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7.0 CONFINEMENT

The Universal Storage System Transportable Storage Canister provides confinement for its radioactive contents in long-term storage. The confinement boundary is closed by welding, creating a solid barrier to the release of contents in all of the design basis normal, off-normal and accident conditions. The welds are visually inspected and nondestrucively examined to verify integrity. The containment boundary is leak tight as defined by ANSI N 14.5 [1].

The sealed canister contains an inert gas (helium). The confinement boundary retains the helium and also prevents the entry of outside air into the canister in long term storage. The exclusion of air precludes degradation of the fuel rod cladding, over time, due to cladding oxidation failures.

The Universal Storage System canister confinement system meets the requirements of 10 CFR 72.24 for protection of the public from release of radioactive material [2]. It also meets the requirements of 10 CFR 72.122 for protection of the spent fuel contents in long-term storage such that future handling of the contents would not pose an operational safety concern.

7.1 Confinement Boundary

The transportable storage canister provides confinement of the PWR or BWR contents in long-term storage. The welded canister forms the confinement vessel.

The primary confinement boundary of the canister consists of the canister shell, bottom plate, shield lid, the two port covers, and the welds that join these components. A secondary confinement boundary consists of the canister shell, the structural lid, and the welds that join the structural lid and canister shell. The confinement boundaries are shown in Figures 7.1-1 and 7.1-2. There are no bolted closures or mechanical seals in the primary or secondary confinement boundary. The confinement boundary welds are described in Table 7.1-1.

7.1.1 Confinement Vessel

The canister consists of three principal components: the canister shell, the shield lid, and the structural lid. The canister shell is a right circular cylinder constructed of 0.625-inch thick rolled Type 304L stainless steel plate. The edges of the rolled plate are joined using full penetration welds. It is closed at the bottom end by a 1.75-inch thick circular plate joined to the shell by a full penetration weld. The inside and outside diameters of the canister are 65.81 inches and 67.06 inches, respectively. The canister has a length that is variable, depending on the class of fuel stored (See Figure 7.1-1).

The canister is fabricated in accordance with the ASME Boiler and Pressure Vessel Code, Section III, Subsection NB, except for the field installed structural lid and shield lid closure welds [3]. These welds are not full penetration welds, but are inspected either ultrasonically or by using a progressive liquid penetrant examination.

After loading, the canister is closed at the top by a shield lid and a structural lid. The shield lid is a 7-inch-thick Type 304 stainless steel plate. It is joined to the canister shell using a field installed bevel weld. The shield lid contains the drain and vent penetrations and provides gamma radiation shielding for the operators during the welding, draining, drying and inerting operations. After the shield lid is welded in place, the canister is pressure tested and leak tested to ensure leak tightness. Following draining, drying and inerting operations, the vent and drain penetrations are closed with Type 304 stainless steel port covers that are welded in place with bevel welds. The operating procedures, describing the handling steps to close the canister, are presented in Section 8.1.1. The pressure and leak test procedures are described in Section 9.1.

A secondary, or redundant, confinement boundary is formed at the top of the canister by the structural lid, which is placed over the shield lid. The structural lid is a 3-inch thick Type 304L stainless steel plate. The structural lid provides the attachment points for lifting the loaded canister. The structural lid is welded to the shell using a field installed bevel weld.

The weld specifications and the weld examination and acceptance criteria for the shield lid and stuctural lid welds are presented in Sections 7.1.3.2 and 7.1.3.3, respectively.

The confinement boundaries are shown in Figures 7.1-1 and 7.1-2. As illustrated in Figure 7.1-2, the secondary confinement boundary includes the structural lid, the upper 3.2 inches of the canister shell and the joining weld. This boundary provides additional assurance of the leak tightness of the canister during its service life.

7.1.1.1 Design Documents, Codes and Standards

The canister is constructed in accordance with the license drawings presented in Section 1.6. The principal Codes and Standards that apply to the canister design, fabrication and assembly are described in Sections 7.1.1 and 7.1.3, and are shown on the licensing drawings.

7.1.1.2 Technical Requirements for the Canister

The canister confines up to 24 PWR, or 56 BWR, fuel assemblies. Over its 50-year design life, the canister precludes the release of radioactive contents and the entry of air that could potentially damage the cladding of the stored spent fuel. The design of the canister to the requirements of the ASME Code Section III, Subsection NB ensures that the canister maintains confinement in all of the evaluated normal, off-normal, and accident conditions.

The canister has no exposed penetrations, no mechanical closures, and does not employ seals to maintain confinement. There is no requirement for continuous monitoring of the welded closures. The design of the canister allows the recovery of stored spent fuel should it become necessary.

The minimum helium purity level of 99.9% specified in Section 8.1.1 of the Operating Procedures maintains the quantity of oxidizing contaminants to less than one mole per canister for all loading conditions. Based on the calculations presented in Section 4.4.5, the free gas volume of the empty canister is less than 300 moles. Conservatively assuming that all of the impurities in 99.9% pure helium are oxidents, a maximum of 0.3 moles of oxidants could exist in the largest NAC-UMS canister during storage. By limiting the amount of oxidants to less than one mole, the recommended limits for preventing cladding degradation found in the Pacific Northwest Laboratory, "Evaluation of Cover Gas Impuritities and Their Effects on the Dry Storage of LWR Spent Fuel," PNL-6365 [7] are satisfied.

The design criteria that apply to the canister, as an element of the NAC-UMS dry storage system, are presented in Table 1.2-1. The design basis parameters of the PWR and BWR spent fuel contents are presented in Section 1.3.

7.1.1.3 Release Rate

The primary confinement boundary is formed by joining the canister confinement boundary stainless steel components by welding. The canister shell longitudinal and girth welds are visually inspected, ultrasonically examined and pressure tested as described in Section 7.1.3.3 to confirm integrity. The shield lid welds are liquid penetrant examined following the root and the final weld passes. The shield lid to canister shell weld is pressure tested as described in Section 7.1.3.3. The structural lid to canister shell multi-pass weld is either: 1) progressively liquid penetrant examined; or 2) ultrasonically examined in conjunction with a liquid penetrant examination of the final weld surface.

To demonstrate leak tightness of the shield lid to canister shell weld, the leaktight criteria of 1×10^{-7} ref cm^3/sec, or 2×10^{-7} cm^3/sec (helium) at standard conditions, as defined in Section 2.1 of ANSI N14.5-1997, is applied. "Standard" conditions are defined as the leak rate at 298 K (25°C) with a one atmosphere pressure differential in the test condition. Since helium at approximately 25°C (77°F) is injected into the canister, at the point of the procedure (Section 8.1.1) that the leak test is performed, the actual temperature of the helium is always equal to, or higher than, 25°C due to the decay heat of the contents. This results in a pressure within the canister that is higher than the 0 psig (helium) that is initially established. To ensure that the leak test is conservatively performed, the ANSI N14.5 defined leak rate of 2×10^{-7} cm^3/sec is used. The higher temperature and higher pressure differential that actually exist in the canister, are conservatively ignored. The sensitivity of the leak test is 1×10^{-7} cm^3/sec (helium). Using this criterion, there is no maximum allowable leak rate specified for the canister, and calculation of the radionuclide inventory is not required. The leak test is described in Section 7.1.3.3 and in Section 8.1.1.

These steps provide reasonable assurance that the confinement boundary is leak tight and does not provide a path for the release of any of the content particulates, fission gases, volatiles, corrosion products or fill gases.

7.1.2 Confinement Penetrations

Two penetrations (with quick disconnect fittings) are provided in the canister shield lid for operator use. One penetration is used for draining residual water from the canister. It connects to a drain tube that extends to the bottom of the canister. The other penetration extends only to the underside of the shield lid. It is used to introduce air, or inert gas, into the top of the canister.

Once draining is completed, either penetration may be used for vacuum drying and backfilling with helium. After backfilling, both penetrations are closed with port covers that are welded to the shield lid. When the port covers are in place, the penetrations are not accessible. These port covers are enclosed and covered by the structural lid, which is also welded in place to form the secondary confinement boundary. The structural lid and the remainder of the canister have no penetrations.

7.1.3 Seals and Welds

This section describes the process used to properly assemble the confinement vessel (canister). Weld processes and inspection and acceptance criteria are described in Sections 7.1.3.2 and 7.1.3.3.

No elastomer or metallic seals are used in the confinement boundary of the canister.

7.1.3.1 Fabrication

All cutting, machining, welding, and forming are performed in accordance with Section III, Article NB-4000 of the ASME Code, unless otherwise specified in the approved fabrication drawings and specifications. License drawings are provided in Section 1.6. Code exceptions are listed in Table 12B3-1 of Appendix 12B in Chapter 12.

7.1.3.2 Welding Specifications

The canister body is assembled using longitudinal and circumferential welds in the shell and a circumferential weld at the bottom plate/ shell juncture.

Weld procedures and qualifications are in accordance with ASME Code Section IX. The welds joining the canister shell are radiographed in accordance with ASME Code Section V, Article 2. The weld joining the bottom plate to the canister shell is ultrasonically examined in accordance with ASME Code Section V, Article 5 [5]. The acceptance criteria for these welds is as specified in ASME Code Section III, NB-5320 (radiographic) and NB-5330 (ultrasonic). The finished surfaces of these welds are liquid penetrant examined in accordance with ASME Code, Section III, NB-5350.

After loading, the canister is closed by the shield lid and the structural lid using field installed groove welds.

After the shield lid is welded in place, the canister is pneumatically (air over water) pressure tested. Following draining, drying and inerting operations, the vent and drain ports are closed with port covers that are welded in place. The root and final surfaces of the shield lid to port cover welds are liquid penetrant examined in accordance with ASME Code Section V, Article 6. Acceptance is in accordance with ASME Code Section III, NB-5350. The shield lid to canister shell weld is liquid penetrant examined at the root and final surfaces in accordance with ASME Code Section V, Article 6, with acceptance in accordance with ASME Code Section III, NB-5350, and is pressure and leak tested to ensure leaktightness. The operating procedures, describing the handling steps to seal the canister are presented in Section 8.1.1. The pressure and leak test procedures are described in Sections 8.1.1 and 9.1.3.

A redundant confinement boundary is provided at the top of the canister by the structural lid, which is placed over the shield lid. The structural lid is welded to the canister shell using a field-installed groove weld. The structural lid to canister shell weld is either: 1) ultrasonically examined (UT) in accordance with ASME Code Section V, Article 5, with the final weld surface liquid penetrant (PT) examined in accordance with ASME Code Section V, Article 6; or, 2) progressive liquid penetrant examined in accordance with ASME Code Section V, Article 6. Acceptance criteria are specified in ASME Code Section III, NB-5330 (UT) and NB-5350 (PT).

All welding procedures are written and qualified in accordance with Section IX of the ASME Code. Each welder and welding operator must be qualified in accordance with Section IX of the ASME Code.

7.1.3.3 Testing, Inspection, and Examination

The following tests are performed to ensure satisfactory performance of the confinement vessel:

1. All components are visually examined for conformance with the fabrication drawings.

2. All welds that are directly visible are visually examined in accordance with the requirements of ASME Code Section V, Article 9.

3. The acceptance standards for visual examination of canister welded joints are as specified in ASME Code, Section III, Paragraphs NB-4424 and NB-4427. Unacceptable weld defects are repaired in accordance with ASME Code Section III, Subarticle NB-4450 and visually re-examined.

4. Canister welds designated to be examined by radiographic examination are examined in accordance with the requirements of Section V, Article 2 of the ASME Code. The minimum acceptance standards for radiographic examination are as specified in ASME Code Section III, NB-5320. Welds designated for ultrasonic examinations are examined in accordance with the requirements of Section V, Article 5 of the ASME Code. The minimum acceptance standards for ultrasonic examination are as specified in ASME Code Section III, NB-5330. Unacceptable defects in the welds are repaired in accordance with ASME Code Section III, NB-4450 and re-examined.

5. A written report of each weld examined is prepared. At a minimum, the written report will include: identification of part, material, name and level of examiner, NDE procedure used and the findings or dispositions, if any.

6. All personnel performing nondestructive examinations are qualified in accordance with American Society of Nondestructive Testing Recommended Practice No. SNT-TC-1A [6].

7. Field installed welds that are not ultrasonically inspected are root and final surface or progressive (i.e., at weld thickness intervals not exceeding 0.375 inch) liquid penetrant examined to ensure detection of critical weld flaws. As a minimum, liquid penetrant examination is applied to the root pass and final pass of the weld.

8. The results of the liquid penetrant examination, including all relevant indications, are recorded by video, photographic or other means to provide a retrievable record of weld integrity.

9. Individuals qualified for NDT Level I, NDT Level II, or NDT level III may perform nondestructive testing. Only Level II or Level III personnel may interpret the results of an examination or make a determination of the acceptability of examined parts.

10. The vendor completely assembles the canister prior to shipping. The purpose of assembling the canister is to ensure that all items specified have been supplied and to test the fit of the shield lid assembly including the shield lid, drain tube and the structural lid.

11. A pressure test to 35 psia is conducted after welding of the shield lid following loading of the fuel assemblies. The pressure test is performed in accordance with ASME Code, NB-6321.

12. A helium leak test is used to verify that the shield lid welds are leak tight. The canister is pressurized with helium to 0 psig when the canister is closed. A leak test fixture is used to create a volume above the shield lid, which is evacuated. This volume is then tested, using a mass spectrometer type helium leak detector, to verify that the shield lid welds meet the leak tight criteria to a leak test sensitivity of 1×10^{-7} cm^3/sec (helium). The leak test conforms to the evacuated envelope method of ANSI N14.5. As noted in the procedure presented in Section 8.1.1, a "sniffer detector" test method may be used as an optional informational leak test prior to the installation of the vent and drain port covers. This leak test is intended to ensure that there are no leaks in the shield lid welds at a leak rate of 1×10^{-5} cm^3/sec (helium) based on the detector leak rate sensitivity of 5×10^{-6} cm^3/sec (helium).

7.1.4 Closure

The primary closure of the transportable storage canister consists of the welded shield lid and the two welded port covers. There are no bolted closures or mechanical seals in the primary closure. A secondary closure is provided at the top end of the canister by the structural lid. The structural lid, when welded to the canister shell, fully encloses the shield lid and the port covers.

Figure 7.1-1 Transportable Storage Canister Primary and Secondary Confinement Boundaries

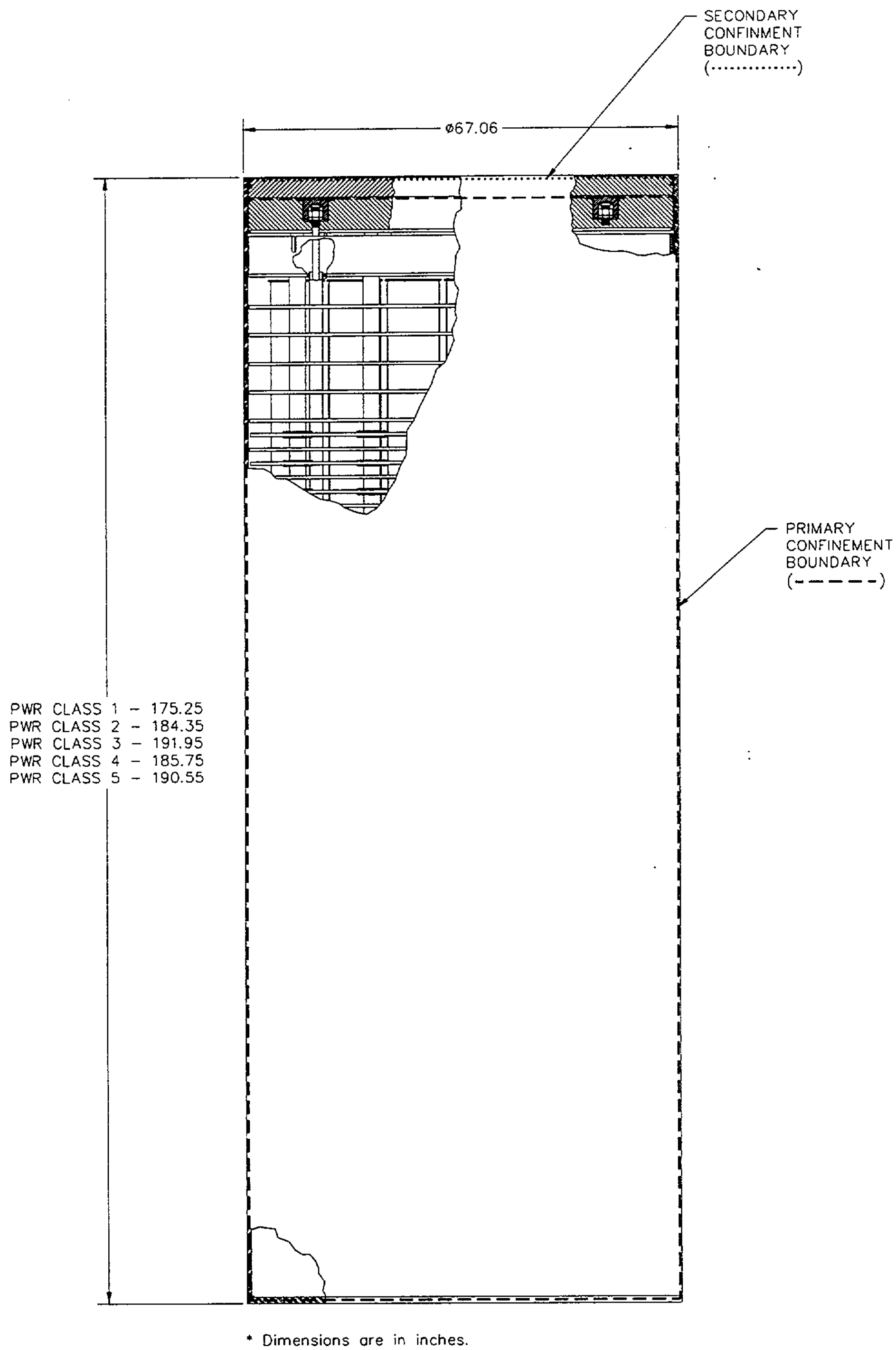

Figure 7.1-2 Confinement Boundary Detail at Shield Lid Penetration

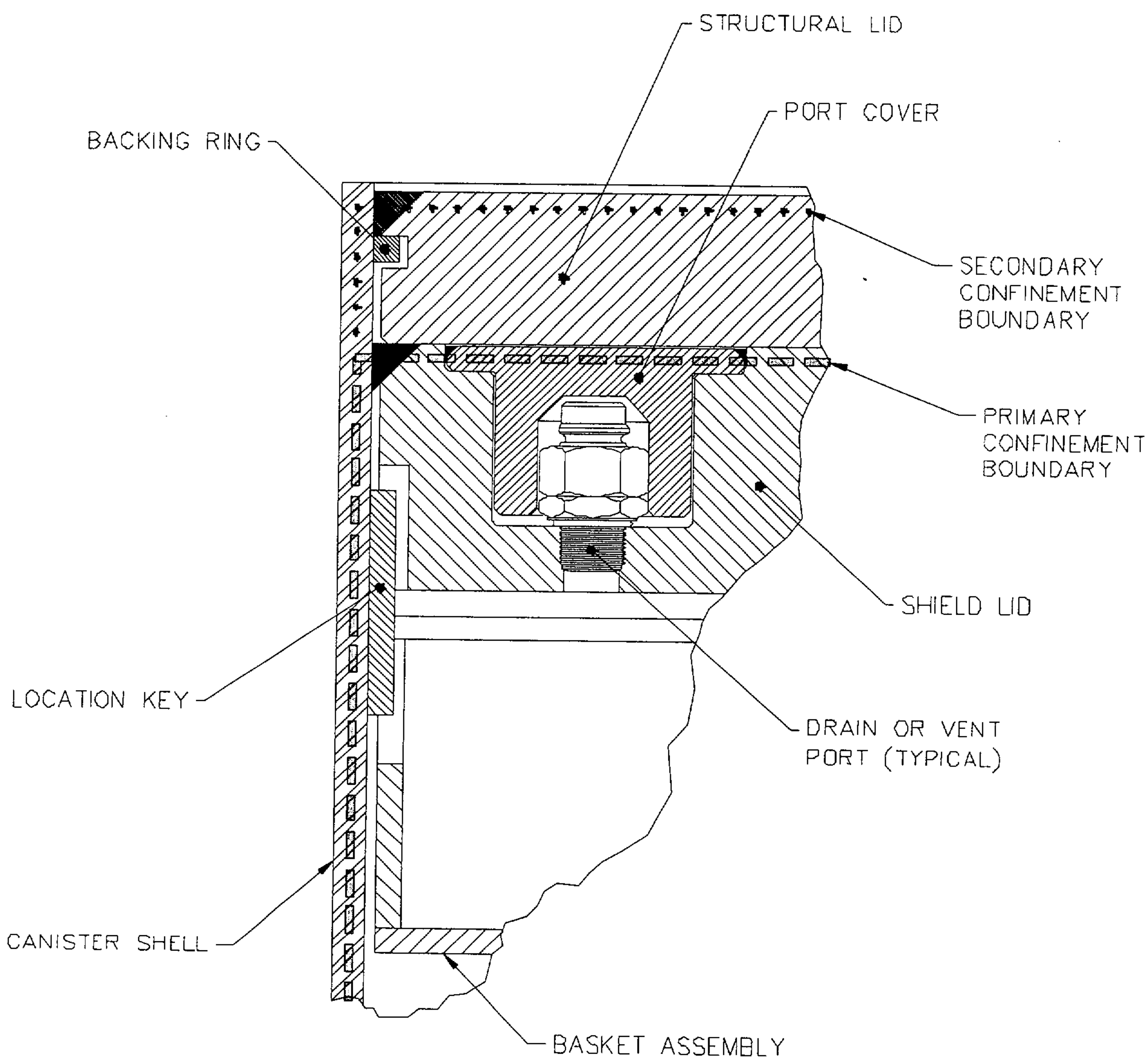

Table 7.1-1 Canister Confinement Boundary Welds

Confinement Boundary Welds		
Weld Location	**Weld Type**	**ASME Code Category (Section III, Subsection NB)**
Shell longitudinal	Full penetration groove (shop weld)	A
Shell circumferential (if used)	Full penetration groove (shop weld)	B
Bottom plate to shell	Full penetration groove (shop weld)	C
Shield lid to shell	Bevel (field weld)	C
Structural lid to shell	Bevel (field weld)	C
Vent and drain port covers to shield lid	Bevel (field weld)	C

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7.2 Requirements for Normal Conditions of Storage

The canister is transferred to a vertical concrete cask using a transfer cask. During this transfer, the canister is subject to handling loads. The evaluation of the canister for normal handling loads is provided in Section 3.4.4. The principal design criteria for the Universal Storage System are provided in Table 2-1.

Once the canister is placed inside of the vertical concrete storage cask, it is effectively protected from direct loading due to natural phenomena, such as wind, snow and ice loading. The principal direct loading for normal operating conditions arises from increased internal pressure caused by decay heat, solar insolation, and ambient temperature. The effect of the normal operating internal pressure is evaluated in Section 3.4.4.

7.2.1 Release of Radioactive Material

The structural analysis of the canister for normal conditions of storage presented in Section 3.4.4 shows that the canister is not breached in any of the normal operating events. Consequently, there is no release of radioactive material during normal conditions of storage.

7.2.2 Pressurization of the Confinement Vessel

The canister is vacuum dried and backfilled with helium at one atmosphere absolute prior to installing and welding the penetration port covers. In normal service, the internal pressure increases due to an increase in temperature of the helium and due to the postulated failure of fuel rod cladding of 3% of the fuel rods, which releases 30% of the available fission gases in those rods.

The canister, shield lid, fittings, and the canister basket are fabricated from materials that do not react with ordinary or borated spent fuel pool water to generate gases. The aluminum heat transfer disks are protected by an oxide film that forms shortly after fabrication. This oxide layer effectively precludes further oxidation of the aluminum components or other reaction with water in the canister at temperatures less than 200°F, which is higher than the typical spent fuel pool water temperature. The BORAL criticality control poison plates in the fuel baskets are enclosed by a welded stainless steel cover. No steels requiring protective coatings or paints are used in the PWR configuration canister, shield lid, fittings, or basket, or in the BWR configuration canister, shield lid, or fittings. Carbon steel support disks are used in the BWR configuration basket. These disks are completely coated to protect the disks in immersion in the spent fuel pool, as defined on Drawing 790-573. The consequence of the use of a coating in BWR spent fuel pools is evaluated in Sections 3.4.1.2.3 and 3.4.1.2.4. That evaluation shows that no adverse interactions result from the use of the coating. The coating does not contain Zinc, and no gases are formed as a result of the exposure of this coating to the neutrally buffered water used in BWR spent fuel pools.

Since the canister is vacuum dried and backfilled with helium prior to sealing, no significant moisture or gases, such as air, remain in the canister. Consequently, there is no potential that radiolytic decomposition could cause an increase in canister internal pressure or result in a build up of explosive gases in the canister.

The calculation of the canister pressure increase based on these conditions is less than the pressure evaluated in Section 3.4.4 for the maximum normal operating pressure. As shown in Section 3.4.4, there are no adverse consequences due to the internal pressure resulting from normal storage conditions.

Since the containment boundary is closed by welding and contains no seals or O-rings, and since the boundary is not ruptured or otherwise compromised in normal handling events, no leakage of contents occurs in normal conditions.

7.3 Confinement Requirements for Hypothetical Accident Conditions

The evaluation of the canister for off-normal and accident condition loading is provided in Sections 11.1 and 11.2, respectively.

Once the canister is placed inside the vertical concrete cask, it is effectively protected from direct loading due to natural phenomena, such as seismic events, flooding and tornado (wind driven) missiles. Accident conditions assume the cladding failure of all the fuel rods stored in the canister. Consequently, there is an increase in canister internal pressure due to the release of a fraction of the fission product and charge gases. The accident conditions internal pressure for the PWR and BWR configurations is calculated in Section 11.2.1.

For evaluation purposes, a class of events identified as off-normal is also considered in Section 11.1. The off-normal class of events is not considered here, since off-normal conditions are bounded by the hypothetical accident conditions.

The structural analysis of the canister for off-normal and accident conditions of storage, presented in Chapter 11, show that the canister is not breached in any of the evaluated events. Consequently, based on a leaktight configuration, there is no release of radioactive material during off-normal or accident conditions of storage.

The resulting site boundary dose due to a hypothetical accident is, therefore, less than the 5 rem whole body or organ (including skin) dose at 100 meter minimum boundary required by 10 CFR 72.106 (b) for accident exposures.

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7.4 Confinement Evaluation for Site Specific Spent Fuel

This section presents the confinement evaluation for fuel assembly types or configurations, which are unique to specific reactor sites. Site specific spent fuel configurations result from conditions that occurred during reactor operations, participation in research and development programs, and from testing programs intended to improve reactor operations. Site specific fuel includes fuel assemblies that are uniquely designed to accommodate reactor physics, such as axial fuel blanket and variable enrichment assemblies, and fuel rod or assemblies that are classified as damaged.

The design of the Transportable Storage Canister incorporates a leak tight configuration as described in Section 7.1 and as defined by ANSI N 14.5. Consequently, site specific fuel configurations need be evaluated only if the configuration results in a modification of the confinement boundary of the canister that is intended for use or when the configuration could result in a higher internal pressure or temperature than is used in the design basis analysis.

7.4.1 Confinement Evaluation for Maine Yankee Site Specific Spent Fuel

Maine Yankee site specific spent fuel is to be stored in either the Class 1 or Class 2 Transportable Storage Canister, depending on the overall length of the fuel assembly, including inserted non fuel-bearing components. These canisters are closed by welding and are inspected and tested to confirm the leak tight condition.

Site specific fuel includes fuel having variable enrichment radial zoning patterns and annular axial fuel blankets, removed fuel rods or empty rod positions, fuel rods placed in guide tubes, consolidated fuel, damaged fuel, and high burnup fuel (fuel with a burnup between 45,000 MWD/MTU and 50,000 MWD/MTU). These configurations are not included in the standard fuel analysis, but are present in the site fuel inventory that must be stored. As discussed in Section 4.5.1, the site specific fuel configurations do not result in a canister pressure or temperature that exceeds the canister design basis. Since the canisters are leak tight, there is no release from a canister containing Maine Yankee high burnup fuel rods site specific spent fuel.

Intact site specific fuel is loaded directly into the fuel tubes in the PWR basket. Damaged fuel is inserted into a fuel can, shown in Drawings 412-501 and 412-502, which precludes the release of gross particulate material from the fuel can. The fuel can is sized to allow its insertion into a fuel position in the PWR basket.

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7.5 References

1. ANSI N14.5-1997, "American National Standard for Radioactive Materials - Leakage Tests on Packages for Shipment," American National Standards Institute, 1997.

2. Title 10 of the Code of Federal Regulations, Part 72 (10 CFR 72), "Licensing Requirements for the Storage of Spent Fuel in an Independent Spent Fuel Storage Installation," April 1996 Edition.

3. ASME Boiler and Pressure Vessel Code, Section III, Division I, "Rules for Construction of Nuclear Power Plant Components," 1995 Edition with 1997 Addenda.

4. ASME Boiler and Pressure Vessel Code, Section IX, "Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators," 1995 Edition with 1997 Addenda.

5. ASME Boiler and Pressure Vessel Code, Section V, "Nondestructive Examination," 1995 Edition with 1997 Addenda.

6. SNT-TC-1A, Recommended Standard Practice, " Personnel Qualification and Certification in Nondestructive Testing," American Society for Nondestructive Testing, August 1984.

7. PNL-6365, "Evaluation of Cover Gas Impuritities and Their Effects on the Dry Storage of LWR Spent Fuel," Pacific Northwest Laboratory, Richland, Washington, November, 1987.

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8.0 OPERATING PROCEDURES

This chapter provides general guidance for operating the Universal Storage System. Three operating conditions are addressed. The first is loading the transportable storage canister, installing it in the vertical concrete cask, and transferring it to the storage (Independent Spent Fuel Storage Installation (ISFSI)) pad. The second is the removal of the loaded canister from the concrete storage cask. The third is opening the canister to remove spent fuel in the unlikely event that this should be necessary.

The operating procedure for transferring a loaded canister from a storage cask to the Universal Transport Cask, is described in Section 7.2.2 of the UMS® Universal Transport Cask Safety Analysis Report. [1]

Users shall develop site-specific written and approved procedures that incorporate the requirements presented here, consistent with the Technical Specifications presented in Appendix 12A and the Approved Contents and Design Features presented in Appendix 12B in Chapter 12.0. Site-specific procedures shall also incorporate site-specific Technical Specifications, surveillance requirements, administrative controls, and other limits appropriate to the use of the NAC UMS® Storage System at the ISFSI. The procedures shall incorporate spent fuel assembly selection and verification requirements to ensure that the spent fuel assemblies loaded into the UMS® Storage System are as authorized by the Certificate of Compliance.

Operation of the Universal Storage System requires the use of ancillary equipment items. The ancillary equipment supplied with the system is shown in Table 8.1.1-1. The system does not rely on the use of bolted closures, but bolts are used to secure retaining rings and lids. The hoist rings used for lifting the shield lid and canister have threaded fittings. Table 8.1.1-2 provides the torque values for installed bolts and hoist rings. Supplemental shielding may be employed to reduce radiation exposure for certain of the tasks specified by these procedures. Use of supplemental shielding is at the discretion of the User.

The design of the Universal Storage System is such that the potential for spread of contamination during handling and future transport of the canister is minimized. The transportable storage canister is loaded in the spent fuel pool but is protected from gross contact with pool water by a jacket of clean or filtered pool water while it is in the transfer cask. The top of the canister is closed by the structural lid, which is not contaminated when it is installed. Consequently, the canister external surface is expected to be essentially free of contamination. There are no radioactive effluents from the canister or the concrete cask in routine operations or in the design basis accident events.

When used in accordance with these procedures, the user dose is As Low As Reasonably Achievable (ALARA).

A training program is described in Section A5.0 of Chapter 12, Appendix 12A, that is intended to assist the User in complying with the training and dry run requirements of 10 CFR 72. This program addresses the controls and limits applicable to the UMS® Storage System. It also addresses the system operational features and requirements.

8.1 Procedures For Loading the Universal Storage System

The Universal Storage System consists of three principal components: the transportable storage canister (canister), the transfer cask, and the vertical concrete cask. The transfer cask is used to hold the canister during loading and while the canister is being closed and sealed. The transfer cask is also used to transfer the canister to the concrete cask and to load the canister into the transport cask. The principal handling operations involve closing and sealing the canister by welding, and placing the loaded canister in the vertical concrete cask. The vent and drain port locations are shown in Figure 8.1.1-1.

This procedure assumes that the canister with an empty basket is installed in the transfer cask, that the transfer cask is positioned in the decontamination area or other suitable work station, and that the vertical concrete cask is positioned in the plant cask receiving area or other suitable staging area. The transfer cask extension must be installed on the transfer cask if its use is required. To facilitate movement of the transfer cask to the concrete cask, the staging area should be within the operational "footprint" of the cask handling crane. The concrete cask may be positioned on a heavy-haul transporter, or on the floor of the work area.

The User must ensure that the fuel assemblies selected for loading conform to the Approved Contents provisions of Section B2.0 of Appendix 12B and to the Certificate of Compliance. Fuel assembly loading may also be administratively controlled to ensure that fuel assemblies with specific characteristics are preferentially loaded in specified positions in the canister. Preferential loading requirements are described in Appendix 12B, Section B2.1.2 and B2.1.3.

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8.1.1 Loading and Closing the Transportable Storage Canister

1. Visually inspect the basket fuel tubes to ensure that they are unobstructed and free of debris. Ensure that the welding zones on the canister, shield, and structural lids, and the port covers are prepared for welding. Ensure transfer cask door lock bolts are installed and secure.
2. Fill the canister with clean or filtered pool water until the water is about 4 inches from the top of the canister.
   Note: Do not fill the canister completely in order to avoid spilling water during the transfer to the spent fuel pool.
3. Attach clean or filtered pool water lines to the transfer cask.
4. If it is not already attached, attach the transfer cask lifting yoke to the cask handling crane, and engage the transfer cask lifting trunnions.
   Note: The minimum temperature of the transfer cask (i.e., surrounding air temperature) must be verified to be higher than 0°F prior to lifting, in accordance with Appendix 12B, Section B3.4 (8).
5. Raise the transfer cask and move it over the pool, following the prescribed travel path.
6. Lower the transfer cask to the pool surface and turn on the clean or filtered pool water line to fill the canister and the annulus between the transfer cask and canister.
7. Lower the transfer cask as the annulus fills with clean or filtered pool water until the trunnions are at the surface, and hold that position until the clean or filtered pool water fills the remainder of the canister and overflows the sides of the transfer cask. Then lower the transfer cask to the bottom of the pool cask loading area.
   Note: If an intermediate shelf is used to avoid wetting the cask handling crane hook, follow the plant procedure for use of the crane lift extension piece.
8. Disengage the transfer cask lifting yoke to provide clear access to the canister.
9. Load the previously designated fuel assemblies into the canister.
   Note: Contents must be in accordance with the Approved Contents provisions of Appendix 12B, Section B2.0.
   Note: Contents may be administratively controlled to ensure that fuel assemblies with certain characteristics are preferentially loaded in specified positions in the basket. Preferential loading requirements are presented in Appendix 12B, Section B2.1.2 and B2.1.3.
10. Attach a three-legged sling to the shield lid using the swivel hoist rings. Torque hoist rings in accordance with Table 8.1-2. Attach the suction pump fitting to the vent port.
    Caution: Verify that the hoist rings are fully seated against the shield lid.

Note: Ensure that the shield lid key slot aligns with the key welded to the canister shell.

11. Using the cask handling crane, or auxiliary hook, lower the shield lid until it rests in the top of the canister.
12. Raise the transfer cask until its top just clears the pool surface. Hold at that position, and using a suction pump, drain the pool water from above the shield lid. After the water is removed, continue to raise the cask. Note the time that the transfer cask is removed from the pool. Operations through Step 28 must be completed within 17 hours.

    Note: Alternately, the temperature of the water in the canister may be used to establish the time for completion through Step 28. Those operations must be completed within 2 hours of the time that the canister water temperature is 200°F. For this alternative, the water temperature must be determined every 2 hours beginning 17 hours after the time the transfer cask is removed from the pool.
13. As the cask is raised, spray the transfer cask outer surface with clean or filtered pool water to wash off any gross contamination.
14. When the transfer cask is clear of the pool surface, but still over the pool, turn off the clean or filtered pool water flow to the annulus, remove hoses and allow the annulus water to drain to the pool. Move the transfer cask to the decontamination area or other suitable work station.

    Note: Access to the top of the transfer cask is required. A suitable work platform may need to be erected.
15. Verify that the shield lid is level and centered.
16. Attach the suction pump to the suction pump fitting on the vent port. Operate the suction pump to remove free water from the shield lid surface. Disconnect the suction pump and suction pump fitting. Remove any free standing water from the shield lid surface and from the vent and drain ports.
17. Decontaminate the top of the transfer cask and shield lid as required to allow welding and inspection activities.

    Note: Supplemental shielding may be used for activities around the shield lid.
18. Insert the drain tube assembly through the drain port of the shield lid into the basket drain tube sleeve. Torque the drain tube assembly to 125 ± 5 ft-lbs. Install a mating quick-disconnect fitting in the vent line to open the vent.
19. Connect the suction pump to the drain port. Verify that the vent port is open. Remove approximately 50 gallons of water from the canister. Disconnect and remove the pump.

    Caution: Radiation level may increase as water is removed from the canister.
20. Install the automatic welding equipment.

21. Attach the hydrogen gas detector to the vent port. Verify that the concentration of any detectable hydrogen gas is below 2.4%.

    Note: If the concentration exceeds 2.4%, operate the vacuum system to remove gases from the underside of the shield lid and re-verify the hydrogen gas concentration. Disconnect and remove vacuum system.
22. Operate the welding equipment to complete the root weld joining the shield lid to the canister shell following approved procedures to minimize canister shell and weld stress.
23. Examine the root weld using liquid penetrant and record the results.
24. Complete welding of the shield lid to the canister shell. Remove the weld equipment and the hydrogen gas detector.
25. Liquid penetrant examine the final weld surface and record the results.
26. Attach a regulated air supply line to the vent port. Install a valved fitting on the drain port and ensure the valve is closed. Pressurize the canister to 35 psia (approximately 20.5 psig) and hold the pressure. There must be no loss of pressure for 10 minutes.
27. Release the pressure. Visually examine the shield lid to canister shell weld for indications of defects. Perform a liquid penetrant examination of the final weld surface. Record the results of the examinations.
28. Attach the suction pump to the drain line. Ensure that the vent line is open. Using the pump, remove the remaining free water from the canister cavity. Note the time that the last free water is removed from the canister cavity.

    Caution: Radiation levels at the top and sides of the transfer cask may rise as water is removed.

    Note: The time duration from completion of draining through the completion of helium backfill (Step 34) shall be monitored in accordance with LCO 3.1.1.
29. Attach the vacuum equipment to the vent and drain ports. Dry any free standing water in the vent and drain port recesses.
30. Operate the vacuum equipment until a vacuum of 3 mm of mercury exists in the canister.

    Note: Vacuum drying pressure must conform to the requirements of LCO 3.1.2.
31. Verify that no water remains in the canister by holding the vacuum for 30 minutes. If water is present in the cavity, the pressure will rise as the water vaporizes. Continue the vacuum/hold cycle until the conditions of LCO 3.1.2 are met.
32. Backfill the canister cavity with helium having a minimum purity of 99.9% to a pressure of one atmosphere (0 psig).

    Note: As an option, an informational helium leak test may be conducted at this point of the procedure using the following steps (the record leak test is performed at Step 49):

32a. Backfill the canister cavity with helium having a minimum purity of 99.9% to a pressure of 15 psig.

32b. Using a helium leak detector ("sniffer" detector) with a test sensitivity of 5×10^{-6} cm^3/sec (helium), survey the weld joining the shield lid and canister shell.

32c. At the completion of the survey, vent the canister helium pressure to one atmosphere (0 psig).

33. Restart the vacuum equipment and operate until a vacuum of 3 mm of mercury exists in the canister.
34. Backfill the canister with helium having a minimum purity of 99.9% to a pressure of one atmosphere (0 psig).

    Note: Canister helium backfill pressure must conform to the requirements of LCO 3.1.3.

    Note: Monitor the time from this step (completion of helium backfill) until completion of canister transfer to the concrete cask in accordance with LCO 3.1.4.
35. Disconnect the vacuum and helium supply lines from the vent and drain ports. Dry any residual water that may be present in the vent and drain port cavities.
36. Install the vent and drain port covers.
37. Complete the root pass weld of the drain port cover to the shield lid.
38. Prepare the weld and perform a liquid penetrant examination of the root pass. Record the results.
39. Complete welding of the drain port cover to the shield lid.
40. Prepare the weld and perform a liquid penetrant examination of the drain port cover weld final pass. Record the results.
41. Complete the root pass weld of the vent port cover to the shield lid.
42. Prepare the weld and perform a liquid penetrant examination of the root pass. Record the results.
43. Complete welding of the vent port cover to the shield lid.
44. Prepare the weld and perform a liquid penetrant examination of the weld final surface. Record the results.
45. Remove any supplemental shielding used during shield lid closure activities.
46. Install the helium leak test fixture.
47. Attach the vacuum line and leak detector to the leak test fixture fitting.
48. Operate the vacuum system to establish a vacuum in the leak test fixture.
49. Operate the helium leak detector for 15 minutes to verify that there is no indication of a helium leak exceeding 2×10^{-7} cm^3/second in accordance with the requirements of LCO 3.1.5.
50. Release the vacuum and disconnect the vacuum and leak detector line from the fixture.

51. Remove the leak test fixture.
52. Attach a three-legged sling to the structural lid using the swivel hoist rings.

    Caution: Ensure that the hoist rings are fully seated against the structural lid. Torque the hoist rings in accordance with Table 8.1.1-2. Verify that the backing ring is in place on the structural lid.

    Note: Verify that the structural lid is stamped or otherwise marked to provide traceability of the canister contents.
53. Using the cask handling crane or the auxiliary hook, install the structural lid in the top of the canister. Verify that the structural lid does not protrude above the canister shell. If so, remove the lid and inspect the surface of the shield lid for the cause of the interference. Verify that the gap in the backing ring is not aligned with the shield lid alignment key. Remove the hoist rings.
54. Install the automatic welding equipment on the structural lid.
55. Operate the welding equipment to complete the root weld joining the structural lid to the canister shell, following approved procedures to minimize canister shell and weld stress.
56. Prepare the weld and perform a liquid penetrant examination of the weld root pass. Record the results.
57. Continue with the welding procedure, examining the weld at 3/8-inch intervals using liquid penetrant. Record the results of each intermediate examination.

    Note: If ultrasonic testing of the weld is used, testing is performed after the weld is completed.
58. Remove the weld equipment.
59. Perform a smear survey of the accessible area at the top of the canister to ensure that the surface contamination is less than the limits established for the site. Smear survey results shall meet the requirements of Technical Specification LCO 3.2.1.
60. Install the transfer cask retaining ring. Torque bolts to 155 ± 10 ft-lbs. (Table 8.1.1-2).
61. Decontaminate the external surface of the transfer cask to the limits established for the site.

Figure 8.1.1-1 Vent and Drain Port Locations

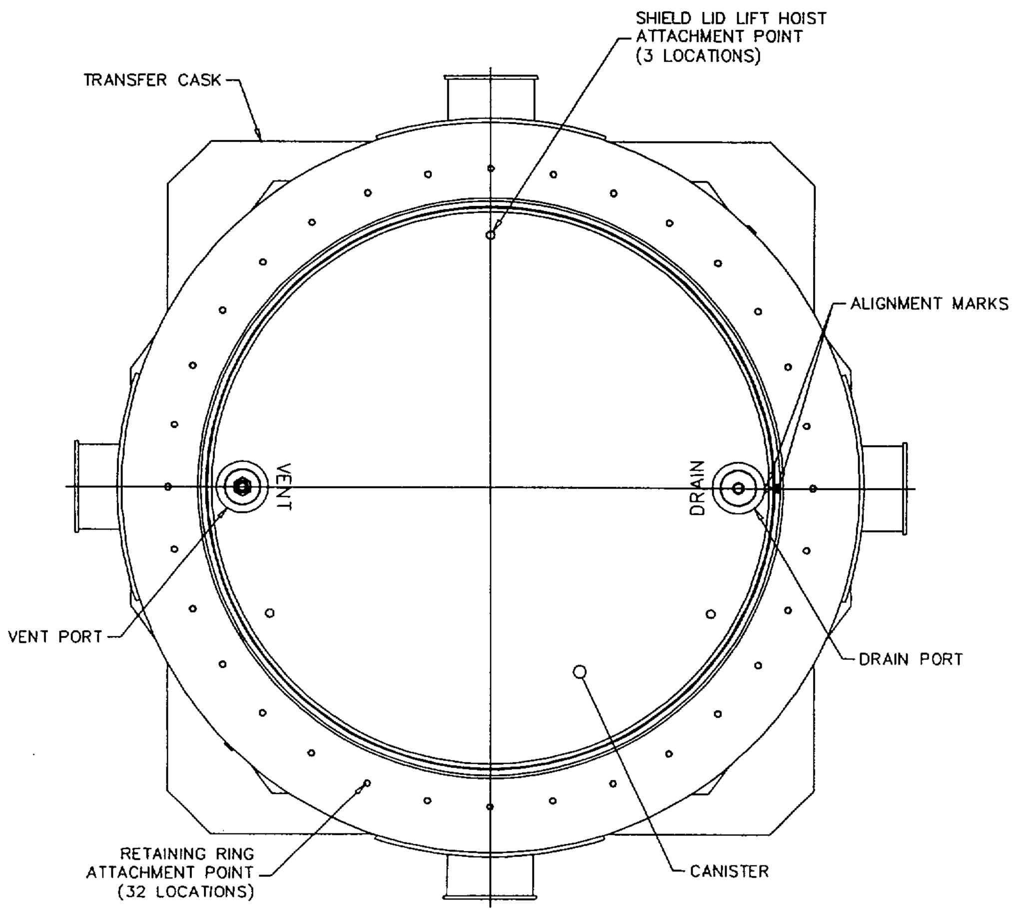


Table 8.1.1-1 List of Ancillary Equipment

Item	Description
Transfer Cask Lifting Yoke	Required for lifting and moving the transfer cask.
Heavy-Haul Transporter (Optional)	Heavy-haul (double drop frame) trailer required for moving the loaded and empty vertical concrete cask to and from the ISFSI pad.
Mobile Lifting Frame (Optional)	A self-propelled or towed A-frame lifting device for the concrete cask. Mobile Lifting Frame is used to lift the cask and move it using four lifting lugs in the top of the concrete cask.
Helium Supply System	Supplies helium to the canister for helium backfill and purging operations.
Vacuum Drying System	Used for evacuating the canister. Used to remove residual water, air and initial helium backfill.
Automated Welding System	Used for welding the shield lid and structural lid to the canister shell.
Self-Priming Pump	Used to remove water from the canister.
Shield Lid Sling	A three-legged sling used for lifting the shield lid. It is also used to lift the concrete cask shield plug and lid.
Canister Sling	A set of 2 three-legged slings joined by a master link, used for lifting the structural lid by itself, or for lifting the canister when the structural lid is welded to it. The master link allows the slings to be loaded simultaneously during the lift.
Transfer Adapter	Used to align the transfer cask to the vertical concrete cask or the Universal Transport Cask. Provides the platform for the operation of the transfer cask shield doors.
Transfer Cask Extension	A carbon steel ring used to extend the height of the transfer cask when using the next larger size canister.
Hydraulic Unit	Operates the shield doors of the transfer cask.
Lift Pump Unit	Jacking system for raising and lowering the concrete cask.
Air Pad Rig Set	Air cushion system used for moving the concrete cask.

Table 8.1.1-2 Torque Values

Fastener	Torque Value (ft-lbs)	Torque Pattern
Transfer Adapter Bolts	40 ± 5	None
Transfer Cask Retaining Ring	155 ±10	None
Transfer Cask Extension	155 ±10	None
Vertical Concrete Cask Lid	40 ± 5	None
Lifting Hoist Rings		
Shield Lid	230 (+30, -0)	None
Structural Lid	800 (+80, -0)	None
Concrete Cask Lid	60 (+10, -0)	None
Shield Plug	230 (+30, -0)	None
Canister Lid Plug Bolts	Hand Tight	None
Shield Lid Plug Bolts	Hand Tight	None
Transfer Cask Door Lock Bolts	Hand Tight	None
Canister Drain Tube	125 ± 5	None

8.1.2 Loading the Vertical Concrete Cask

This section of the loading procedure assumes that the vertical concrete cask is located on the bed of a heavy-haul transporter, or on the floor of the work area, under a crane suitable for lifting the loaded transfer cask. The vertical concrete cask shield plug and lid are not in place, and the bottom pedestal plate cover is installed.

1. Using a suitable crane, place the transfer adapter on the top of the concrete cask.
2. Using the transfer adapter bolt hole pattern, align the adapter to the concrete cask. Bolt the adapter to the cask using four (4) socket head cap screws.
3. Verify that the shield door connectors on the adapter plate are in the fully extended position.
4. If not already done, attach the transfer cask lifting yoke to the cask handling crane. Verify that the transfer cask retaining ring is installed.
5. Install six (6) swivel hoist rings in the structural lid of the canister and torque to the value specified in Table 8.1.1-2. Attach two (2) three-legged slings to the hoist rings.
   Caution: Ensure that the hoist rings are fully seated against the structural lid.
6. Stack the slings on the top of the canister so they are available for use in lowering the canister into the storage cask.
7. Engage the transfer cask trunnions with the transfer cask lifting yoke. Ensure that all lines are disconnected from the transfer cask.
   Note: The minimum temperature of the transfer cask (i.e., temperature of the surrounding air) must be verified to be higher than 0°F prior to lifting, in accordance with Appendix 12B, Section B3.4(8).
   Note: Verify that the transfer cask extension is installed if required.
8. Raise the transfer cask and move it over the concrete cask. Lower the transfer cask, ensuring that the transfer cask shield door rails and connector tees align with the adapter plate rails and door connectors. Prior to final set down, remove transfer cask shield door lock bolts.
9. Ensure that the shield door connector tees are engaged with the adapter plate door connectors.
10. Disengage the transfer cask yoke from the transfer cask and from the cask handling crane hook.
11. Return the cask handling crane hook to the top of the transfer cask and engage the two (2) three-legged slings attached to the canister by attaching the master link to the crane hook.
    Caution: The master link must be at least 75 inches or equivalent above the top of the canister.

12. Lift the canister slightly (about ½ inch) to take the canister weight off of the transfer cask shield doors.

    Note: A load cell may be used to determine when the canister is supported by the crane.

    Caution: Avoid raising the canister to the point that the canister top engages the transfer cask retaining ring, as this could result in lifting the transfer cask.

13. Using the hydraulic system, open the shield doors to access the concrete cask cavity.
14. Lower the canister into the concrete cask, using a slow crane speed as the canister nears the pedestal at the base of the concrete cask.
15. When the canister is properly seated, disconnect the slings from the canister at the crane hook, and close the transfer cask shield doors.
16. Retrieve the transfer cask lifting yoke and attach the yoke to the transfer cask.
17. Lift the transfer cask off of the vertical concrete cask and return it to the decontamination area or designated work station.
18. Using the auxiliary crane, remove the adapter plate from the top of the concrete cask.
19. Remove the swivel hoist rings from the structural lid and replace them with threaded plugs.
20. Install three swivel hoist rings in the shield plug and torque in accordance with Table 8.1.1-2.
21. Using the auxiliary crane, retrieve the shield plug and install the shield plug in the top of the concrete cask. Remove swivel hoist rings and insert threaded plugs.
22. Install seal tape around the diameter of the lid bolting pattern on the concrete cask flange.
23. Using the auxiliary crane, retrieve the concrete cask lid and install the lid in the top of the concrete cask. Secure the lid using six stainless steel bolts. Torque bolts in accordance with Table 8.1.1-2.
24. Ensure that there is no foreign material left at the top of the concrete cask. Install the tamper-indicating seal.

8.1.3 Transport and Placement of the Vertical Concrete Cask

This procedure assumes that the loaded vertical concrete cask is positioned on a heavy-haul transporter and is to be positioned on the ISFSI pad using the air pad set. Alternately, the concrete cask may be lifted and moved using a mobile lifting frame. The mobile lifting frame lifts the cask using four lifting lugs at the top of the concrete cask. The lifting frame may be self-propelled or towed, and does not use the air pad set.

The vertical concrete cask lift height limit is 20-inches when the cask is moved using the air pad set or the mobile lifting frame in accordance with the requirements of Appendix 12A, Section A5.1.1. Because of lift fixture configuration, the maximum lift height of the concrete cask using the jacking arrangement is approximately 4 inches.

The concrete cask surface dose rates must be verified in accordance with the requirements of LCO 3.2.2. These measurements may be made prior to movement of the cask, at a location along the transport path, or at the ISFSI.

1. Using a suitable towing vehicle, tow the heavy-haul transporter to the dry storage pad (ISFSI). Verify that the bed of the transporter is approximately at the same height as the pad surface. Install four (4) hydraulic jacks at the four (4) designated jacking points at the air inlets in the bottom of the vertical concrete cask.
2. Raise the concrete cask approximately 3-inches.
   Caution: Do not exceed a maximum lift height of 20 inches, in accordance with the requirements of Administrative Control A5.1.1.
3. Move the air-bearing rig set under the cask.
   Note: A hydraulic skid may also be used to move the concrete cask. The height the concrete cask is raised depends upon the height of the skid or air pad set used, but may not exceed 20 inches.
5. Inflate the air-bearing rig set. Remove the four (4) hydraulic jacks.
6. Using a suitable towing vehicle, move the concrete cask from the bed of the transporter to the designated location on the storage pad.
   Note: Spacing between concrete casks must not be less than 15 feet (center-to-center).
7. Turn off the air-bearing rig set, allowing it to deflate.
8. Reinstall the four (4) hydraulic jacks and raise the concrete cask approximately 3 inches.
   Caution: Do not exceed a maximum lift height of 20 inches, in accordance with the requirements of Administrative Control A5.1.1.

9. Remove the air-bearing rig set pads. Ensure that the surface of the dry storage pad under the concrete cask is free of foreign objects.
10. Lower the concrete cask to the surface and remove the four (4) hydraulic jacks.
11. Install the screens in the inlets and outlets.
12. Install/connect temperature monitoring equipment and verify operation in accordance with LCO 3.1.6.
13. Scribe/stamp concrete cask name plate to indicate loading information.

8.2 Removal of the Loaded Transportable Storage Canister from the Vertical Concrete Cask

Removal of the loaded canister from the vertical concrete cask is expected to occur at the time of shipment of the canistered fuel off site. Alternately, removal could be required in the unlikely event of an accident condition that rendered the concrete cask or canister unsuitable for continued long-term storage or for transport. This procedure assumes that the concrete cask is being returned to the reactor cask receiving area. However, the cask may be moved to another facility or area using the same operations. It identifies the general steps to return the loaded canister to the transfer cask and return the transfer cask to the decontamination station, or other designated work. area or facility. Since these steps are the reverse of those undertaken to place the canister in the concrete cask, as described in Section 8.1.2, they are only summarized here.

The concrete cask may be moved using the air pad set or a mobile lifting frame. This procedure assumes the use of the air pad set. If a lifting frame is used, the concrete cask is lifted using four lifting lugs in the top of the cask, and the air pad set and heavy haul transporter are not required. The mobile lifting frame may be self-powered or towed.

At the option of the user, the canister may be removed from the concrete cask and transferred to another concrete cask or to the Universal Transport Cask at the ISFSI site. This transfer is done using the transfer cask, which provides shielding for the canister contents during the transfer.

1. Remove the screens and instrumentation.
2. Using the hydraulic jacking system and the air pad set, move the concrete cask from the ISFSI pad to the heavy-haul transporter. The bed of the transporter must be approximately level with the surface of the pad and sheet metal plates are placed across the gap between the pad and the transporter bed.
   Caution: Do not exceed a maximum lift height of 20 inches when raising the concrete cask.
3. Tow the transporter to the cask receiving area or other designated work area or facility.
4. Remove the concrete cask shield plug and lid. Install the hoist rings in the canister structural lid and torque to the value specified in Table 8.1.1-2. Verify that the hoist rings are fully seated against the structural lid and attach the lift slings. Install the transfer adapter on the top of the concrete cask.

5. Retrieve the transfer cask with the retaining ring installed, and position it on the transfer adapter. Attach the shield door hydraulic cylinders.

   Note: The surrounding air temperature for cask unloading operations shall be ≥ 0°F.
6. Open the shield doors. Attach the canister lift slings to the cask handling crane hook.

   Caution: The master link must be at least 75 inches above the top of the canister.
7. Raise the canister into the transfer cask.

   Caution: Avoid raising the canister to the point that the canister top engages the transfer cask retaining ring, as this could result in lifting the transfer cask.
8. Close the shield doors. Lower the canister to rest on the shield doors. Disconnect the canister slings from the crane hook. Install and secure door lock bolts.
9. Retrieve the transfer cask lifting yoke. Engage the transfer cask trunnions and move the transfer cask to the decontamination area or designated work station.

After the transfer cask containing the canister is in the decontamination area or other suitable work station, additional operations may be performed on the canister. It may be opened, transferred to another storage cask, or placed in the Universal Transport Cask.

8.3 Unloading the Transportable Storage Canister

This section describes the basic operations required to open the sealed canister if circumstances arise that dictate the opening of a previously loaded canister and the removal of the stored spent fuel. It is assumed that the canister is positioned in the transfer cask and that the transfer cask is in the decontamination station or other suitable work station in the facility. The principal mechanical operations are the cutting of the closure welds, filling the canister with water, cooling the fuel contents, and removing the spent fuel. Supplemental shielding is used as required. The time duration for holding the canister in the transfer cask shall not exceed 4 hours without forced air cooling. Once forced air cooling is initiated, the amount of time that the canister may be in the transfer cask is not limited. The canister cooling water temperature, flow rate and pressure must be limited in accordance with this procedure.

1. Remove the transfer cask retaining ring.
2. Survey the top of the canister to establish the radiation level and contamination level at the structural lid.
3. Set up the weld cutting equipment to cut the structural lid weld (Abrasive grinding, hydrolaser, or similar cutting equipment).
4. Enclose the top of the transfer cask in a radioactive material retention tent, as required.
   Caution: Monitor for any out-gassing. Wear respiratory protection as required.
5. Operate the cutting equipment to cut the structural lid weld.
6. After proper monitoring, remove the retention tent. Remove the cutting equipment and attach a three-legged sling to the structural lid.
7. Using the auxiliary crane, lift the structural lid from the canister and out of the transfer cask.
8. Survey the top of the shield lid to determine radiation and contamination levels. Use supplemental shielding as necessary. Decontaminate the top of the shield lid, if necessary.
9. Reinstall the retention tent. Using an abrasive grinder or hydrolaser, and wearing suitable respiratory protection, cut the welds joining the vent and drain port covers to the shield lid.
   Caution: The canister could be pressurized.
10. Remove the port covers. Monitor for any out-gassing and survey the radiation level at the quick-disconnect fittings. Attach a manually valved line with a vacuum bottle to the vent port quick-disconnect. Open the valve to the vacuum bottle to obtain a gas sample from the vent line. Analyze the gas sample to determine the make up of the canister atmosphere. The presence of fission gases indicates failed fuel and the possible need to handle ruptured fuel.

11. Attach a nitrogen gas line to the drain port quick-disconnect and a discharge line from the vent port quick-disconnect to an off-gas handling system in accordance with the schematic shown in Figure 8.3-1. Set up the vent line with appropriate instruments so that the pressure in the discharge line and the temperature of the discharge gas are indicated. Continuously monitor the radiation level of the discharge line.

    Caution: The discharge gas temperature could initially be above 400°F. The discharge line and fittings may be very hot.

    Note: Any significant radiation level in the discharge gas indicates the presence of fission gas products. The temperature of the gas indicates the thermal conditions in the canister.

12. Start the flow of nitrogen through the line until there is no evidence of fission gas activity in the discharge line. Continue to monitor the gas discharge temperature. When there is no additional evidence of fission gas, stop the nitrogen flow and disconnect the drain and vent port line connections. The nitrogen gas flush must be maintained for at least 10 minutes.

    Note: See Figure 8.3-1 for Canister Reflood Piping and Control Schematic.

13. Perform canister refill and fuel cooldown operations. Attach a source of clean or filtered pool water with a minimum temperature of 70°F and a maximum supply pressure of 25 (+10, -0) psig to the drain port quick-disconnect. Attach a steam rated discharge line to the vent port quick-disconnect and route it to a fuel pool cooler or an in-pool steam condensing unit. Slowly start the flow of clean or filtered pool water to establish a flow rate at 5 (+3, -0) gpm. Monitor the discharge line pressure gage during canister flooding. Stop filling the canister if the canister vent line pressure exceeds 50 psig. Re-establish water flow when the canister pressure is below 30 psig. The discharge line will initially discharge hot gas, but after the canister fills, it will discharge hot water.

    Caution: Relatively cool water may flash to steam as it encounters hot surfaces within the canister.

    Caution: If there are grossly failed or ruptured fuel rods within the canister, very high levels of radiation could rapidly appear at the discharge line. The radiation level of the discharge gas or water should be continuously monitored.

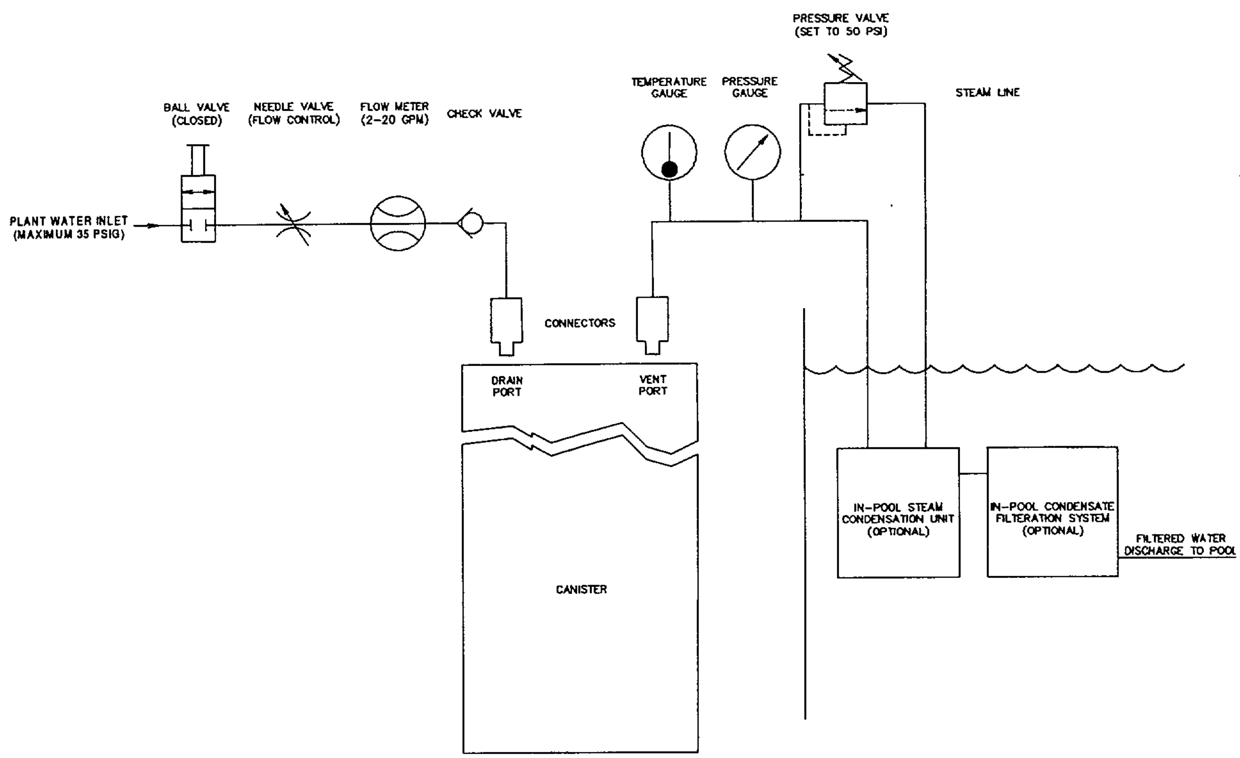
14. Monitor water flow through the canister until the water discharge temperature is below 200°F. Stop the flow of water and remove the connection to the drain line.

    Note: Monitor canister water temperature and reinitiate cooldown operations if temperature exceeds 200°F.

15. Connect a suction pump to the drain port and remove approximately 50 gallons of water. Disconnect and remove the pump.
    Note: Air pressure may be used to force water out of the canister by connecting the air line to the vent port and a drain line to the drain port. Air pressure must be regulated to not exceed 50 psig.
16. Set up the weld cutting equipment to cut the shield lid weld (Abrasive grinding, hydrolaser, or similar cutting equipment.). Route the vent line to avoid interference with the weld cutting operation.
17. Tent the top of the transfer cask and wear respiratory protection equipment as required. Attach a hydrogen gas detector to the vent port. Verify that the concentration of hydrogen gas is less than 2.4%.
18. Operate the cutting equipment to cut the shield lid weld.
    Note: Stop the cutting operation if the hydrogen gas detector indicates a concentration of hydrogen gas above 2.4%. Clear the gas before proceeding with the cutting operation.
19. Remove the cutting equipment. Remove supplemental shielding if used. Install the shield lid lifting hoist rings, verifying that the hoist rings are fully seated against the shield lid, and attach a three-legged sling. Attach a tag line to the sling master link to aid in attaching the sling to the auxiliary crane hook (at Step 24).
20. Attach the clean or filtered pool water line to the transfer cask.
21. Retrieve the transfer cask lifting yoke and engage the transfer cask lifting trunnions.
22. Move the transfer cask over the pool and lower the bottom of the transfer cask to the surface. Start the flow of clean or filtered pool water to the transfer cask annulus. Continue to lower the transfer cask, as the annulus fills with water, until the top of the transfer cask is about 4 inches above the pool surface. Hold this position until clean or filtered pool water fills to the top of the transfer cask.
23. Lower the transfer cask to the bottom of the cask loading area and remove the lifting yoke.
24. Attach the shield lid lifting sling to the crane hook.
    Caution: The drain line tube is suspended from the under side of the shield lid. The lid should be raised as straight as possible until the drain tube clears the canister basket. The under side of the shield lid could be highly contaminated.
25. Slowly lift the shield lid. Move the shield lid to one side after it is raised clear of the transfer cask.
26. Visually inspect the fuel for damage.

At this point, the spent fuel could be transferred from the canister to the fuel racks. If the fuel is damaged, special rigging could be required to remove the fuel. In addition, the bottom of the canister could be highly contaminated. Care must be exercised in the handling of the transfer cask when it is removed from the pool. Highly radioactive particles could rest on flat surfaces of the transfer cask resulting in high dose rates.

Figure 8.3-1 Canister Reflood Piping and Controls Schematic



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8.4 References

1. "Safety Analysis Report for the UMS® Universal Transport Cask," Docket Number 71-9270, NAC International, April 1997.

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9.0 ACCEPTANCE CRITERIA AND MAINTENANCE PROGRAM

This chapter specifies the acceptance criteria and the maintenance program for the Universal Storage System primary components - the Vertical Concrete Cask and Transportable Storage Canister. The system components, such as the concrete cask liner, base and air outlets, and the canister shell with the bottom plate, the shield and structural lids, and the basket that holds the spent fuel, are shop fabricated. The concrete cask consists of reinforced concrete placed around the steel liner and base that are integral to its performance. The liner forms the central cavity of the vertical concrete cask, which is mounted on the base. The liner/base interface forms air inlet passageways to the central cavity. The inlets allow cool ambient air to be drawn in and passed by the canister that contains the fuel. Air outlets at the top of the concrete cask allow the air heated by the canister wall and concrete cask liner to be discharged. The base of the concrete cask acts as a pedestal to support the canister during storage.

The concrete reinforcing steel (rebar) is bent in the shop and delivered to the concrete cask construction site. Concrete cask construction begins with the erection of the cask liner onto the steel base. Reinforcing steel is placed around the liner, followed by a temporary outer form which encircles the cask liner and reinforcing steel. The temporary form creates an annulus region between the liner and the form into which the concrete is placed.

As described in Section 8.1.3, the vertical concrete cask may be lifted by: (1) hydraulic jacks and moved by using air pads underneath the base; or (2) lifting lugs and moved by a mobile lifting frame.

9.1 Acceptance Criteria

The acceptance criteria specified below ensure that the concrete cask, including the liner, base, and canister are fabricated, assembled, inspected and tested in accordance with the requirements of this SAR and the license drawings presented in Section 1.6.

9.1.1 Visual and Nondestructive Examination Inspection

The acceptance test program establishes a set of visual inspections, nondestructive examinations and test requirements and corresponding criteria to determine the adequacy of the fabricated components and sub-components. Similar acceptance requirements and criteria are established for the on-site concrete cask construction. Once in service, cask performance monitoring is used to assure that the cask is operating within the expected temperature range. Satisfactory results for these inspections, examinations and tests demonstrate that the components comply with the requirements of this Safety Analysis Report and the license drawings.

A fit-up test of the canister shell and sub-components is performed during the canister acceptance inspection. The fit-up test demonstrates that the canister, basket, shield lid and structural lid can be properly assembled during canister closure operations, and that the fuel assemblies can be installed in the fuel tubes.

A visual inspection is performed on all materials used for concrete cask, canister and basket fabrication. The visual inspection applies to finished surfaces of the components. All welds (shop and field installed) are visually inspected for defects prior to the nondestructive examinations that may also be specified. The welding of the canister is performed in accordance with ASME Code, Section III, Subsection NB-4000 [1], except as described by this Safety Analysis Report. (See Section 7.1.)

The visual inspections of the canister welds are performed in accordance with the ASME Code, Section V, Article 9 [2]. Acceptance criteria for the visual examinations of the canister welds are in accordance with ASME Code, Section VIII, Division 1, UW-35 and UW-36 [3]. Unacceptable welds in the canister are repaired as required by ASME Code, Section III, Subsection NB-4450 and reexamined in accordance with the original acceptance criteria.

Welding of the vertical concrete cask's steel components, including field installed welds, is performed in accordance with ANSI/AWS D1.1-96 [4], or ASME Code Section VIII, Division 1, Part UW, and inspected in accordance with ANSI/AWS D1.1, Section 8.15.1, or ASME Code Section VIII, Division 1, UW-35 and UW-36. Weld procedures and welder qualifications shall be in accordance with ANSI/AWS D1.1, Section 5 or ASME Code, Section IX [5].

Welding of the basket assemblies for spent fuel is performed in accordance with ASME Code, Section III, Subsection NG-4000 [6]. Visual examination of the welds is performed per the requirements of ASME Code, Section V, Article 9. Acceptance criteria for the visual examination of the basket assembly welds are those of ASME Code, Section III, Paragraphs NB-4424 and NB-4427. Any required weld repairs are performed in accordance with ASME Code, Section III, Subsection NG-4450 and reexamined in accordance with the original acceptance criteria.

All visual inspections are performed by qualified personnel according to written and approved procedures.

9.1.1.1 Nondestructive Weld Examination

The acceptance test program establishes a set of visual inspections, nondestructive examinations and test requirements for the fabrication and assembly of the storage cask, canister and transfer cask. Satisfactory results for these inspections, examinations and tests demonstrate that the components comply with the requirements of the SAR and the license drawings.

A fit-up test of the canister and its components is performed during the acceptance inspection. The fit-up test demonstrates that the canister, basket, shield lid and structural lid can be properly assembled during fuel loading and canister closure operations.

A visual inspection is performed on all materials and welds used for storage cask, canister, basket and transfer cask fabrication. The visual inspection applies to finished surfaces of the components. All welds (shop and field installed) are visually inspected for defects prior to the nondestructive examinations that are specified.

The fabrication of the canister is performed in accordance with ASME Code, Section III, Article NB-4000, except as described in Section 7.1.3 and Table 12B3-1. The visual examinations of the canister welds are performed in accordance with the ASME Code Section V, Article 9 [2]. Acceptance criteria for the visual examinations of the canister welds are in accordance with ASME Code Section III, NB-4424 and NB-4427. Required weld repairs on the canister are performed in accordance with ASME Code Section III, NB-4450, and are reexamined in accordance with the original acceptance criteria.

Fabrication of the storage cask's steel components, including field installed welds, is performed in accordance with either: 1) ANSI/AWS D1.1-96 [4] with visual examination in accordance with ANSI/AWS D1.1, Section 8.15.1; or 2) ASME Code Section VIII with visual examination in accordance with ASME Code Section V, Article 9.

Fabrication of the basket assembly for spent fuel is performed in accordance with ASME Code Section III, NG-4000 [6]. Visual examination of the welds is performed per the requirements of ASME Code Section V, Article 9. Acceptance criteria for the visual examination of the basket assembly welds is that of ASME Code Section III, Subsection NG-5360. Any required weld repairs are performed in accordance with ASME Code Section III, NG-4450 and the repaired weld is reexamined in accordance with the original acceptance criteria.

Qualified personnel perform all visual inspections according to written and approved procedures. The results of all visual weld inspections are recorded.

9.1.1.2 Fabrication Inspections

Materials used in the fabrication of the vertical concrete cask and transportable storage canister are procured with material certifications and supporting documentation as necessary to assure compliance with procurement specifications. All materials are receipt inspected for appropriate acceptance requirements, and for traceability to required material certification, appropriate for the safety classification of the components.

The canister is fabricated to the requirements of ASME Code, Section III, Subsection NB. Specific exceptions to the ASME Code are described in Chapter 12, Appendix 12A, Table 12B3-1. The basket structure is fabricated to ASME Code, Section III, Subsection NG. Shop fabricated components of the concrete cask are fabricated in accordance with ANSI/AWS D1.1-96, or ASME Code, Section VIII, Part UW.

A complete dimensional inspection of critical components and a components fit-up test is performed on the canister to ensure proper assembly in the field. Dimensions shall conform to the engineering drawings.

On completion of fabrication, the canister, basket and other shop fabricated components are inspected for cleanliness. All components must be free of any foreign material, oil, grease and solvents. All surfaces of carbon steel components assembled for the concrete cask that are not in direct contact with the concrete, are coated with a corrosion-resistant paint.

9.1.1.3 Construction Inspections

Concrete mixing slump, air entrainment, strength and density are field verified using either the American Concrete Institute (ACI) or the American Society for Testing and Materials (ASTM) standard testing methods and acceptance criteria, as appropriate, to ensure adequacy. Reinforcing steel is installed per specification requirements based on ACI-318 [7].

9.1.2 Structural and Pressure Test

The transportable storage canister is pressure tested at the time of use. After loading of the canister basket with spent fuel, the shield lid is welded in place after approximately 50 gallons of water are removed from the canister. Removal of the water ensures that the water level in the canister is below the bottom of the shield lid during welding of the shield lid to the canister shell. Prior to removing the remaining spent fuel pool water from the canister, the canister is pressure tested at 35 psia. This pressure is held for 10 minutes. Any loss of pressure during the test period is unacceptable. The leak must be located and repaired. The pressure test procedure is described in Section 8.1.1.

Transfer Cask

The transfer cask lifting trunnions and the bottom shield doors shall be tested in accordance with the requirements of ANSI N14.6, "Special Lifting Devices for Shipping Containers Weighing 10,000 pounds (4,500 kg) or More for Nuclear Materials" [8].

The lifting trunnion load test shall consist of applying a vertical load of 660,000 pounds, which is greater than 300 percent of the maximum service load (207,616 pounds) for the loaded canister with the shield lid and full of water. The bottom shield door load test shall consist of applying a vertical load of 266,000 pounds, which is over 300 percent of the maximum service load (88,376 pounds) for the loaded canister with the shield lid and full of water. These maximum service loads are based on the Class 5 BWR configuration, which is the heaviest configuration and, thus, bounds all of the other configurations.

The load tests shall be held for a minimum of 10 minutes and shall be performed in accordance with approved, written procedures.

Following completion of the lifting trunnion load tests, all trunnion welds and all load bearing surfaces shall be visually inspected for permanent deformation, galling or cracking. Magnetic particle examinations shall be performed in accordance with ASME Code Section V, Articles 1 and 7, with acceptance in accordance with ASME Code Section III, NF-5340. Similarly, following completion of the bottom shield door load tests, all door rail welds and all load bearing surfaces shall be visually inspected for permanent deformation, galling or cracking.

Any evidence of permanent deformation, cracking or galling of the load bearing surfaces or unacceptable liquid penetrant examination results, shall be cause for evaluation, rejection, or rework of the affected component. Liquid penetrant examinations of all load bearing welds shall be performed in accordance with ASME Code Section V, Article 6, with acceptance in accordance with ASME Code Section III, NF-5350.

Concrete Cask

The concrete cask, at the option of the user/licensee, may be provided with lifting lugs to allow for the vertical handling and movement of the concrete cask. The lifting lugs are provided as two sets of two lugs each, through which a lifting pin is inserted and connected to a specially designed mobile lifting frame. The concrete cask lifting lug system and mobile lifting frame and pins are designed, analyzed, and load tested in accordance with ANSI N14.6. The concrete cask lifting lug load test shall consist of applying a vertical load of 515,200 pounds, which is greater than 150 percent of the maximum concrete cask weight of 312,210 pounds plus a 10 percent dynamic load factor.

The test load shall be applied for a minimum of 10 minutes in accordance with approved, written procedures. Following completion of the load test, all load bearing surfaces of the lifting lugs shall be visually inspected for permanent deformation, galling, or cracking. Liquid penetrant examinations of load bearing surfaces shall be performed in accordance with ASME Code, Section V, Article 6, with acceptance criteria in accordance with ASME Code, Section III, Subsection NF, NF-5350.

Any evidence of permanent deformation, cracking, or galling, or unacceptable liquid penetrant examination results for the load bearing surfaces of the lifting anchors shall be cause for evaluation, rejection, or rework and retesting.

9.1.3 Leak Tests

The canister is leak tested at the time of use. After the pressure test described in Section 9.1.2, the canister is drained of residual water, vacuum dried and backfilled with helium. The canister is pressurized with helium to 0 psig. The shield lid to canister shell weld and the weld joining the port covers to the shield lid, are helium leak tested using a leak test fixture installed above the shield lid. The leaktight criteria of 2.0×10^{-7} cm^3/sec (helium) of ANSI N14.5[1] is applied. The leak test is performed at a sensitivity of 1.0×10^{-7} cm^3/sec (helium). Any indication of a leak of 2.0×10^{-7} cm^3/sec (helium), or greater, is unacceptable and repair is required as appropriate.

9.1.4 Component Tests

The components of the Universal Storage System do not require any special tests in addition to the material receipt, dimensional, and form and fit tests described in this chapter.

9.1.4.1 Valves, Rupture Disks and Fluid Transport Devices

The transportable storage canister and the vertical concrete cask do not contain rupture disks or fluid transport devices. There are no valves that are part of the confinement boundary for transport or storage. Quick-disconnect valves are installed in the vent and drain ports of the shield lid. These valves are convenience items for the operator, as they provide a means of quickly connecting ancillary drain and vent lines to the canister. During storage and transport, these fittings are not accessible, as they are covered by port covers that are welded in place when the canister is closed. As presented for storage and transport, the canister has no accessible valves or fittings.

9.1.4.2 Gaskets

The transportable storage canister and the vertical concrete cask have no mechanical seals or gaskets that form an integral part of the system, and there are no mechanical seals or gaskets in the confinement boundary.

9.1.5 Shielding Tests

Based on the conservative design of the Universal Storage System for shielding criteria and the detailed construction requirements, no shielding tests of the vertical concrete cask are required.

9.1.6 Neutron-Absorber Tests

Neutron-absorbing material, BORAL®, is used as a poison in the BWR and PWR fuel tubes. BORAL is manufactured by AAR Advanced Structures (AAR) of Livonia, Michigan, under a Quality Assurance/Quality Control program in conformance with the requirements of 10 CFR 50, Appendix B. The computer-aided manufacturing process consists of several steps - the first being the mixing of the aluminum and boron-carbide powders that form the core of the finished material, with the amount of each powder a function of the desired ^{10}B areal density. The methods used to control the weight and blend the powders are patented and proprietary processes of AAR.

After manufacturing, test samples from each batch of BORAL® neutron absorber (poison) sheets shall be tested using neutron absorption and/or wet chemistry techniques to verify the presence, proper distribution, and minimum weight percent of ^{10}B. The tests shall be performed in accordance with approved written procedures.

Preparation of Samples

Detailed written procedures to perform wet chemistry and/or neutron absorption tests of each batch of BORAL® sheets shall be established by the manufacturer and approved by NAC. For each batch of BORAL® sheets, a sample shall be taken from each end of randomly selected sheets. The samples shall be indelibly marked and recorded for identification. At least 2 percent of the sheets in a batch shall be fully tested as described, with the remaining sheets to be tested at one location to ensure the presence of boron in those sheets.

Neutron-Absorber Test Performance

Neutron attenuation testing of this material is performed on test samples from each BORAL sheet pour to verify the presence, proper distribution, and areal density of neutron-absorbing material. This real-time radiographic test of the samples is performed in accordance with approved, written procedures by an approved facility with a neutron beam capability. For each batch of neutron absorber, a 2-inch-wide sample is taken from each end of a sheet. The samples are indelibly marked and recorded for identification. A reference BORAL standard for the appropriate ^{10}B areal density is used as the test acceptance standard. For system calibration, a camera is placed in the neutron beam path and the reference BORAL standard plate is placed in a stationary, fixed location between the camera and beamport. A luminance level is then determined at a location near the center of the specimen. The BORAL standard is then replaced by the BORAL test specimen and a luminance level is determined at a location near the center of the specimen.

The test results are considered acceptable if the luminance level determined for each test specimen is equal to or less than that of the BORAL standard. The minimum acceptable areal density for BORAL ^{10}B loading is of 0.011 g/cm^2 for the BORAL sheets used in the BWR fuel tubes and 0.025 g/cm^2 for the PWR BORAL sheets. Any specimen not meeting the acceptance criterion is rejected, and the sheets from that pour are similarly rejected or individually tested for acceptance.

Wet Chemistry Test Performance

An approved facility with chemical analysis capability shall be selected to perform the wet chemistry tests. The tests will ensure the presence of boron and enable the calculation of the ^{10}B areal density.

The most common method of verifying the acceptability of neutron absorber material is the wet chemistry method—a chemical analysis where the aluminum is separated from a sample with known thickness and volume. The remaining boron-carbide material is weighed and the areal density of ^{10}B is computed. A statistical conclusion about the BORAL® sheet from which the sample was taken and that batch of BORAL® sheets may then be drawn based on the test results and the established manufacturing processes previously noted.

Acceptance Criteria

The wet chemistry test results shall be considered acceptable if the ^{10}B areal density is determined to be equal to, or greater than, that specified on the fuel tube drawings.

The neutron absorption test shall be considered acceptable if the neutron count determined for each test specimen is less than or equal to the highest permissible neutron count rate determined from the reference sheet(s), which are based on the ^{10}B areal density specified on the fuel tube drawings.

Any specimen not meeting the acceptance criteria shall be rejected and all of the sheets from that batch shall be similarly rejected.

9.1.7 Thermal Tests

No thermal acceptance testing of the Universal Storage System is required during construction. Thermal performance of the system is confirmed in accordance with the procedure specified in Section 9.2.3. In addition, temperature measurements are taken at the air outlets of the concrete cask(s) placed in service, in accordance with Chapter 12.0, as verification of the thermal performance of the storage system.

9.1.8 Cask Identification

A stamped, stainless steel nameplate is permanently attached on the outer surface of the concrete cask as shown on Drawing No. 790-562.

The nameplate is installed at approximately eye level and includes the following information:

Vertical Concrete Cask

Owner:	(Utility Name)
Designer:	NAC International Inc.
Fabricator:	(Vendor Name)
Date of Manufacture:	(mm/dd/yy)
Model Number:	(UMS-XXX)
Cask No.:	(XXX)
Date of Loading:	(mm/dd/yy)
Empty Weight:	(Pounds [kilograms])

9.2 Maintenance Program

The Universal Storage System is a passive system. No active components or systems are incorporated in the design. Consequently, only a minimal amount of maintenance is required over its lifetime, as described in Section 9.2.3.

9.2.1 Subsystems Maintenance

The Universal Storage System has no active or passive subsystems that require scheduled maintenance. As described in Section 9.2.3, the air inlets and outlets are subject to daily inspection to identify blockage of the vents, which could result in a reduction in cooling air flow.

9.2.2 Valves, Rupture Discs, and Gaskets on the Containment Vessel

The Universal Storage System has no valves, gaskets, rupture discs, seals, or accessible penetrations. Consequently, there is no maintenance associated with these types of features.

9.2.3 Continuing Maintenance Requirements

Recommended maintenance for the vertical concrete cask in normal conditions is specified below. The surveillance requirements are described in Technical Specification LCO 3.1.6 in Appendix 12A of Chapter 12. It is not necessary to inspect the canister during the storage period as long as the thermal performance is normal, based on daily temperature verification.

1. Daily surveillance of the vertical concrete casks:

    - Visual inspection of air inlet and outlets for detection of blockage.

    - Verify that the inlet and outlet screens are in place, and are whole and secure.

    - Record the ambient temperature and air outlet temperature for each vertical concrete cask upon placement in service. Thereafter, the temperatures shall be recorded on a daily basis to verify the continuing thermal performance of the system.

    - Visual inspection of the ISFSI site for security and safeguards.

2. Annual inspection of the vertical concrete cask exterior:

   - Visual inspection of surface for chipping, spalling or other surface defects. Any defects larger than one inch in diameter (or width) and deeper than one inch shall be regrouted, according to the grout manufacturer's recommendations.

   - Reapplication of corrosion-inhibiting (external) coatings on accessible surfaces, including concrete cask lifting lugs, if present.

9.2.4 Required Maintenance of First Storage System Placed in Service

For the first Universal Storage System placed in service, the canister is loaded with spent fuel assemblies and the decay heat load calculated for that canister. The canister is then loaded into the vertical concrete cask, and the cask's thermal performance is evaluated by measuring the ambient and air outlet temperatures for normal air flow. The purpose of the test is to measure the heat removal performance of the Universal Storage System and to establish baseline data. A letter report summarizing the results of the test and evaluation is submitted to the NRC within 30 days of placing the cask in service in accordance with 10 CFR 72.4.

Should the first canister not be loaded with spent fuel that has the design basis heat load, the user may use a lesser heat load for the test. However, a calculation of the temperature difference between the inlet and outlet temperatures must be performed using the same methodology and inputs documented in this Safety Evaluation Report. The calculation and the measured temperature data must be reported to the NRC in accordance with 10 CFR 72.4.

9.2.5 Transfer Cask Maintenance

The transfer cask trunnions and shield door assemblies shall be visually inspected for gross damage and proper function prior to each use. Annually, the lifting trunnions, shield doors and shield door rails shall be either dye penetrant or magnetic particle examined, using the examination method appropriate to the material. The examination method shall be in accordance with Section V of the ASME Code. The acceptance criteria shall be in accordance with Section III, Subsection NF, Article NF-5350 or NF-5340 as appropriate to the examination method, as required by ANSI N14.6.

The annual examination may be omitted in periods of nonuse of the transfer cask, provided that the transfer cask examination is performed prior to the next use of the transfer cask.

Annually, the coating applied to the carbon steel surfaces of the transfer cask shall be inspected, and any chips, cracks or other defects in the coating shall be repaired.

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9.3 References

1. ASME Boiler and Pressure Vessel Code, Section III, Division I, Subsection NB, "Class 1 Components," 1995 Edition with 1997 Addenda.

2. ASME Boiler and Pressure Vessel Code, Section V, "Nondestructive Examination," 1995 Edition with 1997 Addenda.

3. ASME Boiler and Pressure Vessel Code, Section VIII, Subsection B, Part UW, "Requirements for Pressure Vessels Fabricated by Welding," 1995 Edition with 1997 Addenda.

4. American Welding Society, Inc., "Structural Welding Code - Steel," AWS D1.1, 1996.

5. ASME Boiler and Pressure Vessel Code, Section IX, "Welding and Brazing Qualifications," 1995 Edition with 1997 Addenda.

6. ASME Boiler and Pressure Vessel Code, Section III, Division I, Subsection NG, "Core Support Structures," 1995 Edition with 1997 Addenda.

7. American Concrete Institute, "Building Code Requirements for Structural Concrete," ACI-318-95, October 1995.

8. American National Standards Institute, "Radioactive Materials - Special Lifting Devices for Shipping Containers Weighting 10,000 Pounds (4,500 kg) or More," ANSI N14.6-1993, 1993.

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10.0 RADIATION PROTECTION

10.1 Ensuring that Occupational Radiation Exposures Are As Low As Is Reasonably Achievable (ALARA)

The Universal Storage System provides radiation protection for all areas and systems that may expose personnel to radiation or radioactive materials. The components of the PWR and BWR configurations of the system that require operation, maintenance and inspection are designed, fabricated, located, and shielded so as to minimize radiation exposure to personnel.

10.1.1 Policy Considerations

It is the policy of NAC to ensure that the Universal Storage System is designed so that operation, inspection, repair and maintenance can be carried out while maintaining occupational exposure as low as is reasonably achievable (ALARA).

10.1.2 Design Considerations

The design of the Universal Storage System complies with the requirement of 10 CFR 72.3 [1] concerning ALARA and meets the requirements of 10 CFR 72.126(a) and 10 CFR 20.1101 [2] with regard to maintaining occupational radiation exposures ALARA. Specific design features that demonstrate the ALARA philosophy are:

- Material selection and surface preparation that facilitate decontamination.
- A basket configuration that allows spent fuel canister loading using accepted standard practice and current experience.
- Positive clean water flow in the transfer cask/canister annulus to minimize the potential for contamination of the canister surface during in-pool loading.
- Passive confinement, thermal, criticality, and shielding systems that require no maintenance.
- Thick steel and concrete walls to reduce the side surface dose rate of the concrete cask to less than 50 mrem/hr (average).

- Nonplanar cooling air pathways to minimize radiation streaming at the inlets and outlets of the vertical concrete cask.

- Use of remote, automated outlet air temperature measurement to reduce surveillance time.

10.1.3 Operational Considerations

The ALARA philosophy is incorporated into the procedural steps necessary to operate the Universal Storage System in accordance with its design. The following features or actions, which comprise a baseline radiological controls approach, are incorporated in the design or procedures to minimize occupational radiation exposure:

- Use of automatic equipment for welding the shield lid and structural lid to the canister shell.

- Decontamination of the exterior surface of the transfer cask, welding of the shield lid, and pressure testing of the canister while the canister remains filled with water.

- Use of quick disconnect fittings at penetrations to facilitate required service connections.

- Use of remote handling equipment, where practical, to reduce radiation exposure.

- Use of prefabricated, shaped temporary shielding, if necessary, during automated welding equipment set up and removal, during manual welding, during weld inspection of the shield lid, and during all other canister closing and sealing operations conducted at the shield lid.

The operational procedures at a particular facility are determined by the user's operational conditions and facilities.

10.2 Radiation Protection Design Features

The description of the radiation shielding design is provided in Section 5.3.1. The design criteria radiation exposure rates are summarized in Table 2-1. The principal radiation protection design features are the shielding necessary to meet the design objectives, the placement of penetrations near the edge of the canister shield lid to reduce operator exposure and handling time, and the use of shaped supplemental shielding for work on and around the shield lid, as necessary. This supplemental shielding reduces operator dose rates during the welding, inspection, draining, drying and backfilling operations that seal the canister.

Radiation exposure rates at various work locations are determined for the principal Universal Storage System operational steps using a combination of the SAS4 [3] and SKYSHINE III [4] computer codes. The use of SAS4 is described in Section 5.1.2. The SKYSHINE-III code is discussed in Section 10.4. The calculated dose rates decrease with time.

10.2.1 Design Basis for Normal Storage Conditions

The radiation protection design basis for the Universal Storage System vertical concrete cask is derived from 10 CFR 72 and the applicable ALARA guidelines. The design basis surface dose rates, and the calculated surface and 1 meter dose rates are:

Vertical Concrete Cask	Design Basis Surface Dose Rate (mrem/hr)	Surface Dose Rate (mrem/hr)		1 Meter Maximum Dose Rate (mrem/hr)	
		PWR	BWR	PWR	BWR
Side wall	50.0 (avg.)	37.3	22.7	25.3	15.4
Air inlet	100.0	6.8	8.5	<5.0	5.0
Air outlet	100.0	65.6	50.6	12.5	7.5
Top lid	50.0 (avg.)	26.1	19.7	13.3	8.5

The calculated dose rates at these, and at other dose points, are reported in Sections 5.1.3 and 5.4.3. The dose rates presented are for the design basis 40,000 MWD/MTU, 5-year cooled, fuel. These dose rates bound those of the higher burnup, but longer cooled, fuel described in Sections 2.1 and 2.5.

Activities associated with closing the canister, including welding of the shield and structural lids, draining, drying, backfilling and testing, may employ temporary shielding to minimize personnel dose in the performance of those tasks.

10.2.2 Design Basis for Accident Conditions

Damage to the vertical concrete cask after a design basis accident does not result in a radiation exposure at the controlled area boundary in excess of 5 rem to the whole body or any organ. The high energy missile impact is estimated to reduce the concrete shielding thickness, locally at the point of impact, by approximately 6 inches. Localized cask surface dose rates for the removal of 6 inches of concrete are estimated to be less than 250 mrem/hr for the PWR and BWR configurations.

A hypothetical accident event, tip-over of the vertical concrete, is considered in Section 11.2.12. There is no design basis event that would result in the tip-over of the vertical concrete cask.

10.3 Estimated On-Site Collective Dose Assessment

Occupational radiation exposures (person-mrem) resulting from the use of the Universal Storage System are calculated using the estimated exposure rates presented in Sections 5.1.3, 5.4.3 and 10.2.1. Exposure is evaluated by identifying the tasks and estimating the duration and number of personnel performing those tasks based on industry experience. The tasks identified are based on the design basis operating procedures, as presented in Chapter 8.0.

Dose rates are calculated using the shielding analysis design basis fuel assemblies. The shielding design basis PWR assembly is the Westinghouse 17X17 Standard fuel assembly, with an initial enrichment of 3.7 wt % ^{235}U. The design basis BWR assembly is the GE 9X9, with 79 fuel rods and an initial enrichment of 3.25 wt % ^{235}U. Both design basis fuel assemblies have an assumed burnup of 40,000 MWD/MTU, and a cool time of 5 years. The selection of these assemblies for the shielding design basis is described in Section 5.1. The principal parameters of these assemblies are presented in Table 2.1-1.

10.3.1 Estimated Collective Dose for Loading a Single Universal Storage System

This section estimates the collective dose due to the loading, sealing, transfer and placement on the ISFSI pad, of the Universal Storage System. The analysis assumes that the exposure incurred by the operators is independent of background radiation, as background radiation varies from site to site. The number of persons allocated to task completion is generally the minimum number required for the task. Working area exposure rates are assigned based on the orientation of the worker with respect to the source and take into account the use of temporary shielding.

Table 10.3-1 summarizes the estimated total exposure by task, attributable to the loading, transfer, sealing and placement of a design basis Universal Storage System. Exposures associated with shield lid operations are based on the presence of a 5-inch thick steel temporary shield.

This estimated dose is considered to be conservative as it assumes the loading of a cask with design basis fuel, and does not account for efficiencies in the loading process that occur with experience.

10.3.2 Estimated Annual Dose Due to Routine Operations

Once in place, the ISFSI requires limited ongoing inspection and surveillance throughout its service life. The annual dose evaluation considers the combination of inspection and surveillance requirements specified in Appendix 12A of Chapter 12, and those tasks that are anticipated to be representative of an operational facility. Other than an inspection of the Vertical Concrete Cask surface, no annual maintenance of the storage system is required. Collective dose due to design basis off-normal conditions and accident events, such as clearing the blockage of air vents, is accounted for in Chapter 11.0, and is not included in this evaluation.

Routine operations are expected to include:

- Daily visual inspection of the cask array. This inspection consists of the inspection for blockage of the inlets and outlets. Inspection of the inlets and outlets is assumed to take one operator 1 minute per cask.

- Daily electronic measurement of air outlet temperatures. Outlet temperature indicators are located away from the cask array. Remote temperature measurement is not assumed to contribute to operator dose.

- A daily security inspection of the fence and equipment surrounding the storage area. This surveillance is assumed to be performed by the operator concurrently with the inlet and outlet vent inspection. The security inspection is assumed to make no additional contribution to operator dose.

- Grounds maintenance performed every other week by 1 maintenance technician. Grounds maintenance is assumed to require 0.5 hour.

- Quarterly radiological surveillance. The surveillance consists of a radiological survey comprised of a surface radiation measurement on each cask, the determination and/or verification of general area exposure rates and radiological postings. This surveillance is assumed to require 1 hour and 1 person.

- Annual inspection of the general condition of the casks. This inspection is estimated to require 15 minutes per cask and require 2 technicians.

Calculation of the dose due to annual operation and surveillance requirements is estimated based on a single cask containing design basis fuel, and on an ISFSI array of 20 casks that are assumed to be loaded at the rate of 2 casks per year over a ten year period. Consequently, the casks in the array are assumed to have the cool times as shown in Table 10.3-2. To account for the reduction in source term with cool time, weighting factors are applied to the neutron and gamma radiation spectra as shown in Table 10.3-3.

The annual operation and surveillance requirements result in an estimated annual collective exposure of 71.4 person-mrem for a single PWR cask containing design basis fuel and 46.8 person-mrem for a single design basis BWR cask. The annual operation and surveillance requirements for the assumed single cask and total estimated dose is shown in Table 10.3-4 for the single PWR cask, and in Table 10.3-6 for the BWR cask. The annual operation and surveillance requirements for the assumed 20 cask ISFSI are shown in Tables 10.3-5, and 10.3-7 for PWR and BWR configurations, respectively. These tables show an estimated annual collective exposure of 1086 person-mrem for the PWR cask configuration, and 733 person-mrem for the BWR cask configuration for operation and maintenance of a 20-cask array.

Figure 10.3-1 Typical ISFSI 20 Cask Array Layout

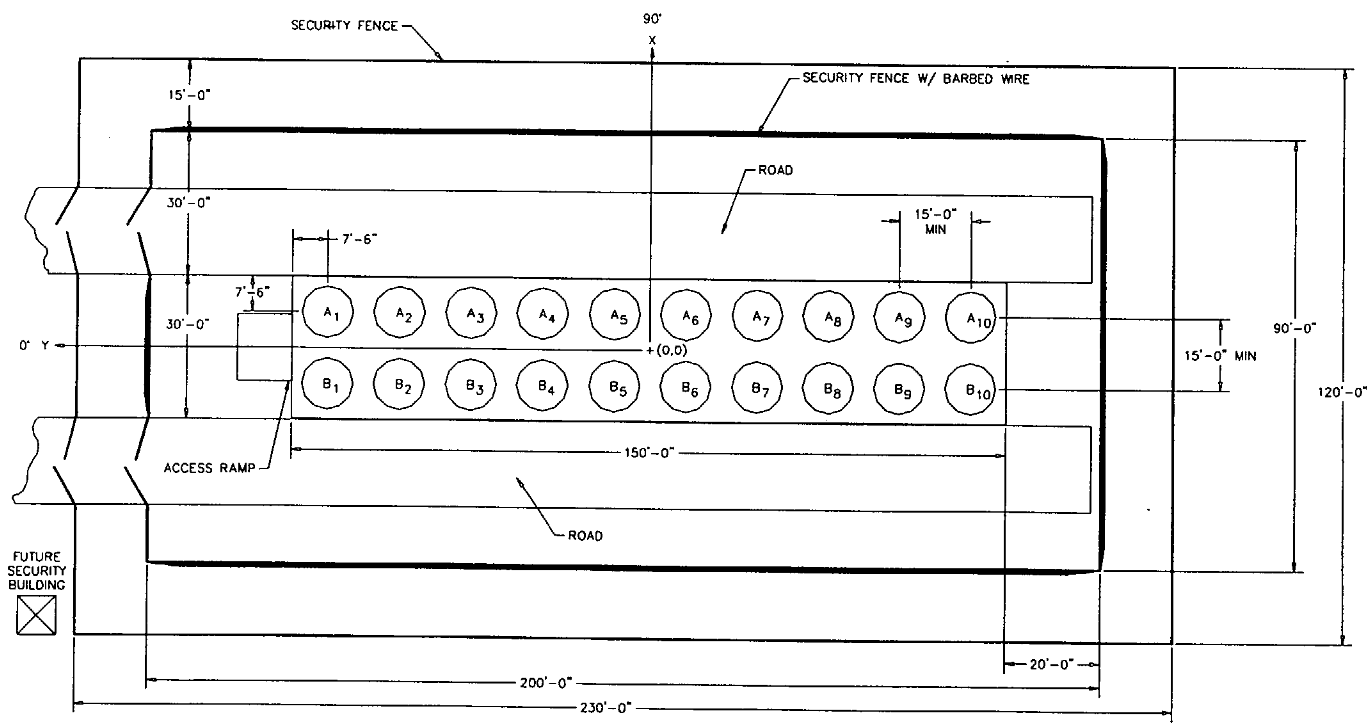

Table 10.3-1 Estimated Person-Mrem Exposure for Operation of the Universal Storage System

Design Basis Fuel Assemblies Loading and Handling Activity	Estimated Number of Personnel	Activity Duration (hr)	Average Dose Rate (mrem/hr)		Exposure (person-mrem)	
			PWR	BWR	PWR	BWR
Load Canister	2	9/21[1]	2.00	2.00	36	84
Move to Decon Area/Prep for Weld	2	3	15.17	10.00	91	60
Setup Shield Lid Weld	2	2	29.63[3]	19.88[3]	119	80
Welding Operation (Automated)	1	6	BDR[2]	BDR[2]	0	0
Weld Inspections[4]	1	8	29.63[3]	19.88[3]	237	159
Drain/ Vacuum Dry/Backfill and Leak Test[5]	1	5.5	4.55[3]	3.09[3]	25	17
Weld and Inspect Port Covers[4]	1	2	59.00[3]	38.50[3]	118	77
Setup Structural Lid Weld	2	2	20.13[3]	12.63[3]	81	51
Welding Operation (Automated)	1	6	BDR[2]	BDR[2]	0	0
Weld Inspections[4]	1	8	20.13[3]	12.63[3]	162	102
Transfer to Vertical Concrete Cask	4	2	27.50	16.63	220	133
Position on ISFSI Pad	2	2	4.94	3.52	26	18
Total					1,115	781

1. Assumes 22.5 minutes for the loading of each PWR or BWR fuel assembly.
2. Background Dose Rate (BDR). No exposure is estimated due to the canister contents.
3. Dose rates associated with the presence of a temporary shield on top of the shield lid.
4. Includes root, progressive, and final weld surface inspections.
5. Includes fixturing, connection and monitoring time. Operators not present during routine draining and drying process.

Table 10.3-2 Contents and Assumed Cooling Time of the Vertical Concrete Casks Depicted in the Typical ISFSI Array

Cask Number	Cooling Time (yr)		Cask Number	Cooling Time (yr)	
	PWR	BWR		PWR	BWR
A-1	14	14	B-1	14	14
A-2	13	13	B-2	13	13
A-3	12	12	B-3	12	12
A-4	11	11	B-4	11	11
A-5	10	10	B-5	10	10
A-6	9	9	B-6	9	9
A-7	8	8	B-7	8	8
A-8	7	7	B-8	7	7
A-9	6	6	B-9	6	6
A-10	5	5	B-10	5	5

Table 10.3-3 Vertical Concrete Cask Radiation Spectra Weighting Factors

Cask Numbers	Axial Neutron Weighting Factor		Axial Gamma Weighting Factor		Radial Neutron Weighting Factor		Radial Gamma Weighting Factor	
	PWR	BWR	PWR	BWR	PWR	BWR	PWR	BWR
A-1, B-1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
A-2, B-2	0.96	0.96	0.83	0.84	0.96	0.96	0.83	0.83
A-3, B-3	0.93	0.93	0.72	0.74	0.93	0.93	0.72	0.74
A-4, B-4	0.89	0.89	0.65	0.67	0.89	0.89	0.65	0.67
A-5, B-5	0.86	0.86	0.59	0.62	0.86	0.86	0.59	0.62
A-6, B-6	0.83	0.83	0.55	0.58	0.83	0.83	0.55	0.58
A-7, B-7	0.80	0.80	0.52	0.55	0.80	0.80	0.52	0.55
A-8, B-8	0.77	0.77	0.50	0.52	0.77	0.77	0.50	0.52
A-9, B-9	0.74	0.74	0.47	0.50	0.74	0.74	0.48	0.50
A-10, B-10	0.72	0.72	0.45	0.48	0.72	0.72	0.46	0.48

Table 10.3-4 Estimate of Annual Exposure for the Operation and Surveillance of a Single PWR Cask

Activity	Dose Rate Distance (meters)	Frequency (days)	Time (min)	Dose Rate (mrem/hr)	Personnel Required	Total Exposure (Pers-mrem)
Visual inspection	4	365	1	7.40	1	45.0
Radiological surveillance	4	4	15	7.40	1	7.4
Annual inspection						
Operations	1	1	15	25.30	1	6.3
Radiological Support	1	1	3	25.30	1	1.3
Grounds maintenance	10	26	15	1.76	1	11.4
Total Person-mrem						71.4

Table 10.3-5 Estimate of Annual Exposure for the Operation and Surveillance of a 20 Cask Array of PWR Casks

Activity	Dose Rate Distance (meters)	Frequency (days)	Time (min)	Dose Rate (mrem/hr)	Personnel Required	Total Exposure (Pers-mrem)
Visual inspection	4	365	1(1)	5.83	1	709.3
Radiological surveillance	4	4	60	5.83	1	23.3
Annual inspection						
Operations	1	1	15(1)	47.91	1	239.6
Radiological Support	1	1	3(1)	47.91	1	47.9
Grounds maintenance	10	26	60	2.55	1	66.3
Total Person-mrem for the 20 Cask Array						1086.4
Total Person-mrem for a Single Cask in the Array						54.0

(1) Time listed is per cask; it is multiplied by 20 for the cask array.

Table 10.3-6 Estimate of Annual Exposure for the Operation and Surveillance of a Single BWR Cask

Activity	Dose Rate Distance (meters)	Frequency (days)	Time (min)	Dose Rate (mrem/hr)	Personnel Required	Total Exposure (mrem)
Visual inspection	4	365	1	4.9	1	29.8
Radiological surveillance	4	4	15	4.9	1	4.9
Annual inspection						
Operations	1	1	15	15.2	1	3.8
Radiological Support	1	1	3	15.2	1	0.8
Grounds maintenance	10	26	15	1.16	1	7.5
Total Person - mrem						46.8

Table 10.3-7 Estimate of Annual Exposure for the Operation and Surveillance of a 20 Cask Array of BWR Casks

Activity	Dose Rate Distance (meters)	Frequency (days)	Time (min)	Dose Rate (mrem/hr)	Personnel Required	Total Exposure (mrem)
Visual inspection	4	365	1(1)	4.04	1	491.5
Radiological surveillance	4	4	60	4.04	1	16.2
Annual inspection						
Operations	1	1	15(1)	29.85	1	149.3
Radiological Support	1	1	3(1)	29.85	1	29.9
Grounds maintenance	10	26	60	1.79	1	46.5
Total Person - mrem for the 20 Cask Array						733.4
Total Person - mrem for a Single Cask in the Array						37.0

(1) Time listed is per cask; it is multiplied by 20 for the cask array.

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10.4 Exposure to the Public

The NAC Version 5.0.1 of the SKYSHINE-III code is used to evaluate the placement of the controlled area boundary for a single cask containing design basis fuel, and for a 20 cask array. For the 20-cask array, the casks are assumed to be loaded with design basis fuel at the rate of two casks per year. SKYSHINE III calculates dose rates for user defined detector locations for up to 100 point sources.

Version 5.0.1 of SKYSHINE-III, explicitly calculates cask self shielding based on the cask geometry and arrangement of the cask array. A ray tracing technique is utilized. Given the source position on the cask surface and the direction cosines for the source emission, geometric tests are made to see if any adjacent casks are in the path of the emission. If so, the emission history does not contribute to the air scatter dose. Also, given the source position on the cask surface and the direction cosines for the source to detector location, geometric tests are made to see if any adjacent casks are in the source path. If so, the emission position does not contribute to the uncollided dose at the detector location.

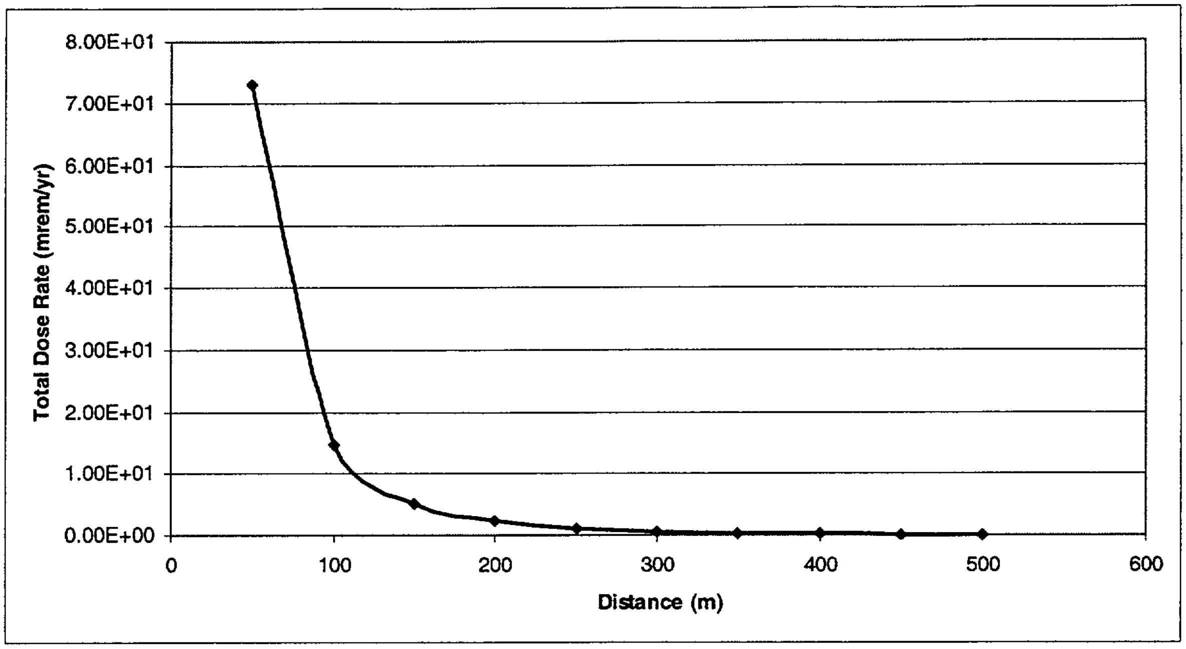
The code is benchmarked by modeling a set of Kansas State University ^{60}Co skyshine experiments and by modeling two Kansas State University neutron computational benchmarks. The code compares well with these benchmarks for both neutron and gamma doses versus distance.

The cask array is explicitly modeled in the code, with the source term from each cask represented as top and side surface sources. Surface source emission fluxes are provided from 1D SAS1 shielding evaluations. The top and side source energy distributions for both neutron and gamma radiation are taken from the design basis cask shielding evaluation. As stated in Section 10.3, the array cask source strengths are multiplied by weighting factors to correct for the differences in cooling times resulting from the assumption of a loading rate of 2 casks per year. The SKYSHINE cask surface fluxes (sources) are adjusted to reflect the higher cask surface fluxes calculated by the SAS4 3-D shielding evaluation. Surface fluxes are also adjusted for dose peaks associate with fuel assembly end-fitting hardware and radiation streaming through the cask vents and canister-to-cask annulus. The 2x10 ISFSI cask array layout is presented in Figure 10.3-1. For this analysis the cask-to-cask pitch is conservatively taken at 16 feet, as opposed to the minimum 15 feet, to minimize cask-to-cask shadowing. These results are conservative for the minimum 15-foot cask center-to-center-spacing specified in Section 4.5.2 Appendix 12A.

Exposures are determined at distances ranging from 50 to 500 meters surrounding a single PWR and BWR cask containing design basis fuel. The results are presented graphically in Figures 10.4-1 and 10.4-2, for the PWR or BWR single cask, respectively. The casks in the 2x10 array are assumed to be loaded at the rate of 2 per year with design basis PWR and BWR spent fuel, with credit taken for the cool time that occurs during the 10 year period that the ISFSI array is completed. For both the single cask and 2 x 10 array calculations, the controlled area boundary is based on the 25 mrem/year limit. Occupancy at the controlled area boundary is assumed at 2080 hours per year. While higher occupancy may be required at certain sites, the increased exposure time will likely be offset by increased cool time or decreased burnup.

Table 10.4-1 presents a summary of the results of the SKYSHINE-III evaluation for single PWR and BWR cask containing design basis fuel. The results show that minimum distances from a single cask to the site boundary of <100 meters (PWR) and <100 meters (BWR) are required for compliance with the requirements of 10 CFR 72.104(a), i.e., a dose rate of 25 mrem/ year. Table 10.4-2 results show that a minimum site boundary of ≈160 meters is required for a 2 x 10 PWR cask array to meet the 10 CFR 72.104(a) 25 mrem/year requirement. The 2 x 10 BWR cask array requires a minimum site boundary of ≈150 meters to meet 10 CFR 72.104(a).

Figure 10.4-1 SKYSHINE Exposures from a Single Cask Containing Design Basis PWR Fuel

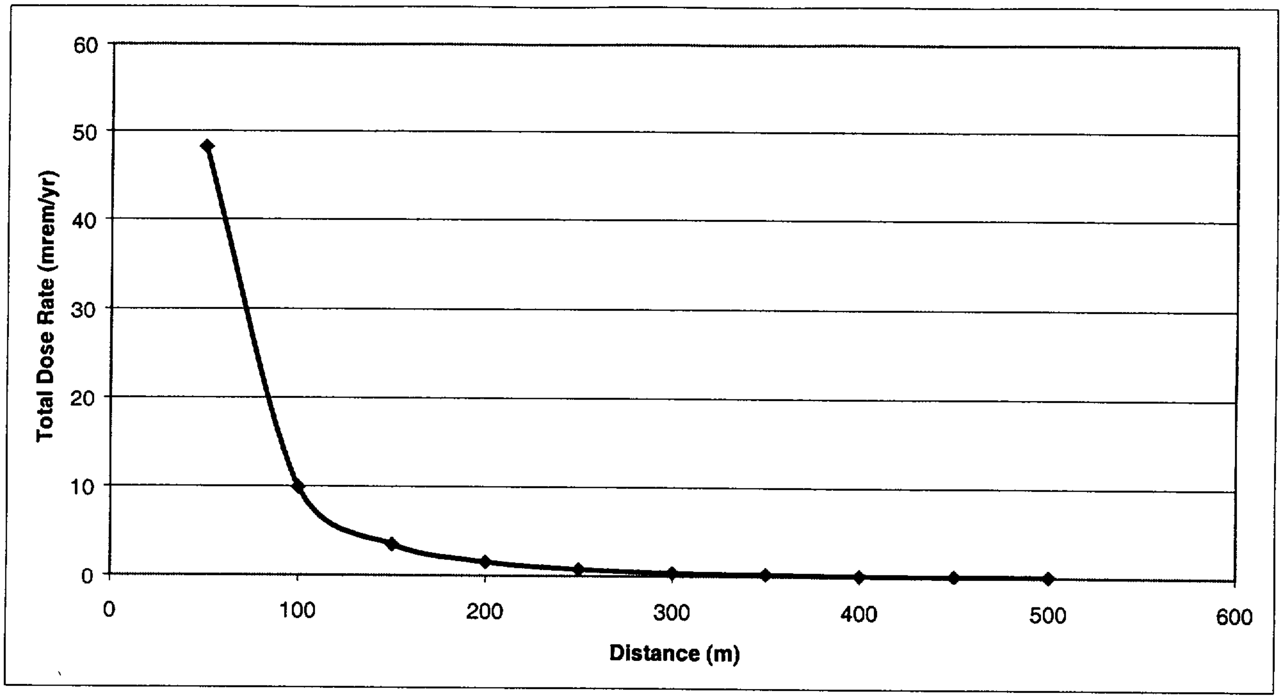


Distance (m)	Gamma (Radial)	Neutron (Radial)	Neutron-Gamma- (Radial)	Neutron-Gamma (Axial)	Total
50	7.28E+01	1.12E-01	2.92E-06	2.59E-06	7.29E+01
100	1.47E+01	3.11E-02	2.26E-06	2.51E-06	1.48E+01
150	5.25E+00	1.36E-02	2.13E-06	2.55E-06	5.26E+00
200	2.32E+00	7.03E-03	2.05E-06	2.50E-06	2.33E+00
250	1.15E+00	3.93E-03	1.93E-06	2.35E-06	1.16E+00
300	6.12E-01	2.32E-03	1.76E-06	2.13E-06	6.14E-01
350	3.40E-01	1.42E-03	1.57E-06	1.86E-06	3.42E-01
400	1.97E-01	8.89E-04	1.36E-06	1.58E-06	1.98E-01
450	1.18E-01	5.70E-04	1.15E-06	1.31E-06	1.18E-01
500	7.19E-02	3.72E-04	9.52E-07	1.07E-06	7.23E-02

General Notes:

1. Based on a 2,080-hour exposure.
2. Axial gamma and neutron doses are negligible.

Figure 10.4-2 SKYSHINE Exposures from a Single Cask Containing Design Basis BWR Fuel



Distance (m)	Gamma (Radial)	Neutron (Radial)	Neutron-Gamma-(Radial)	Neutron-Gamma (Axial)	Total
50	4.81E+01	1.64E-01	5.95E-06	3.75E-06	4.82E+01
100	9.86E+00	4.59E-02	3.38E-06	3.65E-06	9.91E+00
150	3.53E+00	2.00E-02	3.01E-06	3.71E-06	3.55E+00
200	1.57E+00	1.03E-02	2.82E-06	3.64E-06	1.58E+00
250	7.78E-01	5.78E-03	2.61E-06	3.43E-06	7.84E-01
300	4.15E-01	3.40E-03	2.37E-06	3.11E-06	4.18E-01
350	2.33E-01	2.08E-03	2.09E-06	2.72E-06	2.35E-01
400	1.35E-01	1.31E-03	2.09E-06	2.32E-06	1.37E-01
450	8.12E-02	8.38E-04	1.52E-06	1.92E-06	8.20E-02
500	5.00E-02	5.47E-04	1.26E-06	1.56E-06	5.05E-02

General Notes:

1. Based on a 2,080-hour exposure.
2. Axial gamma and neutron doses are negligible.

Table 10.4-1 Dose Versus Distance For a Single Cask Containing Design Basis PWR or BWR Fuel

Detector Distance (m)	PWR Cask Total Dose Rate (mrem/year)[1]	BWR Cask Total Dose Rate (mrem/year)[1]
50	7.29E+01	4.82E+01
100	1.48E+01	9.91E+00
150	5.26E+00	3.55E+00
200	2.33E+00	1.58E+00
250	1.16E+00	7.84E-01
300	6.14E-01	4.18E-01
350	3.42E-01	2.35E-01
400	1.98E-01	1.37E-01
450	1.18E-01	8.20E-02
500	7.23E-02	5.05E-02

1. Based on a 2,080 hour exposure.

Table 10.4-2 Annual Exposures From a PWR or BWR 2 x 10 Cask Array

Detector Distance (Meters)	PWR Cask Total Dose Rate[1] (mrem/year)	BWR Cask Total Dose Rate[1] (mrem/year)
50	5.40E+02	3.74E+02
100	1.13E+02	7.76E+01
150	4.03E+01	2.76E+01
200	1.80E+01	1.23E+01
250	9.00E+00	6.14E+00
300	4.81E+00	3.29E+00
350	2.68E+00	1.85E+00
400	1.55E+00	1.08E+00
450	9.28E-01	6.45E-01
500	5.67E-01	3.97E-01

1. Based on a 2,080 hour worker year.

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10.5 Radiation Protection Evaluation for Site Specific Spent Fuel

This section presents the radiation protection evaluation of fuel assemblies or configurations, which are unique to specific reactor sites. These site specific configurations result from conditions that occurred during reactor operations, participation in research and development programs, and from testing programs intended to improve reactor operations. Site specific fuel includes fuel assemblies that are uniquely designed to accommodate reactor physics, such as axial fuel blanket and variable enrichment assemblies, and fuel that is classified as damaged.

Site specific fuel assembly configurations are either shown to be bounded by the analysis of the standard design basis fuel assembly configuration of the same type (PWR or BWR), or are shown to be acceptable contents by specific evaluation of the configuration.

10.5.1 Radiation Protection Evaluation for Maine Yankee Site Specific Spent Fuel

The shielding evaluation of Maine Yankee site specific fuel characteristics is presented in Section 5.6.1.1. In the shielding evaluation, the specific fuel assembly and non-fuel hardware sources are shown to be bounded by the design basis fuel assembly characteristics. To ensure that the Maine Yankee contents are bounded by the design basis fuel, specific evaluations are performed and minimum cooling time and loading restrictions are established.

Because the dose rates from the Maine Yankee contents are bounded by the design basis fuel, the radiological evaluations performed for the design basis fuel in Sections 10.3 and 10.4 are also bounding. Therefore, detailed radiological evaluations for the Maine Yankee site specific fuel configurations are not required and the evaluated on-site and off-site doses presented in Sections 10.3 and 10.4 can be used in site planning considerations.

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10.6 References

1. Title 10 of the Code of Federal Regulations, Part 72 (10 CFR 72), "Licensing Requirements for the Storage of Spent Fuel in an Independent Spent Fuel Storage Installation," April 1996.

2. Title 10 of the Code of Federal Regulations, Part 20 (10 CFR 20), "Standards for Protection Against Radiation," April 1996.

3. ORNL/NUREG/CSD-2/V1/R5, Volume 1, Section S4, "SAS4: A Monte Carlo Cask Shielding Analysis Module Using an Automated Biasing Procedure," Tang, J. S., September 1995.

4. SKYSHINE III, "Calculation of the Effects of Structure Design on Neutron, Primary Gamma-Ray and Secondary Gamma-Ray Dose Rates in Air," RISC Code Package CCC-289, NAC International, Version 4.0.1, February 1997.

5. ORNL/NUREG/CSD-2/V3/R5, Volume 1, Section S1, "SAS1: A One-Dimensional Shielding Analysis Module," Knight, J.R. et al., September 1995.

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