems

This Chapter presents the operating procedures for the standardized NUHOMS®-32PT system described in previous chapters and shown on the drawings in Section M.1.5. The procedures include preparation of the DSC and fuel loading, closure of the DSC, transport to the ISFSI using the TC, 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 NUHOMS® CoC are not exceeded.

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 [8.1]. 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.

M.8.1 Procedures for Loading the Cask

Process flow diagrams for the NUHOMS® System operation are presented Figure M.8-1 and Figure M.8-2. The location of the various operations may vary with individual plant requirements. The following steps describe the recommended generic operating procedures for the standardized NUHOMS® System.

M.8.1.1 Preparation of the TC and DSC

1. Prior to placement in dry storage, the candidate intact fuel 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.

2. Prior to being placed in service, the TC 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 TC in the vertical position in the cask decon area using the cask handling crane and the TC 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 TC top cover plate and examine the cask cavity for any physical damage and ready the cask for service. If loading 32PT-S100 or 32PT-L100 DSC (qualified for 100-ton crane capacity), drain neutron shield water from the TC.

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 1.2.15a.

   NOTE: A TC/DSC annulus pressurization tank filled with demineralized water as described above is connected to the top vent port of the TC via a hose to provide a positive head above the level of water in the TC/DSC annulus. This is an optional arrangement, which provides additional assurance that contaminated water from the fuel pool will not enter the TC/DSC annulus, provided a positive head is maintained at all times.

10. Place the top shield plug onto the DSC. Examine the top shield plug to ensure a proper fit.

11. Position the cask lifting yoke and engage the cask lifting trunnions and the rigging cables to the DSC top shield plug. Adjust the rigging cables as necessary to obtain even cable tension.

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

13. Connect the vacuum drying system (VDS) or optional liquid pump to the siphon port of the DSC and position the connecting hose such that the hose will not interfere with loading (yoke, fuel, shield plug, rigging, etc.). A flowmeter must be installed at a suitable location as part of this connection.

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

15. 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.

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

17. 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.

M.8.1.2 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 move the yoke and the top shield plug clear of the cask. Spray the lifting yoke and top shield plug with clean demineralized water if 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, position the lifting yoke and the top shield plug 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 TC.

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

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

11. Raise the TC 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 TC 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. Check the radiation levels at the center of the top shield plug and around the perimeter of the cask.

16. If loading 32PT-S100 or 32PT-L100 DSC (qualified for 100-ton crane capacity), drain approximately 750 gallons of water (as indicated on the flowmeter) from the DSC back into the fuel pool or other suitable location using the VDS or optional liquid pump.

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

18. Move the TC with loaded DSC to the cask decon area.

19. Replace the approximate 750 gallons of water removed in step 16 (as indicated on the flowmeter) from the DSC with spent fuel pool water. Fill the neutron shield with demineralized water it was drained in Step M..8.1.1.5

M.8.1.3 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.

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 position 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. Drain approximately 750 gallons of water (as indicated on a flowmeter) from the DSC back into the fuel pool or other suitable location using the VDS or an optional liquid pump.

7. Disconnect hose from the DSC siphon port.

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

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

   CAUTION: Insert a 1/4 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.

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

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

    CAUTION: 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% [8.4]. 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 1/4 inch tygon tubing to reduce the hydrogen concentration safely below the 2.4% limit.

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

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

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

15. 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.

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

17. 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.

18. 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 mm Hg, 50 mm Hg, 25 mm Hg, 15 mm Hg, 10 mm Hg, 5 mm Hg, and 3 mm Hg. 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 mm Hg or less as specified in Technical Specification 1.2.2. A time limit of 45 hours for duration of the vacuum drying exists per Technical Specification 1.2.18 to ensure that the 32PT DSC basket structure does not exceed 800°F.

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

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

21. Helium leak test the inner top cover plate weld for leakage in accordance with ANSI N14.5 to a sensitivity of 1×10^{-5} atm cm^3 /sec.

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

23. 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.

24. Re-evacuate the DSC cavity using the VDS. The cavity pressure should be reduced in steps of approximately 10 mm Hg, 5 mm Hg, and 3 mm Hg. 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 mm Hg or less in accordance with Technical Specification 1.2.2 limits.

25. 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 1.2.3a limits.

26. Close the valves on the helium source.

27. Decontaminate as necessary, and store.

<u>M.8.1.4 DSC Sealing Operations</u>

1. Disconnect the VDS from the DSC. Seal weld the prefabricated plugs over the vent and siphon ports, inject helium into blind space just prior to completing welding, and perform a dye penetrant weld examination in accordance with the Technical Specification 1.2.5 requirements.

2. Open the cask drain port valve and remove the remaining water from the cask/DSC annulus.

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

4. Tack weld the outer top cover plate to the DSC shell. Place the outer top cover plate weld root pass.

5. Helium leak test the inner top cover plate and vent/siphon port plate welds using the leak test port in the outer top cover plate in accordance with Technical Specification 1.2.4a limits.

6. If a leak is found, remove the outer cover plate root pass, the vent and siphon port plugs and repair the inner cover plate welds. repeat procedure steps from M.8.1.3 step 18.

7. 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.

8. Seal weld the prefabricated plug over the outer cover plate test port and perform dye penetrant weld examinations in accordance with Technical Specification 1.2.5 requirement.

9. Remove the automatic welding machine from the DSC. Rig the cask top cover plate and lower the cover plate onto the TC.

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

M.8.1.5 TC Downending and Transport to ISFSI

1. If loading 32PT-S100 or 32PT-L100 DSC (qualified for 100-ton crane capacity), drain the neutron shield to an acceptable location.

2. Re-attach the TC lifting yoke to the crane hook, as necessary. Ready the transport trailer and cask support skid for service.

3. 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.

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

5. Position the cask lower trunnions onto the transfer trailer support skid pillow blocks.

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

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

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

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

10. Fill the neutron shield, if it was drained in step M.8.1.5.1.

11. 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 TC. (The temporary shield plug and ram trunnion support frame are not required with integral ram/trailer.)

M.8.1.6 DSC Transfer to the HSM

1. Prior to transporting the cask to the ISFSI, 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. Using a porta-crane, unbolt and remove the cask top cover plate.

7. 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.

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 bracket fasteners 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 collar.

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 TC using the optical survey equipment.

12. Position the hydraulic ram behind the cask in approximate horizontal alignment with the cask and level 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.

19. Install the HSM door using a portable crane and secure it in place. Door may be welded for security.

20. Install the DSC drop-in retainer through the HSM door opening.

21. Replace the TC top cover plate. Secure the skid to the trailer, retract the vertical jacks and disconnect the skid positioning system.

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

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

M.8.1.7 Monitoring Operations

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 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.

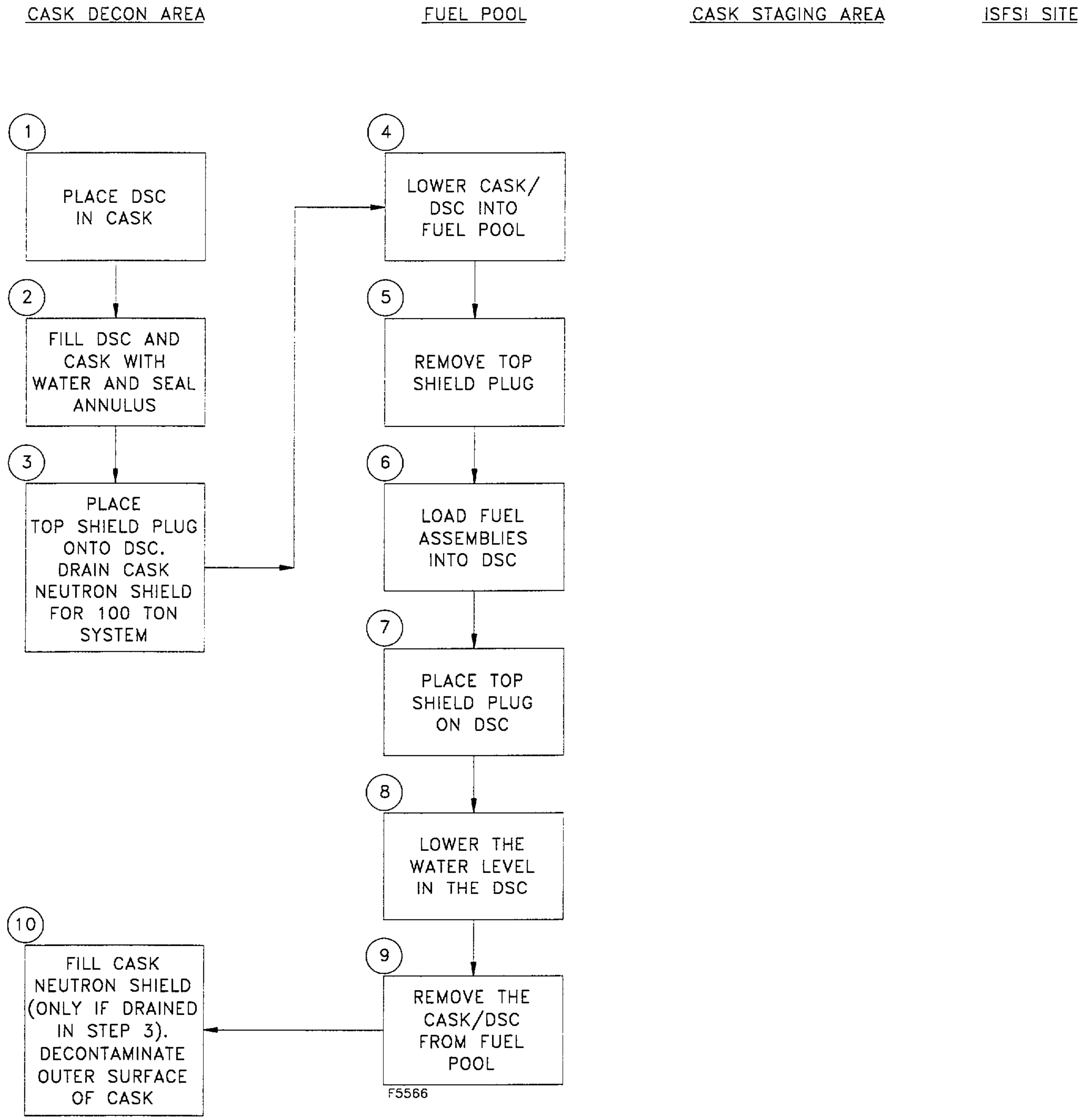


Figure M.8-1
NUHOMS® System Loading Operations Flow Chart

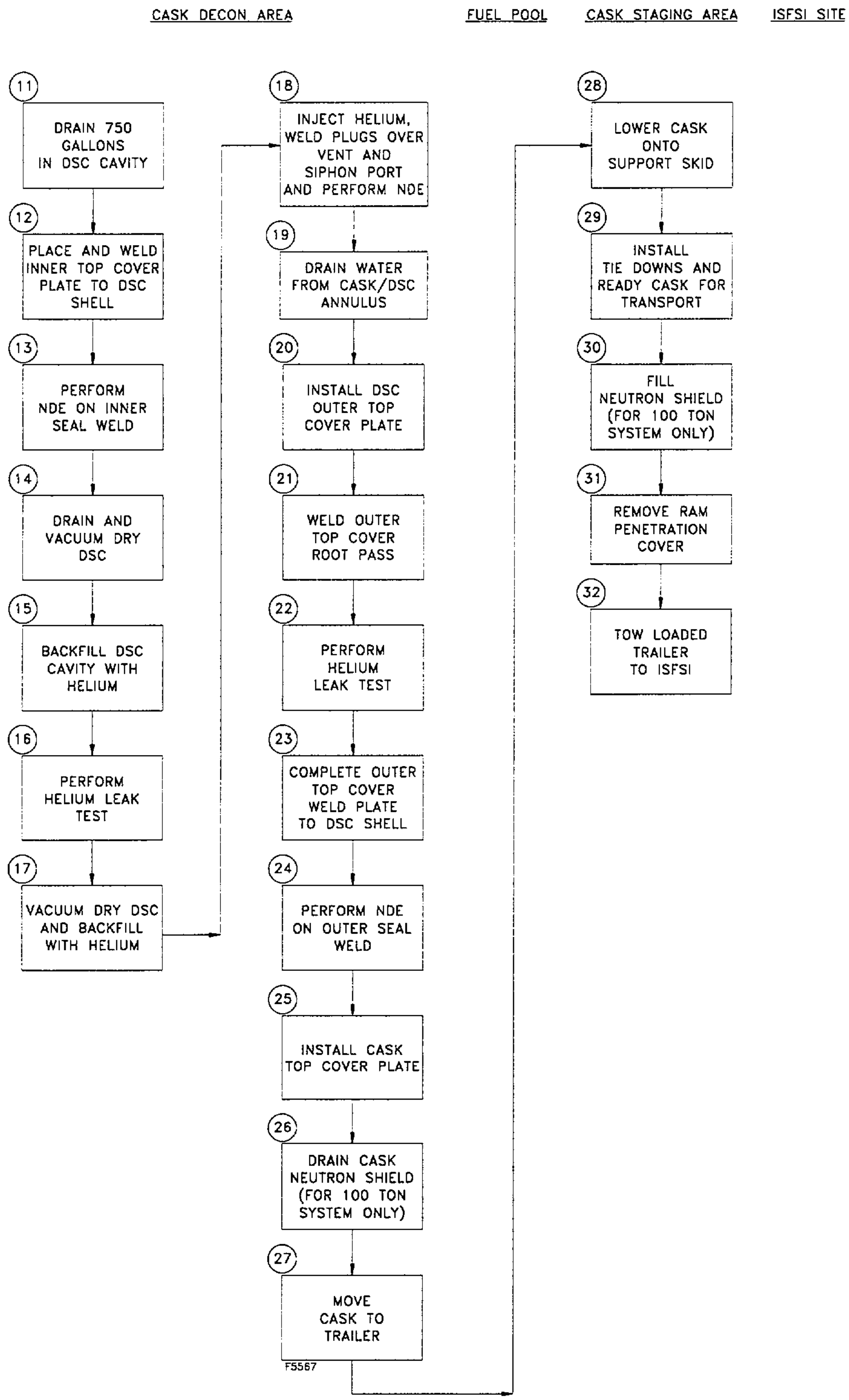


Figure M.8-1
NUHOMS® System Loading Operations Flow Chart
(continued)

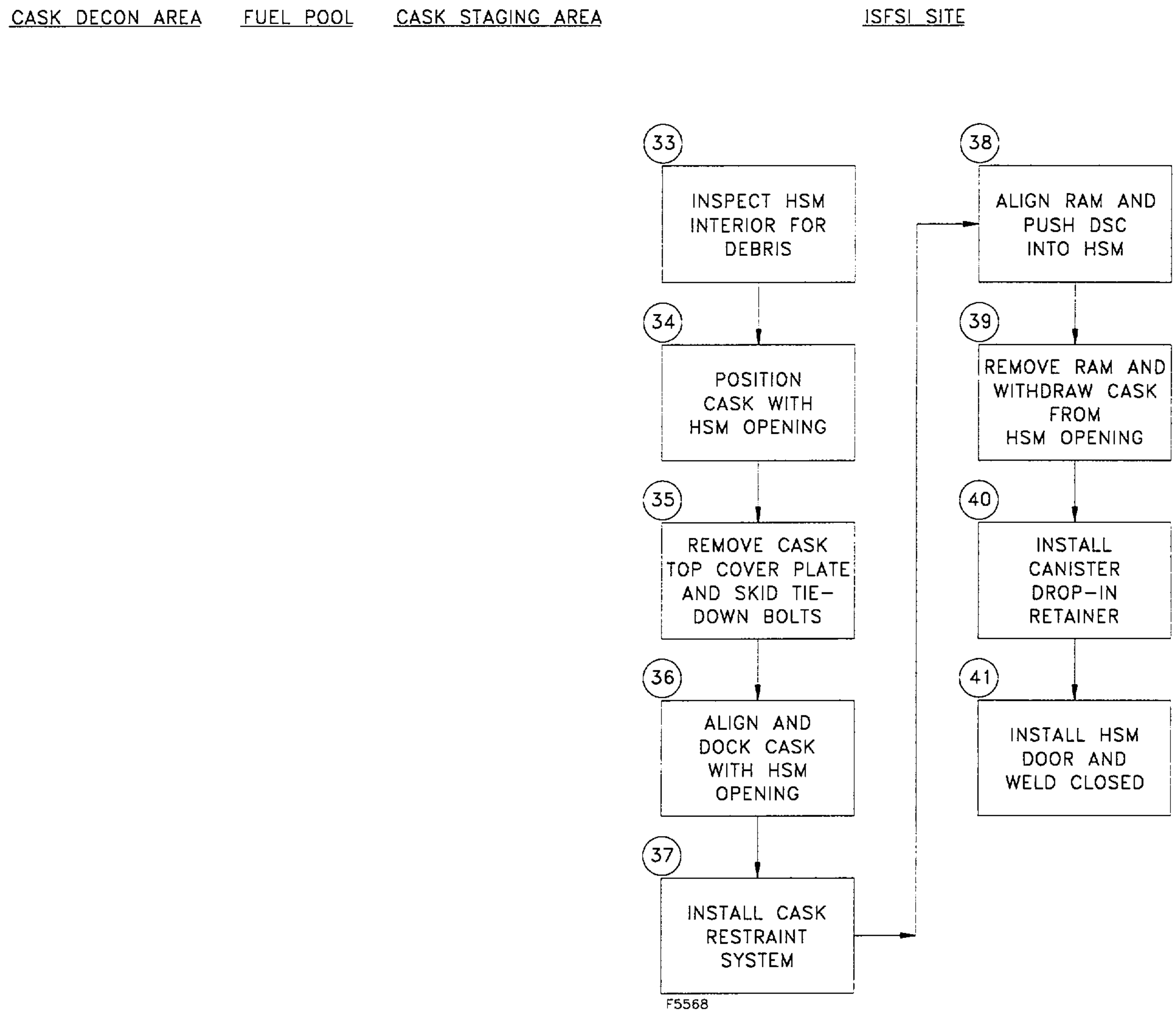


Figure M.8-1
NUHOMS® System Loading Operations Flow Chart
(concluded)

M.8.2 Procedures for Unloading the Cask

M.8.2.1 DSC Retrieval from the HSM

1. Ready the TC, 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 and remove the cask top cover plate.
3. Cut any welds from the door and remove the HSM door using a porta-crane. Remove the DSC drop-in retainer.
4. 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.
5. Using optical survey equipment, verify alignment of the cask with respect to the HSM. Install the cask restraints.
6. Install and align the hydraulic ram with the cask.
7. Extend the ram through the cask into the HSM until it is inserted in the DSC grapple ring.
8. Activate the arms on the ram grapple mechanism with the DSC grapple ring.
9. Retract ram and pull the DSC into the cask.
10. Retract the ram grapple arms.
11. Disengage the ram from the cask.
12. Remove the cask restraints.
13. Using the skid positioning system, disengage the cask from the HSM.
14. Install the cask top cover plate and ready the trailer for transport.
15. Replace the door on the HSM.

M.8.2.2 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 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.

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. If unloading 32PT-S100 or 32PT-L100 DSC (qualified for 100-ton crane capacity), drain water from the neutron shield.

7. 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.

8. 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.

9. Lower the cask into the cask decon area in the vertical position. Fill the neutron shield with water if it was drained in Step M.8.2.2.6.

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

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

12. Unbolt the cask top cover plate.

13. 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.

14. 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 lowering the top of cask below the surface of 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:

15. 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.

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

17. Drill a hole through the DSC top cover plate to expose the siphon port quick connect.

18. Drill a second hole through the top cover plate to expose the vent port quick connect.

19. 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 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) Provide for continuous hydrogen monitoring of the DSC cavity atmosphere during all subsequent cutting operations to ensure that a safety limit of 2.4% is not exceeded [8.4]. Purge with 2-3 psig helium (or any other inert medium) as necessary to maintain the hydrogen concentration safely below this limit.

20. Place welding blankets around the cask and scaffolding.

21. 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.

22. 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.

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

24. Remove the exhaust hood, if necessary.

25. Remove the DSC outer top cover plate.

26. 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.

27. 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.

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

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

30. If unloading 32PT-S100 or 32PT-L100 DSC (qualified for 100-ton crane capacity), drain approximately 750 gallons of water from the DSC. The neutron shield also needs to be drained.

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

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

33. 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.

34. Lower the cask into the fuel pool leaving the top surface of the cask approximately one foot above the surface of the pool water.

35. Fill the DSC with pool water.

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

37. 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.

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

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

40. Lower the top shield plug onto the DSC.

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

42. Engage the lifting yoke onto the cask trunnions.

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

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

45. 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.

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

47. 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.

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

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

50. Move the cask to the cask decon area.

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

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

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

54. 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.

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

56. Activate the liquid pump.

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

58. Close the valves on the VDS.

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

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

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

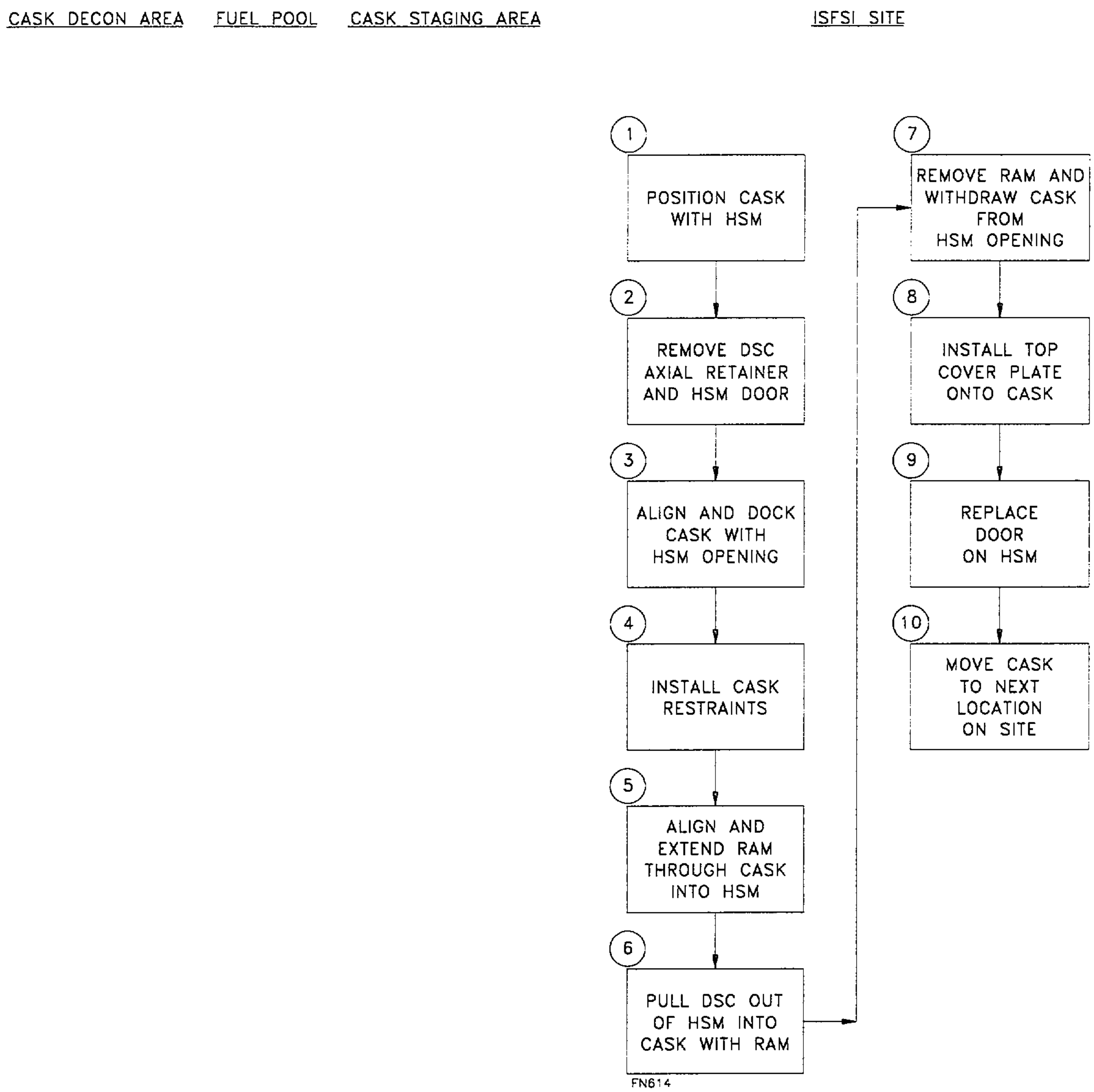


Figure M.8-2
NUHOMS® System Retrieval Operations Flow Chart

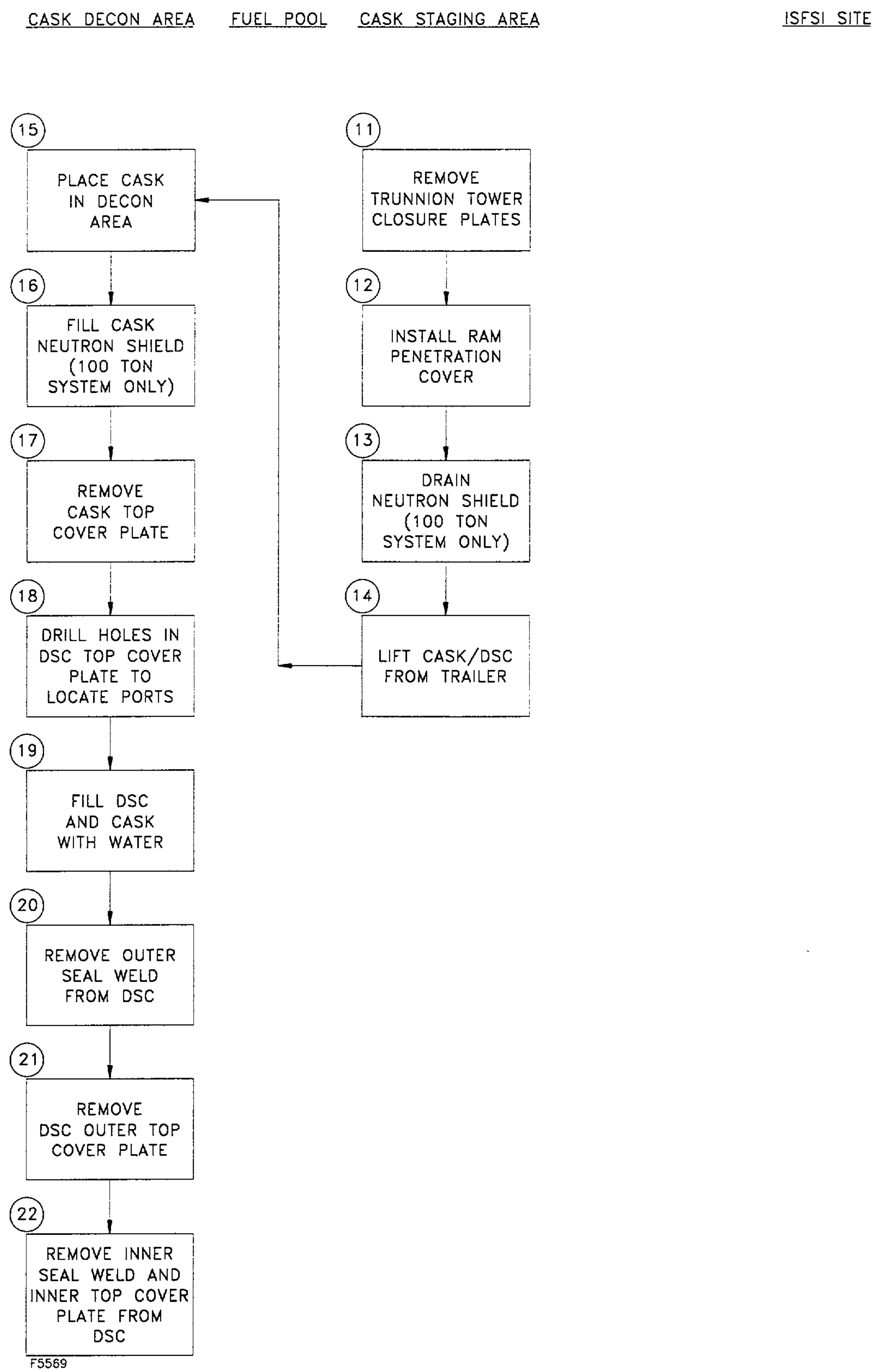


Figure M.8-2
NUHOMS® System Retrieval Operations Flow Chart
(Continued)

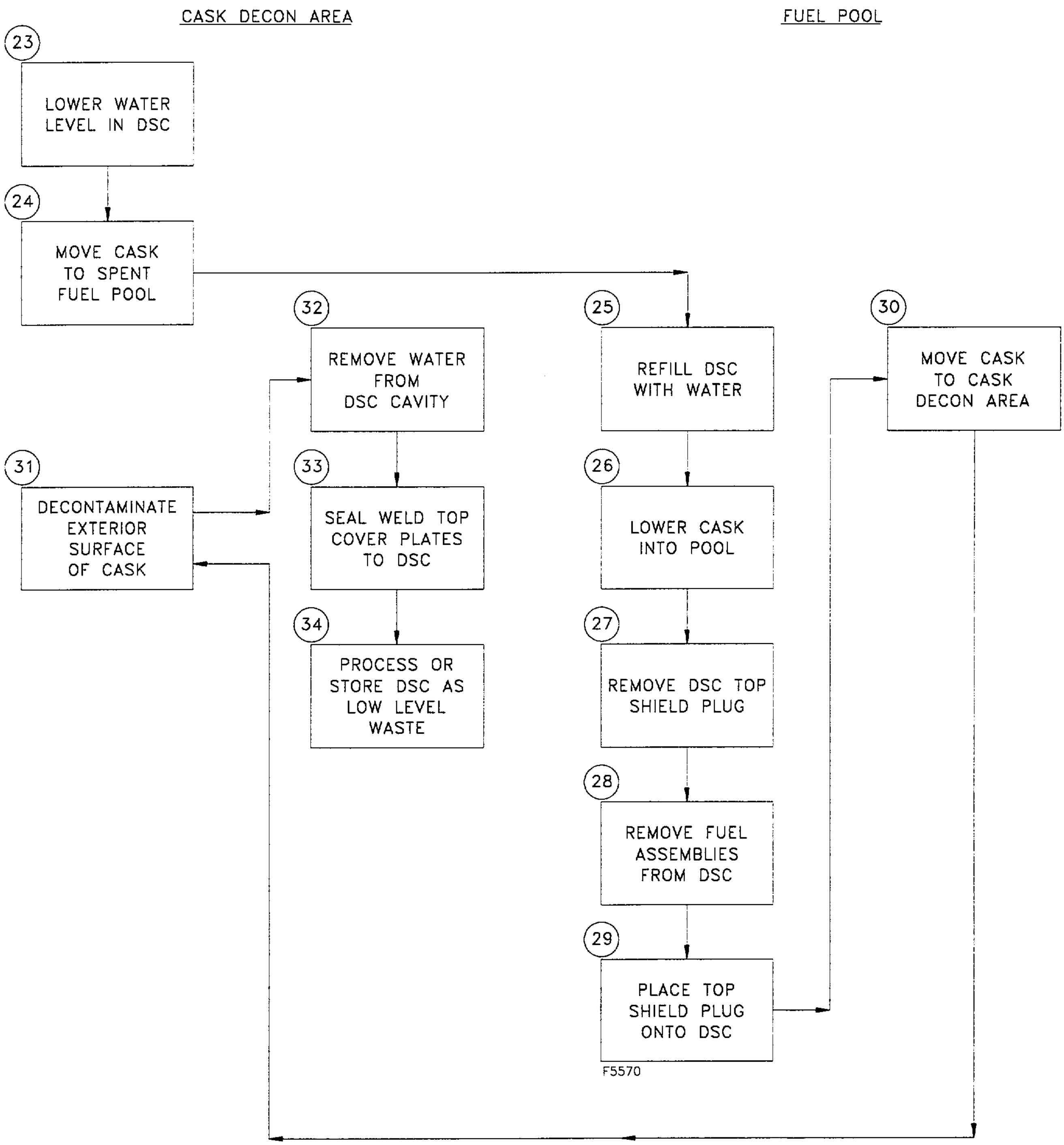


Figure M.8-2
NUHOMS® System Retrieval Operations Flow Chart
(Concluded)

M.8.3 Identification of Subjects for Safety Analysis

No Change.

M.8.4 Fuel Handling Systems

No Change.

M.8.5 Other Operating Systems

No Change.

M.8.6 Operation Support System

No Change.

M.8.7 Control Room and/or Control Areas

No Change.

M.8.8 Analytical Sampling

No Change.

M.8.9 References

8.1 U.S. Nuclear Regulatory Commission, "Standard Format and Content for a Topical Safety Analysis Report for a Spent Fuel Dry Storage Container," Regulatory Guide 3.61 (February 1989).

8.2 Deleted.

8.3 Deleted.

8.4 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.

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

M.9 Acceptance Tests and Maintenance Program

M.9.1 Acceptance Tests

The acceptance requirements for the NUHOMS®-32PT system are given in the FSAR except as described in the following sections. The NUHOMS®-32PT DSC has been enhanced to provide leaktight confinement and the basket includes an updated poison plate design. Additional acceptance testing of the NUHOMS®-32PT DSC welds and poison plates are described.

M.9.1.1 Visual Inspection

There are no changes associated with this amendment.

M.9.1.2 Structural

The NUHOMS®-32PT DSC confinement welds are designed, fabricated, tested and inspected in accordance with ASME B&PV Code Section III, Subsection NB [9.1] with exceptions as listed in Section M.3.1. The following requirements are unique to the NUHOMS®-32PT DSC:

- The inner bottom cover weld is inspected in accordance with Article NB-5231,
- The outer bottom cover weld root and cover are penetrant tested, and
- The outer top cover plate weld root and cover are penetrant tested.

The NUHOMS®-32PT DSC basket is designed, fabricated, and inspected in accordance with ASME B&PV Code Section III, Subsection NG [9.1] with exceptions as listed in Section M.3.1. The following requirement is unique to the NUHOMS®-32PT DSC basket:

- The fuel compartment welds are inspected in accordance with Article NG-5231.

M.9.1.3 Leak Tests

The NUHOMS®-32PT DSC confinement boundary is leak tested to verify that it is leaktight in accordance with ANSI N14.5 [9.2].

The leak tests are typically performed using the helium mass spectrometer method. Alternative methods are acceptable, provided that the required sensitivity is achieved.

M.9.1.4 Components

No changes associated with this amendment.

M.9.1.5 Shielding Integrity

No changes associated with this amendment.

M.9.1.6 Thermal Acceptance

The analyses to ensure that the NUHOMS®-32PT DSCs are capable of performing their heat transfer function are presented in Section M.4.

M.9.1.7 Poison Acceptance

M.9.1.7.1 Functional Requirements of Poison Plates

The poison plates only serve as a neutron absorber for criticality control and as a heat conduction path. The NUHOMS®-32PT DSC safety analyses do not rely upon their mechanical strength. The radiation and temperature environment in the cask is not sufficiently severe to damage the aluminum matrix that retains the boron-containing particles. To assure performance of the plates' Important-to-Safety function, the only critical variables that need to be verified are thermal conductivity and B10 areal density as discussed in the following paragraphs.

M.9.1.7.2 Thermal Conductivity Testing of Poison Plates

The poison plate material shall be qualification tested to verify that the thermal conductivity equals or exceeds the values listed in Section M.4.3. Acceptance testing of the material in production may be done at only one temperature in that range to verify that the conductivity equals or exceeds the corresponding value in Section M.4.3.

Testing may be by ASTM E1225 [9.3], ASTM E1461 [9.4], or equivalent method, performed on a sample of specimens removed from coupons adjacent to the final plates. Section M.9.1.7.3 contains more detail on coupons.

M.9.1.7.3 B10 Areal Density Testing of Poison Plates

There are two poison materials qualified for the NUHOMS®-32PT DSC basket: Borated aluminum and Boralyn®, which is a boron carbide/aluminum metal matrix composite (MMC). The B10 areal density and uniformity of the poison plates shall be verified, based on type, using approved procedures, as follows.

M.9.1.7.3.1 Borated Aluminum Using Enriched Boron, 90% B10 Credit

M.9.1.7.3.1.1 Borated Aluminum Material Description

The poison consists of borated aluminum containing a specified weight percent (wt. %) boron, which is isotopically enriched to 95 wt. % B10. Because of the negligibly low solubility of boron in solid aluminum, the boron appears entirely as discrete second phase particles of AlB_2 in the aluminum matrix. The matrix is limited to any 1000 series aluminum, aluminum alloy 6063, or aluminum alloy 6351 so that no boron-containing phases other than AlB_2 are formed. Titanium may also be added to form TiB_2 particles, which are finer. The effect on the properties of the matrix aluminum alloy are those typically associated with a uniform fine (1-10 micron) dispersion of an inert equiaxed second phase.

The cast ingot may be rolled, extruded, or both to the final plate dimensions.

The specified wt. % boron for full thickness (0.075 inch) plates is 1.5 wt. %. This specified wt. % boron converts to a nominal areal density of B10 as follows: (2.69 g BAl/cm^3)(1.5 wt. % B)(95 wt. % B10)(0.075 inch)(2.54 cm/inch) = 0.0073g $B10/cm^2$, which is intentionally 4% above the design minimum of 0.0070 g $B10/cm^2$. If thinner poison sheets are paired with aluminum sheets, the boron content shall be adjusted to maintain the required minimum B10 areal density.

Note: The poison plates as placed in the canister are made up of the borated aluminum/unborated aluminum laminate. Only the actual thickness of the borated aluminum shall be used to calculate the B-10 areal density.

M.9.1.7.3.1.2 Borated Aluminum Test Coupons

The poison plates are manufactured in a variety of sizes. Coupons will be removed between every other plate or at the end of the plate so that there is at least one coupon contiguous with each plate. Coupons will generally be the full width of the plate. Thermal conductivity coupons may be removed from the full width coupon. The minimum dimension of the coupon shall be as required for acceptance test specimens; 1 to 2 inches is generally adequate. Neutron absorption samples are taken from roughly one centimeter diameter samples through the thickness of the plate.

M.9.1.7.3.1.3 Borated Aluminum Acceptance Testing, Neutronic

Effective B10 content is verified by neutron transmission testing of these coupons. The transmission through the coupons is compared with transmission through calibrated standards composed of a homogeneous boron compound without other significant poisons, for example zirconium diboride or titanium diboride. These standards are paired with aluminum shims sized to match the scattering by aluminum in the poison plates. Uniform but non-homogeneous materials such as metal matrix composites may be used for standards, provided that testing shows them to be equivalent to a homogeneous standard. The effective B10 content of each coupon, minus 3s based on the number of neutrons counted for that coupon, must be greater than or equal to the minimum value 0.007 g $B10/cm^2$.

Macroscopic uniformity of B10 distribution is verified by neutron radioscopy or radiography of the coupons. The acceptance criterion is that there be uniform luminance across the coupon. This inspection shall cover the entire coupon. In addition, a statistical analysis of the neutron transmission results for all accepted plates in a lot shall be used to demonstrate that applying the one-sided tolerance factors for a 95% probability / 95% confidence level results in a minimum areal density greater than specified minimum value 0.007 g $B10/cm^2$. A lot may be defined either as all the plates rolled from a single cast ingot, or all the plates rolled from a single piece of the cast ingot. The analysis shall be based on full data set for the lot. If any lot fails the test, all plates in the lot shall be rejected. The plates may be reexamined by neutron transmission testing at four points on each plate as described below. Acceptance may be based on one of the following three criteria:

a) Individual plates may be accepted by verifying that none of the four points falls below the acceptance criterion, or

b) Selected plates may be re-examined, and the average of the four plate data plus the coupon datum used in a revised statistical analysis in place of the original coupon datum. The lot may then be accepted if the revised statistical analysis meets the acceptance criterion stated above, or

c) If reduced sampling was used after the first 25% of the coupons, 100% of the coupons may be examined, and the statistical analysis revised within this larger sample. The lot may then be accepted if the revised statistical analysis meets the acceptance criterion stated above.

Initial sampling of coupons for neutron transmission measurements and radiography/radioscopy shall be 100%. Rejection of a given coupon shall result in rejection of its associated plate. Reduced sampling (50%) may be introduced based upon acceptance of all coupons in the first 25% of the lot. A rejection during reduced inspection will require a return to 100% inspection of the lot.

In the event that a coupon fails the single neutron measurement, four additional measurements shall be made at separate locations on the plate itself. For each of the additional measurements, the value of areal density less than 3s based on the number of neutrons counted must be greater than or equal to the specified minimum value of 0.007 g $B10/cm^2$ in order to accept the plate.

If any of those four fails, the plate associated with the measurements shall be rejected. However, the average of the five measurements made is to be used as a datum in subsequent analysis conduced on the lot. The use of the datum allows for the possibility that the rejected plate is really identical to the plate that was not rejected.

Neutron absorption samples are taken from roughly one centimeter sample through the thickness of the plate. Any data from materials which are rejected based on physical examination of the materials are not to be used in the statistical analysis. For example, rejection based on thickness or malformation detected by examination of the plate are grounds for excluding the data associated with these materials.

M.9.1.7.3.1.4 Justification for Acceptance Test Requirements, Borated Aluminum

According to NUREG/CR-5661 [9.5]:

> "Limiting added poison material credit to 75% without comprehensive tests is based on concerns for potential 'streaming' of neutrons due to nonuniformities. It has been shown that boron carbide granules embedded in aluminum permit channeling of a beam of neutrons between the grains and reduce the effectiveness for neutron absorption."

Furthermore:

> "A percentage of poison material greater than 75% may be considered in the analysis only if comprehensive tests, capable of verifying the presence *and uniformity* of the poison, are implemented." [emphasis added]

The calculations in Section M.6 use boron areal densities that are 90% of the minimum value of 0.007 g B10/cm^2. This is justified by the following considerations:

a) The coupons for neutronic inspection are removed between every other finished plate. As such, they are taken from locations that are representative of the finished product. Coupons are also removed at the ends of the "stock plate", where under thickness of the plates or defects propagated from the pre-roll ingot would be most likely. The use of representative coupons for inspection is analogous to the removal of specimens from structural materials for mechanical testing.

b) Neutron radiography/radioscopy of coupons across the full width of the plate will detect macroscopic non-uniformities in the B10 distribution such as could be introduced by the fabrication process.

c) Neutron transmission measures effective B10 content directly. The term "effective" is used here because if there are any of the effects noted in NUREG/CR-5661, the neutron transmission technique will measure not the physical B10 areal density, but a lower value. Thus, this technique by its nature screens out the microscopic non-uniformities which have been the source of the recommended 75% credit for B10 in criticality evaluations.

d) The use of neutron transmission and radiography/radioscopy satisfies the "and uniformity" requirement emphasized in NUREG/CR-5661 on both the microscopic and macroscopic scales.

e) The recommendations of NUREG/CR-5661 are based upon testing of a poison with boron carbide particles averaging 85 microns. The boride particles in the borated aluminum are much finer (5-10 microns). Both the manufacturing process and the neutron radioscopy assure that they are uniformly distributed. For a given degree of uniformity, fine particles will be less subject to neutron streaming than coarse particles. Furthermore, because the material reviewed in the NUREG was a sandwich panel, the thickness of the boron carbide containing center could not be directly verified by thickness measurement. The alloy specified here is uniform throughout its thickness.

M.9.1.7.3.2 Boralyn®, 90% B10 credit

M.9.1.7.3.2.1 Boralyn® Material Description

The Boralyn® poison plates consist of a composite of aluminum with a specified volume % boron carbide particulate reinforcement. The material is formed into a billet by powder metallurgical processes and either extruded, rolled, or both to final dimensions. The finished product has near-theoretical density and metallurgical bonding of the aluminum matrix particles. It is "uniform" blend of powder particles from face to face, i.e.; it is not a "sandwich" panel.

The specified volume % boron carbide for full thickness plates (0.075 inch) is 10.7 volume %. This specified volume % boron carbide corresponds to a B10 areal density of 0.107(2.52 g/cm^3 B_4C)(0.782 gB/gB_4C)(0.185 g B10/gB)(0.075 in)(2.54 cm/in) =0.0074 g B10/cm^2, which is intentionally 6% above the design minimum of 0.007 g B10/cm^2. If thinner poison sheets are paired with aluminum sheets, the boron content shall be adjusted to maintain the required minimum B10 areal density.

Note: The poison plates as placed in the canister are made up of the Boralyn® unborated aluminum laminate. Only the actual thickness of the Boralyn® shall be used to calculate the B-10 areal density.

The process specifications for the material shall be subject to qualification testing to demonstrate that the process results in a material that:

- has a uniform distribution of boron carbide particles in an aluminum alloy with few or none of the following: voids, oxide-coated aluminum particles, B_4C fracturing, or B_4C/aluminum reaction products,
- meets the requirements for B10 areal density and thermal conductivity, and
- will be capable of performing its Important-to-Safety functions under the thermal and radiological environment of the NUHOMS®-32PT DSC over its 40-year lifetime.

The production of plates for use in the NUHOMS®-32PT DSC is consistent with the process used to produce the qualification test material. Processing changes may be incorporated into the production process, only if they are reviewed and approved by the holder of an NRC-approved QA plan who is supervising fabrication. The basis for acceptance shall be that the changes do not have an adverse effect on either the microstructure or the uniformity of the boron carbide distribution, because these are the characteristics that determine the durability and neutron absorption effectiveness of the material. The evaluation may consist of an engineering review, or it may consist of additional testing. In general, changes in key billet forming variables such as the temperature or pressure would require testing, while changes in mechanical processing variables, such as extrusion speed, would not have to be evaluated. Increasing the boron carbide content would require testing, while decreasing it would not.

Typical processing consists of:

- blending of boron carbide powder with aluminum alloy powder,
- billet formed by vacuum hot pressing,
- billet extruded to intermediate or to final size,
- hot roll, cold roll and flatten as required, and
- anneal.

M.9.1.7.3.3 Boralyn® Test Coupons

The poison plates are manufactured in a variety of sizes. Coupons will be removed between every other plate or at the end of the plate so that there is at least one coupon contiguous with each plate. Coupons will generally be the full width of the plate. Thermal conductivity coupons may be removed from the full width coupon. The minimum dimension of the coupon shall be as required for acceptance test specimens; 1 to 2 inches is generally adequate. Neutron absorption samples are taken from roughly one centimeter diameter samples through the thickness of the plate.

M.9.1.7.3.4 Boralyn® Acceptance Testing, B10 Density

Effective B10 content is verified by neutron transmission testing of these coupons. Acceptance testing is as described for borated aluminum in Section M.9.1.7.3.1.

In this method, the transmission through the coupons is compared with transmission through calibrated standards containing a uniform distribution of boron without other significant poisons, for example zirconium diboride, titanium diboride, or boron carbide metal matrix composites. These standards are paired with aluminum shims sized to match the scattering by aluminum in the poison plates. Uniform but non-homogeneous materials such as metal matrix composites may be used for standards, provided that testing shows them to be equivalent to a homogeneous standard. The effective B10 content of each coupon, minus 3s based on the number of neutrons counted for that coupon, must be greater than or equal to the minimum value given in .

Sampling of B10 density measurement shall be in accordance with Section M.9.1.7.3.1 for borated aluminum.

M.9.1.7.3.5 Justification for Acceptance Test Requirements, Boralyn®

Macroscopic uniformity of B10 distribution is verified by the qualification testing.

According to NUREG/CR-5661

> "...Limiting added poison material credit to 75% without comprehensive tests is based on concerns for potential 'streaming' of neutrons due to nonuniformities. It has been shown that boron carbide granules embedded in aluminum permit channeling of a beam of neutrons between the grains and reduce the effectiveness for neutron absorption."

Furthermore

> "A percentage of poison material greater than 75% may be considered in the analysis only if comprehensive tests, capable of verifying the presence *and uniformity* of the poison, are implemented." [emphasis added]

The calculations in Section M.6 use boron areal densities that are 90% of the minimum value of 0.007 g B10/cm^2. This is justified by the following considerations.

a) The coupons for neutronic inspection are removed between every other finished plate. As such, they are taken from locations that are truly representative of the finished product, and every plate is represented by a contiguous coupon. Coupons are also removed at the ends of the "stock plate", where under thickness of the plates or defects propagated from the pre-roll ingot would be most likely. The use of representative coupons for inspection is analogous to the removal of specimens from structural materials for mechanical testing.

b) Macroscopic uniformity of B10 distribution is verified as part of qualification testing. Thereafter it is assured by controls over the powder metallurgical process and is verified by subsequent measurement of B10 content on coupon samples of production material.

c) Neutron transmission measures effective B10 content directly. The term "effective" is used here because if there are any of the effects noted in NUREG/CR-5661, the neutron transmission technique will measure not the physical B10 areal density, but a lower value. Thus, this technique by its nature screens out the microscopic non-uniformities which have been the source of the recommended 75% credit for B10 in criticality evaluations.

d) The use of neutron transmission and powder metallurgical processing satisfies the "and uniformity" requirement emphasized in NUREG/CR-5661 on both the microscopic and macroscopic scales.

e) The recommendations of NUREG/CR-5661 are based upon testing of a poison with boron carbide particles on the order of 80-100 microns. The boron carbide particles in a typical metal matrix composite are much finer (1-25 microns). The powder metal manufacturing process controls and the qualification testing assure that they are uniformly distributed. For a given degree of uniformity, fine particles will be less subject to neutron streaming than coarse particles. Furthermore, because the material reviewed in the NUREG was a sandwich panel, the thickness of the boron carbide containing center could not be directly verified by thickness measurement. The metal matrix composite specified here is uniform throughout its thickness.

M.9.1.7.4 B_4C Linear Density Testing for Poison Rod Assemblies (PRAs)

The PRAs are shown in Figure M.1-2, and additional physical requirements are listed in Table M.2-4. The B_4C poison is inserted into the stainless steel tubes shown in Figure M.1-2. Table M.2-4 specifies the minimum B_4C content per unit length in the axial direction of the rods for the various PRA designs. The minimum B_4C content per unit length is consistent with the criticality analysis (Section M.6) with an additional 25% margin.

Pellets or powder representing each powder lot shall be tested per ASTM C751 [9.6] or ASTM C750 (Type 2) [9.7] (or equivalent). Density and diameter shall be measured to verify conformance to the specification requirements.

Deviations from the specified dimensions or density may be accepted, so long as the resulting minimum B_4C mass per unit length is maintained.

M.9.2 Maintenance Program

NUHOMS®-32PT system is a totally passive system and therefore requires little, if any, maintenance over the lifetime of the ISFSI. Typical NUHOMS®-32PT system maintenance tasks are performed in accordance with the FSAR.

M.9.3 References

9.1 ASME Boiler and Pressure Vessel Code, Section III, 1998 Edition including 1999 addenda.

9.2 ANSI N14.5-1997, "American National Standard for Leakage Tests on Packages for Shipment of Radioactive Materials," February 1998.

9.3 ASTM E1225, "Thermal Conductivity of Solids by Means of the Guarded-Comparative-Longitudinal Heat Flow Technique."

9.4 ASTM E1461, "Thermal Diffusivity of Solids by the Flash Method."

9.5 NUREG/CR-5661, "Recommendations for Preparing the Criticality Safety Evaluation of Transportation Packages," 1997.

9.6 ASTM C751, "Standard Specification for Nuclear-Grade Boron Carbide Pellets."

9.7 ASTM C750, "Standard Specification for Nuclear-Grade Boron Carbide Powder."

M.10 Radiation Protection

Section 7.4.1 discusses 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, several of which involve potential exposure to personnel.

M.10.1 Occupational Exposure

The expected occupational dose for placing a canister of spent fuel into dry storage is based on the operational steps outlined in Table 7.4-1. The total exposure for the occupational dose due to placing a single NUHOMS®-32PT DSC into storage is conservatively estimated to be 1.8 person-rem (125-ton configuration) and 3.8 person-rem (100-ton configuration). This is a very conservative estimate because the dose rates on and around the 32PT DSC used in these calculations are based on very conservative assumptions for the design-basis source terms. As in Section M.5, no credit is taken for the thicker door described in Section 8.1.1.6 or for any steel liners around the vent openings for the occupational exposure analysis. The calculated exposures for both configurations are due mainly to the expected gamma dose rate during preparation for welding. The increased calculated exposure for the 100-ton configuration is due to the thinner shield plug and due to draining the NUHOMS®-32PT DSC to meet a 100-ton crane limit as described in Section M.8.

The NUHOMS® System loading operations, the number of workers required for each operation, and the amount of time required for each operation are presented in Table M.10-1 and Table M.10-2 for the 125-ton and 100-ton configurations respectively. This information is used as the basis for estimating the total occupational exposure associated with one fuel load. This evaluation is performed for the storage of one design-basis NUHOMS®-32PT DSC in an HSM. The dose rates applicable for each operation are based on the results presented in Section M.5.4 for loading operations. Engineering judgment and operational experience are used to estimate dose rates that were not explicitly evaluated. This evaluation assumes that a transfer trailer/skid with an integral ram is used for the DSC transfer operations. Licensees may elect to use different equipment and/or different procedures. Each Licensee must evaluate any such changes in accordance with their ALARA program.

The amount of time required to complete some operations is sometimes far greater than the actual amount of time spent in a radiation field. The process of vacuum drying the DSC includes setting up the vacuum drying system (VDS), verifying that the VDS is operating correctly, evacuating the DSC cavity, monitoring the DSC pressure, and disconnecting the VDS from the DSC. Of these tasks, only setup and removal of the VDS require a worker to spend time near the DSC. The most time consuming task, evacuating the DSC, does not require anyone to be present at all. The total exposure calculated for each task is therefore not necessarily equal to the number of workers multiplied by the time required multiplied by a dose rate. The exposure estimation for each task accounts for cases such as vacuum drying correctly, and assumes that good ALARA practices are followed.

The results of the evaluations are presented in Table M.10-1 and Table M.10-2 for the 125-ton and 100-ton configurations, respectively

M.10.2 Off-Site Dose Calculations

Calculated dose rates in the immediate vicinity of the NUHOMS®-32PT system are presented in Section M.5 which provides a detailed description of source term configuration, analysis models and bounding dose rates. Dose rates at longer distances (off-site dose rates and doses) are presented in this section. This evaluation determines the neutron and gamma-ray off-site dose rates including skyshine in the vicinity of the two generic ISFSI layouts containing design-basis fuel in the NUHOMS®-32PT DSCs. The first generic ISFSI evaluated is a 2x10 back-to-back array of HSMs loaded with design-basis fuel, including BPRAs, in NUHOMS®-32PT DSCs. The second generic layout evaluated is two 1x10 front-to-front arrays of HSMs loaded with design-basis fuel, including BPRAs, in NUHOMS®-32PT DSCs. This calculation provides results for distances ranging from 6.1 to 600 meters from each face of the two arrays of HSMs. As in Section M.5, no credit is taken for the thicker door described in Section 8.1.1.6 or for any steel liners around the vent openings for the site dose analysis.

The total annual exposure for each ISFSI layout as a function of distance from each face is given in Table M.10-3 and plotted in Figure M.10-1. The total annual exposure assumes 100% occupancy for 365 days.

The Monte Carlo computer code MCNP [3.1] calculated the dose rates at the specified locations around the arrays of HSMs. The results of this calculation provide an example of how to demonstrate compliance with the relevant radiological requirements of 10CFR20 [3.2], 10CFR72 [3.3], and 40CFR190 [3.4] for a specific site. Each site must perform specific site calculations to account for the actual layout of the HSMs and fuel source.

The assumptions used to generate the geometry of the two ISFSIs for the MCNP analysis are summarized below.

- The 20 HSMs in the 2x10 back-to-back array are modeled as a box enveloping the 2x10 array of HSMs including the six inch gaps between modules and the 2-foot shield walls on the two sides of the array. MCNP starts the source particles on the surfaces of the box.

- The 20 HSMs in the two 1x10 front-to-front arrays are modeled as two boxes which envelope each 1x10 array of HSMs including the six inch gaps between modules and the 2-foot shield walls on the two sides and back of each array. MCNP starts the source particles on the surfaces of one of the boxes.

- The ISFSI approach slab is modeled as concrete. Because the ground composition has, at best, only a secondary impact on the dose rates at the detectors, any differences between this assumed layout and the actual layout would not have a significant affect on the site dose rates.

- For the 2x10 array, the interiors of the HSMs and shield walls are modeled as air. Most particles that enter the interiors of the HSMs and shield walls will therefore pass through unhindered.

- For the two 1x10 arrays, the interiors of the HSMs and shield walls modeled the 1x10 array in which the source is as air. Most particles that enter the interiors of these HSMs and shield walls will therefore pass through unhindered. Model the other 1x10 array as concrete to simulate the shielding provided by the second array of HSMs for the direct radiation from the front of the opposing 1x10 array.

- The "universe" is a sphere surrounding the ISFSI. To account for skyshine radius of this sphere (r=500,000 cm) is more than 10 mean free paths for neutrons and 50 mean free paths for gammas greater than that of the outermost surface, thus ensuring that the model is of a sufficient size to include all interactions, including skyshine, affecting the dose rate at the detectors.

The assumption used to generate the HSM surface sources for the MCNP analysis is summarized below.

- The HSM surface sources are bootstrapped (input to provide an equivalent boundary condition) using the HSM surface average dose rates calculated in Section M.5.4.

The assumptions used for the MCNP analysis are summarized below.

MCNP starts the source particles on the ISFSI array surface with initial directions following a cosine distribution. Radiation fluxes outside thick shields such as the HSM walls and roof tend to have forward peaked angular distributions; therefore, a cosine function is a reasonable approximation for the starting direction distribution. Vents through shielding regions such as the HSM vents tend to collimate particles such that a semi-isotropic assumption would not be appropriate.

Point detectors determine the dose rates on the four sides of the ISFSI as a function of distance from the ISFSI. All detectors represent the dose rate at three feet above ground level.

Source information required by MCNP includes gamma-ray and neutron spectra for the HSM array surfaces, total gamma-ray and neutron activities for each HSM array face and total gamma-ray and neutron activities for the entire ISFSI. The neutron and gamma-ray spectra are determined using a 1-D ANISN [3.6] run through the HSM roof using the design-basis in-core neutron and gamma fuel sources. Use of the roof is conservative because it represents the thickest cross section of the HSM shield. The thicker shield increases the dose rate importance of the higher energy neutrons and gamma-rays from the fuel because the thicker shield filters out the lower energy particles. Therefore, use of the thickest part of the shield results in a harder spectrum for all of the other surfaces. The HSM spectra as determined from ANISN are normalized to a one mrem/hour source using the flux-to-dose-factors from Reference [3.5]. These normalized spectra are then input in the MCNP ERG source variable.

The probability of a particle being born on a given surface is proportional to the total activity of that surface. The activity of each surface is determined by multiplying the sum of the normalized group fluxes, calculated above, by the average surface dose rate and by the area of the surface. This calculation is performed for the roof, sides, back and front of the HSM. The sum of the surface activities is then input as the tally multiplier for each of the MCNP tallies to convert the tally results to fluxes (particles per second per square centimeter).

Gamma-ray spectrum calculations for the HSM are shown in Table M.10-4. The group fluxes on the HSM roof are taken from the ANISN run. The dose rate contribution from each group is the product of the flux and the flux-to-dose factor. The "Input Flux" column in Table M.10-4 is simply the roof flux in each group, divided by the total dose rate and represents the roof flux normalized to one mrem per hour. Similar calculations for neutrons are shown in Table M.10-5.

M.10.2.1 Activity Calculations

2x10 Back-to-Back Array

A box that envelops the HSM array and shield walls, as modeled in MCNP, approximates the 2x10 back-to-back array of HSMs. The dimensions of the box also include the width of the HSM end shield walls. As discussed above, the total activity of each face of the box is calculated by multiplying the flux per mrem/hr by the average dose rate of the face and by the area of the face.

Two 1x10 Front-to-Front Arrays

A box that envelops the HSM array and shield walls, as modeled in MCNP, approximates the two 1x10 arrays of HSMs. The dimensions of the box also include the width of the HSM end and back shield walls. As discussed above, the total activity of each face of the box is calculated by multiplying the flux per mrem/hr by the average dose rate of the face and by the area of the face.

The HSM surface activities are summarized in Table M.10-6.

M.10.2.2 Dose Rates

Dose rates are calculated for distances of 6.1 meters (20 feet) to 600 meters from the edges of the two ISFSI designs. The HSM is modeled in MCNP as a box, representing the HSM arrays.

Neutron and gamma-ray sources are placed on each HSM, with shield walls, surface using the spectra and activities determined above. The angular distribution of source particles is modeled as a cosine distribution. The contribution of capture gamma-rays has been neglected, as has the contribution of bremsstrahlung electrons. The inclusion of coherent scattering greatly increases the variance in a problem with point detector tallies without improving the accuracy of the calculation. Thus, coherent scattering of photons is ignored.

The MCNP models of the two ISFSI layouts are described herein. For the 2x10 back-to-back array of HSMs with end shield walls the "box", dimensions are as follows. The total width is 1158 cm. The length of the "box" is 3220 cm and the height of the "box" is 457 cm.

For the two 1x10 front-to-front arrays of HSMs with end and back shield walls the "box", dimensions for each array are as follows. The total width is 640 cm. The length of the "box" is 3220 cm and the height of the "box" is 457 cm. The two 1x10 arrays are 1066 cm (35 feet) apart.

Point detectors are placed at the following locations as measured from each face of the "box": 6.095 m (20 feet), 10 m, 20 m, 30 m, 40 m, 50 m, 60 m, 70 m, 80 m, 90 m, 100 m, 200 m, 300 m, 400 m, 500 m, and 600 m. Each point detector is placed 91.4 cm (3 feet) above the ground.

The MCNP results for each detector from the front of 2x10 back-to-back array are summarized in Table M.10-7. The MCNP results as a function of distance from the back of the two 1x10 front-to-front arrays are summarized in Table M.10-8. The MCNP results as a function of distance from the side of the 2x10 back-to-back array and the two 1x10 front-to-front arrays are summarized in Table M.10-9. The results from Table M.10-7, Table M.10-8 and Table M.10-9 are plotted in Figure M.10-1.

M.10.3 References

3.1 "MCNP 4 - Monte Carlo Neutron and Photon Transport Code System," CCC-200A/B, Oak Ridge National Laboratory, RSIC Computer Code Collection, File Number QA040.215.0002, October 1991.

3.2 Title 10, "Energy," Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation."

3.3 Title 10, "Energy," Code of Federal Regulations, Part 72, "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel and High-Level Radioactive Waste."

3.4 Title 40, "Protection of Environment," Part 190, "Environmental Radiation Protection Standards for Nuclear Power Operations."

3.5 "American National Standard Neutron and Gamma-Ray Fluence-to-Dose Factors," ANSI/ANS-6.1.1-1977, American Nuclear Society, La Grange Park, Illinois, March 1977.

3.6 "ANISN-ORNL - One-Dimensional Discrete Ordinates Transport Code System with Anisotropic Scattering," CCC-254, Oak Ridge National Laboratory, RSIC Computer Code Collection, April 1991.

Table M.10-1
Occupational Exposure Summary
(125-ton configuration)

Task	Number of Workers	Completion Time (hours)
Location: Auxiliary Building and Fuel Pool		
Ready the DSC and TC for Service(1)	2	4
Place the DSC into the TC(1)	3	1
Fill the Cask/DSC Annulus with Clean Water and Install the Inflatable Seal	2	2
Fill the DSC Cavity with Water(2)	1	6
Install Shield Plug and Connect VDS	2	0.5
Place the Cask Containing the DSC in the Fuel Pool	5	0.5
Verify and Load the Candidate Fuel Assemblies into the DSC	3	8
Place the Top Shield Plug on the DSC	2	1
Raise the Cask/DSC to the Fuel Pool Surface	5	0.5
Remove the Cask/DSC from the Fuel Pool and Place them in the Decon Area	2	0.5
Location: Cask Decon Area		
Decontaminate the Outer Surface of the Cask (on the hook)(3)	3	1
Cask Decontamination (in the decon area)(3)	3	1
Remove the Cask/DSC Annulus Seal and Set-up Welder(3)	2	1.5
Drain the DSC Cavity(3)	2	0.5
Weld the Inner Top Cover to the DSC Shell and Perform NDE(3)	2	6
Vacuum Dry and Backfill the DSC with Helium(3)	2	16
Helium Leak Test the Shield Plug Weld	2	1
Seal Weld the Prefabricated Plugs to the Vent and Siphon Port and Perform NDE	1	1
Drain Cask/DSC Annulus(3)	1	0.25
Install DSC Outer Top Cover Plate(3)	2	1
Weld the Outer Top Cover Plate to DSC Shell and Perform NDE(3)	2	16
Install the Cask Lid	2	1
Location: Reactor /Fuel Building Bay		
Ready the Cask Support Skid and Transport Trailer for Service(1)	2	2
Place the Cask Onto the Skid and Secure(2)	3	0.5
Location: ISFSI Site		
Ready the HSM and Hydraulic Ram System for Service(1)	2	2
Transport the Cask to the ISFSI(1)	6	1
Position the Cask in Close Proximity with the HSM(1)	3	1
Remove the Cask Lid	3	1
Align and Dock the Cask with the HSM	2	0.25
Position and Align Ram with Cask(3)	2	0.5
Remove the RAM Access Cover Plate	2	0.25
Transfer the DSC from the Cask to the HSM(1)	3	0.5
Un-Dock the Cask from the HSM	2	0.083
Install the HSM Access Door	2	0.5
Total estimated dose is 1.8 person-rem per canister load		
Total estimated completion time is 80 hrs.		

(1) Performed away from any significant radiation sources.
(2) Personnel are not present throughout this activity.
(3) Dose rates and locations vary during this task.

Table M.10-2
Occupational Exposure Summary
(100-ton configuration)

Task	Number of Workers	Completion Time (hours)
Location: Auxiliary Building and Fuel Pool		
Ready the DSC and TC for Service(1)	2	4
Place the DSC into the TC(1)	3	1
Fill the Cask/DSC Annulus with Clean Water and Install the Inflatable Seal	2	2
Fill the DSC Cavity with Water(2)	1	6
Install Shield Plug and Connect VDS	2	0.5
Place the Cask Containing the DSC in the Fuel Pool	5	0.5
Verify and Load the Candidate Fuel Assemblies into the DSC	3	8
Place the Top Shield Plug on the DSC	2	1
Raise the Cask/DSC to the Fuel Pool Surface	5	0.5
Drain Water from DSC Cavity	1	1
Remove the Cask/DSC from the Fuel Pool and Place them in the Decon Area	2	0.5
Location: Cask Decon Area		
Decontaminate the Outer Surface of the Cask (on the hook)(3)	3	1
Fill Cask Neutron Shield and DSC Cavity	1	0.1
Cask Decontamination (in the decon area)(3)	3	1
Remove the Cask/DSC Annulus Seal and Set-up Welder(3)	2	1.5
Drain the DSC Cavity(3)	2	0.5
Weld the Inner Top Cover to the DSC Shell and Perform NDE(3)	2	6
Vacuum Dry and Backfill the DSC with Helium(3)	2	16
Helium Leak Test the Shield Plug Weld	2	1
Seal Weld the Prefabricated Plugs to the Vent and Siphon Port and Perform NDE	1	1
Drain Cask/DSC Annulus(3)	1	0.25
Install DSC Outer Top Cover Plate(3)	2	1
Weld the Outer Top Cover Plate to DSC Shell and Perform NDE(3)	2	16
Install the Cask Lid	2	1
Location: Reactor /Fuel Building Bay		
Ready the Cask Support Skid and Transport Trailer for Service(1)	2	2
Place the Cask Onto the Skid and Secure(2)	3	0.5
Location: ISFSI Site		
Ready the HSM and Hydraulic Ram System for Service(1)	2	2
Transport the Cask to the ISFSI(1)	6	1
Position the Cask in Close Proximity with the HSM(1)	3	1
Remove the Cask Lid	3	1
Align and Dock the Cask with the HSM	2	0.25
Position and Align Ram with Cask(3)	2	0.5
Remove the RAM Access Cover Plate	2	0.25
Transfer the DSC from the Cask to the HSM(1)	3	0.5
Un-Dock the Cask from the HSM	2	0.083
Install the HSM Access Door	2	0.5
Total estimated dose is 3.8 person-rem per canister load		
Total estimated completion time is 81 hrs.		

(1) Performed away from any significant radiation sources.
(2) Personnel are not present throughout this activity.
(3) Dose rates and locations vary during this task.

Table M.10-3
Total Annual Exposure

2x10 Back-To-Back Array		
Distance (meters)	Front Total Dose (mrem)	Side Total Dose (mrem)
6.096	399000	19600
10	234000	13700
20	86400	8200
30	42700	5240
40	24700	3960
50	15600	3040
60	10900	2320
70	7810	1930
80	5970	1530
90	4460	1280
100	3510	1060
200	575	233
300	164	72
400	53	22
500	19	10
600	7	4

Two 1x10 Front-To-Front Array		
Distance (meters)	Back Total Dose (mrem)	Side Total Dose (mrem)
6.096	15400	130000
10	12900	65600
20	8500	20700
30	5820	10300
40	4360	6370
50	3350	4350
60	2690	3140
70	2070	2470
80	1690	1900
90	1410	1520
100	1230	1250
200	268	264
300	83	70
400	29	28
500	10	9
600	4	3

Table M.10-4
HSM Gamma-Ray Spectrum Calculation Results

Group Number	E_{upper} (MeV)	E_{mean} (MeV)	Flux-Dose ANSI/ANS-6.1.1-1977 (mR/hr)/(γ/cm²-sec)	Roof Flux (γ/cm²-sec)	Dose Rate (mR/hr)	Input Flux (γ/cm²-sec per mrem/hr)
23	10	9	8.77E-03	5.35E-01	4.69E-03	1.15E-02
24	8	7.25	7.48E-03	4.49E+00	3.36E-02	9.64E-02
25	6.5	5.75	6.37E-03	5.60E+00	3.57E-02	1.20E-01
26	5	4.5	5.41E-03	7.30E+00	3.95E-02	1.56E-01
27	4	3.5	4.62E-03	1.97E+01	9.09E-02	4.22E-01
28	3	2.75	3.96E-03	3.67E+01	1.46E-01	7.88E-01
29	2.5	2.25	3.47E-03	4.13E+02	1.43E+00	8.87E+00
30	2	1.83	3.02E-03	3.49E+02	1.06E+00	7.49E+00
31	1.66	1.495	2.63E-03	1.41E+03	3.72E+00	3.03E+01
32	1.33	1.165	2.21E-03	2.98E+03	6.57E+00	6.39E+01
33	1	0.9	1.83E-03	2.74E+03	5.02E+00	5.87E+01
34	0.8	0.7	1.52E-03	4.19E+03	6.38E+00	8.99E+01
35	0.6	0.5	1.17E-03	6.61E+03	7.75E+00	1.42E+02
36	0.4	0.35	8.76E-04	4.53E+03	3.97E+00	9.72E+01
37	0.3	0.25	6.31E-04	6.18E+03	3.90E+00	1.33E+02
38	0.2	0.15	3.83E-04	1.41E+04	5.42E+00	3.03E+02
39	0.1	0.08	2.67E-04	3.97E+03	1.06E+00	8.52E+01
40	0.05	0.03	9.35E-04	1.14E+01	1.07E-02	2.45E-01
			Totals	**4.76E+04**	**4.66E+01**	**1.02E+03**

Table M.10-5
HSM Neutron Spectrum Calculations

Group Number	E_{upper} (MeV)	E_{mean} (MeV)	Flux-Dose ANSI/ANS-6.1.1-1977 (mR/hr)/(n/cm^2-sec)	Roof Flux (n/cm^2-sec)	Dose Rate (mR/hr)	Input Flux (n/cm^2-sec per mrem/hr)
1	1.49E+01	1.36E+01	1.94E-01	7.41E-05	1.44E-05	3.14E-04
2	1.22E+01	1.11E+01	1.60E-01	5.41E-04	8.65E-05	2.29E-03
3	1.00E+01	9.09E+00	1.47E-01	1.86E-03	2.74E-04	7.88E-03
4	8.18E+00	7.27E+00	1.48E-01	1.47E-02	2.17E-03	6.22E-02
5	6.36E+00	5.66E+00	1.53E-01	4.15E-02	6.37E-03	1.76E-01
6	4.96E+00	4.51E+00	1.51E-01	3.88E-02	5.84E-03	1.64E-01
7	4.06E+00	3.54E+00	1.39E-01	4.56E-02	6.33E-03	1.93E-01
8	3.01E+00	2.74E+00	1.28E-01	1.11E-01	1.43E-02	4.70E-01
9	2.46E+00	2.41E+00	1.25E-01	1.04E-01	1.30E-02	4.39E-01
10	2.35E+00	2.09E+00	1.26E-01	1.66E-01	2.10E-02	7.03E-01
11	1.83E+00	1.47E+00	1.29E-01	2.58E-01	3.33E-02	1.09E+00
12	1.11E+00	8.30E-01	1.17E-01	2.71E-01	3.17E-02	1.15E+00
13	5.50E-01	3.31E-01	6.52E-02	3.90E-01	2.54E-02	1.65E+00
14	1.11E-01	5.72E-02	9.19E-03	6.55E-01	6.02E-03	2.77E+00
15	3.35E-03	1.97E-03	3.71E-03	3.15E-01	1.17E-03	1.33E+00
16	5.83E-04	3.42E-04	4.01E-03	3.79E-01	1.52E-03	1.60E+00
17	1.01E-04	6.50E-05	4.29E-03	3.17E-01	1.36E-03	1.34E+00
18	2.90E-05	1.96E-05	4.48E-03	2.30E-01	1.03E-03	9.71E-01
19	1.01E-05	6.58E-06	4.57E-03	3.12E-01	1.42E-03	1.32E+00
20	3.06E-06	2.09E-06	4.54E-03	2.80E-01	1.27E-03	1.18E+00
21	1.12E-06	7.67E-07	4.37E-03	2.98E-01	1.30E-03	1.26E+00
22	4.14E-07	2.12E-07	3.71E-03	1.65E+01	6.14E-02	7.00E+01
			Totals	**2.08E+01**	**2.36E-01**	**8.79E+01**

Table M.10-6
Summary of ISFSI Surface Activities

2x10 Back-To-Back Array

Source	Area (cm^2)	Gamma-Ray Activity (γ/sec)	Neutron Activity (neutrons/sec)
Roof	$3.73x10^6$	$2.08x10^{11}$	$2.47x10^8$
Front 1	$1.47x10^6$	$1.30x10^{11}$	$1.18x10^9$
Front 2	$1.47x10^6$	$1.30x10^{11}$	$1.18x10^9$
Side 1	$5.30x10^5$	$9.30x10^8$	$2.18x10^6$
Side 2	$5.30x10^5$	$9.30x10^8$	$2.18x10^6$
Total		$4.69x10^{11}$	$2.62x10^9$

Two 1x10 Front-To-Front Arrays

Source	Area (cm^2)	Gamma-Ray Activity (γ/sec)	Neutron Activity (neutrons/sec)
Roof	$2.06x10^6$	$1.15x10^{11}$	$1.36x10^8$
Front	$1.47x10^6$	$1.30x10^{11}$	$1.18x10^9$
Back	$1.47x10^6$	$7.23x10^8$	$2.16x10^6$
Side 1	$2.93x10^5$	$5.14x10^8$	$1.21x10^6$
Side 2	$2.93x10^5$	$5.14x10^8$	$1.21x10^6$
Total		$2.46x10^{11}$	$1.32x10^9$

Table M.10-7
MCNP Front Detector Dose Rates for 2x10 Array

Distance (meters)	Gamma Dose Rate (mrem/hr)	Neutron Dose Rate (mrem/hr)	Total Dose Rate (mrem/hr)
6.10E+00	4.01E+01	5.43E+00	4.56E+01
1.00E+01	2.36E+01	3.11E+00	2.67E+01
2.00E+01	8.73E+00	1.13E+00	9.86E+00
3.00E+01	4.32E+00	5.53E-01	4.87E+00
4.00E+01	2.50E+00	3.12E-01	2.82E+00
5.00E+01	1.59E+00	1.88E-01	1.78E+00
6.00E+01	1.11E+00	1.37E-01	1.24E+00
7.00E+01	8.00E-01	9.09E-02	8.91E-01
8.00E+01	5.95E-01	8.60E-02	6.81E-01
9.00E+01	4.58E-01	5.17E-02	5.09E-01
1.00E+02	3.61E-01	4.00E-02	4.01E-01
2.00E+02	5.98E-02	5.80E-03	6.56E-02
3.00E+02	1.68E-02	1.98E-03	1.88E-02
4.00E+02	5.32E-03	7.70E-04	6.09E-03
5.00E+02	1.90E-03	3.09E-04	2.21E-03
6.00E+02	7.19E-04	1.18E-04	8.36E-04

Table M.10-8
MCNP Back Detector Dose Rates for the Two 1x10 Arrays

Distance (meters)	Gamma Dose Rate (mrem/hr)	Neutron Dose Rate (mrem/hr)	Total Dose Rate (mrem/hr)
6.10E+00	1.35E+00	4.03E-01	1.75E+00
1.00E+01	1.14E+00	3.32E-01	1.47E+00
2.00E+01	7.61E-01	2.09E-01	9.70E-01
3.00E+01	5.36E-01	1.28E-01	6.64E-01
4.00E+01	4.09E-01	8.95E-02	4.98E-01
5.00E+01	3.20E-01	6.19E-02	3.82E-01
6.00E+01	2.60E-01	4.65E-02	3.07E-01
7.00E+01	2.04E-01	3.21E-02	2.36E-01
8.00E+01	1.67E-01	2.63E-02	1.93E-01
9.00E+01	1.40E-01	2.00E-02	1.61E-01
1.00E+02	1.21E-01	1.95E-02	1.41E-01
2.00E+02	2.74E-02	3.19E-03	3.06E-02
3.00E+02	8.19E-03	1.34E-03	9.53E-03
4.00E+02	2.64E-03	6.19E-04	3.26E-03
5.00E+02	9.91E-04	1.88E-04	1.18E-03
6.00E+02	4.05E-04	1.00E-04	5.06E-04

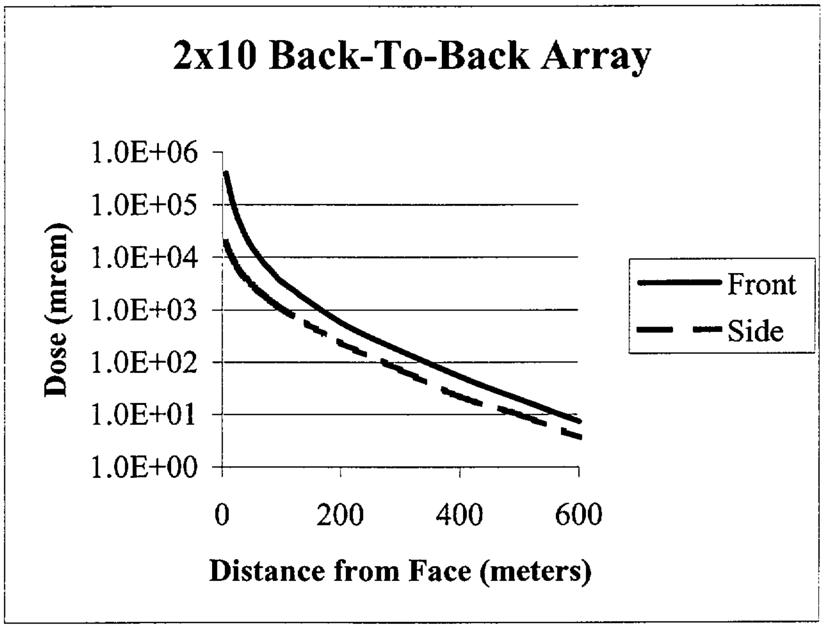
Table M.10-9
MCNP Side Detector Dose Rates

2x10 Back-to-Back Array

Distance (meters)	Gamma Dose Rate (mrem/hr)	Neutron Dose Rate (mrem/hr)	Total Dose Rate (mrem/hr)
6.10E+00	1.79E+00	4.45E-01	2.24E+00
1.00E+01	1.25E+00	3.13E-01	1.56E+00
2.00E+01	7.36E-01	2.00E-01	9.36E-01
3.00E+01	4.89E-01	1.10E-01	5.99E-01
4.00E+01	3.79E-01	7.32E-02	4.52E-01
5.00E+01	2.76E-01	7.08E-02	3.47E-01
6.00E+01	2.25E-01	4.03E-02	2.65E-01
7.00E+01	1.83E-01	3.71E-02	2.20E-01
8.00E+01	1.50E-01	2.52E-02	1.75E-01
9.00E+01	1.24E-01	2.19E-02	1.46E-01
1.00E+02	1.03E-01	1.78E-02	1.21E-01
2.00E+02	2.37E-02	2.99E-03	2.66E-02
3.00E+02	7.10E-03	1.09E-03	8.19E-03
4.00E+02	1.99E-03	5.04E-04	2.49E-03
5.00E+02	9.40E-04	1.84E-04	1.12E-03
6.00E+02	2.73E-04	1.46E-04	4.19E-04

Two 1x10 Front-To-Front Arrays

Distance (meters)	Gamma Dose Rate (mrem/hr)	Neutron Dose Rate (mrem/hr)	Total Dose Rate (mrem/hr)
6.10E+00	1.30E+01	1.85E+00	1.49E+01
1.00E+01	6.54E+00	9.44E-01	7.49E+00
2.00E+01	2.04E+00	3.18E-01	2.36E+00
3.00E+01	1.01E+00	1.69E-01	1.17E+00
4.00E+01	6.24E-01	1.03E-01	7.27E-01
5.00E+01	4.20E-01	7.57E-02	4.96E-01
6.00E+01	3.11E-01	4.71E-02	3.58E-01
7.00E+01	2.41E-01	4.04E-02	2.82E-01
8.00E+01	1.86E-01	3.07E-02	2.16E-01
9.00E+01	1.51E-01	2.27E-02	1.73E-01
1.00E+02	1.25E-01	1.69E-02	1.42E-01
2.00E+02	2.72E-02	2.92E-03	3.02E-02
3.00E+02	7.06E-03	9.25E-04	7.98E-03
4.00E+02	2.20E-03	9.72E-04	3.18E-03
5.00E+02	8.27E-04	1.46E-04	9.73E-04
6.00E+02	2.87E-04	8.73E-05	3.74E-04



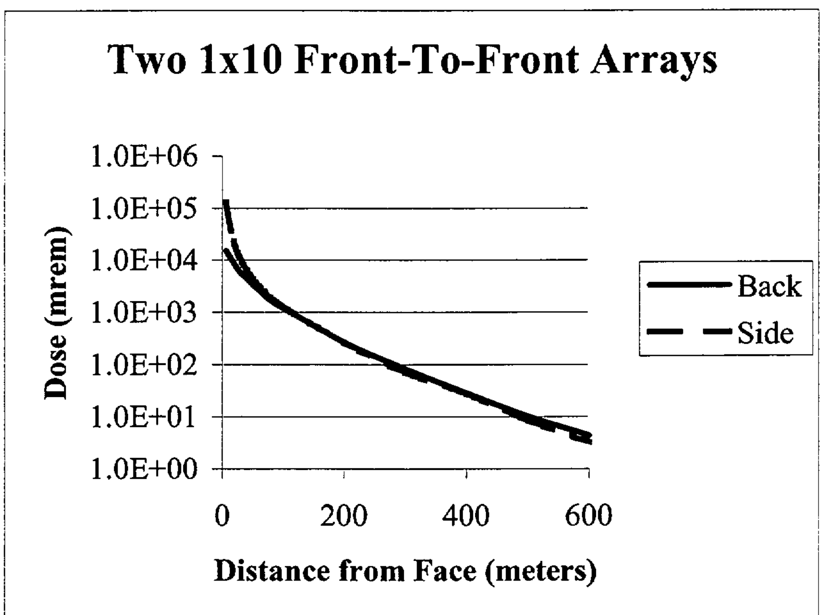


Figure M.10-1
Annual Exposure from the ISFSI as a Function of Distance

M.11 Accident Analyses

This section describes the postulated off-normal and accident events that could occur during transfer and storage of the NUHOMS®-32PT DSC. Sections which do not affect the evaluation presented in Chapter 8 are identified as "No change." Detailed analysis of the events are provided in other sections and referenced herein.

M.11.1 Off-Normal Operations

Off-normal operations are design events of the second type (Design Event II) as defined in ANSI/ANS 57.9 [11.1]. Off-normal conditions consist of that set of events that, although not occurring regularly, can be expected to occur with moderate frequency or on the order of once during a calendar year of ISFSI operation.

The off-normal conditions considered for the NUHOMS®-32PT DSC are off-normal transfer loads, extreme temperatures and a postulated release of radionuclides.

M.11.1.1 Off-Normal Transfer Loads

No change. The limiting off-normal event is the jammed DSC during loading or unloading from the HSM. This event is described in Section 8.1.2. Other off-normal events are bounded by the jammed DSC.

M.11.1.1.1 Postulated Cause of Event

See Section 8.1.2. The probability of a jammed DSC does not increase with the NUHOMS®-32PT DSC, since the outside diameter of the DSC is the same as the NUHOMS®-24P.

M.11.1.1.2 Detection of Event

No change. See Section 8.1.2.

M.11.1.1.3 Analysis of Effects and Consequences

A detailed evaluation of this event is presented in Section M.3.6.2 and is summarized below. The NUHOMS®-32PT DSC has a 0.5 inch shell wall thickness, while the NUHOMS®-24P and -52B have 0.62 inch thick shells. Therefore, the stresses in the canister shell are increased. The DSC shell stress due to the 2,690 in-kip moment due to axial sticking of the DSC is S_{mx} = 1.55 ksi. This magnitude of stress is negligible when compared to the allowable membrane stress of 17.5 ksi.

The DSC shell stress due to the 1,400 pound axial load during the binding of the DSC is 15.7 ksi. As stated in Section M.3.6.2.1, this stress is considered secondary and is enveloped by other handling stresses.

The evaluation of the basket due to normal and off-normal handling and transfer loads is presented in Section M.3.6.1.3.

M.11.1.1.4 Corrective Actions

No change. See Section 8.1.2.

M.11.1.2 Extreme Temperatures

No change. The off-normal maximum ambient temperature of 125°F is used in Section 8.1.2.2. For the NUHOMS®-32PT system, a maximum ambient temperature of 117°F is used. Therefore, the analyses in Section 8.1.2.2 bound the NUHOMS®-32PT system.

M.11.1.2.1 Postulated Cause of Event

No change. See Section 8.1.2.2.

M.11.1.2.2 Detection of Event

No change. See Section 8.1.2.2.

M.11.1.2.3 Analysis of Effects and Consequences

The thermal evaluation of the NUHOMS®-32PT system for off-normal conditions is presented in Section M.4.5. The 100°F normal condition with insolation bounds the 117°F case without insolation for the DSC in the TC. Therefore the normal condition maximum temperatures are bounding. The 117°F case with the DSC in the HSM is not bounded by the normal conditions.

The structural evaluation of the 32PT DSC for off-normal temperature conditions is presented in Section M.3.6.2.2. The structural evaluation of the basket due to off-normal thermal conditions is presented in Section M.3.4.4.

M.11.1.2.4 Corrective Actions

Restrictions for onsite handling of the TC with a loaded DSC under extreme temperature conditions are presented in Technical Specifications 1.2.13 and 1.2.14. There is no change to this requirement as a result of addition of the NUHOMS®-32PT DSC.

M.11.1.3 Off-Normal Releases of Radionuclides

The NUHOMS®-32PT DSC is designed and tested to the leak tight criteria of ANSI N14.5 [11.2]. Therefore the estimated quantity of radionuclides expected to be released annually to the environment due to normal or off-normal events is zero.

M.11.1.3.1 Postulated Cause of Event

In accordance with the Standard Review Plan, NUREG-1536 [11.3] and ISG-5 Rev. 1 [11.4] for off-normal conditions, it is conservatively assumed that 10% of the fuel rods fail.

M.11.1.3.2 Detection of Event

Failed fuel rods would go undetected, but are not a safety concern since the canister is designed and tested to leak tight criteria.

M.11.1.3.3 Analysis of Effects and Consequences

The bounding off-normal pressure for the NUHOMS®-32PT DSC is calculated with the DSC in either the HSM or in the TC in Section M.4.5.4 as 15.2 psig. The NUHOMS®-32PT DSC stresses due to these pressures are below the allowable stresses for off-normal conditions, as shown in M.3.6.

The NUHOMS®-32PT DSC is designed and tested to the leak tight criteria of ANSI N14.5. Therefore the estimated quantity of radionuclides expected to be released annually to the environment due to normal or off-normal events is zero.

M.11.1.3.4 Corrective Actions

None required.

M.11.1.4 Radiological Impact from Off-Normal Operations

The NUHOMS®-32PT DSC is designed and tested to the leak tight criteria of ANSI N14.5. The off-normal conditions have been evaluated in accordance with the ASME B&PV code [11.5]. The resulting stresses are below the allowable stresses. There will be no breach of the confinement boundary due to the off-normal conditions. Therefore, the estimated quantity of radionuclides expected to be released annually to the environment due to off-normal events is zero.

M.11.2 Postulated Accidents

M.11.2.1 Reduced HSM Air Inlet and Outlet Shielding

M.11.2.1.1 Cause of Accident

No change. See Section 8.2.1.1.

M.11.2.1.2 Accident Analysis

There are no structural consequences that affect the safe operation of the NUHOMS®-32PT system resulting from the separation of the HSMs. The thermal effects of this accident results from the blockage of HSM air inlet and outlet openings on the HSM side walls in contact with each other. This would block the ventilation air flow provided to the HSMs in contact from these inlet and outlet openings. The increase in spacing between the HSM on the opposite side from 6 inches to 12 inches, will reduce the ventilation air flow resistance through the air inlet and outlet openings on these side walls, which will partially compensate the ventilation reduction from the blocked side. However, the effect on the NUHOMS®-32PT DSC, HSM and fuel temperatures is bounded by the complete blockage of air inlet and outlet openings described in Section M.11.2.7. The radiological consequences of this accident are described in the paragraph below.

M.11.2.1.3 Accident Dose Calculations

The off-site radiological effects that result from a partial loss of adjacent HSM shielding is an increase in the air scattered (skyshine) and direct doses from the 12 inch gap between the separated HSMs. The air scattered (skyshine) and direct doses are reduced from the gap between the HSMs that are in contact with each other. On-site radiological effects result from an increase in the direct radiation during recovery operations and increased skyshine radiation. Table 8.2-2 shows the comparisons of the increased dose rate as a function of distance due to the reduced shielding effects of the adjacent HSM for the 24P DSC with 5-year cooled design basis fuel. Table M.11-1 provides a similar table for the NUHOMS®-32PT System. For the NUHOMS®-32PT System, the dose received by a person located 100 meters away from the NUHOMS® installation for eight hours a day for five days (estimated recovery time) would be 32 mrem. The increased dose to an off-site person for 24 hours a day for five days located 2000 feet away would be about 0.20 mrem. Thus, the 10CFR72 requirements for this postulated event are met.

M.11.2.1.4 Corrective Actions

No change. See Section 8.2.1.4.

M.11.2.2 Earthquake

M.11.2.2.1 Cause of Accident

No change. See Section 8.2.3.1.

M.11.2.2.2 Accident Analysis

Section 8.2.3.2 describes the analyses performed to demonstrate that the NUHOMS® System withstands the design basis seismic event. Section M.3.7.3 presents the changes to this analysis resulting from the addition of NUHOMS®-32PT DSC. As documented in Chapter 8 the HSM and the TC have been evaluated for a payload that bounds the 32PT DSC payload, and thus these two components are not affected by the 32PT DSC. Therefore, only those analyses documented in Chapter 8 that are affected by the increased weight of the 32PT DSC are addressed in Section M.3.7.3. The results of this analysis show that seismic stresses are well below allowables and, thus, the leak-tight integrity of the canister is not compromised.. The basket stresses are also low and do not result in deformations that would prevent fuel from being unloaded from the canister.

M.11.2.2.3 Accident Dose Calculations

The design earthquake does not damage the NUHOMS®-32PT system. Hence, no radioactivity is released and there is no associated dose increase due to this event.

M.11.2.2.4 Corrective Actions

After a seismic event, the NUHOMS® HSMs and TC would be inspected for damage. Any debris would be removed. An evaluation would be performed to determine if the cask were still within the licensed design basis.

M.11.2.3 Extreme Wind and Tornado Missiles

M.11.2.3.1 Cause of Accident

The determination of the tornado wind and tornado missile loads acting on the HSM are detailed in Section 8.2.2.

M.11.2.3.2 Accident Analysis

An evaluation of the HSM and TC with respect to tornado winds and tornado missiles is presented in Section 8.2.2. Changes to this analysis, as a result of the addition of the NUHOMS®-32PT DSC, are presented in Section M.3.7.2. The analysis presented in Section 8.2.2 is bounding.

M.11.2.3.3 Accident Dose Calculations

The NUHOMS®-32PT DSC is designed and tested as a leak-tight containment boundary. Tornado wind and tornado missiles do not breach the containment boundary. Therefore, there is no increase in site boundary dose due to this accident event.

M.11.2.3.4 Corrective Actions

After excessive high winds or a tornado, the HSM's and TC would be inspected for damage. Any debris would be removed. Any damage resulting from impact with a missile would be evaluated to determine if the system was still within the licensed design basis.

M.11.2.4 Flood

M.11.2.4.1 Cause of Accident

No change. See Section 8.2.4.1.

M.11.2.4.2 Accident Analysis

The HSM is evaluated for flooding in Section 8.2.4. This evaluation is bounding for the NUHOMS®-32PT DSC as described in Section M.3.7.4. The canister is designed and tested to be leak tight. The stresses in the canister due to the design basis flood are well below the allowable stresses for Service Level C of the ASME Code Subsection NB [11.5]. Therefore, the NUHOMS®-32PT DSC will withstand the design basis flood without breach of the confinement boundary.

M.11.2.4.3 Accident Dose Calculations

The radiation dose due to flooding of the HSM is negligible. The NUHOMS®-32PT DSC is designed and tested as a leak-tight containment boundary. Flooding does not breach the containment boundary. Therefore radioactive material inside the DSC will remain sealed in the DSC and, therefore, will not contaminate the encroaching flood water. See also Section 8.2.4.3.

M.11.2.4.4 Corrective Actions

No change. See Section 8.2.4.4.

M.11.2.5 Accidental TC Drop

M.11.2.5.1 Cause of Accident

See Section M.3.7.5.1.

M.11.2.5.2 Accident Analysis

The evaluation of the NUHOMS®-32PT DSC shell and basket assemblies due to an accidental drop is presented in Section M.3.7.5. As documented in Chapter 8 the TC have been evaluated for a payload that bounds the 32PT DSC payload, and therefore is not affected by the 32PT DSC. As shown in Section M.3.7.5, the DSC shell and basket stress intensities are within the appropriate ASME Code Service Level D allowable limits and maintain their structural integrity.

For the case of a liquid neutron shield, a complete loss of neutron shield was evaluated at the 100°F ambient condition with full solar load. It is conservatively assumed that the neutron shield jacket is still present but all the liquid is lost. The maximum DSC shell temperature is 378°F. The maximum cask inner shell, cask outer shell, and cask neutron shield jacket temperatures are bounded by analyses presented in Section 8.1.3.3 which are 393°F, 384°F and 238°F respectively. The DSC shell temperatures and hence fuel cladding temperature are bounded by the HSM plugged vent case shown in Table M.4-14. Accident thermal conditions, such as loss of the liquid neutron shield, need not be considered in the load combination evaluation. Rather the peak stresses resulting from the accident thermal conditions must be less than the allowable fatigue stress limit for 10 cycles from the appropriate fatigue design curves in Appendix I of the ASME Code. Similar analyses of other NUHOMS® TCs have shown that fatigue is not a concern. Therefore, these stresses in a TC with a liquid neutron shield need not be evaluated for the accident condition.

M.11.2.5.3 Accident Dose Calculations for Loss of Neutron Shield

The postulated accident condition for the on-site TC assumes that after a drop event, the water in the neutron shield is lost. The loss of neutron shield is modeled using the normal operation models described in Section M.5.4 by replacing the neutron shield with air.

The accident condition dose rates are summarized in Table M.11-2 and Figure M.11-1 for the bounding 100-ton 32PT-L100 DSC loaded with design basis fuel plus BPRAs.

A comparison of the results in Table M.11-2 and Table M.5-4, demonstrates a maximum cask surface contact dose rate increase from 9.47E+02 mrem/hr to 4.63E+03 mrem/hr. These dose rates are approximately 2.2 times those reported in Section 8.2.5.3.2. Therefore, one would expect that the additional dose rate to an average on-site worker at an average distance of fifteen feet would also increase from 310 mrem/hr to 700 mrem/hr. Similarly the exposure to off-site individuals at a distance of 2000 feet would also be expected to increase from 0.04 mrem for an assumed eight hour exposure to 0.09 mrem. This exposure is still well within the limits of 10CFR72 for an accident condition.

M.11.2.5.4 Corrective Action

No change. See Section 8.2.5.4.

M.11.2.6 Lightning

No change. The evaluation presented in Section 8.2.6 is not affected by the addition of the NUHOMS®-32PT DSC to the NUHOMS® System.

M.11.2.7 Blockage of Air Inlet and Outlet Openings

This accident conservatively postulates the complete blockage of the HSM ventilation air inlet and outlet openings on the HSM side walls.

M.11.2.7.1 Cause of Accident

No change. See Section 8.2.7.1.

M.11.2.7.2 Accident Analysis

This event is evaluated in Section 8.2.7.2 . The section below describes the additional analyses performed to demonstrate the acceptability of the system with the NUHOMS®-32PT DSC. The thermal evaluation of this event is presented in Section M.4.6. The temperatures determined in Section M.4.6 are used in the structural evaluation of this event, which is presented in Sections M.3.7.7 and M.3.4.4.3.

M.11.2.7.3 Accident Dose Calculations

There are no off-site dose consequences as a result of this accident. The only significant dose increase is that related to the recovery operation. This is bounded by the evaluation of the NUHOMS® System with the 24P canister. See Section 8.2.7.3 .

M.11.2.7.4 Corrective Action

No change. See Section 8.2.7.4.

M.11.2.8 DSC Leakage

The NUHOMS®-32PT DSC is designed as a pressure retaining containment boundary to prevent leakage of contaminated materials. The analyses of normal, off-normal, and accident conditions have shown that no credible conditions can breach the DSC shell or fail the double seal welds at each end of the DSC. The NUHOMS®-32PT DSC is designed and tested to be leak tight. Therefore DSC leakage is not considered a credible accident scenario. See Section M.7.3.

M.11.2.9 Accident Pressurization of DSC

M.11.2.9.1 Cause of Accident

The bounding internal pressurization of the NUHOMS®-32PT DSC is postulated to result from cladding failure of the spent fuel in combination with the blocked inlet and outlet vents and the consequent release of spent fuel rod fill gas and free fission gas. The evaluation conservatively assumes that 100% of the fuel rods have failed.

M.11.2.9.2 Accident Analysis

The pressure due to this case is evaluated in Section M.4.6. The maximum pressure calculated is 102.9 psig. The accident pressure is conservatively assumed to be 105 psig in the structural load combinations presented in Table M.2-15.

M.11.2.9.3 Accident Dose Calculations

There is no increase in dose rates as a result of this event.

M.11.2.9.4 Corrective Actions

This is a hypothetical event. Therefore no corrective actions are required. The canister is designed to withstand the pressure as a Level D condition. There will be no structural damage to the canister or leakage of radioactive material as a result of this event.

M.11.2.10 Fire and Explosion

M.11.2.10.1 Cause of the Accident

Combustible materials will not normally be stored at an ISFSI. Therefore, a credible fire would be very small and of short duration such as that due to a fire or explosion from a vehicle or portable crane.

However, a hypothetical fire accident is evaluated for the NUHOMS®-32PT System based on a fuel fire. The source of fuel is postulated to be from a ruptured fuel tank of the TC transporter tow vehicle. The bounding capacity of the fuel tank is 300 gallons and the bounding hypothetical fire is an engulfing fire around the TC. Direct engulfment of the HSM is highly unlikely. Any fire within the ISFSI boundary while the DSC is in the HSM would be bounded by the fire during TC movement. The HSM concrete acts as a significant insulating fire wall to protect the 32PT-DSC from the high temperatures of the fire.

M.11.2.10.2 Accident Analysis

The evaluation of the hypothetical fire event is presented in Section M.4.6.3. The fire thermal evaluation is performed primarily to demonstrate the confinement integrity and fuel retrievability of the 32PT-DSC. This is assured by demonstrating that the DSC temperatures and internal pressures will not exceed those of the blocked vent condition (see Section M.11.2.7) during the fire scenario. Peak temperatures for the NUHOMS®-32PT System components are summarized in Table M.4-16.

M.11.2.10.3 Accident Dose Calculations

The 32PT-DSC confinement boundary will not be breached as a result of the postulated fire/explosion scenario. Accordingly, no 32PT-DSC damage or release of radioactivity is postulated. Because no radioactivity is released, no resultant dose increase is associated with this event.

The fire scenario may result in the loss of TC neutron shielding should the fire occur while the 32PT-DSC is in the cask. The effect of loss of the neutron shielding due to a fire is bounded by that resulting from a cask drop scenario. See Section M.11.2.5.3 for evaluation of the dose consequences of a cask drop.

M.11.2.10.4 Corrective Actions

Evaluation of HSM or TC neutron shield damage as a result of a fire is to be performed to assess the need for temporary shielding (for HSM or cask, if fire occurs during transfer operations) and repairs to restore the TC and HSM to pre-fire design conditions.

M.11.3 References

11.1 American Nuclear Society, ANSI/ANS-57.9, Design Criteria for an Independent Spent Fuel Storage Installation (Dry Storage Type), 1992.

11.2 N14.5-1997, "Leakage Tests on Packages for Shipment," February 1998.

11.3 NUREG-1536, "Standard Review Plan for dry Storage Casks, Final Report," US Nuclear Regulatory Commission, January 1997.

11.4 ISG-5, Rev. 1, Confinement Evaluation.

11.5 American Society of Mechanical Engineers, ASME Boiler and Pressure Vessel Code, Section III, 1998 including 2000 addenda.

Table M.11-1
Comparison of Total Dose Rates for HSM with and without Adjacent HSM Shielding Effects

Distance from Nearest HSM Wall, 2x10 Array (meters)	Normal Case Dose Rate[1] (mrem/hr)	Accident Case Dose Rate[1] (mrem/hr)
10	27	54
100	0.40	0.80
500	2.2×10^{-3}	4.4×10^{-3}
600	8.4×10^{-4}	1.7×10^{-3}

(1) Air scattered plus direct radiation

Table M.11-2
TC Bounding Accident Dose Rate Results

Cask			
	Side (mrem/hr)	**Top (mrem/hr)**	**Bottom (mrem/hr)**
Neutron	3.78E+03	4.06E+01	9.54E+02
Gamma	1.07E+03	9.48E+01	7.58E+02
Total	4.64E+03	1.08E+02	1.70E+03
1-Meter from Cask			
	Side (mrem/hr)	**Top (mrem/hr)**	**Bottom (mrem/hr)**
Neutron	1.29E+03	1.26E+01	9.10E+01
Gamma	3.88E+02	1.70E+01	1.85E+02
Total	1.67E+03	2.65E+01	2.76E+02
2-Meters from Cask			
	Side (mrem/hr)	**Top (mrem/hr)**	**Bottom (mrem/hr)**
Neutron	6.43E+02	6.33E+00	3.03E+01
Gamma	2.34E+02	8.89E+00	8.07E+01
Total	8.77E+02	1.46E+01	1.11E+02

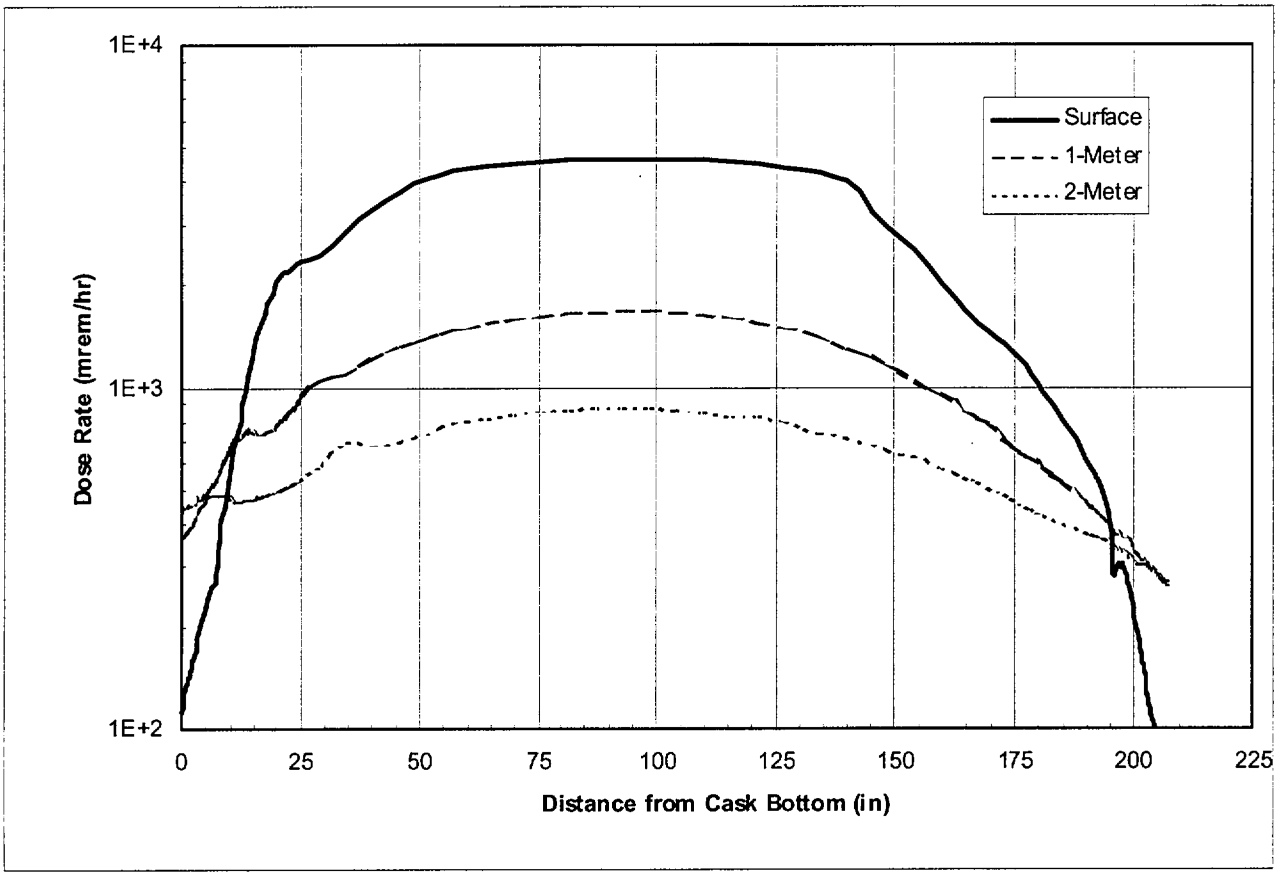


Figure M.11-1
TC Bounding Accident Dose Rate Distribution

M.12 Conditions for Cask Use - Operating Controls and Limits or Technical Specifications

Attachment B of this application provides the suggested changes to the Technical Specifications due to the addition of 32PT DSC to the NUHOMS® System.

M.13 Quality Assurance

Chapter 11.0 provides a description of the Quality Assurance Program to be applied to the safety related and important to safety activities associated with the standardized NUHOMS® System. For the 32PT DSC system, the following is added to clarify the contents of Section 11.2:

> "In lieu of the requirements listed in paragraphs A through H, Category A items may also be procured as commercial grade items and dedicated by in accordance with the guidelines of EPRI NP-5652."

M.14 Decommissioning

There is no change from the decommissioning evaluation presented in Section 9.6 due to the addition of 32PT DSC to the NUHOMS® System.