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5.0 SHIELDING EVALUATION

This chapter provides the shielding evaluation of the NAC-MPC storage system. The system is provided in three configurations. The Yankee Class NAC-MPC is designed to store up to 36 Yankee Class spent fuel assemblies or Yankee Class reconfigured fuel assemblies and is referred to as the Yankee-MPC. The Connecticut Yankee-MPC, referred to as the CY-MPC, is designed to store up to 26 Connecticut Yankee spent fuel assemblies, CY-MPC reconfigured fuel assemblies or CY-MPC damaged fuel cans. The analysis of the Yankee Class spent fuel is performed using the SAS4 code series. The analysis of the Connecticut Yankee spent fuel is performed using the MCBEND code. Separate models are used for each of the fuel types.

The Dairyland Power Cooperative (DPC) La Crosse Boiling Water Reactor (LACBWR) MPC, referred to as MPC-LACBWR, is designed to store up to 68 LACBWR spent fuel assemblies, including up to 32 LACBWR damaged fuel cans. The shielding evaluation of the MPC-LACBWR system is presented in Appendix 5.A of this chapter.

The regulation governing spent fuel storage, 10 CFR 72, does not establish specific cask dose rate limits. However, 10 CFR 72.104 and 10 CFR 72.106 specify that for an array of casks in an Independent Spent Fuel Storage Installation (ISFSI), the annual dose to an individual outside the controlled area boundary must not exceed 25 mrem to the whole body, 75 mrem to the thyroid and 25 mrem to any other organ during normal operations. In the case of a design basis accident, the dose to an individual outside the area boundary must not exceed 5 rem to the whole body or any organ. The ISFSI must be at least 100 meters from the owner controlled area boundary. In addition, the occupational dose limits and radiation dose limits for individual members of the public in 10 CFR Part 20 (Subparts C and D) must be met. Chapter 10, Section 10.3, demonstrates NAC-MPC compliance with the requirements of 10 CFR 72 with regard to annual and occupational doses at the owner controlled area boundary. This chapter presents the shielding evaluations of the NAC-MPC storage system. Dose rate profiles are calculated as a function of distance from the side, top and bottom of the NAC-MPC storage and transfer casks. Shielded source terms from the NAC-MPC storage cask are calculated to establish owner controlled area boundary dose estimates due to the presence of the ISFSI.

5.1 Discussion and Results

This section provides a summary of the results of the shielding evaluation of the NAC-MPC system when the system holds Yankee Class or Connecticut Yankee spent fuel assemblies and non-fuel hardware. Results are provided for the transfer cask and vertical concrete cask components.

A description of the Yankee Class fuel and a summary of the results of the Yankee Class fuel shielding evaluation are presented in Section 5.1.1. The description of the Connecticut Yankee fuel and a summary of the Connecticut Yankee shielding evaluation results are presented in Section 5.1.2.

The NAC-MPC storage system is comprised of a transportable storage canister, a transfer cask, and a vertical concrete storage cask. License drawings for these items are provided in Section 1.7. The transfer cask containing the canister and the basket is loaded under water in the spent fuel pool. Once filled with fuel, the shield lid is placed on top of the canister and transfer cask is removed from the pool. After draining approximately 50 gallons of water from the Yankee-MPC canister or approximately 65 gallons of water from the CY-MPC canister, the shield lid is welded in place, and the canister is drained and dried. Finally, the structural lid is welded in place. The transfer cask is then used to transfer the canister to the storage cask where it is stored dry until transport. Shielding evaluations are performed for the transfer cask with both a wet and dry canister cavity as would occur during the welding of the shield lid and during the welding of the structural lid, respectively. Shielding evaluations are performed for the storage cask with the cavity dry.

Appendix 5.A SHIELDING EVALUATION – MPC-LACBWR MPC STORAGE SYSTEM FOR DAIRYLAND POWER COOPERATIVE LA CROSSE BOILING WATER REACTOR

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5.A SHIELDING EVALUATION FOR THE MPC-LACBWR STORAGE SYSTEM

This section provides the shielding evaluation of the MPC-LACBWR storage system. The MPC-LACBWR is designed to store up to 68 Dairyland Power Cooperative (DPC) La Crosse Boiling Water Reactor (LACBWR) spent fuel assemblies with up to 32 LACBWR damaged fuel cans. The analysis of the LACBWR spent fuel is performed using the SAS2H module of the SCALE package for source terms and MCNP for shielding.

The regulation governing spent fuel storage, 10 CFR 72, does not establish specific cask dose rate limits. However, 10 CFR 72.104 and 10 CFR 72.106 specify that for an array of casks in an Independent Spent Fuel Storage Installation (ISFSI), the annual dose to an individual outside the controlled area boundary must not exceed 25 mrem to the whole body, 75 mrem to the thyroid and 25 mrem to any other organ during normal operations. In the case of a design basis accident, the dose to an individual outside the controlled area boundary must not exceed 5 rem to the whole body or any organ. The ISFSI must be at least 100 meters from the owner controlled area boundary. In addition, the occupational dose limits and radiation dose limits for individual members of the public in 10 CFR Part 20 (Subparts C and D) must be met. Chapter 10, Section 10.A.3, demonstrates MPC-LACBWR compliance with the requirements of 10 CFR 72 with regard to annual and occupational doses at the owner controlled area boundary. This appendix presents the shielding evaluations of the MPC-LACBWR storage system. Dose rate profiles are calculated as a function of distance from the side, top, and bottom of the MPC-LACBWR storage and transfer casks.

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5.A.1 Shielding Discussion and Results for the MPC-LACBWR Storage System

This section provides a summary of the results of the shielding evaluation of the MPC-LACBWR system. Results are provided for the transfer cask and vertical concrete cask components.

The MPC-LACBWR storage system is comprised of a transportable storage canister, a transfer cask, and a vertical concrete storage cask. License drawings for these items are provided in Section 1.A.7. The transfer cask containing the canister and the basket is loaded under water in the spent fuel pool. Once filled with fuel, the closure lid is placed on top of the canister and the transfer cask is removed from the pool. After draining approximately 50 gallons of water from the canister, the closure lid is welded, the closure ring is inserted and welded, and the canister is drained and dried. Finally, the port covers are welded in place. The transfer cask is then used to transfer the canister to the storage cask where it is stored dry until transport. Shielding evaluations are performed for the transfer cask with both a wet and dry canister cavity as would occur during the welding of the closure lid. Shielding evaluations are performed for the storage cask with the cavity dry.

The MPC-LACBWR transfer cask has a multi-wall radial shield comprised of 0.75 inch of carbon steel, 3.5 inches of lead, 2 inches of solid borated polymer (NS-4-FR), and 1.25 inches of carbon steel. An additional 0.5 inch of stainless steel shielding is provided radially by the canister shell. Gamma shielding is provided primarily by the steel and lead layers, and neutron shielding is provided primarily by the NS-4-FR. The transfer cask bottom shield design is a solid section of 9.5 inches of low alloy steel. The top shielding is provided by the stainless steel closure lid, which is 7 inches thick. Temporary shielding may be used during welding, draining, drying, and helium backfill operations but is not credited in the shielding analysis. Temporary shielding is removed prior to storage.

The storage cask radial shield design is comprised of a 2.5-inch-thick carbon steel inner liner surrounded by a 22-inch thickness of concrete. Gamma shielding is provided by both the carbon steel and the concrete. Neutron shielding is provided primarily by the concrete. As in the transfer cask, an additional 0.5-inch thickness of stainless steel radial gamma shielding is provided by the canister shell. The storage cask top shielding design is comprised of 7 inches of stainless steel from the canister closure lid, 1.875 inches of carbon steel from the storage cask lid and 8 inches of concrete from the storage cask lid. Since the bottom of the storage cask sits on a concrete pad, the storage cask bottom shielding is comprised of the 1-inch thick stainless steel canister bottom plate, the 2-inch-thick carbon steel weldment base plate and its 0.25-inch-thick stainless steel cover, and the 1-inch thick carbon steel cask bottom plate. The base plate and bottom plate are structural components that position the canister above the air inlets. The cask bottom plate supports the storage cask during lifting and forms the cooling air inlet channels at the cask bottom.

The MPC-LACBWR accommodates up to 68 stainless steel clad LACBWR spent fuel assemblies. LACBWR fuel assemblies were fabricated by two vendors, Allis Chalmers (AC) and Exxon Nuclear Company (ENC). The AC fuel assemblies have a maximum assembly average burnup of 22,000 MWd/MTU and a minimum cool time of 28 years. The ENC fuel assemblies have a maximum assembly average burnup of 21,000 MWd/MTU and a minimum cool time of 23 years. The physical parameters of the LACBWR fuel assemblies are presented in Table 5.A.2-1.

A canister may contain up to 32 damaged fuel cans positioned in the peripheral locations in the basket. The MPC-LACBWR damaged fuel can may hold a complete fuel assembly. Since the shielding evaluation conservatively assumes that the damaged fuel cans are not present in the canister, the additional shielding provided by the wall of the can would serve to reduce external dose rates. The shielding analysis models ENC fuel in the interior 36 basket locations and AC fuel in the 32 peripheral basket locations. A loading of 37 ENC fuel assemblies and 31 AC assemblies is an acceptable configuration, as is underloading of the basket with less than the full complement of 68 fuel assemblies.

Shielding evaluations of the MPC-LACBWR transfer and storage casks are performed using the MCNP Monte Carlo transport code [A1]. Fuel source terms are developed using the SCALE isotopics sequence SAS2H (Herman). Source terms include fuel neutron, fuel gamma, fuel n-gamma, and activated hardware gamma. Dose rate evaluations include the effect of axial fuel burnup peaking on fuel neutron and gamma source terms.

The resulting dose rate profiles, along with the maximum and average radial and axial dose rates are presented for the storage cask and transfer cask analyses in Section 5.A.4.

5.A.1.1 Undamaged Fuel Dose Rates

The maximum dose rates for the storage cask with undamaged fuel are summarized in Table 5.A.1-1 and Table 5.A.1-2. The standard deviation resulting from the Monte Carlo evaluation used by MCNP (1σ) is indicated in the tables. The storage cask maximum side dose rate is 28.9 (1.3%) mrem/hr slightly below the fuel midplane elevation. The maximum storage cask top axial surface dose rate is 18.7 (6.9%) mrem/hr on the top lid surface just above the annulus between the canister and the storage cask liner. Since the storage cask is vertical during normal storage operation, the bottom is inaccessible. Therefore, no bottom axial dose rates are presented. The average dose rates at the inlets and outlets are 38.3 (1.4%) mrem/hr and 2.0 (0.5%) mrem/hr, respectively.

Under accident conditions involving a projectile impact and a loss of 6 inches of concrete, the surface dose rate increases to 278 mrem/hr at the impact location and 105 mrem/hr at a distance of 1 meter from the surface. There are no design basis accidents that result in a tip-over of the MPC-LACBWR storage cask.

The maximum dose rates for undamaged fuel in the transfer cask for the wet and dry canister cavity configurations encountered during canister closure operations are presented in Table 5.A.1-3 and Table 5.A.1-4, respectively.

With a wet canister cavity (no port covers), the maximum dose rates are 68.2 (2.3%) and 471.2 (1.7%) mrem/hr on the radial surface and top axial surface, respectively. The bottom surface of the cask has a maximum dose rate of 23.8 (2.2%) mrem/hr.

With a dry canister cavity (port covers installed), the maximum dose rates are 102.2 (5.2%) mrem/hr and 598.7 (1.4%) mrem/hr on the radial and top axial surfaces, respectively. The bottom surface of the cask has a maximum dose rate of 54.2 (2.2%) mrem/hr.

5.A.1.2 Damaged Fuel Dose Rates

To ensure that the worst case configuration is considered, two damaged fuel scenarios are evaluated for the 32 peripheral basket locations.

The first scenario assumes the damaged fuel collects over the active fuel length of the fuel assembly. This scenario is modeled by filling the fuel rod interstitial volume with UO_2 and increasing the fuel neutron, gamma, and n-gamma source consistent with this increase in mass. A comparison of dose rate profiles for the 68 assembly intact fuel results and 36 intact and 32 damaged assemblies in Section 5.A.4 demonstrates that the damaged fuel model dose rates are less due to the increase in self-shielding from the 32 peripheral assemblies compensating for the increase in source strength.

In the second scenario, damaged fuel is assumed to migrate from the active fuel into the lower end fitting region of the fuel assembly, filling all the modeled void space. However, no credit is taken for the reduction in lower end fitting hardware dose rate due to the added UO_2 mass and self-shielding nor for the reduction in fuel mass migrated from the active fuel region. In this case, storage cask inlet and transfer cask bottom surface dose rates increase due to the addition of damaged fuel. The storage cask inlet dose rate increase is 36.7 mrem/hr, effectively doubling the air inlet dose rate. The transfer cask bottom axial dose rate increase is 22.1 mrem/hr, increasing the bottom axial dose rate by approximately 41%. Note that the radial location of the maximum dose rate at the bottom of the transfer cask differs between the undamaged and damaged fuel models.

Damaged fuel maximum dose rates are summarized in Table 5.A.1-5 and Table 5.A.1-6.

Table 5.A.1-1 Summary of MPC-LACBWR Storage Cask Maximum Dose Rates – Undamaged Fuel

Location	Source	Surface		1 meter	
		mrem/hr	**FSD**	**mrem/hr**	**FSD**
Top Axial	Neutron	0.5	6.9%	0.1	6.8%
	Gamma	18.2	7.1%	5.5	3.6%
	Total	18.7	6.9%	5.6	3.5%
Side (Normal)	Neutron	0.2	2.0%	0.1	1.5%
	Gamma	28.7	1.3%	11.4	0.9%
	Total	28.9	1.3%	11.5	0.9%
Side (Accident)	Neutron	0.7	1.7%	0.2	1.4%
	Gamma	277.1	1.1%	104.5	0.8%
	Total	277.8	1.1%	104.7	0.8%

Table 5.A.1-2 Summary of MPC-LACBWR Storage Cask Inlet/Outlet Maximum Dose Rates – Undamaged Fuel

Source	Inlet Average		Outlet Average	
	mrem/hr	**FSD**	**mrem/hr**	**FSD**
Fuel Neutron	1.3	1.4%	0.1	1.2%
Fuel Gamma	6.8	6.5%	0.1	7.6%
Fuel Hardware	3.2	3.6%	0.1	2.6%
Lower End Fitting	27.0	0.9%	--	--
Upper Plenum	--	--	1.2	0.4%
Upper End Fitting	--	--	0.5	0.5%
Total	38.3	1.4%	2.0	0.5%

Table 5.A.1-3 Summary of MPC-LACBWR Transfer Cask Maximum Dose Rates – Wet (Port Covers Off) – Undamaged Fuel

		Surface		1 meter	
Location	**Source**	**mrem/hr**	**FSD**	**mrem/hr**	**FSD**
Top	Neutron	0.2	8.5%	0.1	6.9%
	Gamma	471.0	1.7%	205.7	2.0%
	Total	471.2	1.7%	205.8	2.0%
Side	Neutron	22.0	4.9%	4.7	3.7%
	Gamma	46.2	2.5%	16.7	1.5%
	Total	68.2	2.3%	21.4	1.4%
Bottom	Neutron	0.1	13.6%	0.1	10.4%
	Gamma	23.7	2.2%	10.0	1.5%
	Total	23.8	2.2%	10.1	1.4%

Table 5.A.1-4 Summary of MPC-LACBWR Transfer Cask Maximum Dose Rates – Dry (Port Covers On) – Undamaged Fuel

		Surface		1 meter	
Location	**Source**	**mrem/hr**	**FSD**	**mrem/hr**	**FSD**
Top	Neutron	7.9	3.1%	2.4	2.5%
	Gamma	590.8	1.4%	251.7	1.4%
	Total	598.7	1.4%	254.1	1.4%
Side	Neutron	19.6	3.3%	4.4	2.9%
	Gamma	82.6	6.4%	31.1	2.7%
	Total	102.2	5.2%	35.5	2.4%
Bottom	Neutron	17.6	2.0%	4.9	1.2%
	Gamma	36.6	3.1%	15.4	1.1%
	Total	54.2	2.2%	20.3	0.9%

Table 5.A.1-5 Summary of MPC-LACBWR Storage Cask Maximum Dose Rates – Damaged Fuel

Source	**Inlet Average**	
	mrem/hr	**FSD**
Undamaged Fuel	38.3	1.4%
Damaged Neutron	2.3	0.3%
Damaged Gamma	34.4	3.5%
Total	75.0	1.8%

Table 5.A.1-6 Summary of MPC-LACBWR Transfer Cask Maximum Dose Rates – Dry (Port Covers On) – Damaged Fuel

Location	**Source**	**Surface**	
		mrem/hr	**FSD**
Bottom	Undamaged Fuel	45.1	0.8%
	Damaged Neutron	28.5	0.4%
	Damaged Gamma	2.6	8.6%
	Total	76.2	0.6%

5.A.2 MPC-LACBWR Fuel Source Term Specification

The MPC-LACBWR system is designed to safely transfer and store LACBWR spent fuel assemblies. The spent fuel inventory consists of stainless steel clad Allis Chalmers and Exxon Nuclear Company fuel assemblies. Due to differences in source terms, these two fuel types are treated separately in the analysis. Based on the fuel inventory, limiting combinations of burnup, initial enrichment, and cool time for the two fuel types have been identified as shown:

Fuel Type	**Max. Burnup [MWd/MTU]**	**Min. Initial Enrichment [wt % ^{235}U]**	**Min. Cool Time [years]**
Allis Chalmers	22,000	3.6	28
Exxon Nuclear Company	21,000	3.6	23

Minimum initial enrichment produces the maximum source due to spectral hardening.

Cross-sectional sketches of the modeled LACBWR fuel assemblies are shown in Figure 5.A.2-1. The physical parameters of the LACBWR fuel assemblies are presented in Table 5.A.2-1.

The SAS2H code sequence (Herman) is used to generate source terms. This code sequence is part of the SCALE 4.3 code package for the PC (ORNL). SAS2H includes an XSDRNPM (Greene) neutronics model of the fuel assembly and ORIGEN-S (Herman) fuel depletion/source term calculations. Reactor operating conditions assumed for the analysis are shown in Table 5.A.2-2. Source terms are generated for the fuel and fuel assembly hardware. The hardware activation is calculated by light element transmutation using the incore neutron flux spectrum produced by the SAS2H neutronics model.

The 27-group library (27GROUPNDF4) is composed primarily of ENDF/B-IV cross-sections with pre-release ENDF/B-V data for a large number of fission product isotopes. The cross-section set is collapsed using an LWR spectrum. References [A7] through [A11] contain extensive SAS2H validation for PWR burnups up to 47 GWd/MTU and BWR burnups up to 57 GWd/MTU.

The LACBWR design basis fuel source terms are presented in Table 5.A.2-3 through Table 5.A.2-5. The activated hardware source term is provided on a per unit mass basis. Source strengths are defined for four source regions: active fuel, upper end fitting, upper plenum, and lower end fitting. The fuel assembly length, active fuel region length, and fuel assembly hardware lengths are shown for the design basis fuel assemblies in Figure 5.A.2-1.

5.A.2.1. MPC-LACBWR Fuel Gamma Source

The design basis fuel and hardware gamma source spectra are shown in Table 5.A.2-4 and Table 5.A.2-5. The fuel gamma source contains contributions from both fission products and actinides. The spectra are presented in a more discrete 22 group structure than the 18 group SCALE default. The hardware gamma spectra contain contributions primarily from ^{60}Co due to the activation of Type 304 stainless steel with 2 g/kg ^{59}Co impurity and with some minor contributions from ^{59}Ni and ^{58}Fe. The 2 g/kg ^{59}Co impurity represents the maximum cobalt impurity allowed per manufacturer specifications. The magnitudes of these spectra are based on the irradiation of 1 kg of stainless steel in the incore flux spectrum produced by the SAS2H neutronics calculation.

The activated fuel assembly hardware source strength for a given source region is determined as the product of the hardware source strength per unit mass (Table 5.A.2-5), the mass of the hardware (Table 5.A.2-6), and a regional flux activation ratio (Table 5.A.2-6). Table 5.A.2-6 includes the product of the hardware mass and the regional flux activation ratio, which is the "effective" hardware mass. This effective mass is used to compute the light element decay heat (output from SAS2H on a per kilogram basis), which is then added to the actinide and fission product decay heat as shown in Table 5.A.2-7.

The regional flux activation ratio accounts for the effects of both magnitude and spectrum variation on hardware activation. These ratios are based on empirical data (Luksic). A flux ratio of 0.2 is applied to the upper plenum and a flux ratio of 0.1 is applied to the upper end fitting region. A flux ratio of 0.15 is applied to the lower end fitting region.

5.A.2.2 MPC-LACBWR Fuel Neutron Source

The neutron source results from actinide spontaneous fission and from (α,n) reactions with the oxygen in UO_2. The isotopes ^{242}Cm and ^{244}Cm characteristically produce all but a few percent of the spontaneous fission neutrons and (α,n) source in light water reactor fuel. The next largest contribution is from (α,n) reactions from ^{238}Pu. The neutron spectra from spontaneous fission are based on fission spectrum measurements of ^{235}U and ^{252}Cf. Neutron spectra from (α,n) reactions is based on Po-α-O source measurements. These spectra are included in the ORIGEN-S nuclear data libraries of the SCALE 4.3 code package. The spectra are automatically collapsed from the energy group structure of the data library into a 28 group structure more discrete than that of the default SCALE 22 group format.

The effect of subcritical neutron multiplication is not directly computed in the MCNP analysis conducted here, due to difficulties in adequately biasing the calculation. Instead, neutron source rates are scaled by a subcritical multiplication factor (scale factor) based on the system multiplication factor, k_{eff}:

$$\text{Scale Factor} = \frac{1}{1 - k_{eff}}$$

For dry cask conditions, the system k_{eff} is taken as 0.4, with a resulting scale factor of 1.67. For wet conditions, the system k_{eff} is assumed to be the maximum allowable value of 0.95, resulting in a scale factor of 20. The scale factor is a direct input value in the MCNP input file (on the tally cards) to account for system thermal neutron subcritical multiplication.

5.A.2.3 MPC-LACBWR Fuel Source Axial Profile

An enveloping axial burnup shape for three-dimensional shielding and thermal evaluations is created based on measured burnup profile data for LACBWR fuel. The measured axial burnup profiles for Allis Chalmers and Exxon Nuclear Company fuel were reviewed and a bounding profile was constructed. The bounding profile produces a burnup peak of 1.36 as shown in Figure 5.A.2-2.

Neutron and gamma source profiles are computed based on an assumed relation between burnup, B, and source strength, S, in the form:

$$S = aB^b$$

Parameters a and b are determined by plotting the neutron or gamma source strength calculated by SAS2H against burnup on a log-log scale for various values of burnup. The resulting points are a line having a slope of value “b.” The parameter a is a scaling factor. For neutron source strengths, which are non-linear with burnup, the value of b is determined by ORIGEN-S SASH evaluations at various burnups and is 4.22. For gamma source strengths, the value of b is 1.0, reflecting the linear relation between burnup and source rate. Table 5.A.2-8 gives the resulting source rate profiles. The relative source strength in each axial interval is shown, and these values are used directly in the MCNP source strength description. A plot of the axial source profiles is shown in Figure 5.A.2-3.

The axial source profile applied in the shielding evaluation is based on a single in-lattice (core outlet) and out-lattice (core inlet) moderator density (see Table 5.A.2-2). In order to evaluate the effect of axially varying moderator density on the design basis source terms computed in Sections 5.A.2.1 and 5.A.2.2, the design basis source terms are compared to the source terms generated using the axial power and moderator density profile for the bounding LACBWR fuel assembly (based on the assembly with the largest axial peaking factor). Table 5.A.2-9 summarizes the axial burnup and moderator density values used for this study. As shown in Table 5.A.2-10, the design basis source used in the evaluation bounds the node-specific source. Note that Table 5.A.2-10 corrects the design basis neutron source for the integral of the axial neutron source profile, which is slightly less than the 1.822 factor in Table 5.A.2-8 given the use of an actual axial profile rather than a bounding profile. Figure 5.A.2-4 through Figure 5.A.2-6 demonstrate the bounding nature of the design basis source terms in graphical format.

Figure 5.A.2-1 MPC-LACBWR Fuel Assembly Source Regions and Elevations

AC FUEL

ENC FUEL

Figure Withheld Under 10 CFR 2.390

Figure 5.A.2-2 MPC-LACBWR Fuel Bounding Axial Burnup Profile in Active Fuel Region

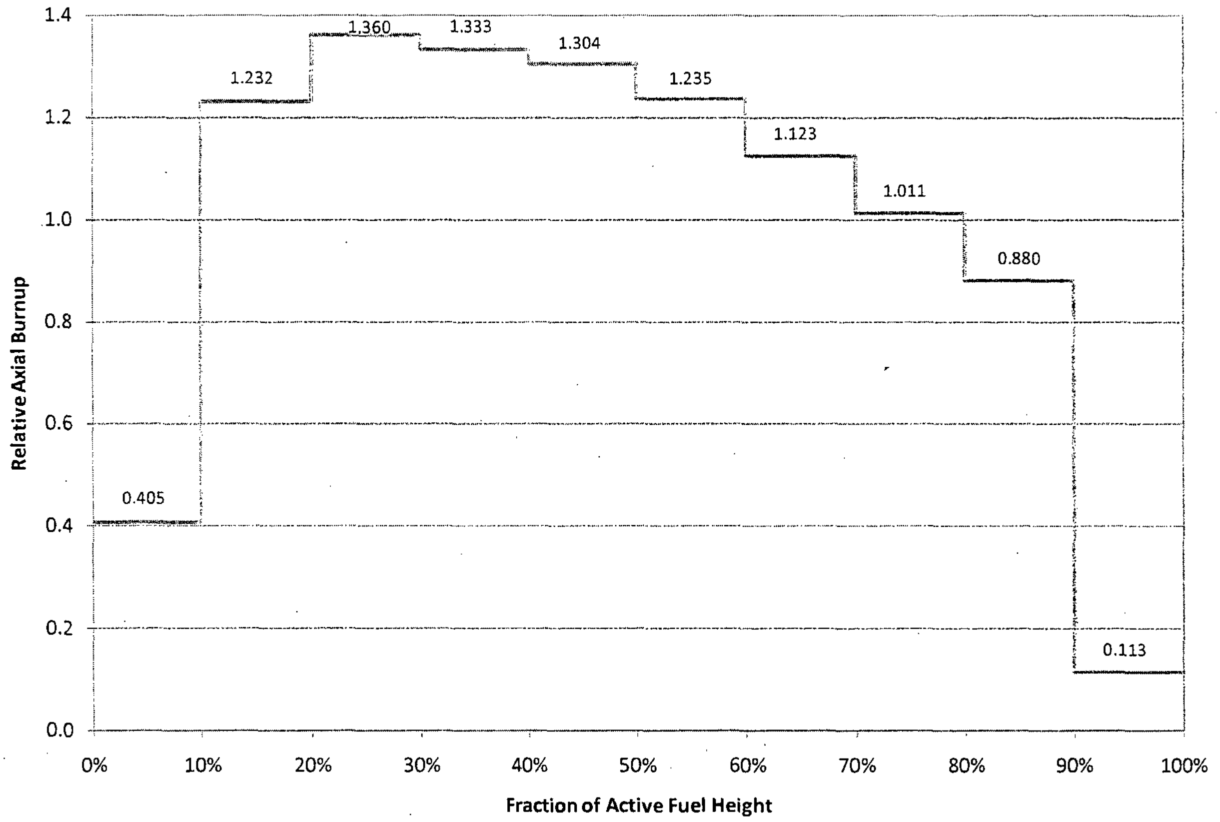

Figure 5.A.2-3 MPC-LACBWR Fuel Axial Neutron and Gamma Source Profiles in Active Fuel Region

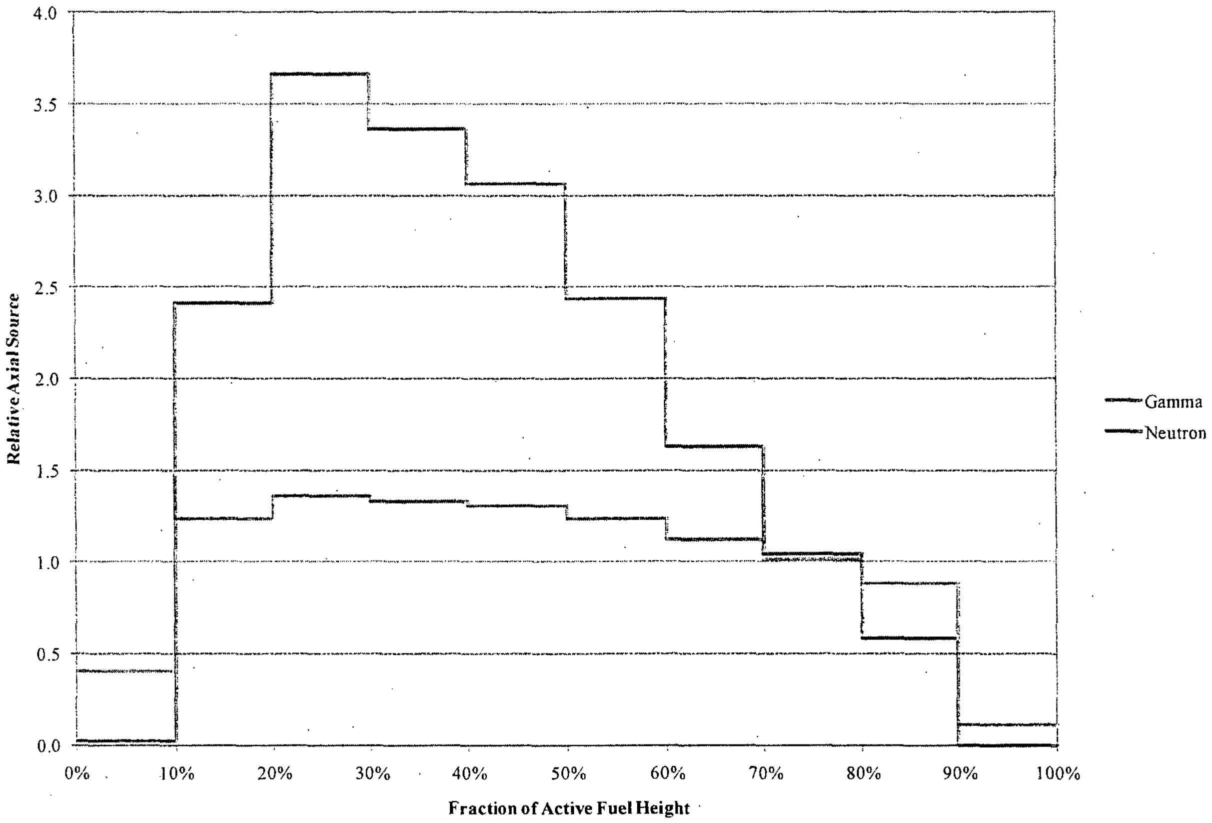

Figure 5.A.2-4 Axial Moderator Density Study Neutron Source Comparison

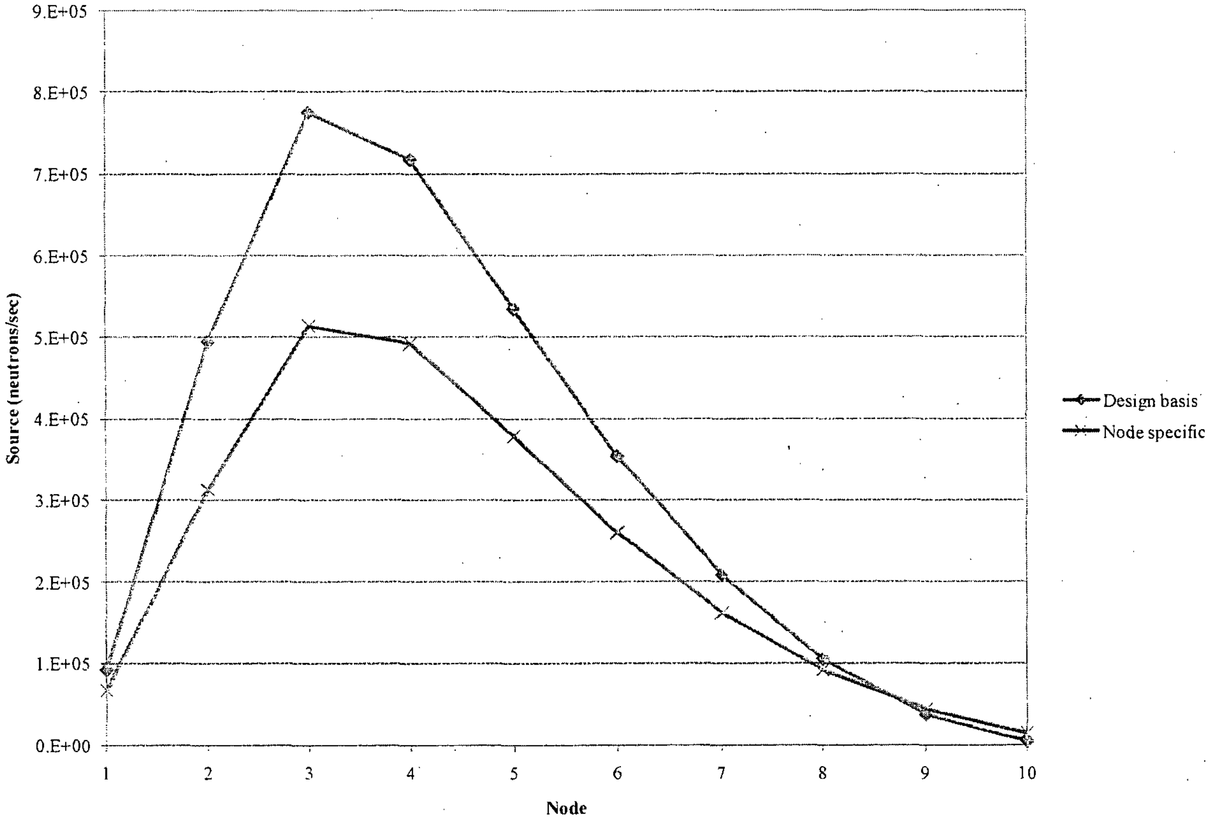

Figure 5.A.2-5 Axial Moderator Density Study Gamma Source Comparison

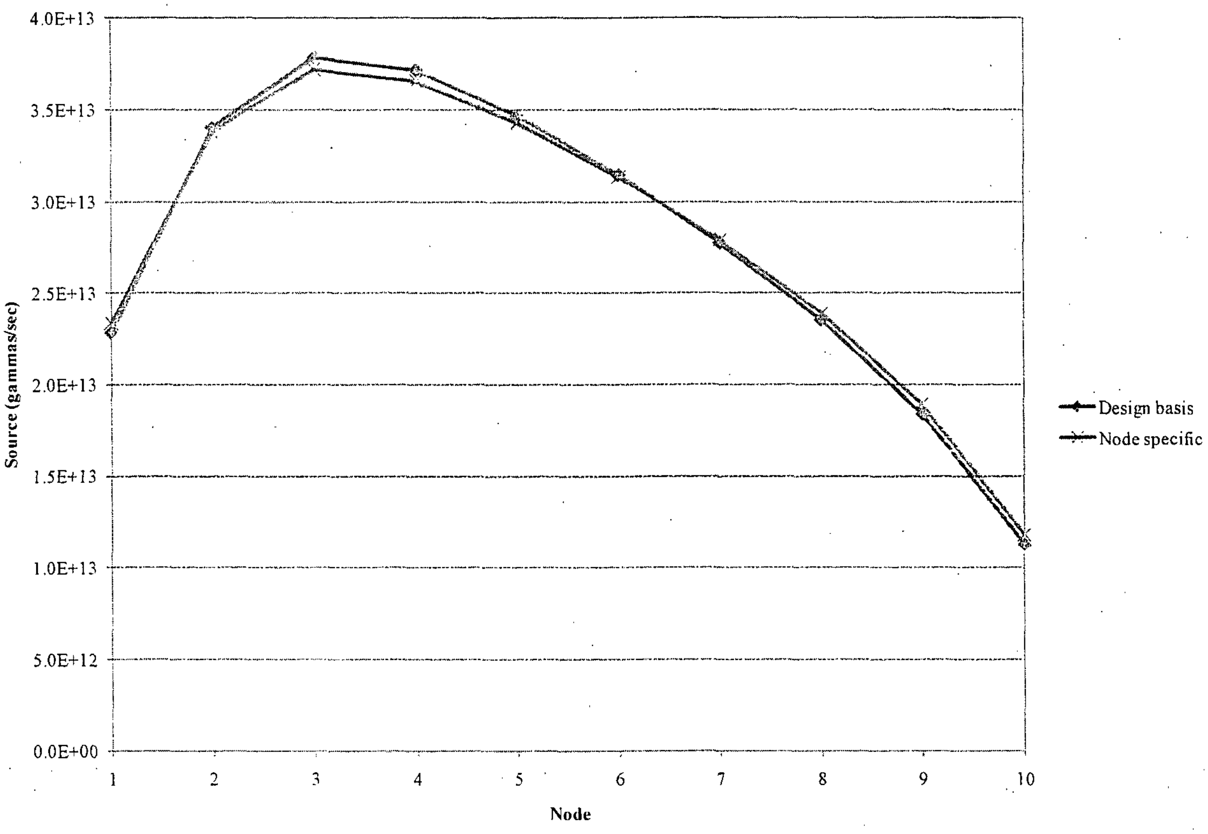

Figure 5.A.2-6 Axial Moderator Density Study Hardware Source Comparison

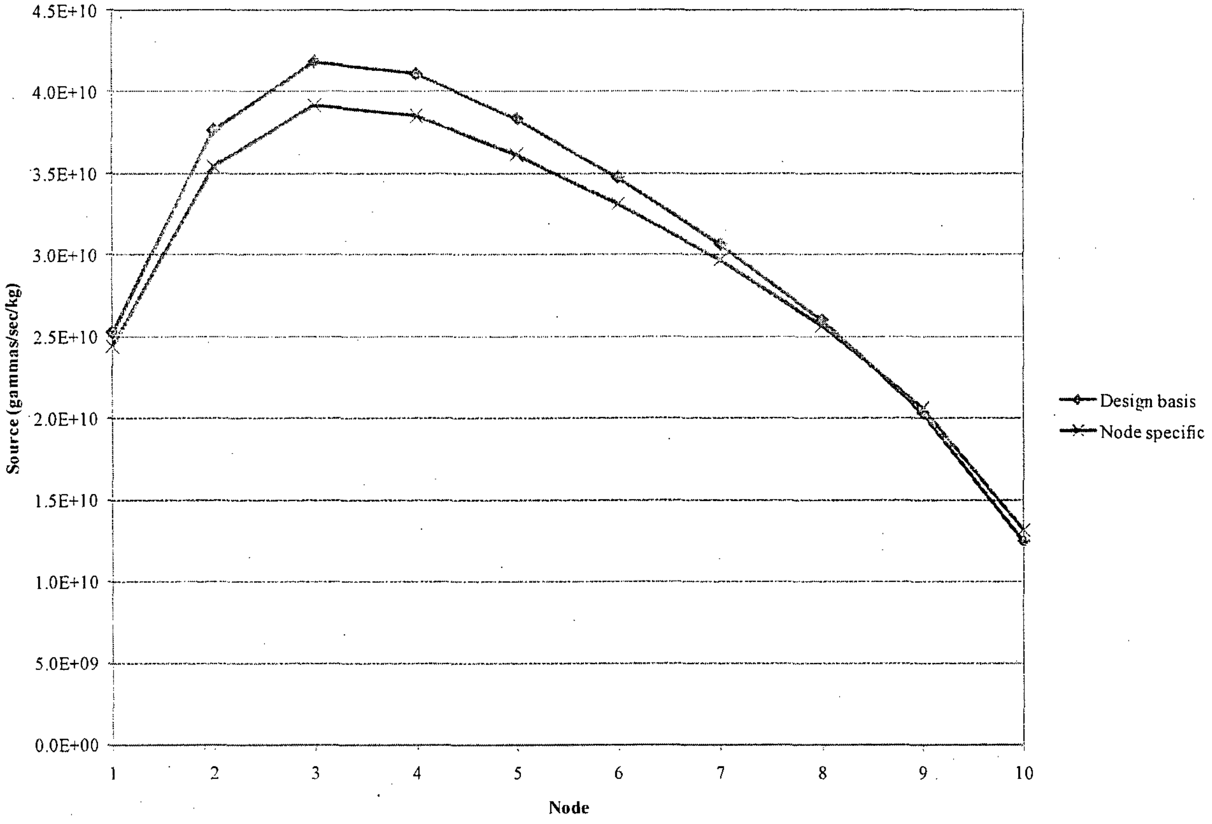

Table 5.A.2-1 MPC-LACBWR Fuel Characteristics for Shielding Evaluations

Parameter	AC Fuel	ENC Fuel
Upper End Fitting Height [cm]	10.8204	9.5504
Gap Fuel Rod to Upper End Fitting [cm]	0.4572	1.3970
Top End-Cap Height [cm]	3.2512	0.9804
Upper Plenum Region Height [cm]	9.3218	9.8806
Active Length [cm]	210.8200	210.8200
Bottom End-Cap Height [cm]	1.6764	1.4605
Gap Fuel Rod to Lower End Fitting [cm]	0.2032	0.2794
Lower End Fitting Height [cm]	25.4000	25.4000
Fuel Rod Height [cm]	223.0628	223.5962
Fuel Assembly Height [cm]	259.9436	260.2230
Fuel Assembly Width [cm]	14.2494	14.2596
Rod Diameter [cm]	1.0058	1.0008
Clad Thickness [cm]	0.0508	0.0559
Pellet Diameter [cm]	0.8890	0.8712
Pitch [cm]	1.4351	1.4148
Number of Fuel Rods	100	96
Number of Inert Rods	0	4
Fuel Loading [MTU]	0.1201	0.1107

Table 5.A.2-2 MPC-LACBWR Fuel Reactor Operating Conditions

Parameter	**AC Fuel**	**ENC Fuel**
Fuel Temperature [K]	814	814
Clad Temperature [K]	594	594
Inlet Moderator Temperature [K]	569	569
Outlet Moderator Temperature [K]	576	576
Inlet Moderator Density (0% void) [g/cm^3]	0.723	0.723
Outlet Moderator Density (40% void) [g/cm^3]	0.434	0.434
Modeled Power Level [MW/assy]	2.41	2.41
Assembly Average Fuel Burnup [MWd/MTU]	22,000	21,000
Initial Enrichment [wt % ^{235}U]	3.6	3.6
Minimum Cool Time [years]	28	23
Number of Cycles	2	2
Burnup Cycle [days]	549.03	483.05
Down Time [days]	60	60

Table 5.A.2-3 MPC-LACBWR Fuel Assembly Neutron Spectra

Group	E Lower [MeV]	E Upper [MeV]	Fuel Neutron Source [neutrons/sec/assy]	
			AC Fuel	**ENC Fuel**
1	1.360E+01	1.460E+01	0.000E+00	0.000E+00
2	1.250E+01	1.360E+01	1.160E+02	8.336E+01
3	1.125E+01	1.250E+01	4.835E+02	3.474E+02
4	1.000E+01	1.125E+01	1.606E+03	1.154E+03
5	8.250E+00	1.000E+01	5.038E+03	3.619E+03
6	7.000E+00	8.250E+00	1.353E+04	9.719E+03
7	6.070E+00	7.000E+00	2.335E+04	1.678E+04
8	4.720E+00	6.070E+00	7.813E+04	5.613E+04
9	3.680E+00	4.720E+00	1.466E+05	1.055E+05
10	2.870E+00	3.680E+00	2.603E+05	1.883E+05
11	1.740E+00	2.870E+00	6.263E+05	4.534E+05
12	6.400E-01	1.740E+00	7.396E+05	5.327E+05
13	3.900E-01	6.400E-01	1.762E+05	1.266E+05
14	1.100E-01	3.900E-01	6.135E+04	4.409E+04
15	6.740E-02	1.100E-01	2.485E+01	1.826E+01
16	2.480E-02	6.740E-02	0.000E+00	0.000E+00
17	9.120E-03	2.480E-02	0.000E+00	0.000E+00
18	2.950E-03	9.120E-03	0.000E+00	0.000E+00
19	9.610E-04	2.950E-03	0.000E+00	0.000E+00
20	3.540E-04	9.610E-04	0.000E+00	0.000E+00
21	1.660E-04	3.540E-04	0.000E+00	0.000E+00
22	4.810E-05	1.660E-04	0.000E+00	0.000E+00
23	1.600E-05	4.810E-05	0.000E+00	0.000E+00
24	4.000E-06	1.600E-05	0.000E+00	0.000E+00
25	1.500E-06	4.000E-06	0.000E+00	0.000E+00
26	5.500E-07	1.500E-06	0.000E+00	0.000E+00
27	7.090E-08	5.500E-07	0.000E+00	0.000E+00
28	1.000E-11	7.090E-08	0.000E+00	0.000E+00
		Total	2.133E+06	1.538E+06

Table 5.A.2-4 MPC-LACBWR Fuel Assembly Gamma Spectra

Group	E Lower [MeV]	E Upper [MeV]	Fuel Gamma Source [photons/sec/assy]	
			AC Fuel	ENC Fuel
1	1.20E+01	1.40E+01	0.0000E+00	0.0000E+00
2	1.00E+01	1.20E+01	5.2748E+01	3.7992E+01
3	8.00E+00	1.00E+01	1.0215E+03	7.3577E+02
4	6.50E+00	8.00E+00	4.8213E+03	3.4728E+03
5	5.00E+00	6.50E+00	2.4653E+04	1.7759E+04
6	4.00E+00	5.00E+00	6.1637E+04	4.4405E+04
7	3.00E+00	4.00E+00	1.8349E+05	1.3653E+05
8	2.50E+00	3.00E+00	2.8405E+07	1.9500E+07
9	2.00E+00	2.50E+00	4.2540E+08	4.3660E+08
10	1.66E+00	2.00E+00	8.4076E+09	8.6387E+09
11	1.44E+00	1.66E+00	7.5368E+10	8.4560E+10
12	1.22E+00	1.44E+00	8.2048E+11	9.4881E+11
13	1.00E+00	1.22E+00	5.0505E+11	5.6041E+11
14	8.00E-01	1.00E+00	1.0605E+12	1.2089E+12
15	6.00E-01	8.00E-01	1.3546E+14	1.3482E+14
16	4.00E-01	6.00E-01	2.3939E+12	2.5708E+12
17	3.00E-01	4.00E-01	3.2789E+12	3.3648E+12
18	2.00E-01	3.00E-01	4.7419E+12	4.8793E+12
19	1.00E-01	2.00E-01	1.5283E+13	1.5782E+13
20	5.00E-02	1.00E-01	2.4748E+13	2.4520E+13
21	2.00E-02	5.00E-02	5.1398E+13	5.2381E+13
22	1.00E-02	2.00E-02	3.9346E+13	3.9607E+13
		Total	2.7912E+14	2.8074E+14

Table 5.A.2-5 MPC-LACBWR Activated Hardware Gamma Spectra

Group	E Lower [MeV]	E Upper [MeV]	Hardware Source [photons/sec/kg]	
			AC Fuel	ENC Fuel
1	1.20E+01	1.40E+01	0.0000E+00	0.0000E+00
2	1.00E+01	1.20E+01	0.0000E+00	0.0000E+00
3	8.00E+00	1.00E+01	0.0000E+00	0.0000E+00
4	6.50E+00	8.00E+00	0.0000E+00	0.0000E+00
5	5.00E+00	6.50E+00	0.0000E+00	0.0000E+00
6	4.00E+00	5.00E+00	0.0000E+00	0.0000E+00
7	3.00E+00	4.00E+00	6.7528E-17	5.3279E-17
8	2.50E+00	3.00E+00	2.4089E+03	4.4665E+03
9	2.00E+00	2.50E+00	1.5535E+06	2.8805E+06
10	1.66E+00	2.00E+00	1.3627E-14	1.0752E-14
11	1.44E+00	1.66E+00	4.1293E-01	7.6567E-01
12	1.22E+00	1.44E+00	1.4717E+11	2.7288E+11
13	1.00E+00	1.22E+00	1.5512E+11	2.8763E+11
14	8.00E-01	1.00E+00	1.0327E+07	1.9159E+07
15	6.00E-01	8.00E-01	2.7388E+05	5.0783E+05
16	4.00E-01	6.00E-01	7.8863E+05	1.4623E+06
17	3.00E-01	4.00E-01	1.2478E+07	2.3137E+07
18	2.00E-01	3.00E-01	9.5103E+06	1.7634E+07
19	1.00E-01	2.00E-01	1.9153E+08	3.5514E+08
20	5.00E-02	1.00E-01	7.9407E+08	1.4722E+09
21	2.00E-02	5.00E-02	2.3122E+09	4.2486E+09
22	1.00E-02	2.00E-02	2.8706E+09	5.1599E+09
Total			3.0849E+11	5.7181E+11

Table 5.A.2-6 MPC-LACBWR Fuel Assembly Activated Hardware Mass and Mass Scale Factors by Source Region

Allis Chalmers			
Source Region	**Hardware Mass [kg]**	**Flux Factor**	**Effective Mass [kg]**
Lower End Fitting	7.607	0.15	1.141
Active Fuel	25.999	1	25.999
Upper Plenum	3.588	0.2	0.718
Upper End Fitting	1.952	0.1	0.195
		Total	28.053
Exxon Nuclear Company			
Source Region	**Hardware Mass [kg]**	**Flux Factor**	**Effective Mass [kg]**
Lower End Fitting	11.372	0.15	1.706
Active Fuel	28.381	1	28.381
Upper Plenum	2.614	0.2	0.523
Upper End Fitting	1.350	0.1	0.135
		Total	30.745

Table 5.A.2-7 MPC-LACBWR Fuel Assembly Decay Heat

Source	**AC Fuel**	**ENC Fuel**
Actinides [W/assy]	1.590E+01	1.170E+01
Fission Products [W/assy]	4.530E+01	4.590E+01
Light Elements [W/kg]	6.160E-02	1.140E-01
Total [W/assy]	62.9	61.1

Table 5.A.2-8 MPC-LACBWR Axial Gamma and Neutron Source Profiles

% Core Height	Elevation [cm]	Burnup Profile	Photon Source	Neutron Source
0%	27.2796	0.000	0.000	0.000E+00
10%	48.3616	0.405	0.405	2.205E-02
20%	69.4436	1.232	1.232	2.412E+00
30%	90.5256	1.360	1.360	3.660E+00
40%	111.6076	1.333	1.333	3.363E+00
50%	132.6896	1.304	1.304	3.065E+00
60%	153.7716	1.235	1.235	2.437E+00
70%	174.8536	1.123	1.123	1.632E+00
80%	195.9356	1.011	1.011	1.047E+00
90%	217.0176	0.880	0.880	5.831E-01
100%	238.0996	0.113	0.113	1.009E-04
		Average	1.000	1.822

Table 5.A.2-9 Source Term Input for Axial Moderator Density Study

Description	Burnup [MWd/MTU]	Moderator [g/cm^3]		Cycle Length [days]
		Out-Lattice	In-Lattice	
Node 1	18,005	0.739	0.739	449.32
Node 2	26,847	0.739	0.736	669.98
Node 3	29,869	0.739	0.711	745.42
Node 4	29,324	0.739	0.679	731.80
Node 5	27,350	0.739	0.649	682.55
Node 6	24,801	0.739	0.621	618.92
Node 7	21,864	0.739	0.596	545.62
Node 8	18,559	0.739	0.573	463.16
Node 9	14,498	0.739	0.553	361.81
Node 10	8,879	0.739	0.539	221.59
Design basis	22,000	0.723	0.434	549.03

Table 5.A.2-10 Result Comparison for Axial Moderator Density Study

Description	Neutron [n/sec]	Gamma [γ/sec]	Hardware [γ/sec/kg]
Design basis (DB)	3.32E+06	2.79E+14	3.08E+11
Node-specific	2.33E+06	2.79E+14	2.96E+11
Difference, DB to node-specific	42.3%	0.0%	4.2%

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5.A.3 MPC-LACBWR Model Specification

The transfer and concrete casks are evaluated using the MCNP three-dimensional Monte Carlo code. In the MCNP fuel assembly model, the fuel and hardware source regions are homogenized within a volume defined by the fuel assembly width and height. This volume is subdivided axially into active fuel, upper plenum, and upper and lower end fitting source regions. Within these axial volumes, the material masses of the fuel assembly are homogenized. In all models, the cask and TSC shield thicknesses and axial extents are explicitly represented, including streaming paths. Surface detectors are used to estimate the dose profiles at the cask surface and at distances of 1 foot, 1 meter, 2 meter, and 4 meters from the cask surface. The MCNP code employs an automated biasing technique for the Monte Carlo calculation based on weight window adjustments in mesh cells. Radial biasing is performed to estimate dose rates at the transfer cask radial surface and concrete cask radial surface, including air inlets and outlets. Axial biasing is used for cask top and bottom surface dose rates. Angular biasing components are used to capture azimuthal variations in the concrete cask air inlets and outlets.

The geometric description of an MCNP model is based on the combinatorial geometry system embedded in the code. In this system, surfaces and bodies, such as cylinders and rectangular parallelepipeds, and their logical intersections and unions, are used to describe the extent of material zones.

5.A.3.1 MPC-LACBWR Fuel Assembly Model

Based on the fuel assembly parameters provided in Table 5.A.2-1 and Table 5.A.2-6, homogenized treatments are developed for fuel assembly source regions. The homogenized fuel assembly is represented in the model as a stack of boxes with width equal to the fuel assembly width. The height of each box corresponds to the modeled height of the corresponding assembly region, as shown in Figure 5.A.2-1. The fuel model is based on the Allis Chalmers radial and axial geometry. The homogenization of nonfuel regions (upper end fitting, upper plenum, and lower end fitting) is based on the minimum hardware masses of the two designs.

The active fuel region homogenization is shown in Table 5.A.3-1. The interstitial material is a void under dry canister conditions and water (density 0.9982 g/cm^3) under wet canister conditions. The clad region is stainless steel (density 7.94 g/cm^3).

Assembly hardware regions are homogenized as shown in Table 5.A.3-2 based on the minimum regional masses from Table 5.A.2-6. The only material included in the homogenized region is stainless steel. Volume fractions of material are based on the modeled region volume and the volume of stainless steel present as computed from the modeled mass and density (7.94 g/cm^3).

5.A.3.2 MPC-LACBWR Canister and Basket Model

The MCNP description of the canister and basket elements forms a common sub-model employed in all storage and transfer cask analyses. The key features of the basket model are the detailed representation of fuel tubes, basket support and heat transfer disks, and weldment structures. The key feature of the canister model is the inclusion of the vent and drain ports in the canister shield lid.

The vent and drain ports in the canister shield lid are modeled as a series of three stacked cylinders. The port cover is also modeled, but may or may not be in place depending on the particular operational condition specified. In the axial analysis of the transfer cask, the vent and drain port covers are assumed to be installed when the canister is in a dry condition, and removed when the canister is modeled in a wet condition. Port covers are in place in all storage cask model analyses. The port cover is modeled as a solid piece of stainless steel.

The basket model conservatively omits the uppermost and lowermost support disks and models 33% less absorber sheets than specified in the License drawings.

The closure lid diameter is modeled flush with the canister inner shell diameter, not modeling the gap between the closure lid diameter and the canister shell inner diameter. However, radiation streaming through this gap is not a concern due to the following factors: a) the lid support ring will reduce streaming, b) the lid is welded to the canister shell, and c) the closure ring is welded to the canister shell and the closure lid.

The three-dimensional canister/basket model is shown in Figure 5.A.3-1.

5.A.3.3 MPC-LACBWR Transfer Cask Model

In order to estimate occupational dose rates associated with the canister sealing operation, two operational configurations of the transfer cask are considered for the three-dimensional model of the upper cask region. These include wet canister conditions without port covers and dry canister conditions with port covers.

The top configuration of the transfer cask is evaluated in detail for the welding, draining, and drying operations. Model features include:

- Vent and drain port openings in the canister shield lid.
- Upper trunnions cut through the radial shield and extend from the inner shell to the outer shell. No credit for the radial extent of the trunnions outside the cask outer shell is taken.
- Lead and neutron shielding overlap at the top as per the transfer cask drawings.

- Termination of the radial shields at the bottom plate.
- An explicit model of the bottom door assembly.

Details of the elevations and radii used in creating the three-dimensional top model are taken directly from the drawings in Section 1.A.7. Elevations associated with the transfer cask three-dimensional features are established with respect to the center bottom of the canister bottom plate for the MCNP combinatorial geometry model. The three-dimensional transfer cask model is shown in Figure 5.A.3-2.

5.A.3.4 MPC-LACBWR Storage Cask Model

The three-dimensional model of the vertical concrete cask is based on the following features of the storage cask:

- Heat transfer annulus.
- Carbon steel weldment with cutouts for inlets and outlets.
- Concrete shield with rebar.
- Inlet and outlet models including carbon steel channel walls.
- Concrete and carbon steel top lid.
- Carbon steel bottom base plate and cover.
- Carbon steel support stand with four cutouts for air flow.
- Carbon steel storage cask bottom.
- Concrete pad below base plate.

Detailed model parameters used in creating the three-dimensional model are taken directly from the drawings in Section 1.A.7. Elevations associated with the concrete cask three-dimensional features are established with respect to the center bottom of the canister for the MCNP combinatorial model. The three-dimensional concrete cask model is shown in Figure 5.A.3-3.

A detailed sketch of the cask outlet model is shown in Figure 5.A.3-4 in terms of labeled key points in the model. Dimensions for the key points are shown in Table 5.A.3-3.

The bottom weldment model is detailed in Figure 5.A.3-5. The figure shows two sections through the bottom weldment assembly model. The portion of the figure to the left of the centerline is a section through an inlet location. The portion to the right of the centerline is a section through a non-inlet location.

5.A.3.5 MPC-LACBWR Detector Mesh Definition

MCNP surface detectors are used to calculate dose rates at various distances from the casks. The surface tallies are subdivided using the FS tally segmentation card. A graphical illustration of the detector overlay on a cask is shown in Figure 5.A.3-6. Depicted are 1 foot, 1 meter, 2 meter, and 4 meter detector surfaces on the concrete cask. For clarity, the cask surface detector and azimuthal (angular) divisions are not shown. Typical detector grids for the transfer and concrete cask analysis are shown in Table 5.A.3-4 through Table 5.A.3-6. The dose rate maps produced by this method completely enclose the accessible cask surfaces and capture all locations necessary for the evaluation of occupational exposures.

5.A.3.6 MPC-LACBWR Shield Regional Densities

Based on the homogenization described in Section 5.A.3.1, the resulting active fuel regional densities are shown in Table 5.A.3-7. Material descriptions are shown for both wet and dry canister conditions. The upper end fitting is modeled as dry under all scenarios to simulate the partial draindown that occurs prior to welding operations.

Material compositions for the remaining structural and shield materials are shown in Table 5.A.3-8.

Figure 5.A.3-1 MPC-LACBWR Three-Dimensional Canister/Basket Model Detail

Figure Withheld Under 10 CFR 2.390

Figure 5.A.3-2 MPC-LACBWR Three-Dimensional Transfer Cask Model

Figure WIthheld Under 10 CFR 2.390

Figure 5.A.3-3 MPC-LACBWR Three-Dimensional Concrete Cask Model

Figure Withheld Under 10 CFR 2.390

Figure 5.A.3-4 MPC-LACBWR Three-Dimensional Storage Cask Outlet Model Detail

Figure Withheld Under 10 CFR 2.390

Figure 5.A.3-5 MPC-LACBWR Three-Dimensional Storage Cask Bottom Weldment Model Detail

Figure WIthheld Under 10 CFR 2.390

Figure 5.A.3-6 MPC-LACBWR Detector Grid Locations for Concrete Cask

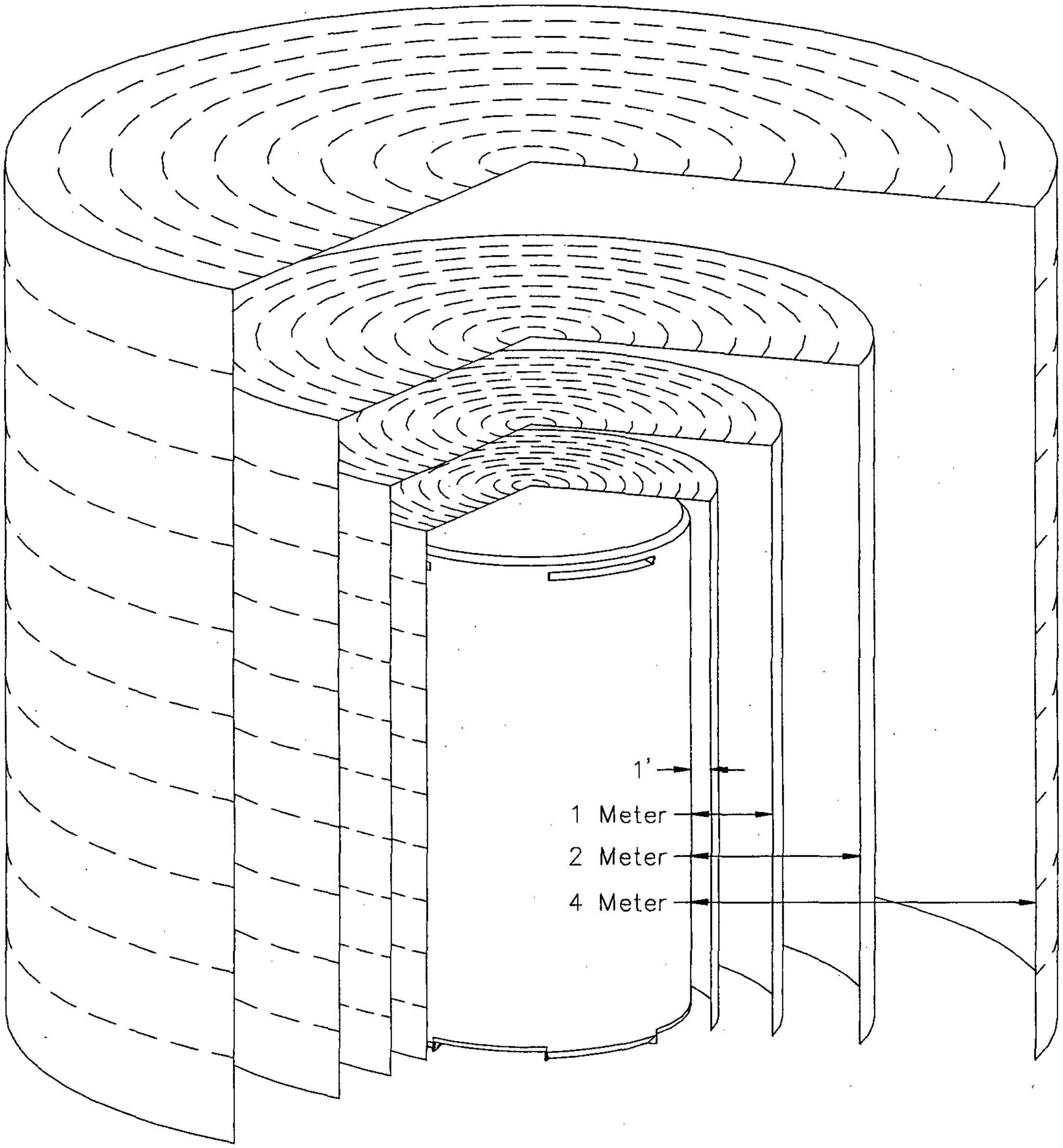

Table 5.A.3-1 MPC-LACBWR Active Fuel Region Homogenization

Component	Volume Fraction of Components			
	UO_2	Void	Clad	Interstitial
Fuel	3.0570E-01	--	--	--
Gap	--	1.0571E-02	--	--
Clad	--	--	7.5066E-02	--
Interstitial	--	--	--	6.0866E-01
Total	3.0570E-01	1.0571E-02	7.5066E-02	6.0866E-01

Table 5.A.3-2 MPC-LACBWR Fuel Assembly Hardware Region Homogenization

Region	Mass SS [kg/assy]	SS Volume [cm^3/assy]	Height [cm]	Volume [cm^3/assy]	Volume Fraction
Lower End Fitting	7.607	9.5806E+02	27.2796	5.5390E+03	1.7297E-01
Upper Plenum	2.614	3.2922E+02	13.0302	2.6457E+03	1.2443E-01
Upper End Fitting	1.350	1.7003E+02	10.8204	2.1970E+03	7.7389E-02

Table 5.A.3-3 MPC-LACBWR Storage Cask Outlet Model Parameters

Key Point[1]	Radial Dimension		Axial Dimension[2]	
	[in]	[cm]	[in]	[cm]
a	54.400	138.176	119.550	303.657
b	54.400	138.176	119.925	304.610
c	50.400	128.016	123.925	314.770
d	50.025	127.064	124.300	315.722
e	56.400	143.256	119.550	303.657
f	56.400	143.256	127.850	324.739
g	54.400	138.176	128.225	325.692
h	50.400	128.016	132.225	335.852
i	50.025	127.064	132.600	336.804
j	64.000	162.560	132.600	336.804
k	64.000	162.560	132.225	335.852
l	64.000	162.560	128.225	325.692
m	64.000	162.560	127.850	324.739

1. Refer to Figure 5.A.3-4.
2. Dimension with respect to bottom of canister bottom plate.

Table 5.A.3-4 MPC-LACBWR Typical Radial Surface Detector Division

Transfer Cask			Concrete Cask		
Location	Axial Div	Azimuthal Div	Location	Axial Div	Azimuthal Div
Surface	15	1	Surface	12	1
1ft	15	1	1ft	12	1
1m	20	1	1m	12	1
2m	20	1	2m	20	1
4m	20	1	4m	20	1

Table 5.A.3-5 MPC-LACBWR Typical Top Surface Detector Division

Transfer Cask			Concrete Cask		
Location	Radial Div	Azimuthal Div	Location	Radial Div	Azimuthal Div
Surface	12	1	Surface	10	1
1ft	12	1	1ft	10	1
1m	12	1	1m	10	1
2m	12	1	2m	10	1
4m	12	1	4m	10	1
Port Surface[1]	1	64	Air Outlet[2]	1	20

Table 5.A.3-6 MPC-LACBWR Typical Air Inlet and Outlet Detector Division

Location	Axial Div[3]	Inlet Azimuthal Div	Outlet Azimuthal Div
Surface	1	36	20
1ft	1	36	20

---

[1] Radial restricted to radial location of vent and drain ports.
[2] Radial restricted to area above air outlets.
[3] Elevation restricted to air inlet and outlet height.

Table 5.A.3-7 MPC-LACBWR Homogenized Fuel Assembly Regional Densities

Material	Nuclide/ Element	Dry Conditions		Wet Conditions	
		Density [atom/-b-cm]	**Density [g/cm^3]**	**Density [atom/-b-cm]**	**Density [g/cm^3]**
Lower End Fitting	Cr	3.0222E-03	1.3734	3.0222E-03	2.1989
	Mn	3.0109E-04		3.0107E-04	
	Fe	1.0293E-02		1.0292E-02	
	Ni	1.3387E-03		1.3386E-03	
	H	--		5.4810E-02	
	O	--		2.7628E-02	
Fuel	Cr	1.3116E-03	3.7790	1.3116E-03	4.3866
	Mn	1.3067E-04		1.3067E-04	
	Fe	4.4666E-03		4.4668E-03	
	Ni	5.8094E-04		5.8095E-04	
	U-235	2.5880E-04		2.5880E-04	
	U-238	6.8424E-03		6.8425E-03	
	O	1.4201E-02		3.4534E-02	
	H	--		4.0339E-02	
Upper Plenum	Cr	2.1741E-03	0.9880	2.1742E-03	1.5956
	Mn	2.1660E-04		2.1660E-04	
	Fe	7.4044E-03		7.4046E-03	
	Ni	9.6302E-04		9.6305E-04	
	H	--		4.0338E-02	
	O	--		2.0333E-02	
Upper End Fitting	Cr	1.3522E-03	0.6145	1.3522E-03	0.6145
	Mn	1.3472E-04		1.3472E-04	
	Fe	4.6052E-03		4.6052E-03	
	Ni	5.9896E-04		5.9896E-04	

Table 5.A.3-8 MPC-LACBWR Structural and Shield Material Regional Densities

Material	**Nuclide/ Element**	**Density [atom/-b-cm]**	**Density [g/cm^3]**
Water	H	6.6752E-02	0.9982
	O	3.3376E-02	
Stainless Steel	Cr	1.7472E-02	7.9400
	Mn	1.7407E-03	
	Fe	5.9505E-02	
	Ni	7.7392E-03	
Carbon Steel	Fe	8.3494E-02	7.8212
	C	3.9250E-03	
Neutron Poison	Al	5.0464E-02	2.6707
	B-10	3.4695E-03	
	B-11	1.4389E-02	
	C	4.4631E-03	
Aluminum	Al	6.0262E-02	2.7000
Lead	Pb	3.2967E-02	11.344
NS-4-FR	B-10	9.1384E-05	1.6316
	Al	7.8002E-03	
	C	2.2621E-02	
	B-11	3.3665E-04	
	H	5.8507E-02	
	N	1.3904E-03	
	O	2.6107E-02	
Concrete	Fe	3.5073E-04	2.3233
	Ca	1.5360E-03	
	Si	1.6788E-02	
	H	1.3882E-02	
	O	4.6535E-02	
	Na	1.7649E-03	
	Al	1.7630E-03	

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5.A.4 MPC-LACBWR Storage System Shielding Evaluation

Shielding calculations are performed for the transfer cask and storage cask designs using the source terms from the two design basis fuel types described in Section 5.A.2: Allis Chalmers fuel at 22,000 MWd/MTU and 28 years cool time and Exxon Nuclear Company fuel at 21,000 MWd/MTU and 23 years cool time. The Allis Chalmers fuel source is modeled in the 32 peripheral basket locations and the Exxon Nuclear Company source is modeled in the 36 interior basket locations. The resulting dose rate profiles are reported as a function of distance from the radial and axial surfaces of the MPC-LACBWR storage cask and transfer cask.

5.A.4.1 MPC-LACBWR Calculational Methods

The shielding evaluations of the transfer and concrete cask are performed with MCNP5 [A1]. Source terms include fuel neutron, fuel gamma, and gamma contributions from activated hardware. As described in Section 5.A.2.3, these evaluations include the effect of fuel burnup peaking on fuel neutron and gamma source terms.

The MCNP shielding models described in Section 5.A.3 are used with the source terms described in Section 5.A.2 to estimate the dose rate profiles at the cask surface and at distances of 1 foot, 1 meter, 2 meters, and 4 meters. The method of solution is continuous energy Monte Carlo, with a Monte Carlo based weight window generator to accelerate code convergence. Radial or axial biasing is performed, depending on the desired dose location. Azimuthal components are included in the weight window mesh to account for the angular variations in the bulk shielding properties of the concrete cask at the inlets and outlets and at the TSC lid ports (transfer evaluation only).

Significant validation literature is available for MCNP, as it is an industry standard tool for spent fuel cask evaluations. Available literature covers a range of shielding penetration problems ranging from slab geometry to spent fuel cask geometries [A2-A6]. Confirmatory calculations against other validated shielding codes [SCALE (ORNL) and MCBEND (Serco Assurance)] on NAC casks have further validated the use of MCNP for shielding evaluations.

5.A.4.2 MCNP Flux-to-Dose Rate Conversion Factors

The ANSI/ANS 6.1.1-1977 flux-to-dose rate conversion factors are used in all cask shielding evaluations. Neutron and gamma dose conversion factors are listed in Table 5.A.4-1 and Table 5.A.4-2, respectively.

5.A.4.3 MPC-LACBWR Storage Cask Three-Dimensional Dose Rates

5.A.4.3.1 Undamaged Fuel

Storage cask three-dimensional model side dose rates are presented in Figure 5.A.4-1. The figure shows the dose rate profiles at various radial distances from the cask surface. Figure 5.A.4-2 shows the contributions to the radial surface dose rate from each source component. Figure 5.A.4-3 shows the corresponding top axial dose rate profile at various axial distances from the cask surface and Figure 5.A.4-4 gives the contributions to the top axial surface dose rate from each source type. The azimuthal dose profile at the air inlet elevation is shown in Figure 5.A.4-5. Similarly, the azimuthal dose rate profile at the cask air outlets is shown in Figure 5.A.4-6.

The maximum radial and top axial surface dose rates for the storage cask are 28.9 (1.3%) and 18.7 (6.9%) mrem/hr, respectively. At the inlet locations, the average dose rate of the four symmetric inlet openings is 38.3 (1.4%) mrem/hr. At the outlets, the average dose rate at the four symmetric outlet locations is 2.0 (0.5%) mrem/hr.

Under accident conditions involving a projectile impact and a loss of 6 inches of concrete, the surface dose rate increases to 278 mrem/hr at the impact location and 105 mrem/hr at a distance of 1 meter from the surface.

5.A.4.3.2 Damaged Fuel

To ensure that the worst case configuration is considered, two damaged fuel scenarios are evaluated for the 32 peripheral basket locations.

The first scenario assumes the damaged fuel collects over the active fuel length of the fuel assembly. This scenario is modeled by filling the fuel rod interstitial volume with UO_2 and increasing the fuel neutron, gamma, and n-gamma source consistent with this increase in mass. A comparison of dose rate profiles for the 68 assembly intact fuel results and 36 intact and 32 damaged assemblies, shown in Figure 5.A.4-7 and Figure 5.A.4-8, demonstrates that the damaged fuel model dose rates are less due to the increase in self-shielding from the 32 peripheral assemblies compensating for the increase in source strength.

In the second scenario, damaged fuel is assumed to migrate from the active fuel into the lower end fitting region of the fuel assembly, filling all the modeled void space. In this case, the combined gamma and neutron sources result in a maximum radial dose rate of 4.3 mrem/hr at the bottom of the cask (average increase of 1.0 mrem/hr), shown in Figure 5.A.4-9. The inlet dose rate increase, as shown in Figure 5.A.4-10, is 36.7 mrem/hr, effectively doubling the air inlet dose rate. However, no credit is taken for the reduction in lower end fitting hardware dose rate due to the added UO_2 mass and self-shielding nor for the reduction in fuel mass migrated from the active fuel region.

5.A.4.4 MPC-LACBWR Transfer Cask Three-Dimensional Dose Rates

The MPC-LACBWR transfer cask is analyzed under wet and dry conditions corresponding with the operational configurations associated with loading the canister with spent fuel assemblies in a fuel pool environment. Under wet conditions, the canister is assumed to be filled with water to the top of the upper plenum region. This distance accounts for the removal of water from the canister prior to welding the closure lid to the canister in order to prevent water contamination of the closure lid weld.

Transfer cask dose rates are calculated for two lid configurations. The first configuration consists of the closure lid without port covers with the canister in the wet condition. The second configuration consists of the closure lid with the canister in the dry condition and port covers are installed.

5.A.4.4.1 Undamaged Fuel

For a wet canister cavity and no port covers, dose rate profiles are shown in Figure 5.A.4-11 through Figure 5.A.4-16. The maximum dose rates are 68.2 (2.3%) and 471.2 (1.7%) mrem/hr on the radial surface and top axial surface, respectively. The bottom surface of the cask has a maximum dose rate of 23.8 (2.2%) mrem/hr.

For a dry canister cavity and installed port covers, dose rate profiles are shown in Figure 5.A.4-17 through Figure 5.A.4-22. The maximum dose rates are 102.2 (5.2%) mrem/hr and 598.7 (1.4%) mrem/hr on the radial and top axial surfaces, respectively. The bottom surface of the cask has a maximum dose rate of 54.2 (2.2%) mrem/hr.

5.A.4.4.2 Damaged Fuel

The same damaged fuel scenarios were analyzed for the transfer cask under dry conditions as those described for the storage cask. Like the storage cask (scenario 1), a comparison of dose rate profiles for the 68 assembly intact fuel results and 36 intact and 32 damaged assemblies, shown in Figure 5.A.4-23 through Figure 5.A.4-25, demonstrates that the damaged fuel model dose rates are less due to the increase in self-shielding from the 32 peripheral assemblies compensating for the increase in source strength. In the second scenario (damaged fuel in the lower end fitting region), the combined gamma and neutron sources result in a maximum radial dose rate of 23.4 mrem/hr at the bottom of the cask (average increase of 3.7 mrem/hr), shown in Figure 5.A.4-26. The bottom axial dose rate increase is 22.1 mrem/hr, shown in Figure 5.A.4-27, increasing the bottom axial dose rate by approximately 41%. As stated previously, no credit is taken for the reduction in lower end fitting hardware dose rate due to the added UO_2 mass and self-shielding nor for the reduction in fuel mass migrated from the active fuel region.

5.A.4.5 Partial Flooding Evaluation

To confirm that the analyzed dry and wet canister conditions bound a partial flooding scenario, additional MCNP inputs were setup to model a canister filled up to 70% of the active fuel region. The results in Figure 5.A.4-28 and Figure 5.A.4-29 demonstrate that the dry canister configuration produces bounding transfer cask dose rates.

5.A.4.6 Validation of Fresh Fuel Material Composition

The validity of the dose rate results summarized herein is based on the ability to apply fresh fuel material composition based MCNP results to spent fuel. To confirm the accuracy of this assumption, radial dose rates are calculated using the SAS2H-calculated isotopic composition of the design basis Allis Chalmers fuel assembly (22,000 MWd/MTU, 3.6 wt % ^{235}U, and 28 years cool time) in the transfer and storage casks and compared to the fresh fuel results. Radial dose rate profiles for fresh and spent fuel isotopics are shown in Figure 5.A.4-30 and Figure 5.A.4-31 and demonstrate the acceptability of the fresh fuel assumption (i.e., there is no significant dose change associated with the fresh fuel model).

5.A.4.7 Justification of Exxon Fuel in DFCs

In the event that an Exxon Nuclear Company fuel assembly is found to be damaged, the assembly may be loaded in a DFC location rather than a standard location. A bounding scenario, under which a basket is loaded with 31 Allis Chalmers assemblies and 37 Exxon Nuclear Company assemblies (36 undamaged and 1 damaged), the change in 68-assembly source is as follows.

Source	31/37 vs. 32/36 Change
Fuel Neutron	-0.5%
Fuel N-Gamma	-0.5%
Fuel Gamma	0.0%
Fuel Hardware	1.0%
Lower End Fitting	1.3%
Upper Plenum	0.4%
Upper End Fitting	0.4%

While a slight azimuthal increase in gamma dose rate may be present at the radial location of the DFC under this scenario, there is no significant change in cask average dose rates when loading Exxon fuel assemblies into DFCs.

Figure 5.A.4-1 MPC-LACBWR Storage Cask Radial Dose Rate Profiles – Undamaged Fuel

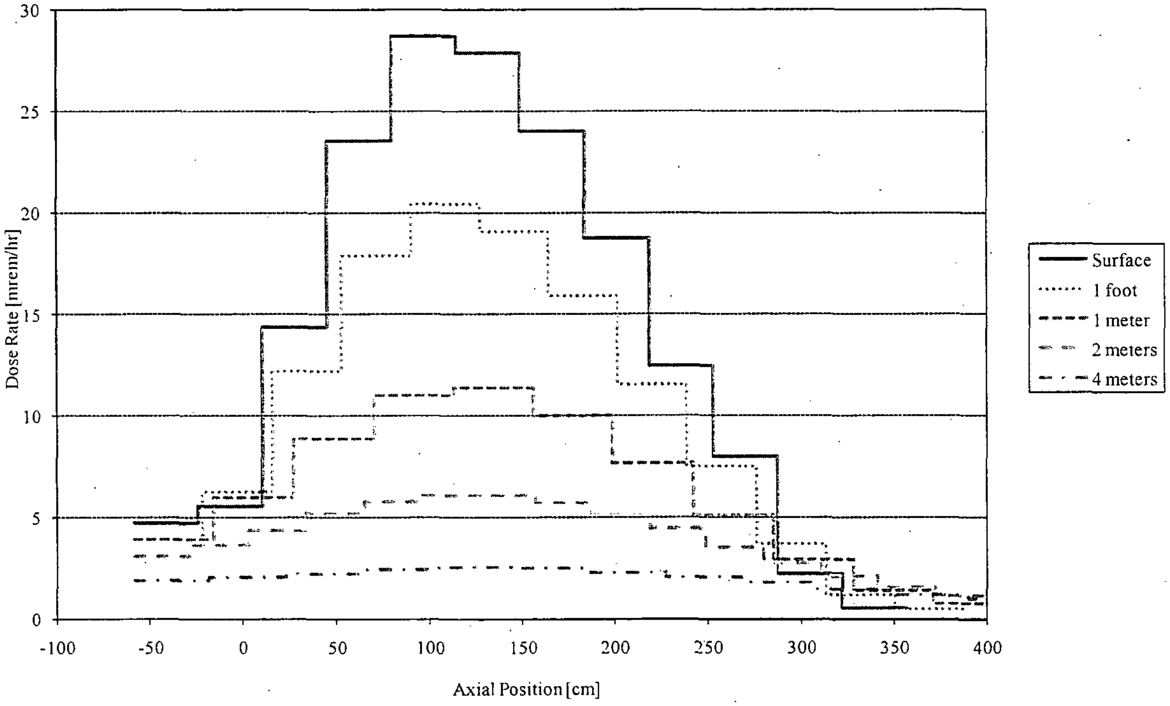

Figure 5.A.4-2 MPC-LACBWR Storage Cask Radial Surface Dose Rate Profile by Source Type – Undamaged Fuel

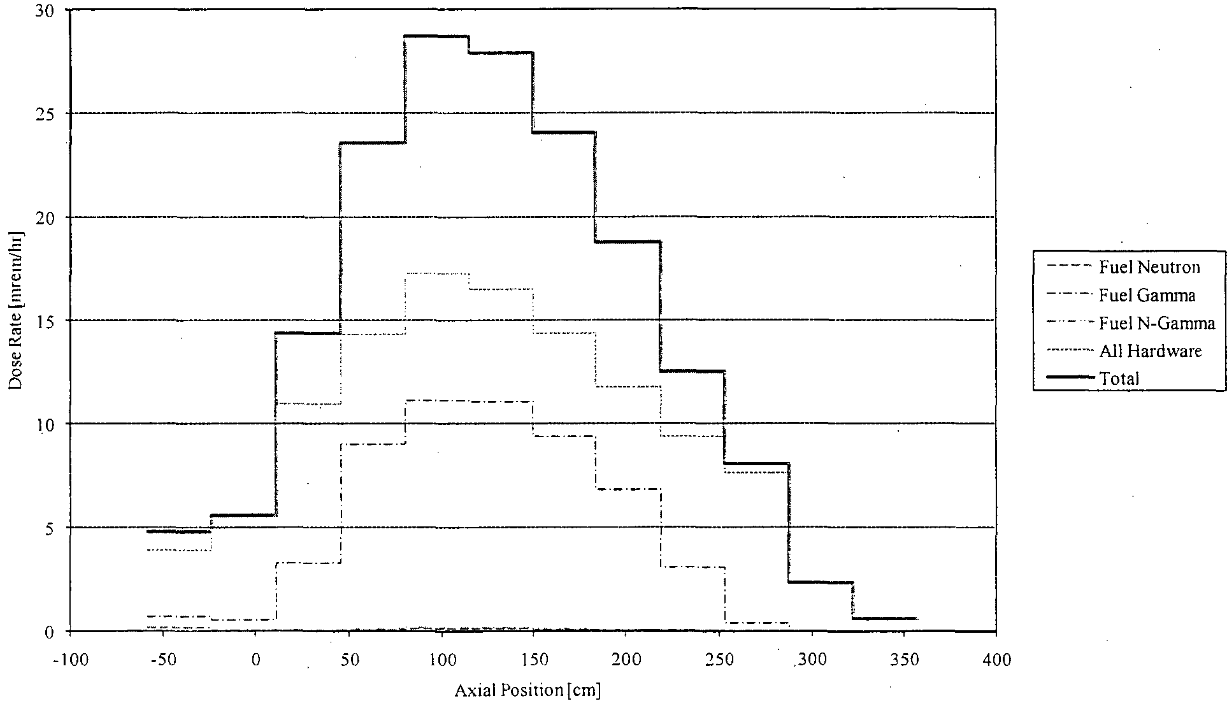

Figure 5.A.4-3 MPC-LACBWR Storage Cask Top Axial Dose Rate Profiles – Undamaged Fuel

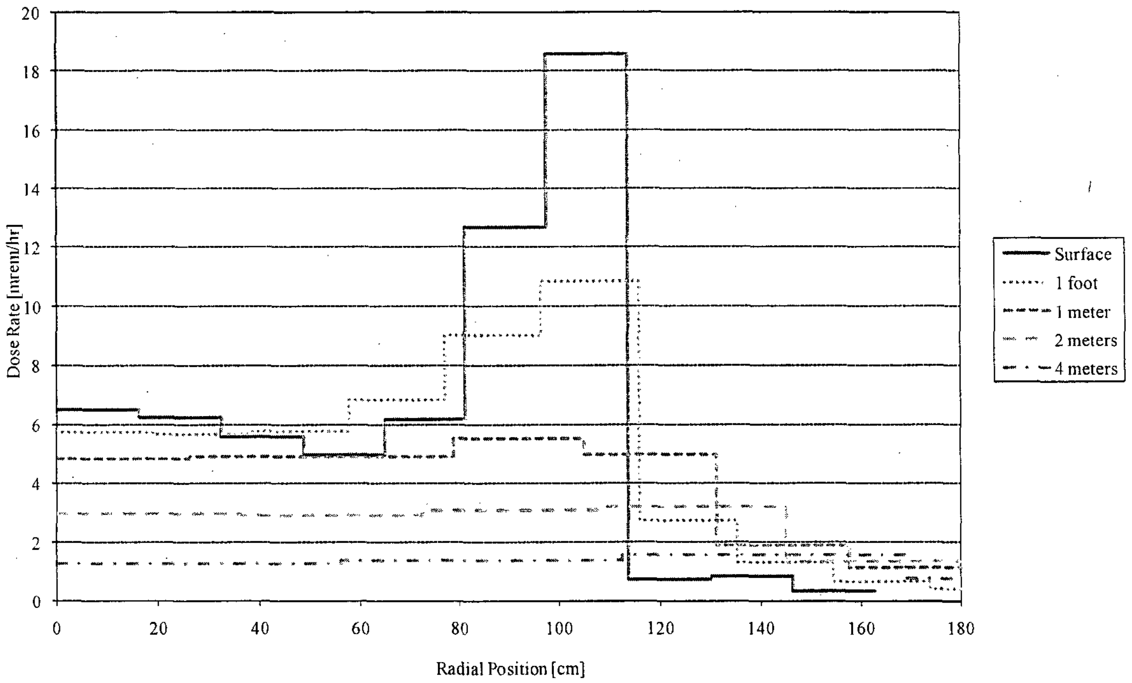

Figure 5.A.4-4 MPC-LACBWR Storage Cask Top Axial Surface Dose Rate Profile by Source Type – Undamaged Fuel

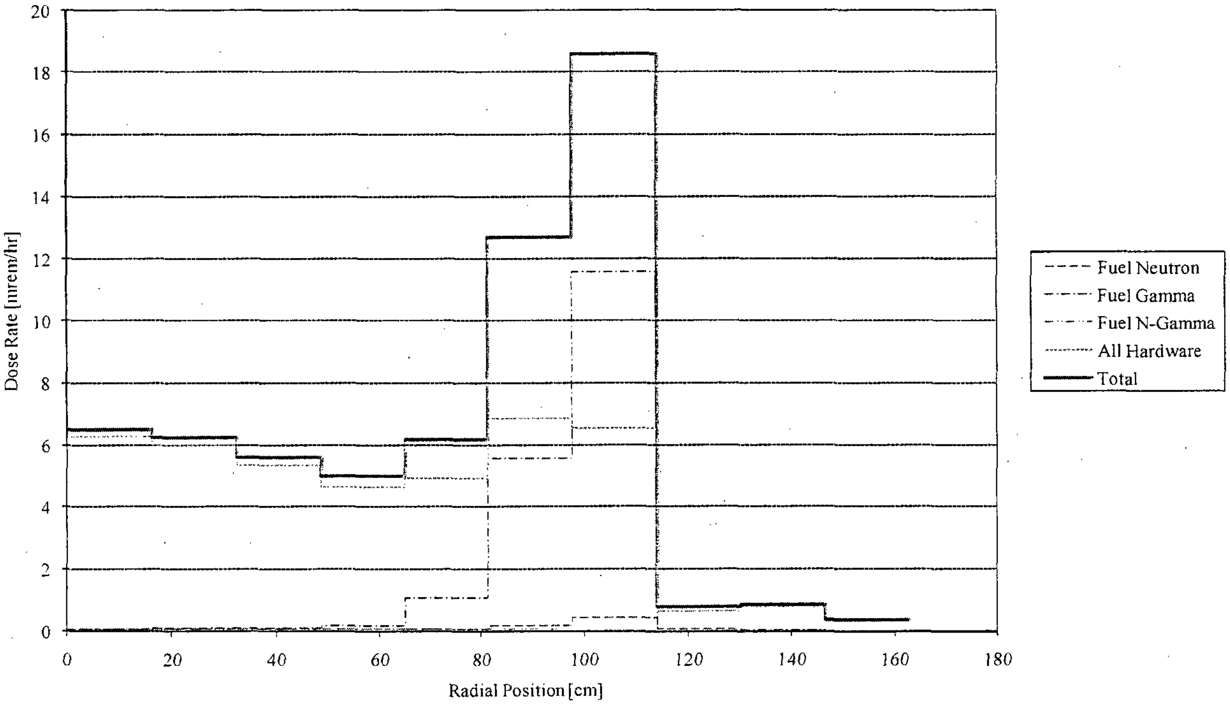

Figure 5.A.4-5 MPC-LACBWR Storage Cask Azimuthal Dose Rate Profile at Air Inlet Elevation – Undamaged Fuel

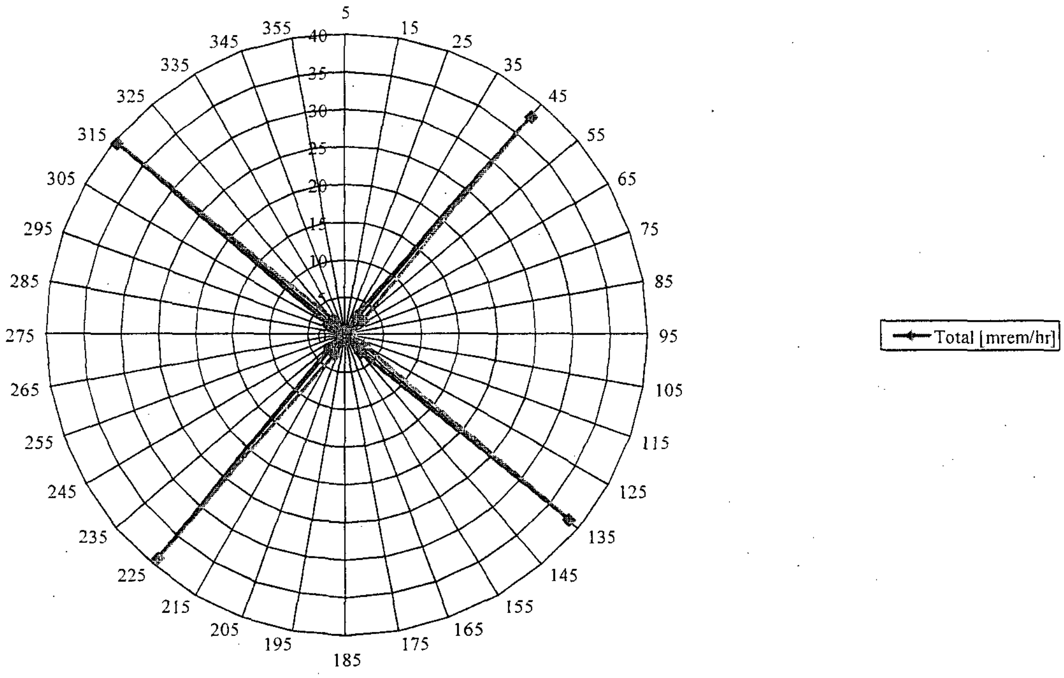

Figure 5.A.4-6 MPC-LACBWR Storage Cask Azimuthal Dose Rate Profile at Air Outlet Elevation – Undamaged Fuel

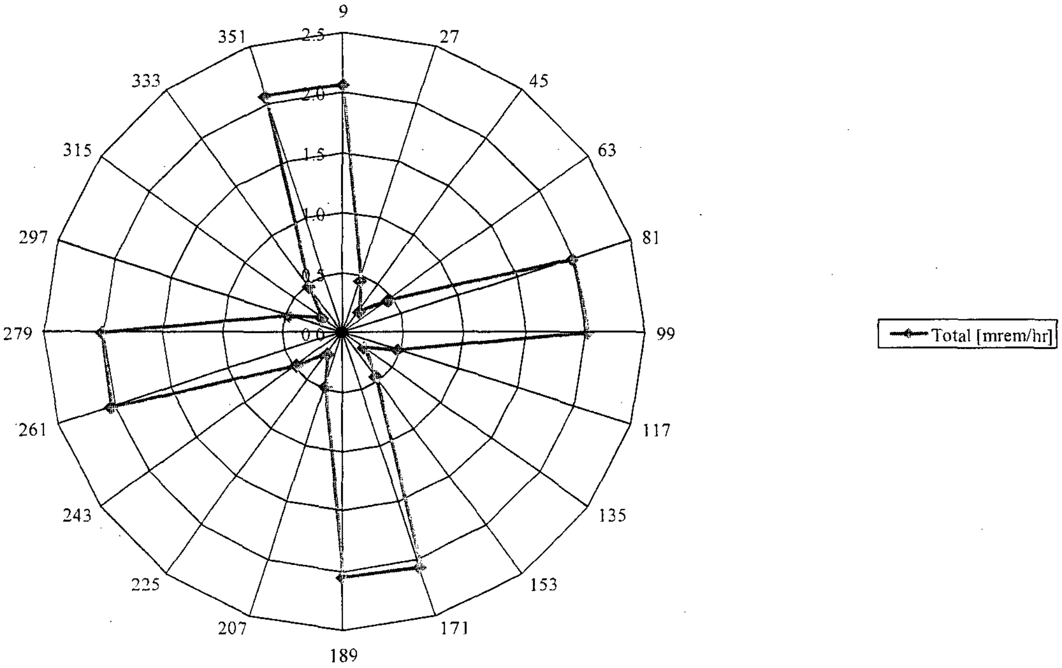

Figure 5.A.4-7 Dose Rate Profile Comparison at Radial Surface of Storage Cask – Active Fuel Damaged Fuel

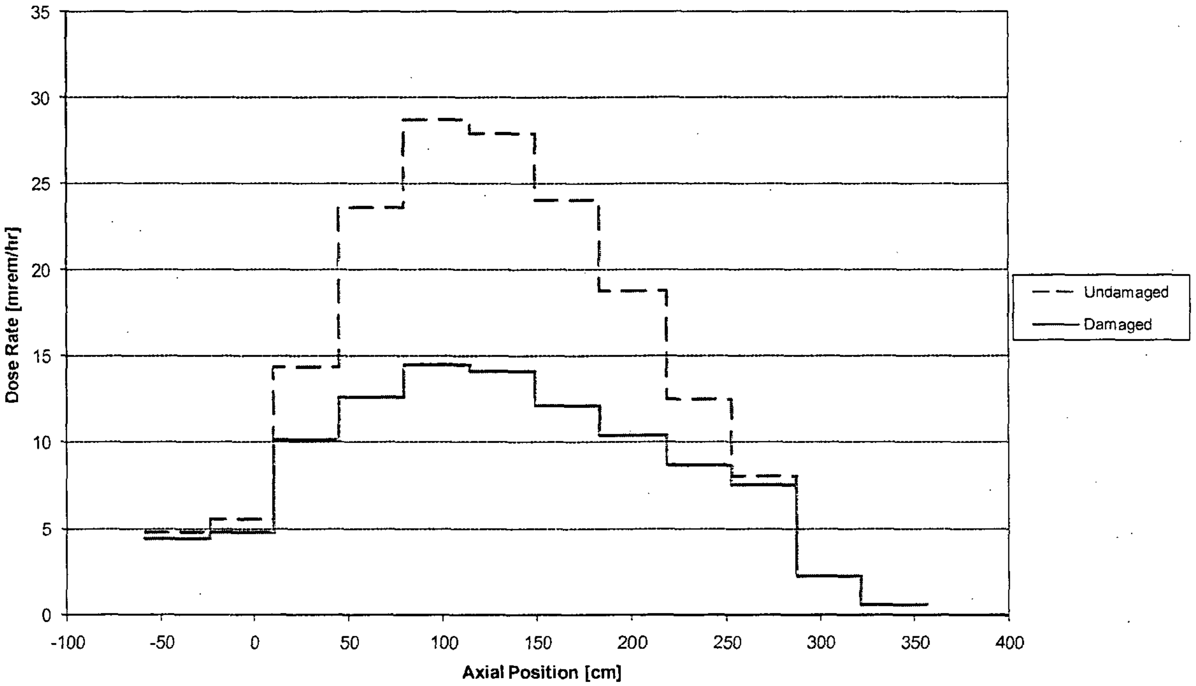

Figure 5.A.4-8 Dose Rate Profile Comparison at Top Axial Surface of Storage Cask – Active Fuel Damaged Fuel

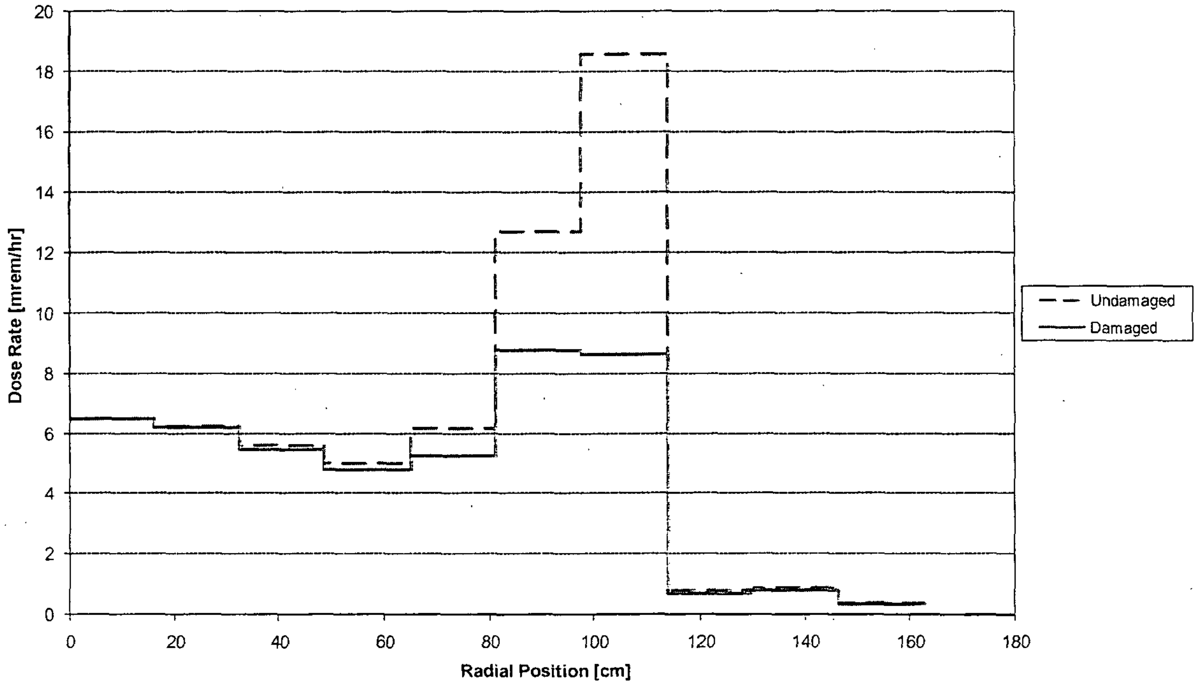

Figure 5.A.4-9 Dose Rate Profile at Radial Surface of Storage Cask – Lower End Fitting Damaged Fuel

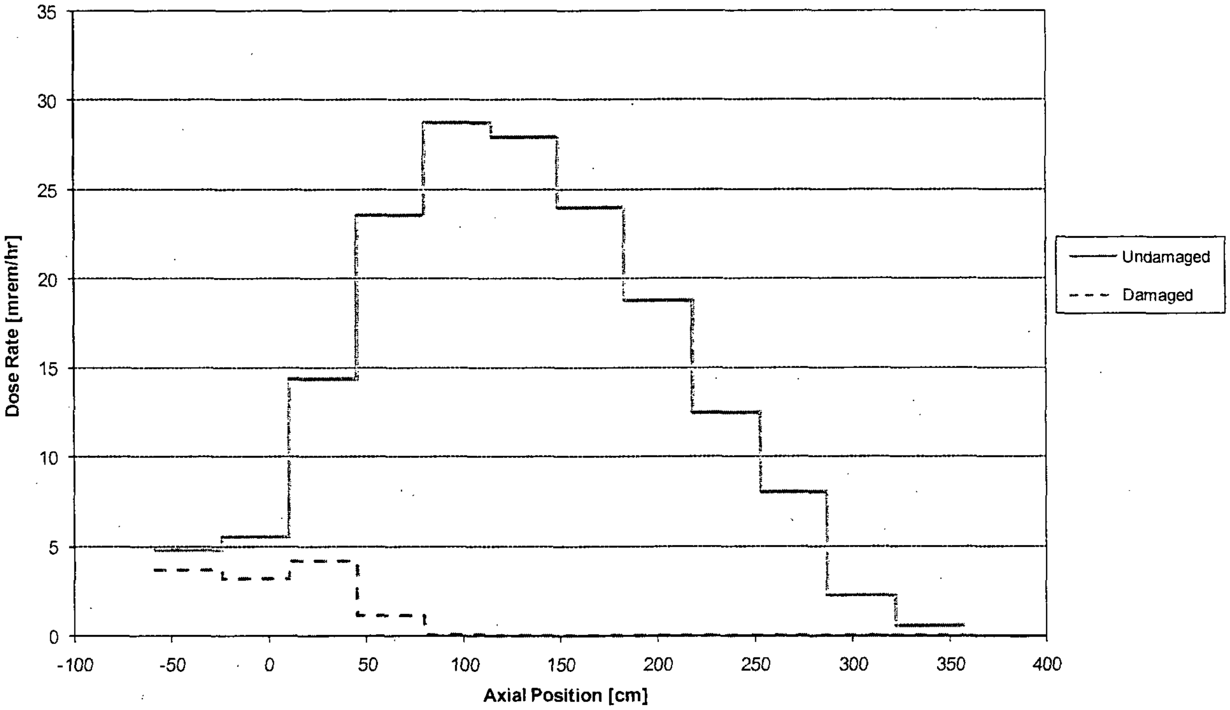

Figure 5.A.4-10 Storage Cask Inlet Dose Rate Profile – Lower End Fitting Damaged Fuel

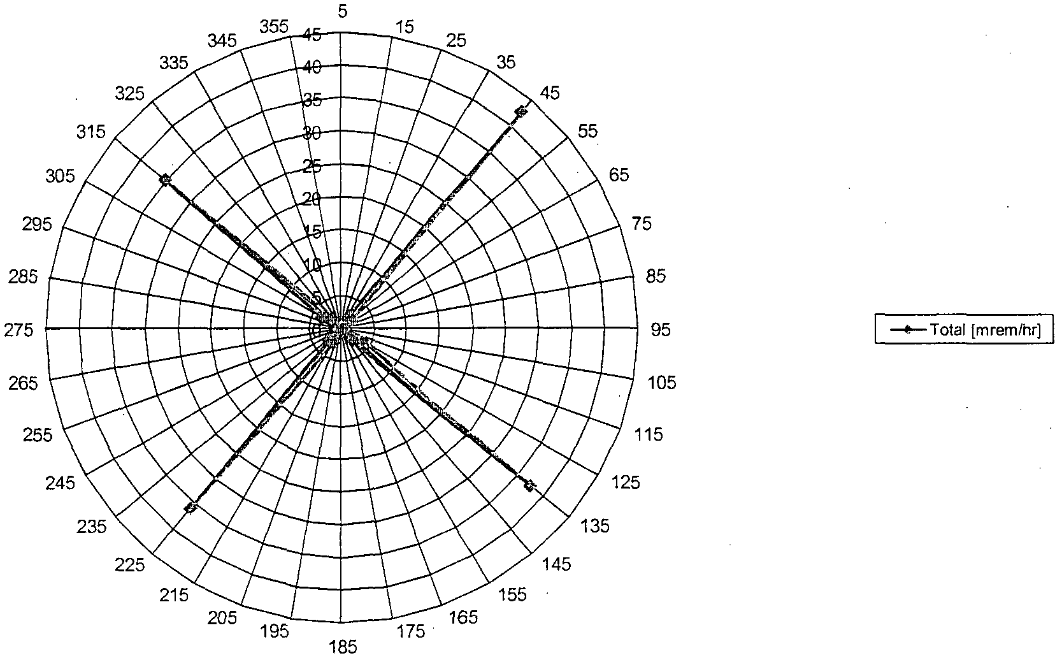

Figure 5.A.4-11 MPC-LACBWR Transfer Cask Top Axial Dose Rate Profiles – Wet Conditions w/o Port Covers – Undamaged Fuel

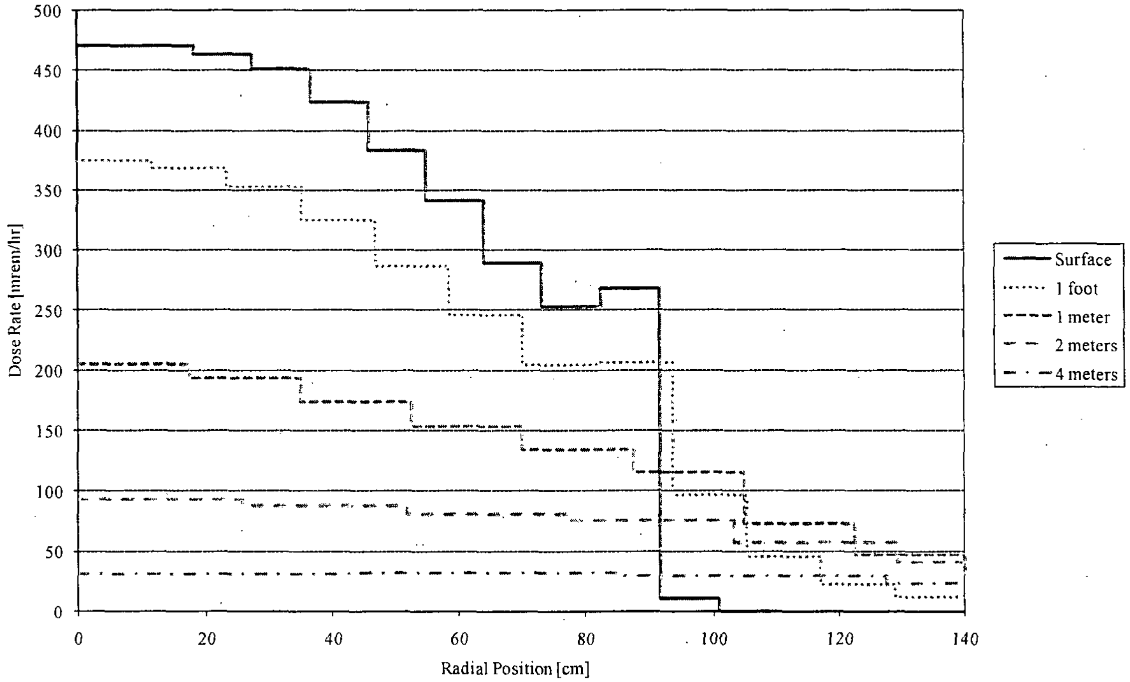

Figure 5.A.4-12 MPC-LACBWR Transfer Cask Top Axial Surface Dose Rate Profile by Source Type – Wet Conditions w/o Port Covers – Undamaged Fuel

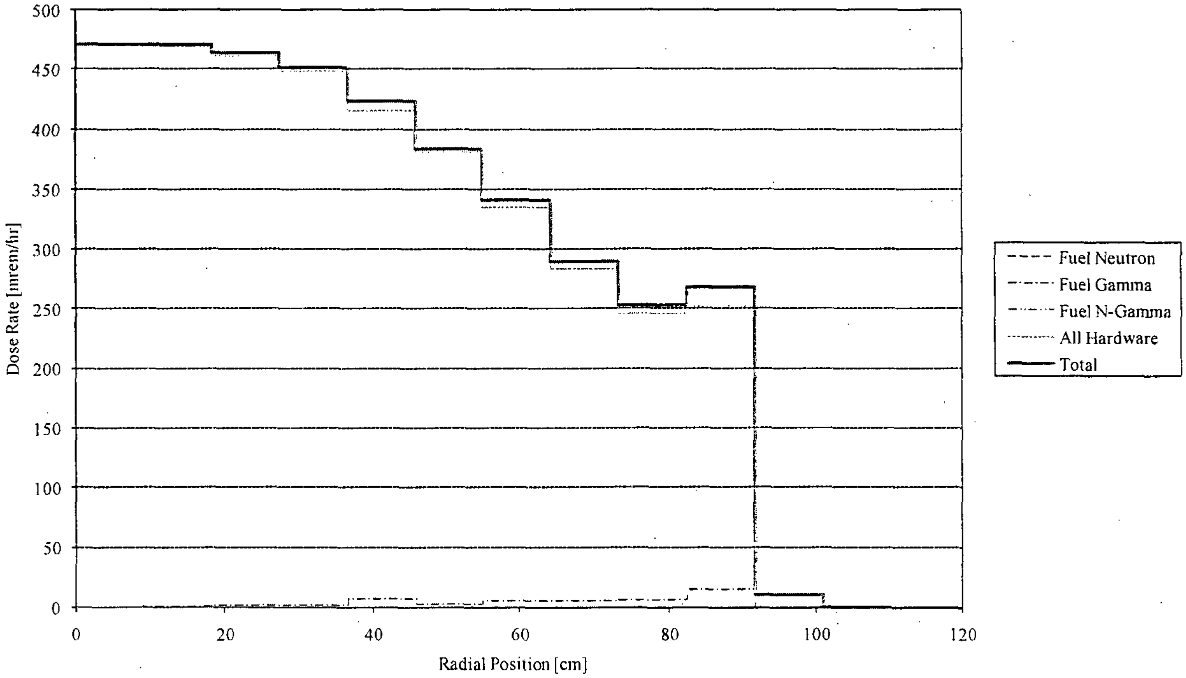

Figure 5.A.4-13 MPC-LACBWR Transfer Cask Radial Dose Rate Profiles – Wet Conditions w/o Port Covers – Undamaged Fuel

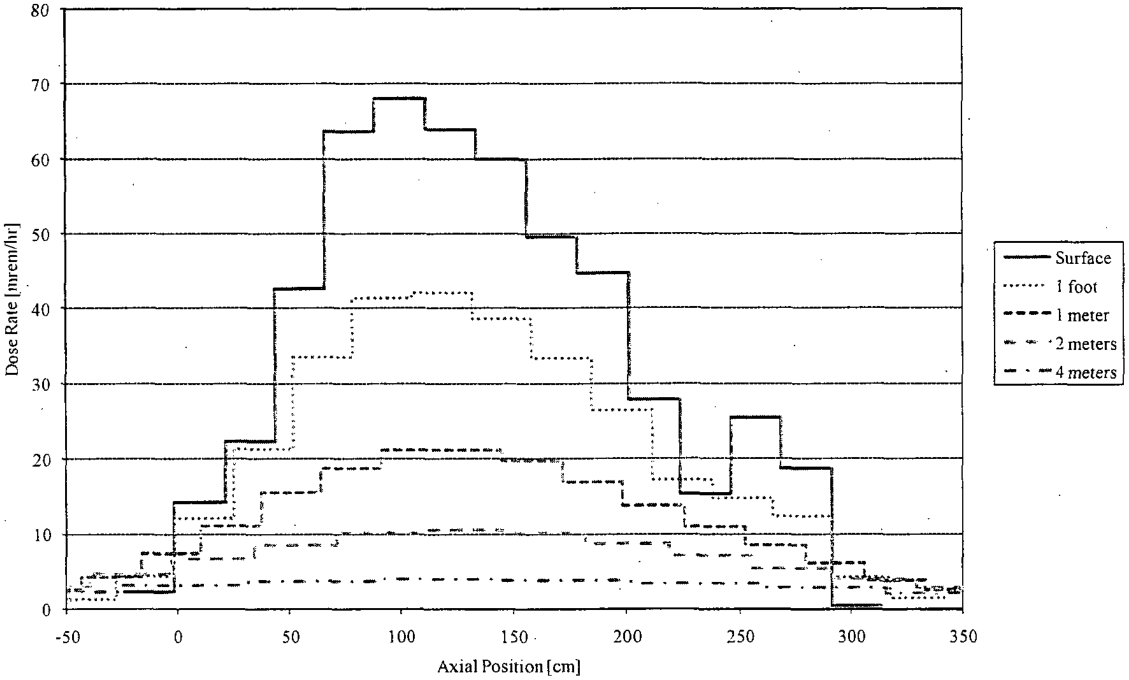

Figure 5.A.4-14 MPC-LACBWR Transfer Cask Radial Surface Dose Rate Profile – Wet Conditions w/o Port Covers – Undamaged Fuel

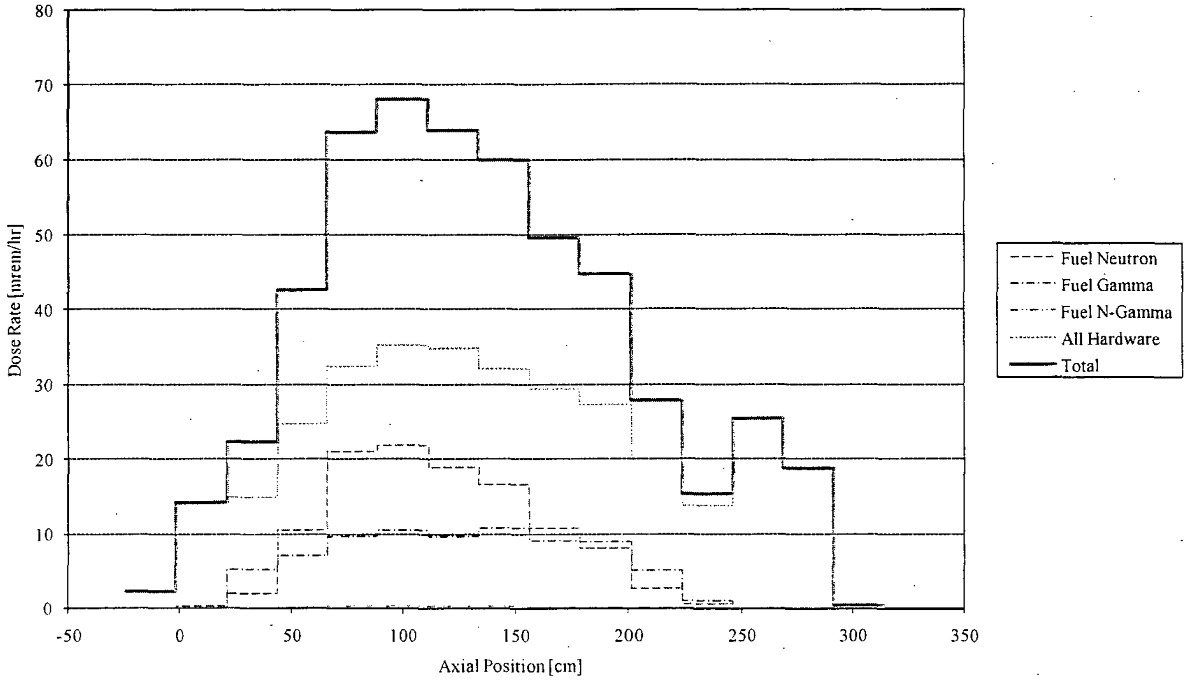

Figure 5.A.4-15 MPC-LACBWR Transfer Cask Bottom Axial Dose Rate Profiles – Wet Conditions w/o Port Covers – Undamaged Fuel

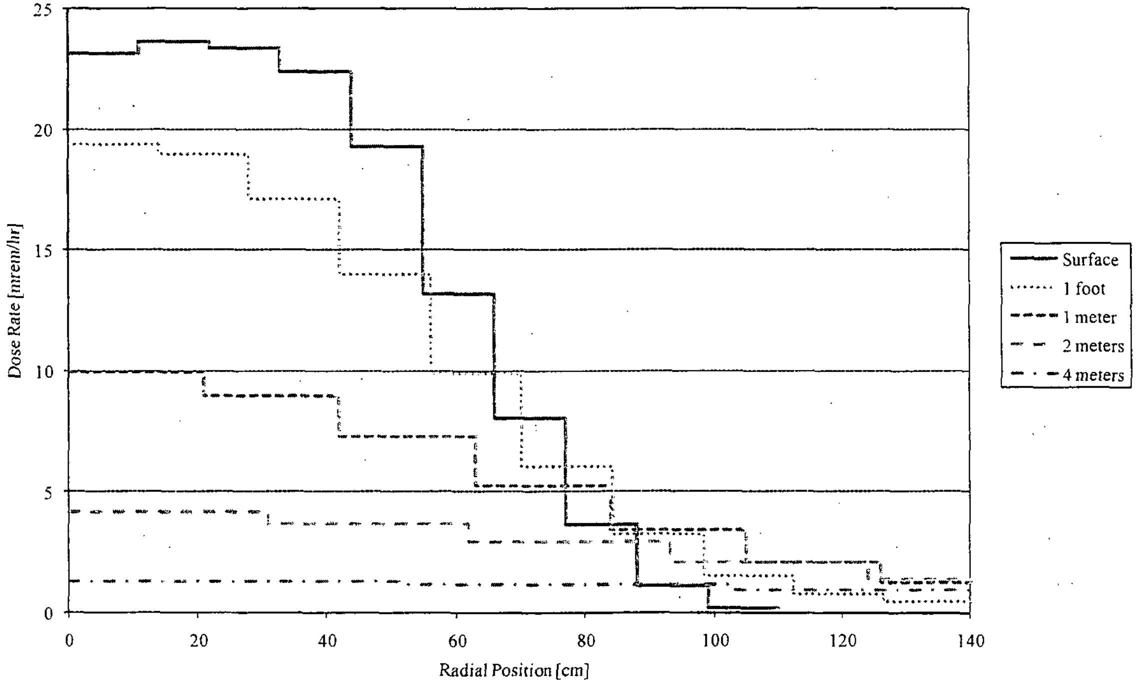

Figure 5.A.4-16 MPC-LACBWR Transfer Cask Bottom Axial Surface Dose Rate Profile by Source Type – Wet Conditions w/o Port Covers – Undamaged Fuel

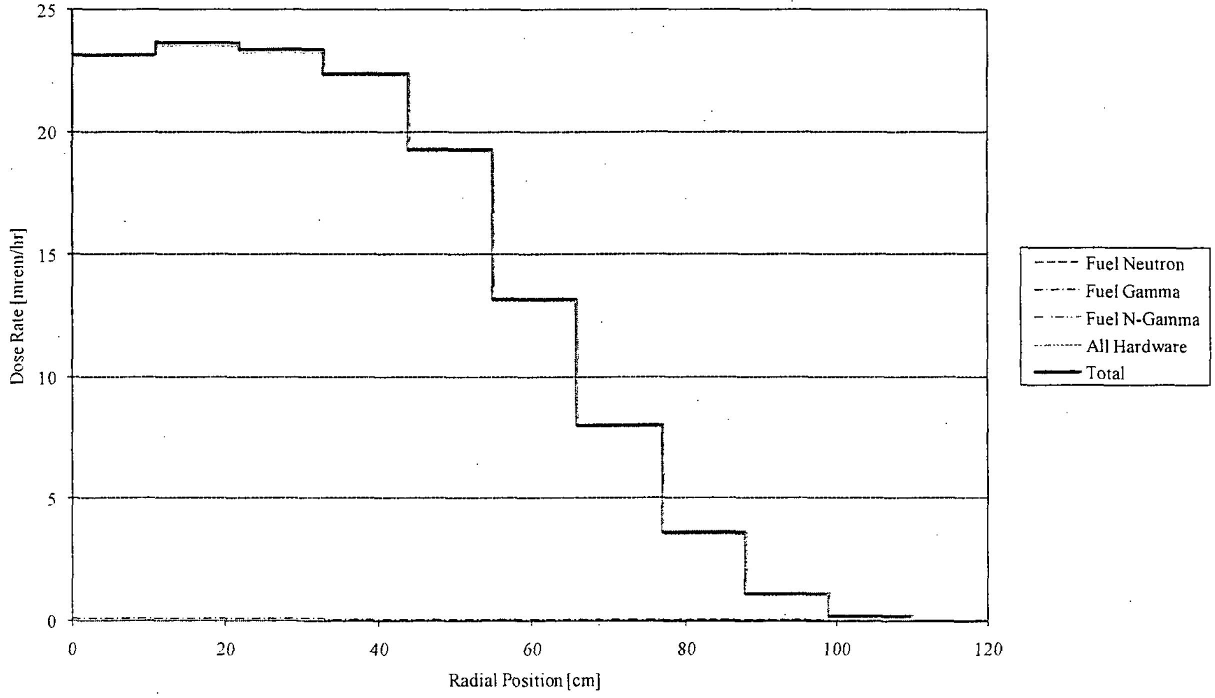

Figure 5.A.4-17 MPC-LACBWR Transfer Cask Top Axial Dose Rate Profiles – Dry Conditions w/Port Covers – Undamaged Fuel

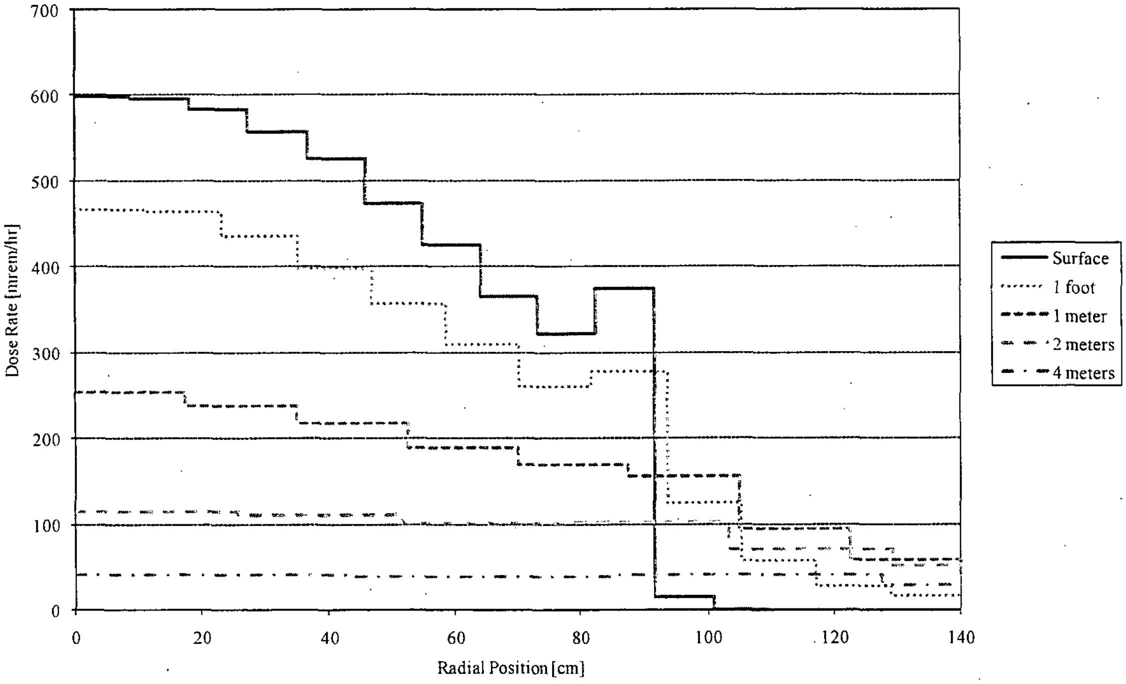

Figure 5.A.4-18 MPC-LACBWR Transfer Cask Top Axial Surface Dose Rate Profile by Source Type – Dry Conditions w/Port Covers – Undamaged Fuel

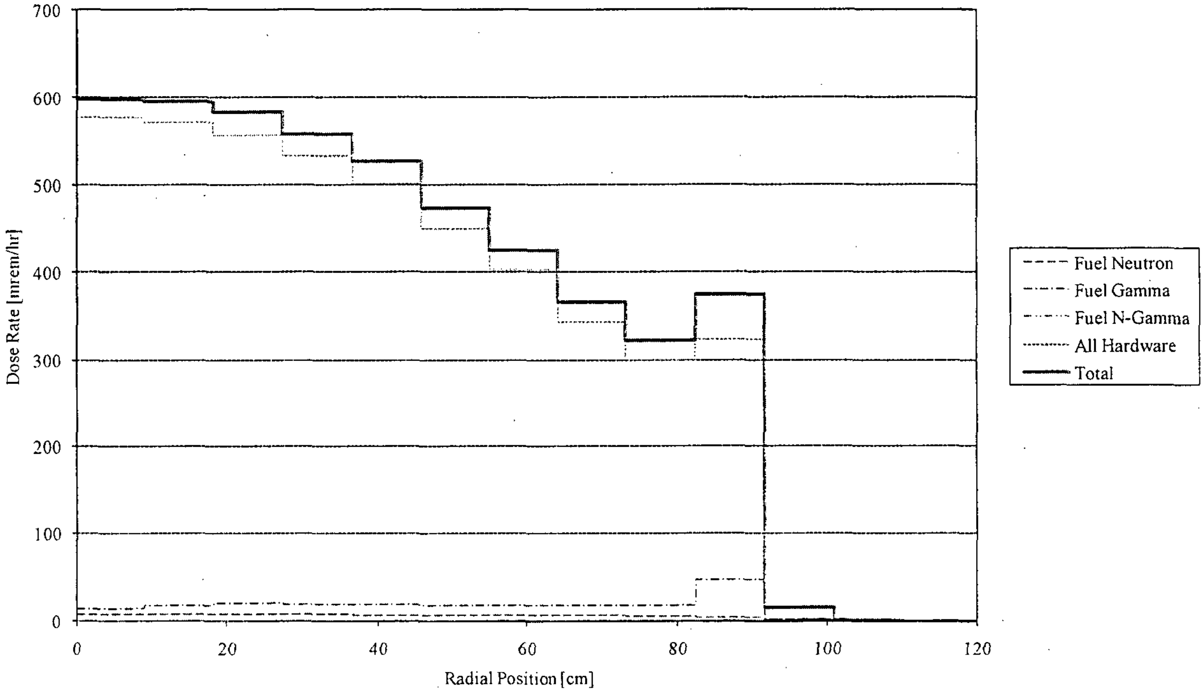

Figure 5.A.4-19 MPC-LACBWR Transfer Cask Radial Dose Rate Profiles – Dry Conditions w/Port Covers – Undamaged Fuel

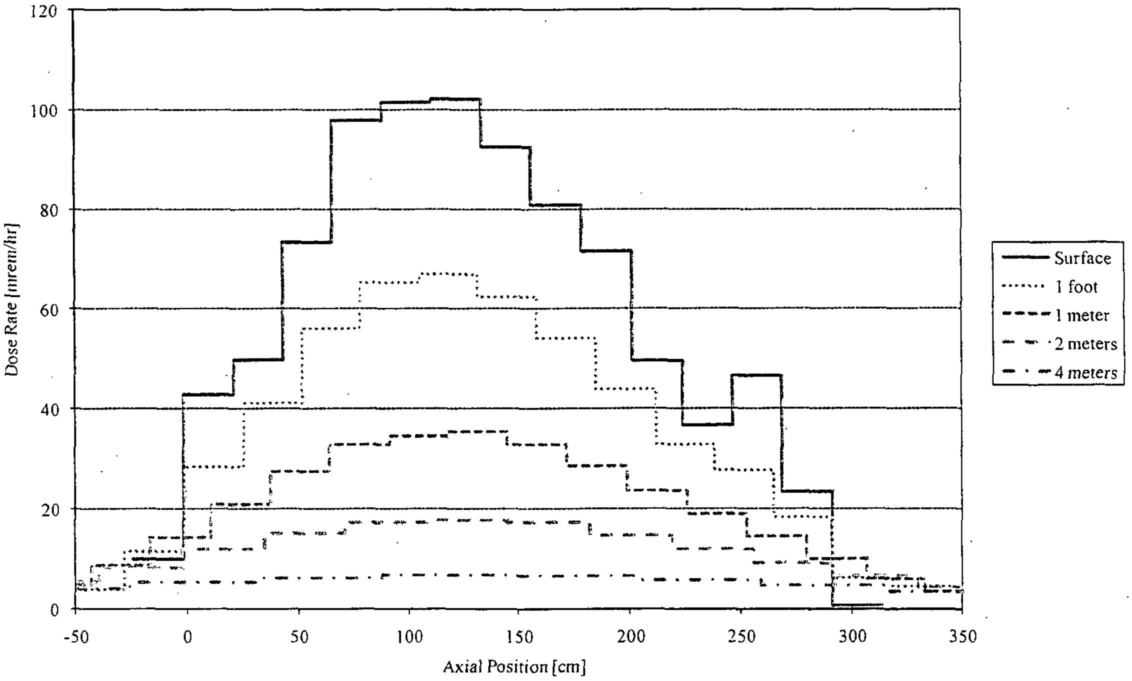

Figure 5.A.4-20 MPC-LACBWR Transfer Cask Radial Surface Dose Rate Profile – Dry Conditions w/Port Covers – Undamaged Fuel

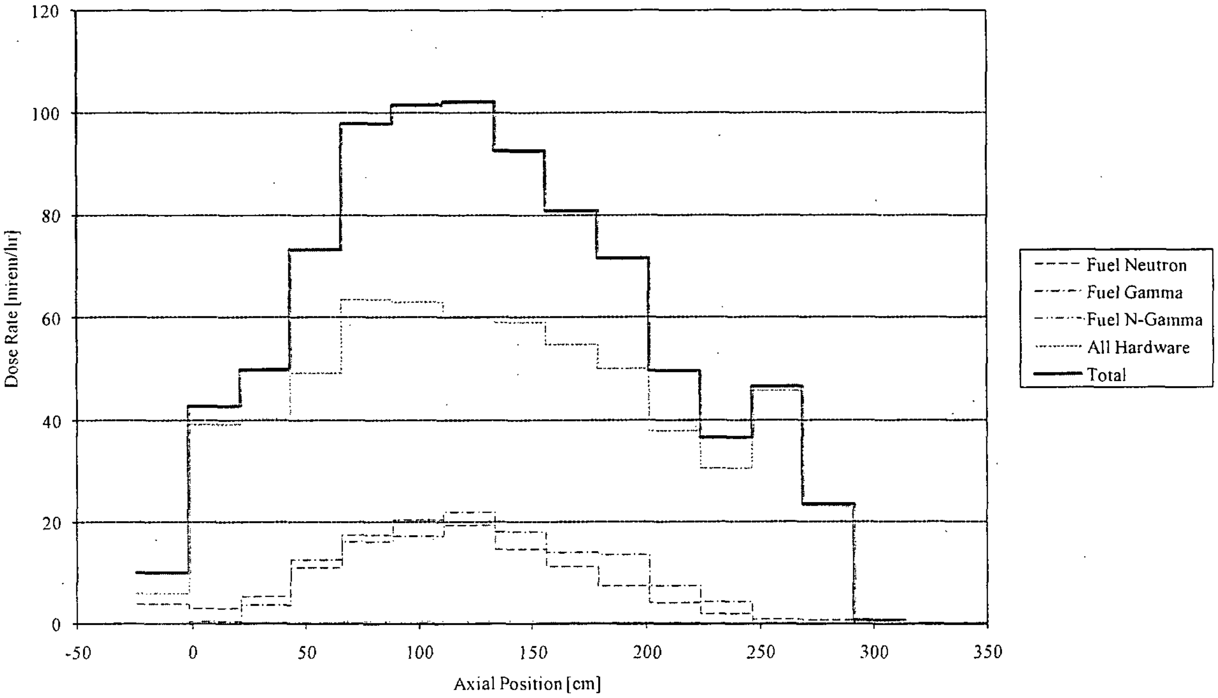

Figure 5.A.4-21 MPC-LACBWR Transfer Cask Bottom Axial Dose Rate Profiles – Dry Conditions w/Port Covers – Undamaged Fuel

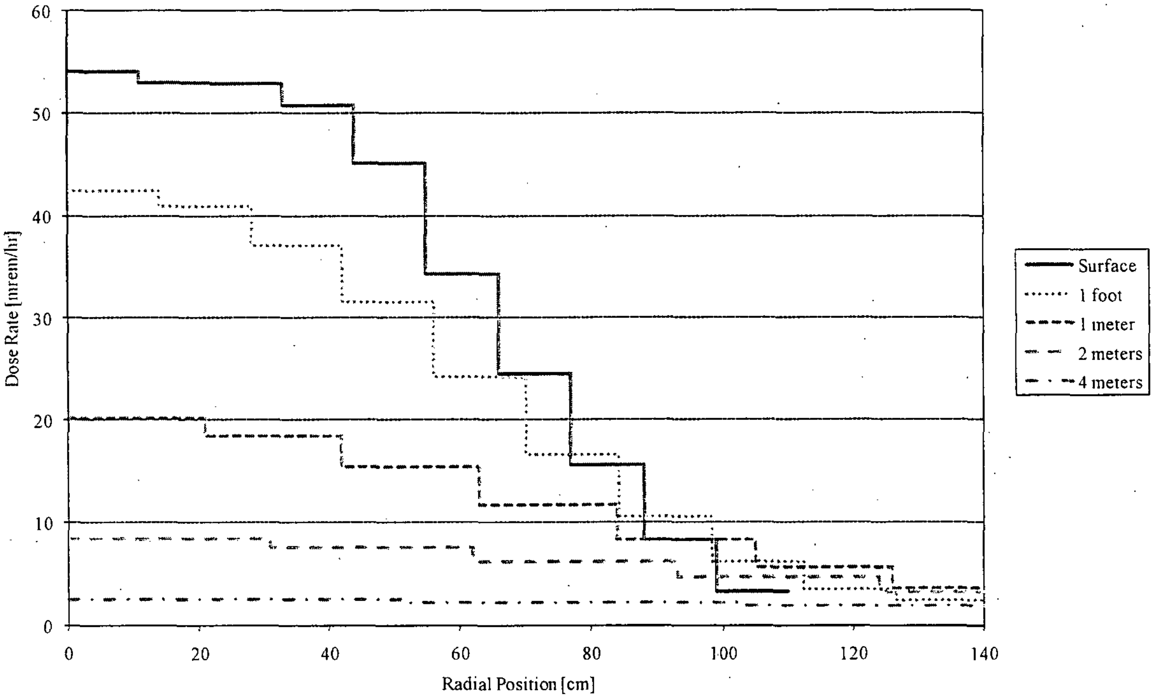

Figure 5.A.4-22 MPC-LACBWR Transfer Cask Bottom Axial Surface Dose Rate Profile by Source Type – Dry Conditions w/Port Covers – Undamaged Fuel

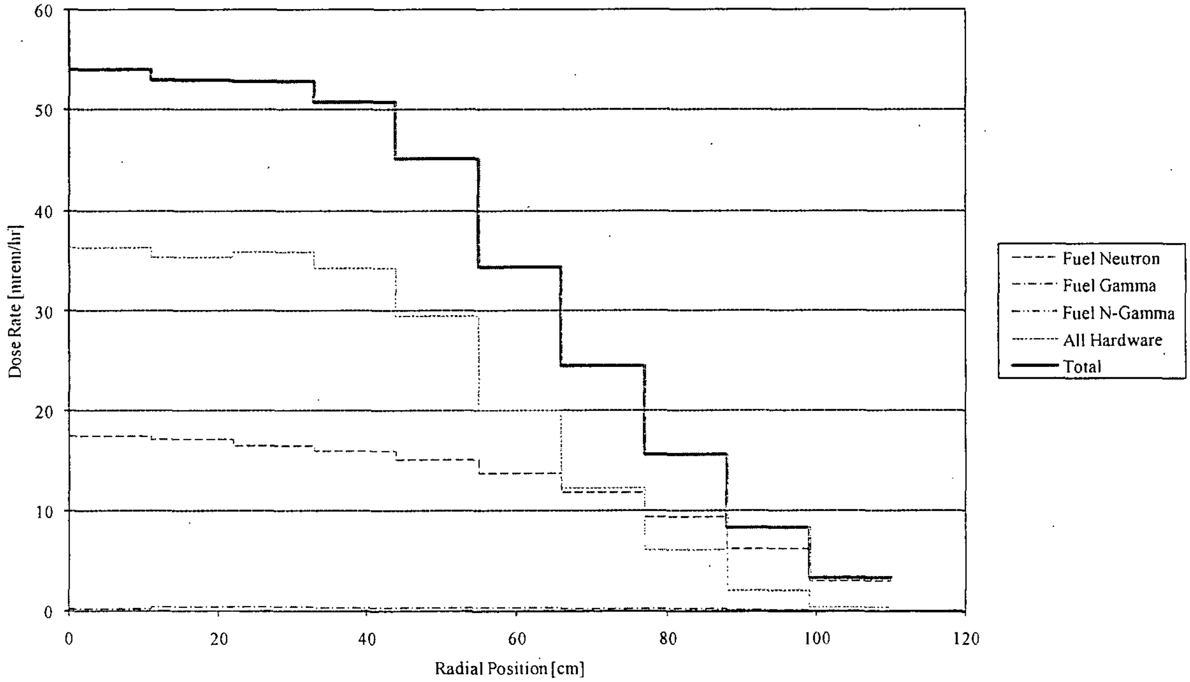

Figure 5.A.4-23 Dose Rate Profile Comparison at Radial Surface of Transfer Cask – Active Fuel Damaged Fuel

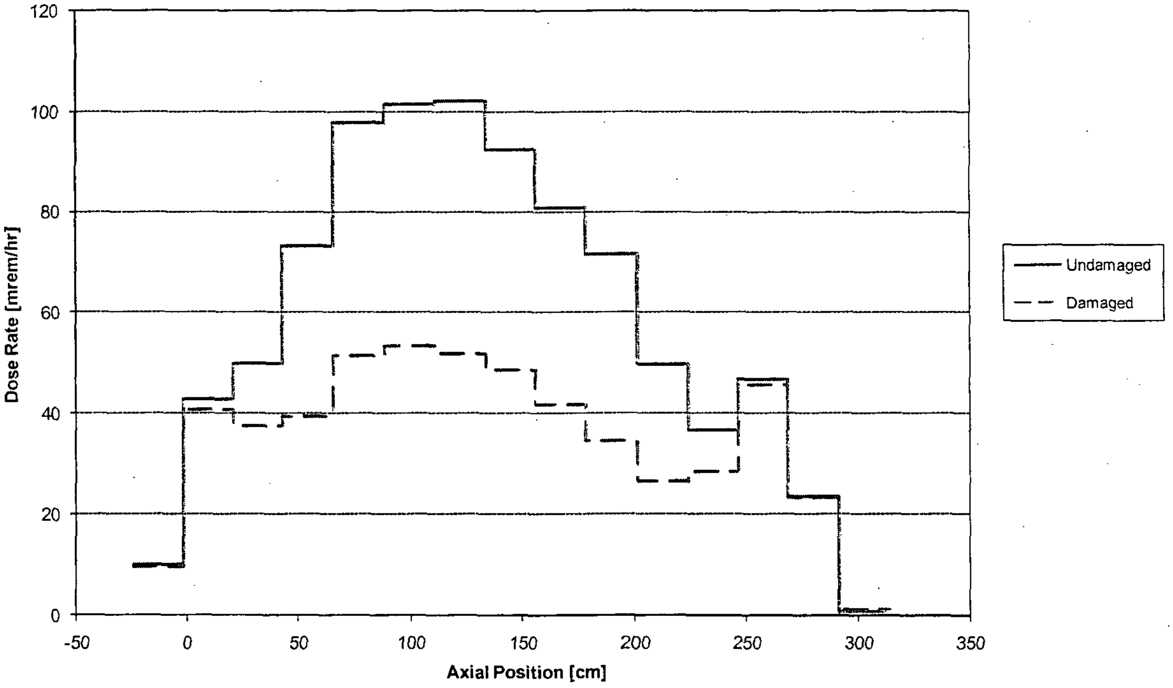

Figure 5.A.4-24 Dose Rate Profile Comparison at Top Axial Surface of Transfer Cask – Active Fuel Damaged Fuel

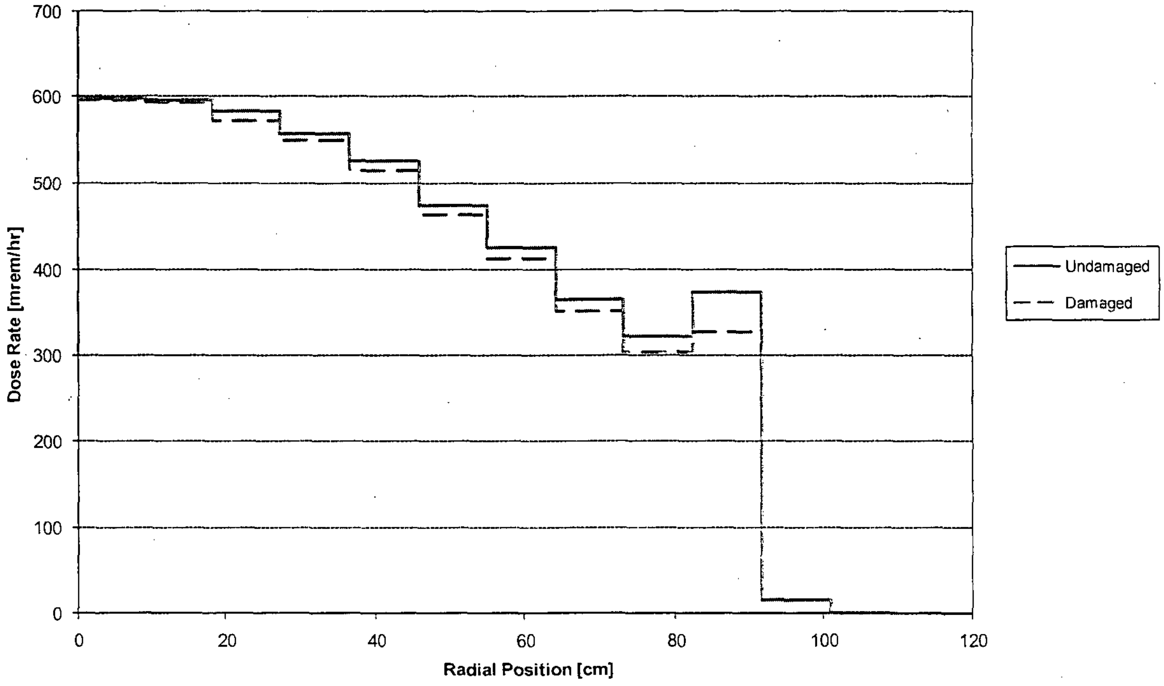

Figure 5.A.4-25 Dose Rate Profile Comparison at Bottom Axial Surface of Transfer Cask – Active Fuel Damaged Fuel

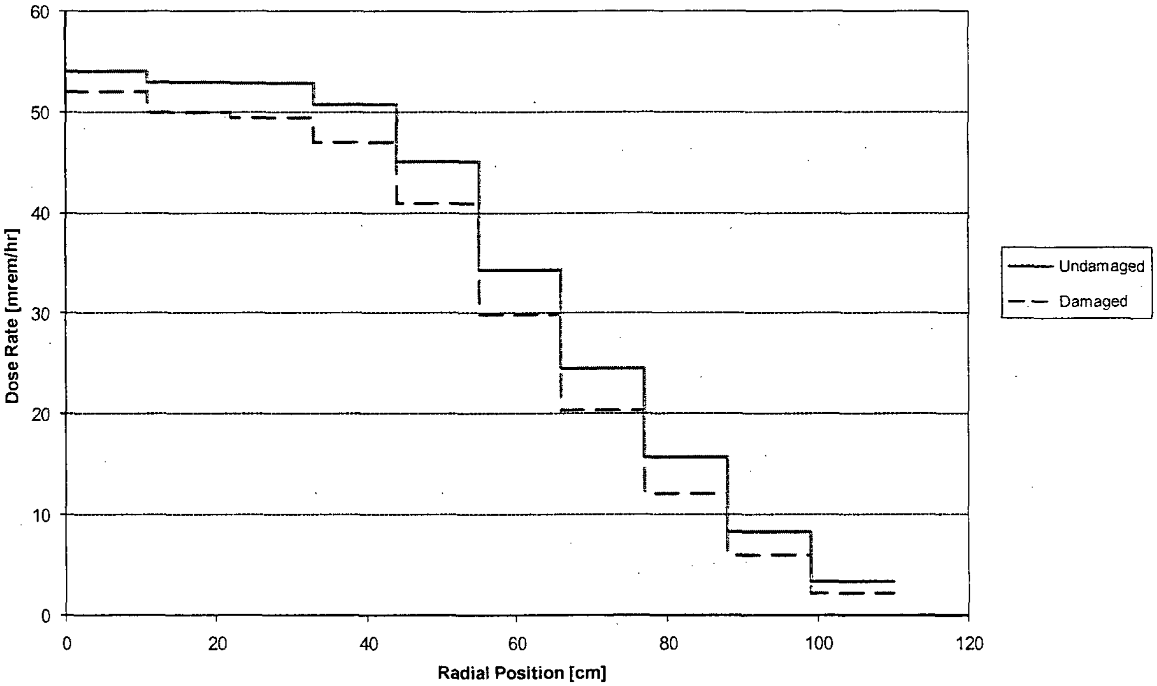

Figure 5.A.4-26 Dose Rate Profile at Radial Surface of Transfer Cask – Lower End Fitting Damaged Fuel

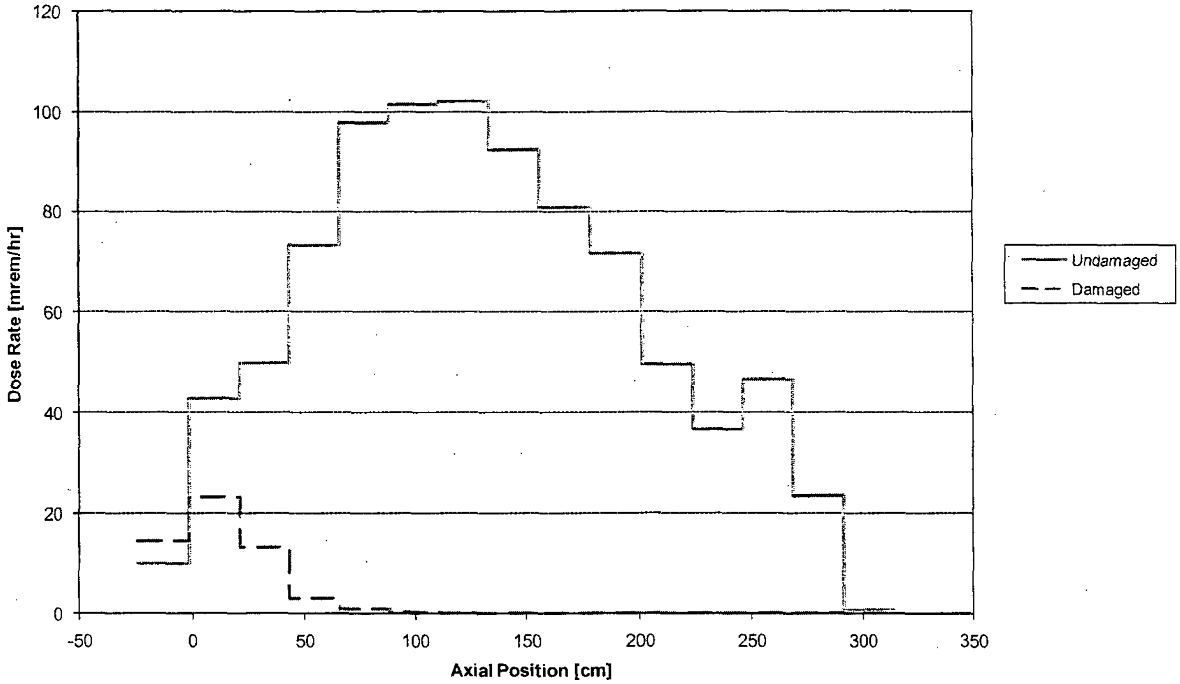

Figure 5.A.4-27 Dose Rate Profile at Bottom Axial Surface of Transfer Cask – Lower End Fitting Damaged Fuel

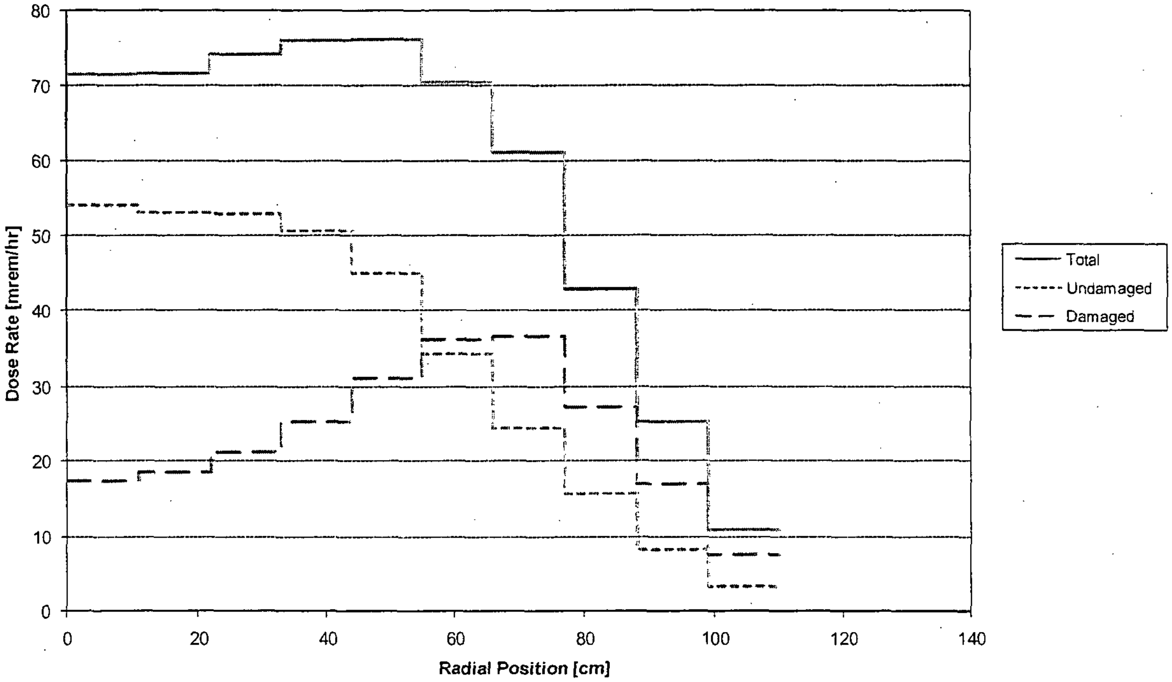

Figure 5.A.4-28 Canister Flood Study – Transfer Cask Radial Surface Dose Rate Profile

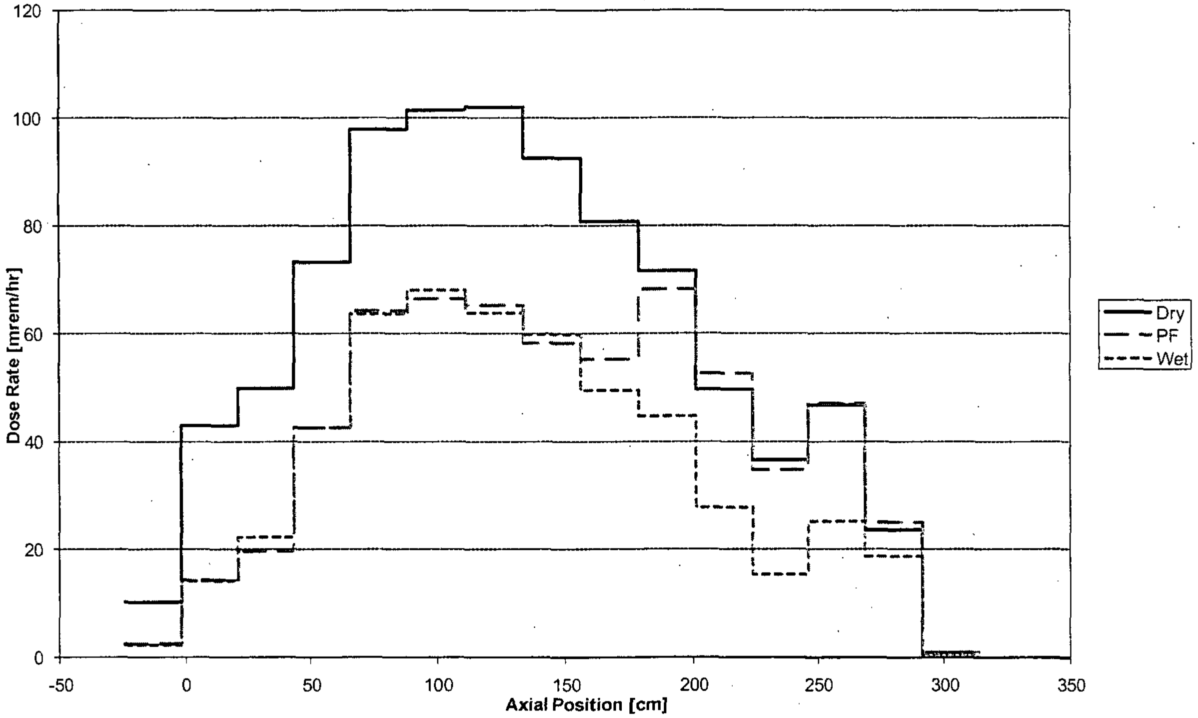

Figure 5.A.4-29 Canister Flood Study – Transfer Cask Radial Surface Dose Rate Profile

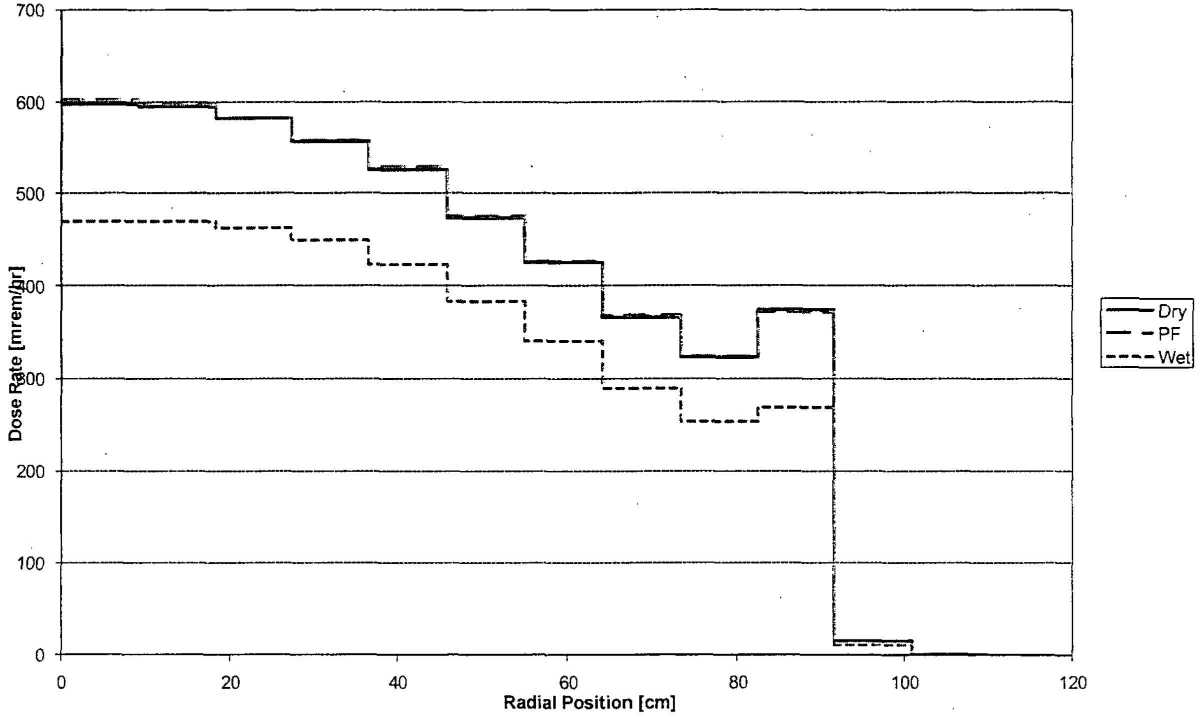

Figure 5.A.4-30 Transfer Cask Radial Dose Rates– Fresh Fuel versus Spent Fuel Isotopics

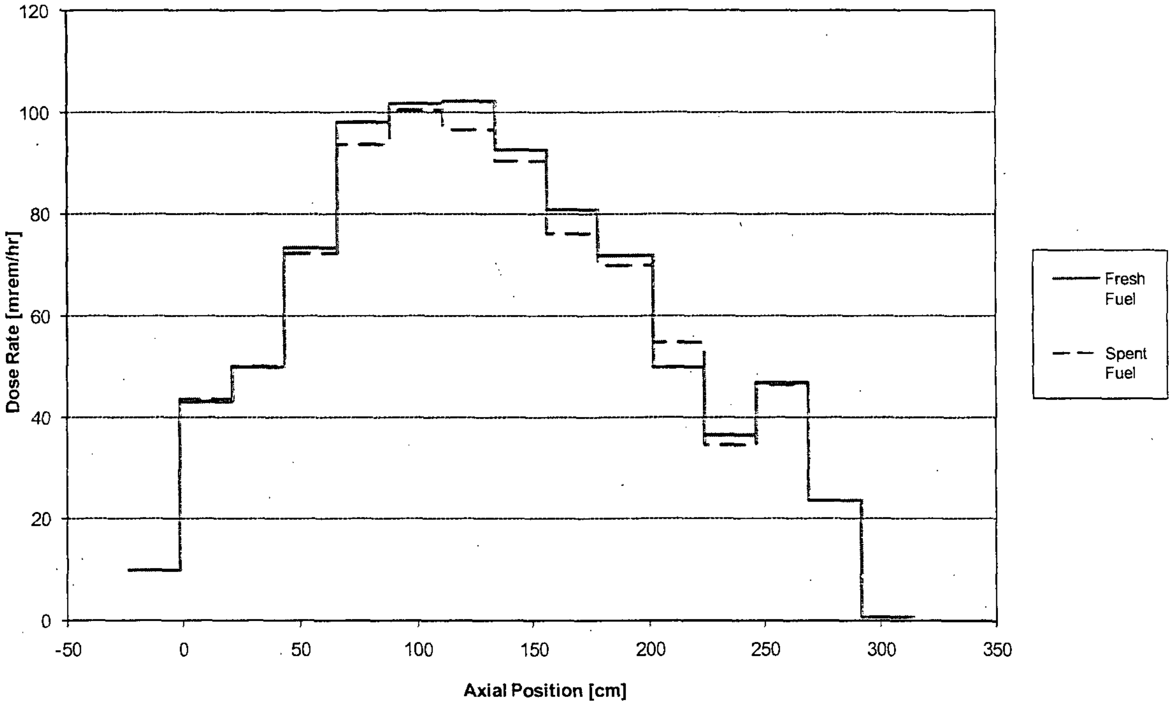

Figure 5.A.4-31 Concrete Cask Radial Dose Rates– Fresh Fuel versus Spent Fuel Isotopics

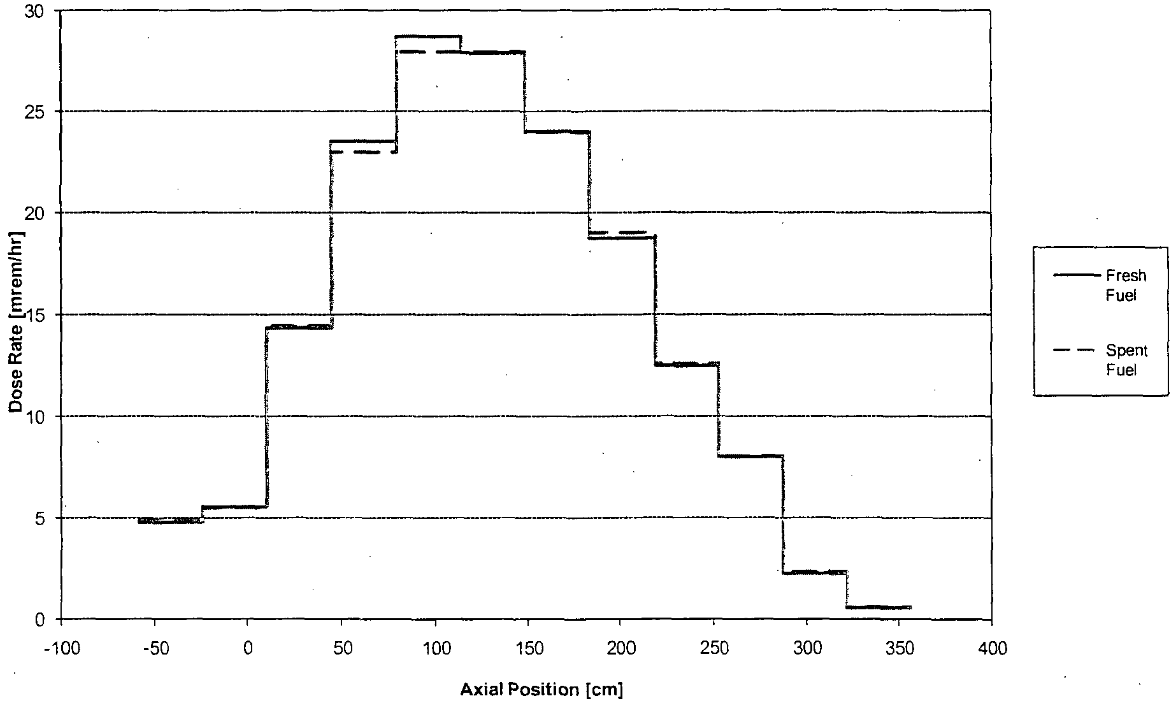

Table 5.A.4-1 ANSI Standard Neutron Flux-To-Dose Rate Factors

Energy (MeV)	**(rem/hr)/(n/cm^2/sec)**
2.5E-08	3.67E-06
1.0E-07	3.67E-06
1.0E-06	4.46E-06
1.0E-05	4.54E-06
1.0E-04	4.18E-06
1.0E-03	3.76E-06
1.0E-02	3.56E-06
1.0E-01	2.17E-05
5.0E-01	9.26E-05
1.0	1.32E-04
2.5	1.25E-04
5.0	1.56E-04
7.0	1.47E-04
10.0	1.47E-04
14.0	2.08E-04
20.0	2.27E-04

Table 5.A.4-2 ANSI Standard Gamma Flux-To-Dose Rate Factors

Energy (MeV)	**(rem/hr)/(γ/cm^2/sec)**	**Energy (MeV)**	**(rem/hr)/(γ/cm^2/sec)**
0.01	3.96E-06	1.4	2.51E-06
0.03	5.82E-07	1.8	2.99E-06
0.05	2.90E-07	2.2	3.42E-06
0.07	2.58E-07	2.6	3.82E-06
0.1	2.83E-07	2.8	4.01E-06
0.15	3.79E-07	3.25	4.41E-06
0.2	5.01E-07	3.75	4.83E-06
0.25	6.31E-07	4.25	5.23E-06
0.3	7.59E-07	4.75	5.60E-06
0.35	8.78E-07	5	5.80E-06
0.4	9.85E-07	5.25	6.01E-06
0.45	1.08E-06	5.75	6.37E-06
0.5	1.17E-06	6.25	6.74E-06
0.55	1.27E-06	6.75	7.11E-06
0.6	1.36E-06	7.5	7.66E-06
0.65	1.44E-06	9	8.77E-06
0.7	1.52E-06	11	1.03E-05
0.8	1.68E-06	13	1.18E-05
1	1.98E-06	15	1.33E-05

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[A11] ORNL/TM-13687, "Prediction of the Isotopic Composition of UO2 Fuel from a BWR: Analysis of the DU1 Sample from the Dodewaard Reactor," Oak Ridge National Laboratory, October 1998.

5.A.6 MPC-LACBWR Storage System Sample Input Files

Sample input files are included here. Figure 5.A.6-1 and Figure 5.A.6-2 show the SAS2H input for Allis Chalmers and Exxon Nuclear Company fuel, respectively. Figure 5.A.6-3 shows the MCNP input file for the storage cask radial analysis for the fuel gamma source. Figure 5.A.6-4 shows the MCNP input file for the transfer cask wet canister model for a top axial analysis of the fuel neutron source. Figure 5.A.6-5 shows the MCNP input file for the transfer cask dry canister model for a bottom axial analysis of the lower end fitting source. Figure 5.A.6-6 shows the MCNP input file for the storage cask model for a damaged fuel gamma source. Figure 5.A.6-7 shows the MCNP input file for the transfer cask dry canister model for a bottom axial analysis of the lower end fitting damaged fuel neutron source.

Figure 5.A.6-1 MPC-LACBWR SAS2H Input File for Allis Chalmers Fuel

```
=SAS2H       PARM=(HALT04,SKIPSHIPDATA)
LACBWR - 3.6 wt % U-235, 22000 MWD/MTU, 28 years cool time
27GROUPNDF4 LATTICECELL
UO2   1 0.950 814 92235 3.6 92238 96.4 END
SS304 2 1.0 594 END
H2O   3 DEN=0.434 1.0 576 END
H2O   4 DEN=0.723 1.0 569 END
SS304 5 1.0 569 END
H2O   6 DEN=0.434 1.0 576 END
END COMP
SQUAREPITCH 1.4351 0.8890 1 3 1.0058 2 0.9042 0 END
NPIN=100 FUEL=210.820 NCYC=2 NLIB=2 PRIN=6 LIGH=5
INPL=2 NUMZ=5 END
6 0.0001 500 8.0967 6 8.2113 5 8.4349 4 9.1285
POWER=2.4063 BURN=549.0286 DOWN=60 END
POWER=2.4063 BURN=549.0286 DOWN=1461 END
FE 0.673 CR 0.1900 NI 0.1150 MN 0.0200 CO 0.002
END
=ORIGENS
0$$  A4 21 A8 26 A10 51 71  E
1$$  1 1T
COOLING 28 YEARS AND FISSION PRODUCT GAMMA REBIN
3$$  21 0 1 28 A33 22 E
54$$  A8 1 E T
35$$  0 T
56$$  0 1 A13 -2 5 3 E
57**  4.0 E T
COOLING 28 YEARS AND FISSION PRODUCT GAMMA REBIN
SINGLE REACTOR ASSEMBLY
60** 28
65$$  A4 1 A7 1 A10 1 A25 1 A28 1 A31 1 A46 1 A49 1 A52 1 E
61**  F.00000001
81$$  2 51 26 1 E
82$$  F6
83**  1.40e+7  1.20e+7  1.00e+7  8.00e+6   6.50e+6  5.00e+6
      4.00e+6  3.00e+6  2.50e+6  2.00e+6   1.66e+6  1.44e+6
      1.22e+6  1.00e+6  0.80e+6  0.60e+6   0.40e+6  0.30e+6
      0.20e+6  0.10e+6  0.05e+6  0.02e+6   0.01e+6
84**  1.46e+7  1.36e+7  1.25e+7  1.125e+7  1.00e+7
      8.25e+6  7.00e+6  6.07e+6  4.72e+6   3.68e+6
      2.87e+6  1.74e+6  0.64e+6  0.39e+6   0.11e+6
      6.74e+4  2.48e+4  9.12e+3  2.95e+3   9.61e+2
      3.54e+2  1.66e+2  4.81e+1  1.60e+1   4.00e+0
      1.50e+0  5.50e-1  7.09e-2  1.00e-5   T
FISSION PRODUCT SPECTRA
56$$ F0  T
END
=ORIGENS
0$$  A4 21 A8 26 A10 51 71  E
1$$  1 1T
COOLING 28 YEARS AND ACTINIDE GAMMA REBIN
3$$  21 0 1 28 A33 22 E
54$$  A8 1 E T
35$$  0 T
56$$  0 1 A13 -2 5 3 E
57**  4.0 E T
COOLING 28 YEARS AND ACTINIDE GAMMA REBIN
SINGLE REACTOR ASSEMBLY
60** 28
65$$  A4 1 A7 1 A10 1 A25 1 A28 1 A31 1 A46 1 A49 1 A52 1 E
61**  F.00000001
81$$  2 51 26 1 E
82$$  F5
```

Figure 5.A.6-1 MPC-LACBWR SAS2H Input File for Allis Chalmers Fuel

```
83**  1.40e+7  1.20e+7  1.00e+7  8.00e+6   6.50e+6  5.00e+6
      4.00e+6  3.00e+6  2.50e+6  2.00e+6   1.66e+6  1.44e+6
      1.22e+6  1.00e+6  0.80e+6  0.60e+6   0.40e+6  0.30e+6
      0.20e+6  0.10e+6  0.05e+6  0.02e+6   0.01e+6
84**  1.46e+7  1.36e+7  1.25e+7  1.125e+7  1.00e+7
      8.25e+6  7.00e+6  6.07e+6  4.72e+6   3.68e+6
      2.87e+6  1.74e+6  0.64e+6  0.39e+6   0.11e+6
      6.74e+4  2.48e+4  9.12e+3  2.95e+3   9.61e+2
      3.54e+2  1.66e+2  4.81e+1  1.60e+1   4.00e+0
      1.50e+0  5.50e-1  7.09e-2  1.00e-5   T
ACTINIDE SPECTRA
56$$ F0  T
END
=ORIGENS
0$$  A4 21 A8 26 A10 51 71  E
1$$  1 1T
COOLING 28 YEARS AND LIGHT ELEMENT GAMMA REBIN
3$$  21 0 1 28 A33 22 E
54$$  A8 1 E T
35$$  0 T
56$$  0 1 A13 -2 5 3 E
57**  4.0 E T
COOLING 28 YEARS AND LIGHT ELEMENT GAMMA REBIN
SINGLE REACTOR ASSEMBLY
60** 28
65$$  A4 1 A7 1 A10 1 A25 1 A28 1 A31 1 A46 1 A49 1 A52 1 E
61**  F.00000001
81$$  2 51 26 1 E
82$$  F4
83**  1.40e+7  1.20e+7  1.00e+7  8.00e+6   6.50e+6  5.00e+6
      4.00e+6  3.00e+6  2.50e+6  2.00e+6   1.66e+6  1.44e+6
      1.22e+6  1.00e+6  0.80e+6  0.60e+6   0.40e+6  0.30e+6
      0.20e+6  0.10e+6  0.05e+6  0.02e+6   0.01e+6
84**  1.46e+7  1.36e+7  1.25e+7  1.125e+7  1.00e+7
      8.25e+6  7.00e+6  6.07e+6  4.72e+6   3.68e+6
      2.87e+6  1.74e+6  0.64e+6  0.39e+6   0.11e+6
      6.74e+4  2.48e+4  9.12e+3  2.95e+3   9.61e+2
      3.54e+2  1.66e+2  4.81e+1  1.60e+1   4.00e+0
      1.50e+0  5.50e-1  7.09e-2  1.00e-5   T
LIGHT ELEMENT SPECTRA
56$$ F0  T
END
```

Figure 5.A.6-2 MPC-LACBWR SAS2H Input File for Exxon Nuclear Company Fuel

```
=SAS2H       PARM=(HALT02,SKIPSHIPDATA)
LACBWR - 3.6 wt % U-235, 21000 MWD/MTU, 23 years cool time
27GROUPNDF4 LATTICECELL
UO2   1 0.950 814 92235 3.6 92238 96.4 END
SS304 2 1.0 594 END
H2O   3 DEN=0.434 1.0 576 END
H2O   4 DEN=0.723 1.0 569 END
ZIRCALLOY 5 1.0 569 END
H2O   6 DEN=0.434 1.0 576 END
SS304 7 1.0 569 END
ZIRCALLOY 8 1.0 569 END
END COMP
SQUAREPITCH 1.4148 0.8712 1 3 1.0008 2 0.8890 0 END
NPIN=96 FUEL=210.820 NCYC=2 NLIB=1 PRIN=6 LIGH=5
INPL=2 NUMZ=7 END
8 0.8890 7 1.0008 6 1.1284 500 7.9820 6 8.0967 5 8.3260 4 9.1285
POWER=2.4063 BURN=483.0545 DOWN=60 END
POWER=2.4063 BURN=483.0545 DOWN=1461 END
FE 0.673 CR 0.1900 NI 0.1150 MN 0.0200 CO 0.002
END
=ORIGENS
0$$  A4 21 A8 26 A10 51 71  E
1$$  1 1T
COOLING 23 YEARS AND FISSION PRODUCT GAMMA REBIN
3$$  21 0 1 28 A33 22 E
54$$  A8 1 E T
35$$  0 T
56$$  0 1 A13 -2 5 3 E
57**  4.0 E T
COOLING 23 YEARS AND FISSION PRODUCT GAMMA REBIN
SINGLE REACTOR ASSEMBLY
60** 23
65$$  A4 1 A7 1 A10 1 A25 1 A28 1 A31 1 A46 1 A49 1 A52 1 E
61**  F.00000001
81$$  2 51 26 1 E
82$$  F6
83**  1.40e+7  1.20e+7  1.00e+7  8.00e+6   6.50e+6  5.00e+6
      4.00e+6  3.00e+6  2.50e+6  2.00e+6   1.66e+6  1.44e+6
      1.22e+6  1.00e+6  0.80e+6  0.60e+6   0.40e+6  0.30e+6
      0.20e+6  0.10e+6  0.05e+6  0.02e+6   0.01e+6
84**  1.46e+7  1.36e+7  1.25e+7  1.125e+7  1.00e+7
      8.25e+6  7.00e+6  6.07e+6  4.72e+6   3.68e+6
      2.87e+6  1.74e+6  0.64e+6  0.39e+6   0.11e+6
      6.74e+4  2.48e+4  9.12e+3  2.95e+3   9.61e+2
      3.54e+2  1.66e+2  4.81e+1  1.60e+1   4.00e+0
      1.50e+0  5.50e-1  7.09e-2  1.00e-5    T
FISSION PRODUCT SPECTRA
56$$ F0  T
END
=ORIGENS
0$$  A4 21 A8 26 A10 51 71  E
1$$  1 1T
COOLING 23 YEARS AND ACTINIDE GAMMA REBIN
3$$  21 0 1 28 A33 22 E
54$$  A8 1 E T
35$$  0 T
56$$  0 1 A13 -2 5 3 E
57**  4.0 E T
COOLING 23 YEARS AND ACTINIDE GAMMA REBIN
SINGLE REACTOR ASSEMBLY
60** 23
65$$  A4 1 A7 1 A10 1 A25 1 A28 1 A31 1 A46 1 A49 1 A52 1 E
61**  F.00000001
```

Figure 5.A.6-2 MPC-LACBWR SAS2H Input File for Exxon Nuclear Company Fuel

```
81$$  2 51 26 1 E
82$$  F5
83**  1.40e+7  1.20e+7  1.00e+7  8.00e+6   6.50e+6  5.00e+6
      4.00e+6  3.00e+6  2.50e+6  2.00e+6   1.66e+6  1.44e+6
      1.22e+6  1.00e+6  0.80e+6  0.60e+6   0.40e+6  0.30e+6
      0.20e+6  0.10e+6  0.05e+6  0.02e+6   0.01e+6
84**  1.46e+7  1.36e+7  1.25e+7  1.125e+7  1.00e+7
      8.25e+6  7.00e+6  6.07e+6  4.72e+6   3.68e+6
      2.87e+6  1.74e+6  0.64e+6  0.39e+6   0.11e+6
      6.74e+4  2.48e+4  9.12e+3  2.95e+3   9.61e+2
      3.54e+2  1.66e+2  4.81e+1  1.60e+1   4.00e+0
      1.50e+0  5.50e-1  7.09e-2  1.00e-5   T
ACTINIDE SPECTRA
56$$ F0  T
END
=ORIGENS
0$$  A4 21 A8 26 A10 51 71  E
1$$  1 1T
COOLING 23 YEARS AND LIGHT ELEMENT GAMMA REBIN
3$$  21 0 1 28 A33 22 E
54$$  A8 1 E T
35$$  0 T
56$$  0 1 A13 -2 5 3 E
57**  4.0 E T
COOLING 23 YEARS AND LIGHT ELEMENT GAMMA REBIN
SINGLE REACTOR ASSEMBLY
60** 23
65$$  A4 1 A7 1 A10 1 A25 1 A28 1 A31 1 A46 1 A49 1 A52 1 E
61**  F.00000001
81$$  2 51 26 1 E
82$$  F4
83**  1.40e+7  1.20e+7  1.00e+7  8.00e+6   6.50e+6  5.00e+6
      4.00e+6  3.00e+6  2.50e+6  2.00e+6   1.66e+6  1.44e+6
      1.22e+6  1.00e+6  0.80e+6  0.60e+6   0.40e+6  0.30e+6
      0.20e+6  0.10e+6  0.05e+6  0.02e+6   0.01e+6
84**  1.46e+7  1.36e+7  1.25e+7  1.125e+7  1.00e+7
      8.25e+6  7.00e+6  6.07e+6  4.72e+6   3.68e+6
      2.87e+6  1.74e+6  0.64e+6  0.39e+6   0.11e+6
      6.74e+4  2.48e+4  9.12e+3  2.95e+3   9.61e+2
      3.54e+2  1.66e+2  4.81e+1  1.60e+1   4.00e+0
      1.50e+0  5.50e-1  7.09e-2  1.00e-5   T
LIGHT ELEMENT SPECTRA
56$$ F0  T
END
```

Figure 5.A.6-3 MPC-LACBWR MCNP Input File for Storage Cask Radial Biasing – Fuel Gamma Source

```
LACBWR VCC - strShlDryRadFg_Pref
C Radial Biasing - Fuel Gamma Source
C Fuel Assembly Cells - v1.0
1 1 -1.3734 -1 -2    u=10 $ Lower Nozzle
2 2 -3.7790 -1 +2 -3   u=10 $ Fuel
3 3 -0.9880 -1 +3 -4   u=10 $ Upper Plenum
4 4 -0.6145 -1 +4    u=10 $ Upper Nozzle
5 0         +1      u=10 $ Outside
C Cells - Standard Fuel Tube  v1.0
101 0          -101       u=5 $ Tube void
102 6 -7.9400 -102 +101       u=5 $ Tube
103 8 -2.6707 -103       u=5 $ Absorber +Y
104 6 -7.9400 -104       u=5 $ Cladding +Y
105 8 -2.6707 -105       u=5 $ Absorber +X
106 6 -7.9400 -106       u=5 $ Cladding +X
107 0          +101 +102 +103 +104 +106 +105  u=5 $ Void
C Cells - DFC Fuel Tube Absorber 2 Sides v1.0
108 0          -107       u=6 $ Tube void
109 6 -7.9400 -108 +107       u=6 $ Tube
110 8 -2.6707 -109       u=6 $ Absorber +Y
111 6 -7.9400 -110       u=6 $ Cladding +Y
112 8 -2.6707 -111       u=6 $ Absorber +X
113 6 -7.9400 -112       u=6 $ Cladding +X
114 0          +107 +108 +109 +110 +112 +111  u=6 $ Void
C Cells - DFC Fuel Tube Absorber 1 Side (Y) v1.0
115 0          -107       u=7 $ Tube void
116 6 -7.9400 -108 +107       u=7 $ Tube
117 8 -2.6707 -109       u=7 $ Absorber +Y
118 6 -7.9400 -110       u=7 $ Cladding +Y
119 0          +107 +108 +109 +110    u=7 $ Void
C Cells - DFC Fuel Tube Absorber 1 Side (X) v1.0
120 0          -107       u=8 $ Tube void
121 6 -7.9400 -108 +107       u=8 $ Tube
122 8 -2.6707 -111       u=8 $ Absorber +X
123 6 -7.9400 -112       u=8 $ Cladding +X
124 0          +107 +108 +111 +112    u=8 $ Void
C Cells - DFC Fuel Tube No Absorber v1.0
125 0          -107       u=9 $ Tube void
126 6 -7.9400 -108 +107       u=9 $ Tube
127 0          +107 +108       u=9 $ Void
c Cell Cards - Disk Stack v1.0
201 6 -7.94 -203 trcl = ( 0.0000 0.0000 2.5400 )    u=4 $ Bottom weldment disk
202 6 -7.94 -201 trcl = ( 0.0000 0.0000 15.0368 )    u=4 $ Support disk 1
203 like 202 but   trcl = ( 0.0000 0.0000 24.7650 )    u=4 $ Support disk 2
204 like 202 but   trcl = ( 0.0000 0.0000 34.4932 )    u=4 $ Support disk 3
205 like 202 but   trcl = ( 0.0000 0.0000 44.2214 )    u=4 $ Support disk 4
206 like 202 but   trcl = ( 0.0000 0.0000 53.9496 )    u=4 $ Support disk 5
207 9 -2.70 -202 trcl = ( 0.0000 0.0000 58.9788 )    u=4 $ Heat transfer disk 1
208 like 202 but   trcl = ( 0.0000 0.0000 63.6778 )    u=4 $ Support disk 6
209 like 207 but   trcl = ( 0.0000 0.0000 68.7070 )    u=4 $ Heat transfer disk 2
210 like 202 but   trcl = ( 0.0000 0.0000 73.4060 )    u=4 $ Support disk 7
211 like 207 but   trcl = ( 0.0000 0.0000 78.4352 )    u=4 $ Heat transfer disk 3
212 like 202 but   trcl = ( 0.0000 0.0000 83.1342 )    u=4 $ Support disk 8
213 like 207 but   trcl = ( 0.0000 0.0000 88.1634 )    u=4 $ Heat transfer disk 4
214 like 202 but   trcl = ( 0.0000 0.0000 92.8624 )    u=4 $ Support disk 9
215 like 207 but   trcl = ( 0.0000 0.0000 97.8916 )    u=4 $ Heat transfer disk 5
216 like 202 but   trcl = ( 0.0000 0.0000 102.5906 )    u=4 $ Support disk 10
217 like 207 but   trcl = ( 0.0000 0.0000 107.6198 )    u=4 $ Heat transfer disk 6
218 like 202 but   trcl = ( 0.0000 0.0000 112.3188 )    u=4 $ Support disk 11
219 like 207 but   trcl = ( 0.0000 0.0000 117.3480 )    u=4 $ Heat transfer disk 7
220 like 202 but   trcl = ( 0.0000 0.0000 122.0470 )    u=4 $ Support disk 12
221 like 207 but   trcl = ( 0.0000 0.0000 127.0762 )    u=4 $ Heat transfer disk 8
```

Figure 5.A.6-3 MPC-LACBWR MCNP Input File for Storage Cask Radial Biasing – Fuel Gamma Source

```
222 like 202 but   trcl = ( 0.0000 0.0000 131.7752 )    u=4 $ Support disk 13
223 like 207 but   trcl = ( 0.0000 0.0000 136.8044 )    u=4 $ Heat transfer disk 9
224 like 202 but   trcl = ( 0.0000 0.0000 141.5034 )    u=4 $ Support disk 14
225 like 207 but   trcl = ( 0.0000 0.0000 146.5326 )    u=4 $ Heat transfer disk 10
226 like 202 but   trcl = ( 0.0000 0.0000 151.2316 )    u=4 $ Support disk 15
227 like 207 but   trcl = ( 0.0000 0.0000 156.2608 )    u=4 $ Heat transfer disk 11
228 like 202 but   trcl = ( 0.0000 0.0000 160.9598 )    u=4 $ Support disk 16
229 like 207 but   trcl = ( 0.0000 0.0000 165.9890 )    u=4 $ Heat transfer disk 12
230 like 202 but   trcl = ( 0.0000 0.0000 170.6880 )    u=4 $ Support disk 17
231 like 207 but   trcl = ( 0.0000 0.0000 175.7172 )    u=4 $ Heat transfer disk 13
232 like 202 but   trcl = ( 0.0000 0.0000 180.4162 )    u=4 $ Support disk 18
233 like 207 but   trcl = ( 0.0000 0.0000 185.4454 )    u=4 $ Heat transfer disk 14
234 like 202 but   trcl = ( 0.0000 0.0000 190.1444 )    u=4 $ Support disk 19
235 like 202 but   trcl = ( 0.0000 0.0000 199.8726 )    u=4 $ Support disk 20
236 like 202 but   trcl = ( 0.0000 0.0000 209.6008 )    u=4 $ Support disk 21
237 like 202 but   trcl = ( 0.0000 0.0000 219.3290 )    u=4 $ Support disk 22
238 like 202 but   trcl = ( 0.0000 0.0000 229.0572 )    u=4 $ Support disk 23
239 like 202 but   trcl = ( 0.0000 0.0000 238.7854 )    u=4 $ Support disk 24
240 like 201 but   trcl = ( 0.0000 0.0000 255.8796 )    u=4 $ Top weldment disk
241 0                 $ Outside Disks
      #201 #202 #203 #204 #205 #206 #207 #208 #209 #210
      #211 #212 #213 #214 #215 #216 #217 #218 #219 #220
      #221 #222 #223 #224 #225 #226 #227 #228 #229 #230
      #231 #232 #233 #234 #235 #236 #237 #238 #239
      #240        u=4
c Cell Cards - Basket v1.0
301 0          -302 #302  fill=8 ( -8.8265 77.5233 0.0000 )      $ Tube/Disk 1
          trcl = ( -8.8265 77.5233 0.0000 )     u=3
302 0          -1  fill=10 trcl = ( -8.8265 77.5233 0.0000 )     u=3 $ Assembly 1
303 0          -302 #304  fill=9 ( 8.8265 77.5233 0.0000 )      $ Tube/Disk 2
          trcl = ( 8.8265 77.5233 0.0000 )     u=3
304 like 302 but     trcl = ( 8.8265 77.5233 0.0000 )     u=3 $ Assembly 2
305 0          -302 #306  fill=8 ( -44.1274 61.2699 0.0000 )      $ Tube/Disk 3
          trcl = ( -44.1274 61.2699 0.0000 )     u=3
306 like 302 but     trcl = ( -44.1274 61.2699 0.0000 )     u=3 $ Assembly 3
307 0          -302 #308  fill=8 ( -26.4770 59.8729 0.0000 )      $ Tube/Disk 4
          trcl = ( -26.4770 59.8729 0.0000 )     u=3
308 like 302 but     trcl = ( -26.4770 59.8729 0.0000 )     u=3 $ Assembly 4
309 0          -302 #310  fill=6 ( -8.8265 59.8729 0.0000 )      $ Tube/Disk 5
          trcl = ( -8.8265 59.8729 0.0000 )     u=3
310 like 302 but     trcl = ( -8.8265 59.8729 0.0000 )     u=3 $ Assembly 5
311 0          -302 #312  fill=6 ( 8.8265 59.8729 0.0000 )      $ Tube/Disk 6
          trcl = ( 8.8265 59.8729 0.0000 )     u=3
312 like 302 but     trcl = ( 8.8265 59.8729 0.0000 )     u=3 $ Assembly 6
313 0          -302 #314  fill=8 ( 26.4770 59.8729 0.0000 )      $ Tube/Disk 7
          trcl = ( 26.4770 59.8729 0.0000 )     u=3
314 like 302 but     trcl = ( 26.4770 59.8729 0.0000 )     u=3 $ Assembly 7
315 0          -302 #316  fill=9 ( 44.1274 61.2699 0.0000 )      $ Tube/Disk 8
          trcl = ( 44.1274 61.2699 0.0000 )     u=3
316 like 302 but     trcl = ( 44.1274 61.2699 0.0000 )     u=3 $ Assembly 8
317 0          -302 #318  fill=8 ( -61.2699 44.1274 0.0000 )      $ Tube/Disk 9
          trcl = ( -61.2699 44.1274 0.0000 )     u=3
318 like 302 but     trcl = ( -61.2699 44.1274 0.0000 )     u=3 $ Assembly 9
319 0          -301 #320  fill=5 ( -42.5399 42.5399 0.0000 )      $ Tube/Disk 10
          trcl = ( -42.5399 42.5399 0.0000 )     u=3
320 like 302 but     trcl = ( -42.5399 42.5399 0.0000 )     u=3 $ Assembly 10
321 0          -301 #322  fill=5 ( -25.5245 42.5399 0.0000 )      $ Tube/Disk 11
          trcl = ( -25.5245 42.5399 0.0000 )     u=3
322 like 302 but     trcl = ( -25.5245 42.5399 0.0000 )     u=3 $ Assembly 11
323 0          -301 #324  fill=5 ( -8.5090 42.5399 0.0000 )      $ Tube/Disk 12
          trcl = ( -8.5090 42.5399 0.0000 )     u=3
324 like 302 but     trcl = ( -8.5090 42.5399 0.0000 )     u=3 $ Assembly 12
325 0          -301 #326  fill=5 ( 8.5090 42.5399 0.0000 )      $ Tube/Disk 13
          trcl = ( 8.5090 42.5399 0.0000 )     u=3
```

Figure 5.A.6-3 MPC-LACBWR MCNP Input File for Storage Cask Radial Biasing – Fuel Gamma Source

```
326 like 302 but     trcl = ( 8.5090 42.5399 0.0000 )     u=3 $ Assembly 13
327 0          -301 #328  fill=5 ( 25.5245 42.5399 0.0000 )      $ Tube/Disk 14
           trcl = ( 25.5245 42.5399 0.0000 )     u=3
328 like 302 but     trcl = ( 25.5245 42.5399 0.0000 )     u=3 $ Assembly 14
329 0          -301 #330  fill=5 ( 42.5399 42.5399 0.0000 )      $ Tube/Disk 15
           trcl = ( 42.5399 42.5399 0.0000 )     u=3
330 like 302 but     trcl = ( 42.5399 42.5399 0.0000 )     u=3 $ Assembly 15
331 0          -302 #332  fill=9 ( 61.2699 44.1274 0.0000 )      $ Tube/Disk 16
           trcl = ( 61.2699 44.1274 0.0000 )     u=3
332 like 302 but     trcl = ( 61.2699 44.1274 0.0000 )     u=3 $ Assembly 16
333 0          -302 #334  fill=6 ( -59.8729 26.4770 0.0000 )      $ Tube/Disk 17
           trcl = ( -59.8729 26.4770 0.0000 )     u=3
334 like 302 but     trcl = ( -59.8729 26.4770 0.0000 )     u=3 $ Assembly 17
335 0          -301 #336  fill=5 ( -42.5399 25.5245 0.0000 )      $ Tube/Disk 18
           trcl = ( -42.5399 25.5245 0.0000 )     u=3
336 like 302 but     trcl = ( -42.5399 25.5245 0.0000 )     u=3 $ Assembly 18
337 0          -301 #338  fill=5 ( -25.5245 25.5245 0.0000 )      $ Tube/Disk 19
           trcl = ( -25.5245 25.5245 0.0000 )     u=3
338 like 302 but     trcl = ( -25.5245 25.5245 0.0000 )     u=3 $ Assembly 19
339 0          -301 #340  fill=5 ( -8.5090 25.5245 0.0000 )      $ Tube/Disk 20
           trcl = ( -8.5090 25.5245 0.0000 )     u=3
340 like 302 but     trcl = ( -8.5090 25.5245 0.0000 )     u=3 $ Assembly 20
341 0          -301 #342  fill=5 ( 8.5090 25.5245 0.0000 )      $ Tube/Disk 21
           trcl = ( 8.5090 25.5245 0.0000 )     u=3
342 like 302 but     trcl = ( 8.5090 25.5245 0.0000 )     u=3 $ Assembly 21
343 0          -301 #344  fill=5 ( 25.5245 25.5245 0.0000 )      $ Tube/Disk 22
           trcl = ( 25.5245 25.5245 0.0000 )     u=3
344 like 302 but     trcl = ( 25.5245 25.5245 0.0000 )     u=3 $ Assembly 22
345 0          -301 #346  fill=5 ( 42.5399 25.5245 0.0000 )      $ Tube/Disk 23
           trcl = ( 42.5399 25.5245 0.0000 )     u=3
346 like 302 but     trcl = ( 42.5399 25.5245 0.0000 )     u=3 $ Assembly 23
347 0          -302 #348  fill=7 ( 59.8729 26.4770 0.0000 )      $ Tube/Disk 24
           trcl = ( 59.8729 26.4770 0.0000 )     u=3
348 like 302 but     trcl = ( 59.8729 26.4770 0.0000 )     u=3 $ Assembly 24
349 0          -302 #350  fill=8 ( -77.5233 8.8265 0.0000 )      $ Tube/Disk 25
           trcl = ( -77.5233 8.8265 0.0000 )     u=3
350 like 302 but     trcl = ( -77.5233 8.8265 0.0000 )     u=3 $ Assembly 25
351 0          -302 #352  fill=6 ( -59.8729 8.8265 0.0000 )      $ Tube/Disk 26
           trcl = ( -59.8729 8.8265 0.0000 )     u=3
352 like 302 but     trcl = ( -59.8729 8.8265 0.0000 )     u=3 $ Assembly 26
353 0          -301 #354  fill=5 ( -42.5399 8.5090 0.0000 )      $ Tube/Disk 27
           trcl = ( -42.5399 8.5090 0.0000 )     u=3
354 like 302 but     trcl = ( -42.5399 8.5090 0.0000 )     u=3 $ Assembly 27
355 0          -301 #356  fill=5 ( -25.5245 8.5090 0.0000 )      $ Tube/Disk 28
           trcl = ( -25.5245 8.5090 0.0000 )     u=3
356 like 302 but     trcl = ( -25.5245 8.5090 0.0000 )     u=3 $ Assembly 28
357 0          -301 #358  fill=5 ( -8.5090 8.5090 0.0000 )      $ Tube/Disk 29
           trcl = ( -8.5090 8.5090 0.0000 )     u=3
358 like 302 but     trcl = ( -8.5090 8.5090 0.0000 )     u=3 $ Assembly 29
359 0          -301 #360  fill=5 ( 8.5090 8.5090 0.0000 )      $ Tube/Disk 30
           trcl = ( 8.5090 8.5090 0.0000 )     u=3
360 like 302 but     trcl = ( 8.5090 8.5090 0.0000 )     u=3 $ Assembly 30
361 0          -301 #362  fill=5 ( 25.5245 8.5090 0.0000 )      $ Tube/Disk 31
           trcl = ( 25.5245 8.5090 0.0000 )     u=3
362 like 302 but     trcl = ( 25.5245 8.5090 0.0000 )     u=3 $ Assembly 31
363 0          -301 #364  fill=5 ( 42.5399 8.5090 0.0000 )      $ Tube/Disk 32
           trcl = ( 42.5399 8.5090 0.0000 )     u=3
364 like 302 but     trcl = ( 42.5399 8.5090 0.0000 )     u=3 $ Assembly 32
365 0          -302 #366  fill=6 ( 59.8729 8.8265 0.0000 )      $ Tube/Disk 33
           trcl = ( 59.8729 8.8265 0.0000 )     u=3
366 like 302 but     trcl = ( 59.8729 8.8265 0.0000 )     u=3 $ Assembly 33
367 0          -302 #368  fill=9 ( 77.5233 8.8265 0.0000 )      $ Tube/Disk 34
           trcl = ( 77.5233 8.8265 0.0000 )     u=3
368 like 302 but     trcl = ( 77.5233 8.8265 0.0000 )     u=3 $ Assembly 34
```

Figure 5.A.6-3 MPC-LACBWR MCNP Input File for Storage Cask Radial Biasing – Fuel Gamma Source

```
369 0          -302 #370  fill=6 ( -77.5233 -8.8265 0.0000 )       $ Tube/Disk 35
           trcl = ( -77.5233 -8.8265 0.0000 )      u=3
370 like 302 but     trcl = ( -77.5233 -8.8265 0.0000 )     u=3 $ Assembly 35
371 0          -302 #372  fill=6 ( -59.8729 -8.8265 0.0000 )       $ Tube/Disk 36
           trcl = ( -59.8729 -8.8265 0.0000 )      u=3
372 like 302 but     trcl = ( -59.8729 -8.8265 0.0000 )     u=3 $ Assembly 36
373 0          -301 #374  fill=5 ( -42.5399 -8.5090 0.0000 )       $ Tube/Disk 37
           trcl = ( -42.5399 -8.5090 0.0000 )      u=3
374 like 302 but     trcl = ( -42.5399 -8.5090 0.0000 )     u=3 $ Assembly 37
375 0          -301 #376  fill=5 ( -25.5245 -8.5090 0.0000 )       $ Tube/Disk 38
           trcl = ( -25.5245 -8.5090 0.0000 )      u=3
376 like 302 but     trcl = ( -25.5245 -8.5090 0.0000 )     u=3 $ Assembly 38
377 0          -301 #378  fill=5 ( -8.5090 -8.5090 0.0000 )       $ Tube/Disk 39
           trcl = ( -8.5090 -8.5090 0.0000 )      u=3
378 like 302 but     trcl = ( -8.5090 -8.5090 0.0000 )     u=3 $ Assembly 39
379 0          -301 #380  fill=5 ( 8.5090 -8.5090 0.0000 )       $ Tube/Disk 40
           trcl = ( 8.5090 -8.5090 0.0000 )      u=3
380 like 302 but     trcl = ( 8.5090 -8.5090 0.0000 )     u=3 $ Assembly 40
381 0          -301 #382  fill=5 ( 25.5245 -8.5090 0.0000 )       $ Tube/Disk 41
           trcl = ( 25.5245 -8.5090 0.0000 )      u=3
382 like 302 but     trcl = ( 25.5245 -8.5090 0.0000 )     u=3 $ Assembly 41
383 0          -301 #384  fill=5 ( 42.5399 -8.5090 0.0000 )       $ Tube/Disk 42
           trcl = ( 42.5399 -8.5090 0.0000 )      u=3
384 like 302 but     trcl = ( 42.5399 -8.5090 0.0000 )     u=3 $ Assembly 42
385 0          -302 #386  fill=6 ( 59.8729 -8.8265 0.0000 )       $ Tube/Disk 43
           trcl = ( 59.8729 -8.8265 0.0000 )      u=3
386 like 302 but     trcl = ( 59.8729 -8.8265 0.0000 )     u=3 $ Assembly 43
387 0          -302 #388  fill=7 ( 77.5233 -8.8265 0.0000 )       $ Tube/Disk 44
           trcl = ( 77.5233 -8.8265 0.0000 )      u=3
388 like 302 but     trcl = ( 77.5233 -8.8265 0.0000 )     u=3 $ Assembly 44
389 0          -302 #390  fill=6 ( -59.8729 -26.4770 0.0000 )       $ Tube/Disk 45
           trcl = ( -59.8729 -26.4770 0.0000 )      u=3
390 like 302 but     trcl = ( -59.8729 -26.4770 0.0000 )     u=3 $ Assembly 45
391 0          -301 #392  fill=5 ( -42.5399 -25.5245 0.0000 )       $ Tube/Disk 46
           trcl = ( -42.5399 -25.5245 0.0000 )      u=3
392 like 302 but     trcl = ( -42.5399 -25.5245 0.0000 )     u=3 $ Assembly 46
393 0          -301 #394  fill=5 ( -25.5245 -25.5245 0.0000 )       $ Tube/Disk 47
           trcl = ( -25.5245 -25.5245 0.0000 )      u=3
394 like 302 but     trcl = ( -25.5245 -25.5245 0.0000 )     u=3 $ Assembly 47
395 0          -301 #396  fill=5 ( -8.5090 -25.5245 0.0000 )       $ Tube/Disk 48
           trcl = ( -8.5090 -25.5245 0.0000 )      u=3
396 like 302 but     trcl = ( -8.5090 -25.5245 0.0000 )     u=3 $ Assembly 48
397 0          -301 #398  fill=5 ( 8.5090 -25.5245 0.0000 )       $ Tube/Disk 49
           trcl = ( 8.5090 -25.5245 0.0000 )      u=3
398 like 302 but     trcl = ( 8.5090 -25.5245 0.0000 )     u=3 $ Assembly 49
399 0          -301 #400  fill=5 ( 25.5245 -25.5245 0.0000 )       $ Tube/Disk 50
           trcl = ( 25.5245 -25.5245 0.0000 )      u=3
400 like 302 but     trcl = ( 25.5245 -25.5245 0.0000 )     u=3 $ Assembly 50
401 0          -301 #402  fill=5 ( 42.5399 -25.5245 0.0000 )       $ Tube/Disk 51
           trcl = ( 42.5399 -25.5245 0.0000 )      u=3
402 like 302 but     trcl = ( 42.5399 -25.5245 0.0000 )     u=3 $ Assembly 51
403 0          -302 #404  fill=7 ( 59.8729 -26.4770 0.0000 )       $ Tube/Disk 52
           trcl = ( 59.8729 -26.4770 0.0000 )      u=3
404 like 302 but     trcl = ( 59.8729 -26.4770 0.0000 )     u=3 $ Assembly 52
405 0          -302 #406  fill=6 ( -61.2699 -44.1274 0.0000 )       $ Tube/Disk 53
           trcl = ( -61.2699 -44.1274 0.0000 )      u=3
406 like 302 but     trcl = ( -61.2699 -44.1274 0.0000 )     u=3 $ Assembly 53
407 0          -301 #408  fill=5 ( -42.5399 -42.5399 0.0000 )       $ Tube/Disk 54
           trcl = ( -42.5399 -42.5399 0.0000 )      u=3
408 like 302 but     trcl = ( -42.5399 -42.5399 0.0000 )     u=3 $ Assembly 54
409 0          -301 #410  fill=5 ( -25.5245 -42.5399 0.0000 )       $ Tube/Disk 55
           trcl = ( -25.5245 -42.5399 0.0000 )      u=3
410 like 302 but     trcl = ( -25.5245 -42.5399 0.0000 )     u=3 $ Assembly 55
411 0          -301 #412  fill=5 ( -8.5090 -42.5399 0.0000 )       $ Tube/Disk 56
```

Figure 5.A.6-3 MPC-LACBWR MCNP Input File for Storage Cask Radial Biasing – Fuel Gamma Source

```
           trcl = ( -8.5090 -42.5399 0.0000 )     u=3
412 like 302 but     trcl = ( -8.5090 -42.5399 0.0000 )     u=3 $ Assembly 56
413 0         -301 #414  fill=5 ( 8.5090 -42.5399 0.0000 )       $ Tube/Disk 57
           trcl = ( 8.5090 -42.5399 0.0000 )     u=3
414 like 302 but     trcl = ( 8.5090 -42.5399 0.0000 )     u=3 $ Assembly 57
415 0         -301 #416  fill=5 ( 25.5245 -42.5399 0.0000 )      $ Tube/Disk 58
           trcl = ( 25.5245 -42.5399 0.0000 )     u=3
416 like 302 but     trcl = ( 25.5245 -42.5399 0.0000 )     u=3 $ Assembly 58
417 0         -301 #418  fill=5 ( 42.5399 -42.5399 0.0000 )      $ Tube/Disk 59
           trcl = ( 42.5399 -42.5399 0.0000 )     u=3
418 like 302 but     trcl = ( 42.5399 -42.5399 0.0000 )     u=3 $ Assembly 59
419 0         -302 #420  fill=7 ( 61.2699 -44.1274 0.0000 )      $ Tube/Disk 60
           trcl = ( 61.2699 -44.1274 0.0000 )     u=3
420 like 302 but     trcl = ( 61.2699 -44.1274 0.0000 )     u=3 $ Assembly 60
421 0         -302 #422  fill=6 ( -44.1274 -61.2699 0.0000 )      $ Tube/Disk 61
           trcl = ( -44.1274 -61.2699 0.0000 )     u=3
422 like 302 but     trcl = ( -44.1274 -61.2699 0.0000 )     u=3 $ Assembly 61
423 0         -302 #424  fill=6 ( -26.4770 -59.8729 0.0000 )      $ Tube/Disk 62
           trcl = ( -26.4770 -59.8729 0.0000 )     u=3
424 like 302 but     trcl = ( -26.4770 -59.8729 0.0000 )     u=3 $ Assembly 62
425 0         -302 #426  fill=6 ( -8.8265 -59.8729 0.0000 )      $ Tube/Disk 63
           trcl = ( -8.8265 -59.8729 0.0000 )     u=3
426 like 302 but     trcl = ( -8.8265 -59.8729 0.0000 )     u=3 $ Assembly 63
427 0         -302 #428  fill=6 ( 8.8265 -59.8729 0.0000 )      $ Tube/Disk 64
           trcl = ( 8.8265 -59.8729 0.0000 )     u=3
428 like 302 but     trcl = ( 8.8265 -59.8729 0.0000 )     u=3 $ Assembly 64
429 0         -302 #430  fill=6 ( 26.4770 -59.8729 0.0000 )      $ Tube/Disk 65
           trcl = ( 26.4770 -59.8729 0.0000 )     u=3
430 like 302 but     trcl = ( 26.4770 -59.8729 0.0000 )     u=3 $ Assembly 65
431 0         -302 #432  fill=7 ( 44.1274 -61.2699 0.0000 )      $ Tube/Disk 66
           trcl = ( 44.1274 -61.2699 0.0000 )     u=3
432 like 302 but     trcl = ( 44.1274 -61.2699 0.0000 )     u=3 $ Assembly 66
433 0         -302 #434  fill=7 ( -8.8265 -77.5233 0.0000 )      $ Tube/Disk 67
           trcl = ( -8.8265 -77.5233 0.0000 )     u=3
434 like 302 but     trcl = ( -8.8265 -77.5233 0.0000 )     u=3 $ Assembly 67
435 0         -302 #436  fill=7 ( 8.8265 -77.5233 0.0000 )      $ Tube/Disk 68
           trcl = ( 8.8265 -77.5233 0.0000 )     u=3
436 like 302 but     trcl = ( 8.8265 -77.5233 0.0000 )     u=3 $ Assembly 68
437 0         +303 +304        $ Canister Cavity Q1
      #303 #311 #313 #315 #325 #327 #329 #331 #341
      #304 #312 #314 #316 #326 #328 #330 #332 #342
      #343 #345 #347 #359 #361 #363 #365 #367
      #344 #346 #348 #360 #362 #364 #366 #368
          fill=4     u=3
438 0         +303 -304        $ Canister Cavity Q2
      #301 #305 #307 #309 #317 #319 #321 #323 #333
      #302 #306 #308 #310 #318 #320 #322 #324 #334
      #335 #337 #339 #349 #351 #353 #355 #357
      #336 #338 #340 #350 #352 #354 #356 #358
          fill=4     u=3
439 0         -303 -304        $ Canister Cavity Q3
      #369 #371 #373 #375 #377 #389 #391 #393 #395
      #370 #372 #374 #376 #378 #390 #392 #394 #396
      #405 #407 #409 #411 #421 #423 #425 #433
      #406 #408 #410 #412 #422 #424 #426 #434
          fill=4     u=3
440 0         -303 +304        $ Canister Cavity Q4
      #379 #381 #383 #385 #387 #397 #399 #401 #403
      #380 #382 #384 #386 #388 #398 #400 #402 #404
      #413 #415 #417 #419 #427 #429 #431 #435
      #414 #416 #418 #420 #428 #430 #432 #436
          fill=4     u=3
C Cells - Canister v1.0
501 0         -501 fill=3      u=2 $ Cavity
```

Figure 5.A.6-3 MPC-LACBWR MCNP Input File for Storage Cask Radial Biasing – Fuel Gamma Source

```
502 6 -7.9400 -507 +501.3      u=2 $ Canister Bottom
503 0         -502 +501.2 -505 trcl = ( 72.8704 22.2787 0.0000 )   u=2 $ Bottom Drain Port
504 0         -503 +505 -506 trcl = ( 72.8704 22.2787 0.0000 )   u=2 $ Middle Drain Port
505 6 -7.9400 -504 +506 -507.2 trcl = ( 72.8704 22.2787 0.0000 )    u=2 $ Top Drain Port
506 like 503 but   trcl = ( -72.8704 -22.2787 0.0000 )    u=2 $ Bottom Vent Port
507 like 504 but   trcl = ( -72.8704 -22.2787 0.0000 )    u=2 $ Middle Vent Port
508 like 505 but   trcl = ( -72.8704 -22.2787 0.0000 )    u=2 $ Top Vent Port
509 6 -7.9400 -507 -501.3 +501.1     u=2 $ Canister Shell
510 6 -7.9400 -507 -501.1 +501.2 #503 #504 #505 #506 #507 #508     u=2 $ Lid
511 0         +507       u=2 $ Outside
c Cell Cards - Storage Cask Geometry v4.0
601 7 -7.8212 -605        u=1 $ Base Plate
602 0         (-614 +612 -601         $ Air Inlet Channel Void
              +643 +644 +645 +646
              +651 +652 +653 +654) :
              (-614 +613 -612 +618)        u=1
603 7 -7.8212 -615 +614 +612 -601     u=1 $ Air Inlet Channel Mat
604 0         (-616 +612 -601         $ Air Inlet Channel Void
              +647 +648 +649 +650
              +655 +656 +657 +658) :
              (-616 +613 -612 +618)        u=1
605 7 -7.8212 -617 +616 +612 -601     u=1 $ Air Inlet Channel Mat
606 0         -619 -612 +613      u=1 $ Stand Cut-Out Top
607 like 606 but *trcl = (0 0 0 90 180 90 0 90 90 90 90 0)      u=1 $ Stand Cut-Out Top
608 7 -7.8212 -601 -612 +613 +618 +605 +614 +616 #606 #607  u=1 $ Stand Material
609 7 -7.8212 (-601 -612 -618) : (-601 +612 -618 +615 +617)        u=1 $ Bottom Plate
610 7 -7.8212 (-606 +607 +618 -610) : (-608 +609 +610 -611)        u=1 $ Baffle Cone Mat
611 0         (-607 +618 -610) : (-609 +610 -611)        u=1 $ Baffle Cone Int. Void
612 0         -613 +618 -611 +606 +608    u=1 $ Void inside stand - A
613 0         -601 -613 +611 +605     u=1 $ Void inside stand - B
614 0         -601 -603 +612 +618 +605 +615 +617  u=1 $ Void stand to liner
615 7 -7.8212 -601 -604 +603 +618 +615 +617   u=1 $ Liner
616 12 -2.3233 -601 +604 +618 +615 +617    u=1 $ Concrete
617 7 -7.8212 -620        u=1 $ VCC Lid
618 7 -7.8212 -621 +622       u=1 $ TopFlange
619 0         -621 -622 +603 +623     u=1 $ Void Cavity to Flange
620 12 -2.3233 -624        u=1 $ Lid Concrete
621 7 -7.8212 -623 +624       u=1 $ Lid Cover
622 12 -2.3233 (-626 +604) : (-627 -602 +628)        u=1 $ Concrete - Outlet Box
623 0         (-629 +630 +604) : (-631 +629 -602)        u=1 $ Air Outlet Void
624 7 -7.8212 -625 -602 +604 #622 #623      u=1 $ Air Outlet Steel
625 12 -2.3233 (-633 +604) : (-634 -602 +635)        u=1 $ Concrete - Outlet Box
626 0         (-636 +637 +604) : (-638 +636 -602)        u=1 $ Air Outlet Void
627 7 -7.8212 -632 -602 +604 #625 #626      u=1 $ Air Outlet Steel
628 12 -2.3233 -602 +604 +621 #622 #623 #624 #625 #626 #627    fill=11  u=1 $ Concrete
629 0         (-639 -641 +603) : (-640 -604 +641)        u=1 $ Air Outlet Liner Void
630 like 629 but *trcl = (0 0 0 90 180 90 0 90 90 90 90 0)      u=1 $ Air Outlet Liner Void
631 7 -7.8212 -602 -604 +603 +621 #629 #630     u=1 $ Liner Minus Voids
632 0         -602 -603 +623  fill=2 ( 0.0000 0.0000 2.5400 )    u=1 $ Cavity
633 12 -2.3233 -642        u=1 $ Concrete pad
634 7 -7.8212 -643 : -644 : -645 : -646        u=1 $ Air inlet pipes +x+y
635 7 -7.8212 -647 : -648 : -649 : -650        u=1 $ Air inlet pipes -x-y
636 7 -7.8212 -651 : -652 : -653 : -654        u=1 $ Air inlet pipes -x+y
637 7 -7.8212 -655 : -656 : -657 : -658        u=1 $ Air inlet pipes +x-y
638 0         +601 +602 +620 +642 #602 #603 #604 #605     u=1 $ Container
C VCC Rebar Cells - v4.0
639 7 -7.8212 -659      u=11 $ Inner hoop 1
640 7 -7.8212 -660      u=11 $ Inner hoop 2
641 7 -7.8212 -661      u=11 $ Inner hoop 3
642 7 -7.8212 -662      u=11 $ Inner hoop 4
643 7 -7.8212 -663      u=11 $ Inner hoop 5
644 7 -7.8212 -664      u=11 $ Inner hoop 6
645 7 -7.8212 -665      u=11 $ Inner hoop 7
646 7 -7.8212 -666      u=11 $ Inner hoop 8
```

Figure 5.A.6-3 MPC-LACBWR MCNP Input File for Storage Cask Radial Biasing – Fuel Gamma Source

```
647 7 -7.8212 -667      u=11 $ Inner hoop 9
648 7 -7.8212 -668      u=11 $ Inner hoop 10
649 7 -7.8212 -669      u=11 $ Inner hoop 11
650 7 -7.8212 -670      u=11 $ Inner hoop 12
651 7 -7.8212 -671      u=11 $ Inner hoop 13
652 7 -7.8212 -672      u=11 $ Inner hoop 14
653 7 -7.8212 -673      u=11 $ Inner hoop 15
654 7 -7.8212 -674      u=11 $ Inner hoop 16
655 7 -7.8212 -675      u=11 $ Inner hoop 17
656 7 -7.8212 -676      u=11 $ Outer hoop 1
657 7 -7.8212 -677      u=11 $ Outer hoop 2
658 7 -7.8212 -678      u=11 $ Outer hoop 3
659 7 -7.8212 -679      u=11 $ Outer hoop 4
660 7 -7.8212 -680      u=11 $ Outer hoop 5
661 7 -7.8212 -681      u=11 $ Outer hoop 6
662 7 -7.8212 -682      u=11 $ Outer hoop 7
663 7 -7.8212 -683      u=11 $ Outer hoop 8
664 7 -7.8212 -684      u=11 $ Outer hoop 9
665 7 -7.8212 -685      u=11 $ Outer hoop 10
666 7 -7.8212 -686      u=11 $ Outer hoop 11
667 7 -7.8212 -687      u=11 $ Outer hoop 12
668 7 -7.8212 -688      u=11 $ Outer hoop 13
669 7 -7.8212 -689      u=11 $ Outer hoop 14
670 7 -7.8212 -690      u=11 $ Outer hoop 15
671 7 -7.8212 -691      u=11 $ Outer hoop 16
672 7 -7.8212 -692      u=11 $ Outer hoop 17
673 7 -7.8212 -693      u=11 $ Outer hoop 18
674 7 -7.8212 -694      u=11 $ Outer hoop 19
675 7 -7.8212 -695      u=11 $ Outer hoop 20
676 7 -7.8212 -696      u=11 $ Outer hoop 21
677 7 -7.8212 -697      u=11 $ Outer hoop 22
678 7 -7.8212 -698      u=11 $ Outer hoop 23
679 7 -7.8212 -699      u=11 $ Outer hoop 24
680 7 -7.8212 -700      u=11 $ Outer hoop 25
681 7 -7.8212 -701      u=11 $ Outer hoop 26
682 7 -7.8212 -702      u=11 $ Outer hoop 27
683 7 -7.8212 -703      u=11 $ Outer hoop 28
684 7 -7.8212 -704      u=11 $ Outer hoop 29
685 7 -7.8212 -705      u=11 $ Outer hoop 30
686 7 -7.8212 -706      u=11 $ Outer hoop 31
687 7 -7.8212 -707      u=11 $ Outer hoop 32
688 7 -7.8212 -708      u=11 $ Outer hoop 33
689 7 -7.8212 -709      u=11 $ Outer hoop 34
690 12 -2.3233  #639 #640 #641 #642 #643 #644 #645 #646 #647 #648       $ Concrete
                #649 #650 #651 #652 #653 #654 #655 #656 #657 #658
                #659 #660 #661 #662 #663 #664 #665 #666 #667 #668
                #669 #670 #671 #672 #673 #674 #675 #676 #677 #678
                #679 #680 #681 #682 #683 #684 #685 #686 #687 #688
                #689      fill=12 u=11
691 7 -7.8212 -710  trcl = ( 115.2525 0.0000 0.0000 )    u=12 $ Inner bar 1
692 like 691 but  trcl = ( 113.5016 20.0134 0.0000 )    u=12 $ Inner bar 2
693 like 691 but  trcl = ( 108.3019 39.4187 0.0000 )    u=12 $ Inner bar 3
694 like 691 but  trcl = ( 99.8116 57.6263 0.0000 )    u=12 $ Inner bar 4
695 like 691 but  trcl = ( 88.2885 74.0829 0.0000 )    u=12 $ Inner bar 5
696 like 691 but  trcl = ( 74.0829 88.2885 0.0000 )    u=12 $ Inner bar 6
697 like 691 but  trcl = ( 57.6263 99.8116 0.0000 )    u=12 $ Inner bar 7
698 like 691 but  trcl = ( 39.4187 108.3019 0.0000 )    u=12 $ Inner bar 8
699 like 691 but  trcl = ( 20.0134 113.5016 0.0000 )    u=12 $ Inner bar 9
700 like 691 but  trcl = ( 0.0000 115.2525 0.0000 )    u=12 $ Inner bar 10
701 like 691 but  trcl = ( -20.0134 113.5016 0.0000 )    u=12 $ Inner bar 11
702 like 691 but  trcl = ( -39.4187 108.3019 0.0000 )    u=12 $ Inner bar 12
703 like 691 but  trcl = ( -57.6263 99.8116 0.0000 )    u=12 $ Inner bar 13
704 like 691 but  trcl = ( -74.0829 88.2885 0.0000 )    u=12 $ Inner bar 14
705 like 691 but  trcl = ( -88.2885 74.0829 0.0000 )    u=12 $ Inner bar 15
```

Figure 5.A.6-3 MPC-LACBWR MCNP Input File for Storage Cask Radial Biasing – Fuel Gamma Source

```
706 like 691 but  trcl = ( -99.8116 57.6263 0.0000 )    u=12 $ Inner bar 16
707 like 691 but  trcl = ( -108.3019 39.4187 0.0000 )    u=12 $ Inner bar 17
708 like 691 but  trcl = ( -113.5016 20.0134 0.0000 )    u=12 $ Inner bar 18
709 like 691 but  trcl = ( -115.2525 0.0000 0.0000 )    u=12 $ Inner bar 19
710 like 691 but  trcl = ( -113.5016 -20.0134 0.0000 )    u=12 $ Inner bar 20
711 like 691 but  trcl = ( -108.3019 -39.4187 0.0000 )    u=12 $ Inner bar 21
712 like 691 but  trcl = ( -99.8116 -57.6262 0.0000 )    u=12 $ Inner bar 22
713 like 691 but  trcl = ( -88.2885 -74.0829 0.0000 )    u=12 $ Inner bar 23
714 like 691 but  trcl = ( -74.0829 -88.2885 0.0000 )    u=12 $ Inner bar 24
715 like 691 but  trcl = ( -57.6263 -99.8116 0.0000 )    u=12 $ Inner bar 25
716 like 691 but  trcl = ( -39.4187 -108.3019 0.0000 )    u=12 $ Inner bar 26
717 like 691 but  trcl = ( -20.0134 -113.5016 0.0000 )    u=12 $ Inner bar 27
718 like 691 but  trcl = ( 0.0000 -115.2525 0.0000 )    u=12 $ Inner bar 28
719 like 691 but  trcl = ( 20.0134 -113.5016 0.0000 )    u=12 $ Inner bar 29
720 like 691 but  trcl = ( 39.4187 -108.3019 0.0000 )    u=12 $ Inner bar 30
721 like 691 but  trcl = ( 57.6262 -99.8116 0.0000 )    u=12 $ Inner bar 31
722 like 691 but  trcl = ( 74.0829 -88.2885 0.0000 )    u=12 $ Inner bar 32
723 like 691 but  trcl = ( 88.2885 -74.0829 0.0000 )    u=12 $ Inner bar 33
724 like 691 but  trcl = ( 99.8116 -57.6263 0.0000 )    u=12 $ Inner bar 34
725 like 691 but  trcl = ( 108.3019 -39.4187 0.0000 )    u=12 $ Inner bar 35
726 like 691 but  trcl = ( 113.5016 -20.0134 0.0000 )    u=12 $ Inner bar 36
727 like 691 but  trcl = ( 149.5425 0.0000 0.0000 )    u=12 $ Outer bar 1
728 like 691 but  trcl = ( 148.6022 16.7434 0.0000 )    u=12 $ Outer bar 2
729 like 691 but  trcl = ( 145.7932 33.2763 0.0000 )    u=12 $ Outer bar 3
730 like 691 but  trcl = ( 141.1507 49.3908 0.0000 )    u=12 $ Outer bar 4
731 like 691 but  trcl = ( 134.7331 64.8841 0.0000 )    u=12 $ Outer bar 5
732 like 691 but  trcl = ( 126.6213 79.5614 0.0000 )    u=12 $ Outer bar 6
733 like 691 but  trcl = ( 116.9170 93.2382 0.0000 )    u=12 $ Outer bar 7
734 like 691 but  trcl = ( 105.7425 105.7425 0.0000 )    u=12 $ Outer bar 8
735 like 691 but  trcl = ( 93.2382 116.9170 0.0000 )    u=12 $ Outer bar 9
736 like 691 but  trcl = ( 79.5614 126.6213 0.0000 )    u=12 $ Outer bar 10
737 like 691 but  trcl = ( 64.8841 134.7331 0.0000 )    u=12 $ Outer bar 11
738 like 691 but  trcl = ( 49.3908 141.1507 0.0000 )    u=12 $ Outer bar 12
739 like 691 but  trcl = ( 33.2763 145.7932 0.0000 )    u=12 $ Outer bar 13
740 like 691 but  trcl = ( 16.7434 148.6022 0.0000 )    u=12 $ Outer bar 14
741 like 691 but  trcl = ( 0.0000 149.5425 0.0000 )    u=12 $ Outer bar 15
742 like 691 but  trcl = ( -16.7434 148.6022 0.0000 )    u=12 $ Outer bar 16
743 like 691 but  trcl = ( -33.2763 145.7932 0.0000 )    u=12 $ Outer bar 17
744 like 691 but  trcl = ( -49.3908 141.1507 0.0000 )    u=12 $ Outer bar 18
745 like 691 but  trcl = ( -64.8841 134.7331 0.0000 )    u=12 $ Outer bar 19
746 like 691 but  trcl = ( -79.5614 126.6213 0.0000 )    u=12 $ Outer bar 20
747 like 691 but  trcl = ( -93.2382 116.9170 0.0000 )    u=12 $ Outer bar 21
748 like 691 but  trcl = ( -105.7425 105.7425 0.0000 )    u=12 $ Outer bar 22
749 like 691 but  trcl = ( -116.9170 93.2382 0.0000 )    u=12 $ Outer bar 23
750 like 691 but  trcl = ( -126.6213 79.5614 0.0000 )    u=12 $ Outer bar 24
751 like 691 but  trcl = ( -134.7331 64.8841 0.0000 )    u=12 $ Outer bar 25
752 like 691 but  trcl = ( -141.1507 49.3908 0.0000 )    u=12 $ Outer bar 26
753 like 691 but  trcl = ( -145.7932 33.2763 0.0000 )    u=12 $ Outer bar 27
754 like 691 but  trcl = ( -148.6022 16.7434 0.0000 )    u=12 $ Outer bar 28
755 like 691 but  trcl = ( -149.5425 0.0000 0.0000 )    u=12 $ Outer bar 29
756 like 691 but  trcl = ( -148.6022 -16.7434 0.0000 )    u=12 $ Outer bar 30
757 like 691 but  trcl = ( -145.7932 -33.2763 0.0000 )    u=12 $ Outer bar 31
758 like 691 but  trcl = ( -141.1507 -49.3908 0.0000 )    u=12 $ Outer bar 32
759 like 691 but  trcl = ( -134.7331 -64.8841 0.0000 )    u=12 $ Outer bar 33
760 like 691 but  trcl = ( -126.6213 -79.5614 0.0000 )    u=12 $ Outer bar 34
761 like 691 but  trcl = ( -116.9170 -93.2382 0.0000 )    u=12 $ Outer bar 35
762 like 691 but  trcl = ( -105.7425 -105.7425 0.0000 )    u=12 $ Outer bar 36
763 like 691 but  trcl = ( -93.2382 -116.9170 0.0000 )    u=12 $ Outer bar 37
764 like 691 but  trcl = ( -79.5614 -126.6213 0.0000 )    u=12 $ Outer bar 38
765 like 691 but  trcl = ( -64.8841 -134.7331 0.0000 )    u=12 $ Outer bar 39
766 like 691 but  trcl = ( -49.3908 -141.1507 0.0000 )    u=12 $ Outer bar 40
767 like 691 but  trcl = ( -33.2763 -145.7932 0.0000 )    u=12 $ Outer bar 41
768 like 691 but  trcl = ( -16.7434 -148.6022 0.0000 )    u=12 $ Outer bar 42
769 like 691 but  trcl = ( 0.0000 -149.5425 0.0000 )    u=12 $ Outer bar 43
```

Figure 5.A.6-3 MPC-LACBWR MCNP Input File for Storage Cask Radial Biasing – Fuel Gamma Source

```
770 like 691 but  trcl = ( 16.7434 -148.6022 0.0000 )     u=12 $ Outer bar 44
771 like 691 but  trcl = ( 33.2763 -145.7932 0.0000 )     u=12 $ Outer bar 45
772 like 691 but  trcl = ( 49.3908 -141.1507 0.0000 )     u=12 $ Outer bar 46
773 like 691 but  trcl = ( 64.8841 -134.7331 0.0000 )     u=12 $ Outer bar 47
774 like 691 but  trcl = ( 79.5614 -126.6213 0.0000 )     u=12 $ Outer bar 48
775 like 691 but  trcl = ( 93.2382 -116.9170 0.0000 )     u=12 $ Outer bar 49
776 like 691 but  trcl = ( 105.7425 -105.7425 0.0000 )     u=12 $ Outer bar 50
777 like 691 but  trcl = ( 116.9170 -93.2382 0.0000 )     u=12 $ Outer bar 51
778 like 691 but  trcl = ( 126.6213 -79.5614 0.0000 )     u=12 $ Outer bar 52
779 like 691 but  trcl = ( 134.7331 -64.8841 0.0000 )     u=12 $ Outer bar 53
780 like 691 but  trcl = ( 141.1507 -49.3908 0.0000 )     u=12 $ Outer bar 54
781 like 691 but  trcl = ( 145.7932 -33.2763 0.0000 )     u=12 $ Outer bar 55
782 like 691 but  trcl = ( 148.6022 -16.7434 0.0000 )     u=12 $ Outer bar 56
783 12 -2.3233 #691 #692 #693 #694 #695 #696 #697 #698 #699         $ Concrete
               #700 #701 #702 #703 #704 #705 #706 #707 #708 #709
               #710 #711 #712 #713 #714 #715 #716 #717 #718 #719
               #720 #721 #722 #723 #724 #725 #726 #727 #728 #729
               #730 #731 #732 #733 #734 #735 #736 #737 #738 #739
               #740 #741 #742 #743 #744 #745 #746 #747 #748 #749
               #750 #751 #752 #753 #754 #755 #756 #757 #758 #759
               #760 #761 #762 #763 #764 #765 #766 #767 #768 #769
               #770 #771 #772 #773 #774 #775 #776 #777 #778 #779
               #780 #781 #782         u=12
C Detector Cells - Radial Biasing
799  0  -799  fill=1  $ Cask
800  0  -800  +799  $ Surface
900  0  -900  +799  +800  $ 1ft
1000  0  -1000  +799  +800  +900  $ 1m
1100  0  -1100  +799  +800  +900  +1000  $ 2m
1200  0  -1200  +799  +800  +900  +1000  +1100  $ 4m
1300  0  +799  +800  +900  +1000  +1100  +1200  $ Exterior

C Fuel Assembly Surfaces - v1.0
1 RPP -7.1247 7.1247 -7.1247 7.1247 0.0000 261.9502  $ Assy
2 PZ 27.2796         $ Lower Nozzle/Fuel
3 PZ 238.0996        $ Fuel/Upper Plenum
4 PZ 251.1298        $ Upper Plenum/Upper Nozzle
C Surfaces - Standard Fuel Tube v1.0
101 RPP -7.3076 7.3076 -7.3076 7.3076 0.0000 274.4470     $ Tube void
102 RPP -7.4295 7.4295 -7.4295 7.4295 0.0000 249.5550     $ Tube
103 RPP -6.5913 6.5913 7.4295 7.6200 2.0320 245.8720    $ Absorber +Y
104 RPP -6.5913 6.5913 7.6200 7.6657 2.0320 245.8720    $ Cladding +Y
105 RPP 7.4295 7.6200 -6.5913 6.5913 2.0320 245.8720    $ Absorber +X
106 RPP 7.6200 7.6657 -6.5913 6.5913 2.0320 245.8720    $ Cladding +X
C Surfaces - DFC Fuel Tube v1.0
107 RPP -7.6251 7.6251 -7.6251 7.6251 0.0000 274.4470     $ Tube void
108 RPP -7.7470 7.7470 -7.7470 7.7470 0.0000 249.5550     $ Tube
109 RPP -6.5913 6.5913 7.7470 7.9375 2.0320 245.8720    $ Absorber +Y
110 RPP -6.5913 6.5913 7.9375 7.9832 2.0320 245.8720    $ Cladding +Y
111 RPP 7.7470 7.9375 -6.5913 6.5913 2.0320 245.8720    $ Absorber +X
112 RPP 7.9375 7.9832 -6.5913 6.5913 2.0320 245.8720    $ Cladding +X
c Surface Cards - Disk Stack  v1.0
201 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 1.5875 88.1380 $ Structural disk
202 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 1.2700 87.7951 $ Heat transfer disk
203 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 2.5400 88.0491 $ Weldment disk
c Surface Cards - Basket v1.0
301 RPP -7.7711 7.7711 -7.7711 7.7711 0.0000 274.4470   $ Std opening
302 RPP -8.0899 8.0899 -8.0899 8.0899 0.0000 274.4470   $ DFC opening
303 PY 0.0000        $ Cut plane
304 PX 0.0000        $ Cut plane
C Surfaces - Canister v1.0
501 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 274.4470 88.4428    $ Cavity
502 CZ 1.3843          $ Bot Cylinder Radius
503 CZ 5.0800          $ Mid Cyclinder Radius
```

Figure 5.A.6-3 MPC-LACBWR MCNP Input File for Storage Cask Radial Biasing – Fuel Gamma Source

```
504 CZ 5.7150           $ Top Cylinder Radius
505 PZ 282.8798           $ Port plane bot/mid
506 PZ 289.3822           $ Port plane mid/top
507 RCC 0.0000 0.0000 -2.5400 0.0000 0.0000 294.7670 89.7128   $ Canister
c Surface Cards - Storage Cask Geometry v4.0
601  RCC 0.0000 0.0000 0.0000 0.0000 0.0000 -58.6740 162.5600 $ Bottom Section Container
602  RCC 0.0000 0.0000 0.0000 0.0000 0.0000 352.5520 162.5600 $ Top Section Container (Not VCC
Lid)
603  CZ 100.3300         $ VCC liner inner
604  CZ 106.6800         $ VCC liner outer
605  RCC 0.0000 0.0000 -5.7150 0.0000 0.0000 5.7150 91.4400 $ Base plate/cover
606  KZ 47.2803 0.1357 -1      $ Baffle weldment bot
607  KZ 45.4435 0.1357 -1      $ Baffle weldment bot void
608  KZ -111.2883 0.1357 1      $ Baffle weldment top
609  KZ -109.4515 0.1357 1      $ Baffle weldment top void
610  PZ -32.0040          $ Baffle middle cut surface
611  PZ -7.8740          $ Baffle top cut surface
612  CZ 63.5000          $ Stand outer
613  CZ 58.4200          $ Stand inner
614 1 RPP -162.5600 162.5600 -15.2400 15.2400 -58.6740 -25.6540  $ Air inlet void
615 1 RPP -162.5600 162.5600 -16.1925 16.1925 -58.6740 -23.1140  $ Air inlet channel
616 2 RPP -162.5600 162.5600 -15.2400 15.2400 -58.6740 -25.6540  $ Air inlet void
617 2 RPP -162.5600 162.5600 -16.1925 16.1925 -58.6740 -23.1140  $ Air inlet channel
618  PZ -56.1340          $ Bottom plate height
619  RPP -25.6540 25.6540 -63.5001 63.5001 -25.6540 -5.7150  $ Stand top cut box
620  RCC 0.0000 0.0000 352.5520 0.0000 0.0000 3.8100 116.2050 $ VCC lid
621  RCC 0.0000 0.0000 347.4720 0.0000 0.0000 5.0800 124.3330 $ Top flange cylinder
622  CZ 102.8700          $ Top flange inner cut cylinder
623  RCC 0.0000 0.0000 331.2668 0.0000 0.0000 21.2852 99.0600 $ Lid concrete enclosure
624  RCC 0.0000 0.0000 332.2193 0.0000 0.0000 20.3327 98.1075 $ Lid concrete
625  RPP -54.2290 54.2290 -162.5600 162.5600 303.6570 336.8040  $ Box for outlet structure
(outside liner)
626  RPP -54.2290 54.2290 -127.0635 127.0635 315.7220 336.8040  $ Upper portion concrete
627  RPP -54.2290 54.2290 -162.5600 162.5600 303.6570 324.7390  $ Lower portion concrete
628  RPP -54.2290 54.2290 -143.2560 143.2560 303.6570 324.7390  $ Lower portion concrete cut
surface
629  RPP -53.2765 53.2765 -138.1760 138.1760 304.6095 335.8515  $ Lower/middle outlet void
630  RPP -53.2765 53.2765 -128.0160 128.0160 314.7695 335.8515  $ Cut box for lower/middle void
631  RPP -53.2765 53.2765 -162.5600 162.5600 325.6915 335.8515  $ Upper void
632  RPP -162.5600 162.5600 -54.2290 54.2290 303.6570 336.8040  $ Box for outlet structure
(outside liner)
633  RPP -127.0635 127.0635 -54.2290 54.2290 315.7220 336.8040  $ Upper portion concrete
634  RPP -162.5600 162.5600 -54.2290 54.2290 303.6570 324.7390  $ Lower portion concrete
635  RPP -143.2560 143.2560 -54.2290 54.2290 303.6570 324.7390  $ Lower portion concrete cut
surface
636  RPP -138.1760 138.1760 -53.2765 53.2765 304.6095 335.8515  $ Lower/middle outlet void
637  RPP -128.0160 128.0160 -53.2765 53.2765 314.7695 335.8515  $ Cut box for lower/middle void
638  RPP -162.5600 162.5600 -53.2765 53.2765 325.6915 335.8515  $ Upper void
639  RPP -54.2290 54.2290 -106.6800 106.6800 303.6570 315.7220  $ Outlet cut in liner
640  RPP -53.2765 53.2765 -106.6800 106.6800 304.6095 314.7695  $ Portion of outlet in liner
641  CZ 104.1400          $ Air outlet inner radius
642  RCC 0.0000 0.0000 -158.6740 0.0000 0.0000 100.0000 162.5600 $ Concrete pad
643 1 RCC 130.8100 -15.2400 -48.5140 0.0000 30.4800 0.0000 5.0800 $ Air inlet pipe 1 +x+y
644 1 RCC 110.4900 -15.2400 -35.8140 0.0000 30.4800 0.0000 5.0800 $ Air inlet pipe 2 +x+y
645 1 RCC 90.1700 -15.2400 -48.5140 0.0000 30.4800 0.0000 5.0800 $ Air inlet pipe 3 +x+y
646 1 RCC 69.8500 -15.2400 -35.8140 0.0000 30.4800 0.0000 5.0800 $ Air inlet pipe 4 +x+y
647 2 RCC 130.8100 -15.2400 -48.5140 0.0000 30.4800 0.0000 5.0800 $ Air inlet pipe 1 -x-y
648 2 RCC 110.4900 -15.2400 -35.8140 0.0000 30.4800 0.0000 5.0800 $ Air inlet pipe 2 -x-y
649 2 RCC 90.1700 -15.2400 -48.5140 0.0000 30.4800 0.0000 5.0800 $ Air inlet pipe 3 -x-y
650 2 RCC 69.8500 -15.2400 -35.8140 0.0000 30.4800 0.0000 5.0800 $ Air inlet pipe 4 -x-y
651 3 RCC 130.8100 -15.2400 -48.5140 0.0000 30.4800 0.0000 5.0800 $ Air inlet pipe 1 -x+y
652 3 RCC 110.4900 -15.2400 -35.8140 0.0000 30.4800 0.0000 5.0800 $ Air inlet pipe 2 -x+y
653 3 RCC 90.1700 -15.2400 -48.5140 0.0000 30.4800 0.0000 5.0800 $ Air inlet pipe 3 -x+y
654 3 RCC 69.8500 -15.2400 -35.8140 0.0000 30.4800 0.0000 5.0800 $ Air inlet pipe 4 -x+y
```

Figure 5.A.6-3 MPC-LACBWR MCNP Input File for Storage Cask Radial Biasing – Fuel Gamma Source

```
655 4 RCC 130.8100 -15.2400 -48.5140 0.0000 30.4800 0.0000 5.0800 $ Air inlet pipe 1 +x-y
656 4 RCC 110.4900 -15.2400 -35.8140 0.0000 30.4800 0.0000 5.0800 $ Air inlet pipe 2 +x-y
657 4 RCC 90.1700 -15.2400 -48.5140 0.0000 30.4800 0.0000 5.0800 $ Air inlet pipe 3 +x-y
658 4 RCC 69.8500 -15.2400 -35.8140 0.0000 30.4800 0.0000 5.0800 $ Air inlet pipe 4 +x-y
C VCC Rebar Surfaces - v4.0
659   TZ 0.0000 0.0000 2.2860 113.3475 0.9525 0.9525  $ Inner hoop 1
660   TZ 0.0000 0.0000 22.6060 113.3475 0.9525 0.9525  $ Inner hoop 2
661   TZ 0.0000 0.0000 42.9260 113.3475 0.9525 0.9525  $ Inner hoop 3
662   TZ 0.0000 0.0000 63.2460 113.3475 0.9525 0.9525  $ Inner hoop 4
663   TZ 0.0000 0.0000 83.5660 113.3475 0.9525 0.9525  $ Inner hoop 5
664   TZ 0.0000 0.0000 103.8860 113.3475 0.9525 0.9525  $ Inner hoop 6
665   TZ 0.0000 0.0000 124.2060 113.3475 0.9525 0.9525  $ Inner hoop 7
666   TZ 0.0000 0.0000 144.5260 113.3475 0.9525 0.9525  $ Inner hoop 8
667   TZ 0.0000 0.0000 164.8460 113.3475 0.9525 0.9525  $ Inner hoop 9
668   TZ 0.0000 0.0000 185.1660 113.3475 0.9525 0.9525  $ Inner hoop 10
669   TZ 0.0000 0.0000 205.4860 113.3475 0.9525 0.9525  $ Inner hoop 11
670   TZ 0.0000 0.0000 225.8060 113.3475 0.9525 0.9525  $ Inner hoop 12
671   TZ 0.0000 0.0000 246.1260 113.3475 0.9525 0.9525  $ Inner hoop 13
672   TZ 0.0000 0.0000 266.4460 113.3475 0.9525 0.9525  $ Inner hoop 14
673   TZ 0.0000 0.0000 286.7660 113.3475 0.9525 0.9525  $ Inner hoop 15
674   TZ 0.0000 0.0000 307.0860 113.3475 0.9525 0.9525  $ Inner hoop 16
675   TZ 0.0000 0.0000 327.4060 113.3475 0.9525 0.9525  $ Inner hoop 17
676   TZ 0.0000 0.0000 2.2860 151.4475 0.9525 0.9525  $ Outer hoop 1
677   TZ 0.0000 0.0000 12.4460 151.4475 0.9525 0.9525  $ Outer hoop 2
678   TZ 0.0000 0.0000 22.6060 151.4475 0.9525 0.9525  $ Outer hoop 3
679   TZ 0.0000 0.0000 32.7660 151.4475 0.9525 0.9525  $ Outer hoop 4
680   TZ 0.0000 0.0000 42.9260 151.4475 0.9525 0.9525  $ Outer hoop 5
681   TZ 0.0000 0.0000 53.0860 151.4475 0.9525 0.9525  $ Outer hoop 6
682   TZ 0.0000 0.0000 63.2460 151.4475 0.9525 0.9525  $ Outer hoop 7
683   TZ 0.0000 0.0000 73.4060 151.4475 0.9525 0.9525  $ Outer hoop 8
684   TZ 0.0000 0.0000 83.5660 151.4475 0.9525 0.9525  $ Outer hoop 9
685   TZ 0.0000 0.0000 93.7260 151.4475 0.9525 0.9525  $ Outer hoop 10
686   TZ 0.0000 0.0000 103.8860 151.4475 0.9525 0.9525  $ Outer hoop 11
687   TZ 0.0000 0.0000 114.0460 151.4475 0.9525 0.9525  $ Outer hoop 12
688   TZ 0.0000 0.0000 124.2060 151.4475 0.9525 0.9525  $ Outer hoop 13
689   TZ 0.0000 0.0000 134.3660 151.4475 0.9525 0.9525  $ Outer hoop 14
690   TZ 0.0000 0.0000 144.5260 151.4475 0.9525 0.9525  $ Outer hoop 15
691   TZ 0.0000 0.0000 154.6860 151.4475 0.9525 0.9525  $ Outer hoop 16
692   TZ 0.0000 0.0000 164.8460 151.4475 0.9525 0.9525  $ Outer hoop 17
693   TZ 0.0000 0.0000 175.0060 151.4475 0.9525 0.9525  $ Outer hoop 18
694   TZ 0.0000 0.0000 185.1660 151.4475 0.9525 0.9525  $ Outer hoop 19
695   TZ 0.0000 0.0000 195.3260 151.4475 0.9525 0.9525  $ Outer hoop 20
696   TZ 0.0000 0.0000 205.4860 151.4475 0.9525 0.9525  $ Outer hoop 21
697   TZ 0.0000 0.0000 215.6460 151.4475 0.9525 0.9525  $ Outer hoop 22
698   TZ 0.0000 0.0000 225.8060 151.4475 0.9525 0.9525  $ Outer hoop 23
699   TZ 0.0000 0.0000 235.9660 151.4475 0.9525 0.9525  $ Outer hoop 24
700   TZ 0.0000 0.0000 246.1260 151.4475 0.9525 0.9525  $ Outer hoop 25
701   TZ 0.0000 0.0000 256.2860 151.4475 0.9525 0.9525  $ Outer hoop 26
702   TZ 0.0000 0.0000 266.4460 151.4475 0.9525 0.9525  $ Outer hoop 27
703   TZ 0.0000 0.0000 276.6060 151.4475 0.9525 0.9525  $ Outer hoop 28
704   TZ 0.0000 0.0000 286.7660 151.4475 0.9525 0.9525  $ Outer hoop 29
705   TZ 0.0000 0.0000 296.9260 151.4475 0.9525 0.9525  $ Outer hoop 30
706   TZ 0.0000 0.0000 307.0860 151.4475 0.9525 0.9525  $ Outer hoop 31
707   TZ 0.0000 0.0000 317.2460 151.4475 0.9525 0.9525  $ Outer hoop 32
708   TZ 0.0000 0.0000 327.4060 151.4475 0.9525 0.9525  $ Outer hoop 33
709   TZ 0.0000 0.0000 337.5660 151.4475 0.9525 0.9525  $ Outer hoop 34
710   RCC 0.0000 0.0000 2.2860 0.0000 0.0000 332.7400 0.9525 $ Bar
C Storage Cask & Pad Container
799   RCC   0.0000   0.0000   -158.6740   0.0000   0.0000   515.0360   162.5601
C Radial Detector DRA (Surface)
800   RCC   0.0000   0.0000   -58.6740   0.0000   0.0000   415.1360   162.6601
801   PZ   -24.0793
802   PZ   10.5153
803   PZ   45.1100
```

Figure 5.A.6-3 MPC-LACBWR MCNP Input File for Storage Cask Radial Biasing – Fuel Gamma Source

```
804  PZ  79.7047
805  PZ  114.2993
806  PZ  148.8940
807  PZ  183.4887
808  PZ  218.0833
809  PZ  252.6780
810  PZ  287.2727
811  PZ  321.8673
C Radial Detector DRB (1ft)
900  RCC  0.0000  0.0000  -58.6740  0.0000  0.0000  445.6160  193.0401
901  PZ  -21.5393
902  PZ  15.5953
903  PZ  52.7300
904  PZ  89.8647
905  PZ  126.9993
906  PZ  164.1340
907  PZ  201.2687
908  PZ  238.4033
909  PZ  275.5380
910  PZ  312.6727
911  PZ  349.8073
C Radial Detector DRC (1m)
1000  RCC  0.0000  0.0000  -58.6740  0.0000  0.0000  515.1360  262.5601
1001  PZ  -15.7460
1002  PZ  27.1820
1003  PZ  70.1100
1004  PZ  113.0380
1005  PZ  155.9660
1006  PZ  198.8940
1007  PZ  241.8220
1008  PZ  284.7500
1009  PZ  327.6780
1010  PZ  370.6060
1011  PZ  413.5340
C Radial Detector DRD (2m)
1100  RCC  0.0000  0.0000  -58.6740  0.0000  0.0000  615.1360  362.5601
1101  PZ  -27.9172
1102  PZ  2.8396
1103  PZ  33.5964
1104  PZ  64.3532
1105  PZ  95.1100
1106  PZ  125.8668
1107  PZ  156.6236
1108  PZ  187.3804
1109  PZ  218.1372
1110  PZ  248.8940
1111  PZ  279.6508
1112  PZ  310.4076
1113  PZ  341.1644
1114  PZ  371.9212
1115  PZ  402.6780
1116  PZ  433.4348
1117  PZ  464.1916
1118  PZ  494.9484
1119  PZ  525.7052
C Radial Detector DRE (4m)
1200  RCC  0.0000  0.0000  -58.6740  0.0000  0.0000  815.1360  562.5601
1201  PZ  -17.9172
1202  PZ  22.8396
1203  PZ  63.5964
1204  PZ  104.3532
1205  PZ  145.1100
1206  PZ  185.8668
1207  PZ  226.6236
```

Figure 5.A.6-3 MPC-LACBWR MCNP Input File for Storage Cask Radial Biasing – Fuel Gamma Source

```
1208  PZ  267.3804
1209  PZ  308.1372
1210  PZ  348.8940
1211  PZ  389.6508
1212  PZ  430.4076
1213  PZ  471.1644
1214  PZ  511.9212
1215  PZ  552.6780
1216  PZ  593.4348
1217  PZ  634.1916
1218  PZ  674.9484
1219  PZ  715.7052

C
C Materials List - Common Materials - v1.0
C
C Homogenized Lower Nozzle
m1     24000 -1.9000E-01
       25055 -2.0000E-02
       26000 -6.9500E-01
       28000 -9.5000E-02
C Homogenized UO2 Fuel
m2     24000 -2.9967E-02
       25055 -3.1544E-03
       26000 -1.0961E-01
       28000 -1.4983E-02
       92235 -2.6729E-02
       92238 -7.1574E-01
        8016 -9.9810E-02
C Homogenized Upper Plenum
m3     24000 -1.9000E-01
       25055 -2.0000E-02
       26000 -6.9500E-01
       28000 -9.5000E-02
C Homogenized Upper Nozzle
m4     24000 -0.190 25055 -0.020 26000 -0.695
       28000 -0.095
C Water
m5     1001 2 8016 1
C Stainless Steel
m6     24000 -0.190 25055 -0.020 26000 -0.695
       28000 -0.095
C Carbon Steel
m7     26000 -0.99 6012 -0.01
C Neutron Poison
m8     13027 -0.8466  5010 -0.0216  5011 -0.0985
        6012 -0.0333
C Aluminum
m9     13027 -1.0
C Lead
m10    82000 -1.0
C NS-4-FR
m11     5010 -9.3127E-04 13027 -2.1420E-01  6012 -2.7627E-01
        5011 -3.7721E-03  1001 -6.0012E-02  7014 -1.9815E-02
        8016 -4.2500E-01
C Concrete
m12    26000 -0.014 20000 -0.044 14000 -0.337
        1001 -0.010  8016 -0.532 11023 -0.029
       13027 -0.034
C Vent Port Middle Cylinder
m13    24000 -0.190 25055 -0.020 26000 -0.695
       28000 -0.095
phys:p 100 0 0 0 1    $ Disable Doppler energy broadening
C
```

Figure 5.A.6-3 MPC-LACBWR MCNP Input File for Storage Cask Radial Biasing – Fuel Gamma Source

```
C Cell Importances
C
imp:p 1 412r 0
C
C BWR Source Definition - Fuel Gamma - Pref
C
sdef x=d1 y=d2 z=d3 erg=d4 cell=799:632:501:d5:2
si1   -7.1247 7.1247
sp1   0 1
si2   -7.1247 7.1247
sp2   0 1
si3   27.2796 48.3616 69.4436 90.5256 111.6076 132.6896 153.7716
      174.8536 195.9356 217.0176 238.0996
sp3   0.0000 0.4050 1.2320 1.3600 1.3330 1.3040 1.2350
      1.1230 1.0110 0.8800 0.1130
si4   1.000E-02 2.000E-02 5.000E-02 1.000E-01 2.000E-01 3.000E-01
      4.000E-01 6.000E-01 8.000E-01 1.000E+00 1.220E+00 1.440E+00
      1.660E+00 2.000E+00 2.500E+00 3.000E+00 4.000E+00 5.000E+00
      6.500E+00 8.000E+00 1.000E+01 1.200E+01 1.400E+01
sp4   0.0000E+00 3.9346E+13 5.1398E+13 2.4748E+13 1.5283E+13 4.7419E+12
      3.2789E+12 2.3939E+12 1.3546E+14 1.0605E+12 5.0505E+11 8.2048E+11
      7.5368E+10 8.4076E+09 4.2540E+08 2.8405E+07 1.8349E+05 6.1637E+04
      2.4653E+04 4.8213E+03 1.0215E+03 5.2748E+01 0.0000E+00
C Source Information
si5 1                  302 304
               306 308 310 312 314 316
           318 320 322 324 326 328 330 332
           334 336 338 340 342 344 346 348
       350 352 354 356 358 360 362 364 366 368
       370 372 374 376 378 380 382 384 386 388
           390 392 394 396 398 400 402 404
           406 408 410 412 414 416 418 420
               422 424 426 428 430 432
                       434 436
C Source Probability
sp5                       0.99 0.99
                0.99 0.99 0.99 0.99 0.99 0.99
           0.99 1.00 1.00 1.00 1.00 1.00 1.00 0.99
           0.99 1.00 1.00 1.00 1.00 1.00 1.00 0.99
      0.99 0.99 1.00 1.00 1.00 1.00 1.00 1.00 0.99 0.99
      0.99 0.99 1.00 1.00 1.00 1.00 1.00 1.00 0.99 0.99
           0.99 1.00 1.00 1.00 1.00 1.00 1.00 0.99
           0.99 1.00 1.00 1.00 1.00 1.00 1.00 0.99
                0.99 0.99 0.99 0.99 0.99 0.99
                          0.99 0.99
mode p
nps 400000000
C
C ANSI/ANS-6.1.1-1977 - Gamma Flux-to-Dose Conversion Factors
C (mrem/hr)/(photons/cm2-sec)
C
de0   0.01 0.03 0.05 0.07 0.1 0.15 0.2
      0.25 0.3 0.35 0.4 0.45 0.5 0.55
      0.6 0.65 0.7 0.8 1 1.4 1.8
      2.2 2.6 2.8 3.25 3.75 4.25 4.75
      5 5.25 5.75 6.25 6.75 7.5 9
      11 13 15
df0   3.96E-03 5.82E-04 2.90E-04 2.58E-04 2.83E-04 3.79E-04 5.01E-04
      6.31E-04 7.59E-04 8.78E-04 9.85E-04 1.08E-03 1.17E-03 1.27E-03
      1.36E-03 1.44E-03 1.52E-03 1.68E-03 1.98E-03 2.51E-03 2.99E-03
      3.42E-03 3.82E-03 4.01E-03 4.41E-03 4.83E-03 5.23E-03 5.60E-03
      5.80E-03 6.01E-03 6.37E-03 6.74E-03 7.11E-03 7.66E-03 8.77E-03
      1.03E-02 1.18E-02 1.33E-02
C
```

Figure 5.A.6-3 MPC-LACBWR MCNP Input File for Storage Cask Radial Biasing – Fuel Gamma Source

```
C Weight Window Generation - Radial
C
wwg 2 0 0 0 0
wwp:p 5 3 5 0 -1 0
mesh geom=cyl ref=78 9 135 origin=0.1 0.1 -160
     imesh 88.4 89.7 100.3 106.7 162.6 662.6
     iints 5 1 1 2 4 1
     jmesh 101 104 134 137 154 162 189 400 424 437 454 491 512 516 1016
     jints 1 1 1 1 1 2 2 10 1 1 3 1 2 1 1
     kmesh 1
     kints 1
wwge:p  1e-3 1 20
fc2 Radial Surface Tally
f2:p +800.1
fm2 1.9038E+16
fs2  -801  -802  -803  -804  -805  -806
     -807  -808  -809  -810  -811  T
tf2
fc12 Radial 1ft Tally
f12:p +900.1
fm12 1.9038E+16
fs12  -901  -902  -903  -904  -905  -906
      -907  -908  -909  -910  -911  T
tf12
fc22 Radial 1m Tally
f22:p +1000.1
fm22 1.9038E+16
fs22  -1001  -1002  -1003  -1004  -1005  -1006
      -1007  -1008  -1009  -1010  -1011  T
tf22
fc32 Radial 2m Tally
f32:p +1100.1
fm32 1.9038E+16
fs32  -1101  -1102  -1103  -1104  -1105  -1106
      -1107  -1108  -1109  -1110  -1111  -1112
      -1113  -1114  -1115  -1116  -1117  -1118
      -1119  T
tf32
fc42 Radial 4m Tally
f42:p +1200.1
fm42 1.9038E+16
fs42  -1201  -1202  -1203  -1204  -1205  -1206
      -1207  -1208  -1209  -1210  -1211  -1212
      -1213  -1214  -1215  -1216  -1217  -1218
      -1219  T
tf42
C
C
C Print Control
C
prdmp -30 -60 1 2
print
C
C Random Number Generator
C
rand gen=2 seed=19073486328125 stride=152917 hist=1
C
C Rotation Matrix
C
C 45 degree rotation around z-axis
*TR1 0.0 0.0 0.0 45 135 90 -45 45 90 90 90 0
C 135 degree rotation around z-axis
*TR2 0.0 0.0 0.0 135 225 90 45 135 90 90 90 0
C 225 degree rotation around z-axis
```

Figure 5.A.6-3 MPC-LACBWR MCNP Input File for Storage Cask Radial Biasing – Fuel Gamma Source

```
*TR3 0.0 0.0 0.0 225 315 90 135 225 90 90 90 0
C 315 degree rotation around z-axis
*TR4 0.0 0.0 0.0 315 405 90 225 315 90 90 90 0
C 10 degree rotation around z-axis
*TR5 0.0 0.0 0.0 10 100 90 -80 10 90 90 90 0
C 20 degree rotation around z-axis
*TR6 0.0 0.0 0.0 20 110 90 -70 20 90 90 90 0
C 30 degree rotation around z-axis
*TR7 0.0 0.0 0.0 30 120 90 -60 30 90 90 90 0
C 40 degree rotation around z-axis
*TR8 0.0 0.0 0.0 40 130 90 -50 40 90 90 90 0
C 50 degree rotation around z-axis
*TR9 0.0 0.0 0.0 50 140 90 -40 50 90 90 90 0
C 60 degree rotation around z-axis
*TR10 0.0 0.0 0.0 60 150 90 -30 60 90 90 90 0
C 70 degree rotation around z-axis
*TR11 0.0 0.0 0.0 70 160 90 -20 70 90 90 90 0
C 80 degree rotation around z-axis
*TR12 0.0 0.0 0.0 80 170 90 -10 80 90 90 90 0
C 100 degree rotation around z-axis
*TR13 0.0 0.0 0.0 100 190 90 10 100 90 90 90 0
C 110 degree rotation around z-axis
*TR14 0.0 0.0 0.0 110 200 90 20 110 90 90 90 0
C 120 degree rotation around z-axis
*TR15 0.0 0.0 0.0 120 210 90 30 120 90 90 90 0
C 130 degree rotation around z-axis
*TR16 0.0 0.0 0.0 130 220 90 40 130 90 90 90 0
C 140 degree rotation around z-axis
*TR17 0.0 0.0 0.0 140 230 90 50 140 90 90 90 0
C 150 degree rotation around z-axis
*TR18 0.0 0.0 0.0 150 240 90 60 150 90 90 90 0
C 160 degree rotation around z-axis
*TR19 0.0 0.0 0.0 160 250 90 70 160 90 90 90 0
C 170 degree rotation around z-axis
*TR20 0.0 0.0 0.0 170 260 90 80 170 90 90 90 0
C 18 degree rotation around z-axis
*TR21 0.0 0.0 0.0 18 108 90 -72 18 90 90 90 0
C 36 degree rotation around z-axis
*TR22 0.0 0.0 0.0 36 126 90 -54 36 90 90 90 0
C 54 degree rotation around z-axis
*TR23 0.0 0.0 0.0 54 144 90 -36 54 90 90 90 0
C 72 degree rotation around z-axis
*TR24 0.0 0.0 0.0 72 162 90 -18 72 90 90 90 0
C 108 degree rotation around z-axis
*TR25 0.0 0.0 0.0 108 198 90 18 108 90 90 90 0
C 126 degree rotation around z-axis
*TR26 0.0 0.0 0.0 126 216 90 36 126 90 90 90 0
C 144 degree rotation around z-axis
*TR27 0.0 0.0 0.0 144 234 90 54 144 90 90 90 0
C 162 degree rotation around z-axis
*TR28 0.0 0.0 0.0 162 252 90 72 162 90 90 90 0
```

Figure 5.A.6-4 MPC-LACBWR MCNP Input File for Transfer Cask Wet Canister Top Axial Biasing – Fuel Neutron Source

```
LACBWR Transfer Cask - trfShwWetTopFn_Pref
C Top Axial Biasing - Fuel Neutron Source
C Fuel Assembly Cells - v1.0
1 1 -2.1989 -1 -2    u=11 $ Lower Nozzle
2 2 -4.3866 -1 +2 -3   u=11 $ Fuel
3 3 -1.5956 -1 +3 -4   u=11 $ Upper Plenum
4 4 -0.6145 -1 +4    u=11 $ Upper Nozzle
5 0         +1     u=11 $ Outside
C Flood Elevation Cells
6 5 -0.9982 -5     u=10 $ Below flood elevation
7 0         5     u=10 $ Above flood elevation
C Cells - Standard Fuel Tube  v1.0
101 0          -101 fill=10      u=5 $ Tube void
102 6 -7.9400 -102 +101       u=5 $ Tube
103 8 -2.6707 -103         u=5 $ Absorber +Y
104 6 -7.9400 -104         u=5 $ Cladding +Y
105 8 -2.6707 -105         u=5 $ Absorber +X
106 6 -7.9400 -106         u=5 $ Cladding +X
107 0          +101 +102 +103 +104 +106 +105 fill=10 u=5 $ Void
C Cells - DFC Fuel Tube Absorber 2 Sides v1.0
108 0          -107 fill=10      u=6 $ Tube void
109 6 -7.9400 -108 +107       u=6 $ Tube
110 8 -2.6707 -109         u=6 $ Absorber +Y
111 6 -7.9400 -110         u=6 $ Cladding +Y
112 8 -2.6707 -111         u=6 $ Absorber +X
113 6 -7.9400 -112         u=6 $ Cladding +X
114 0          +107 +108 +109 +110 +112 +111 fill=10 u=6 $ Void
C Cells - DFC Fuel Tube Absorber 1 Side (Y) v1.0
115 0          -107 fill=10      u=7 $ Tube void
116 6 -7.9400 -108 +107       u=7 $ Tube
117 8 -2.6707 -109         u=7 $ Absorber +Y
118 6 -7.9400 -110         u=7 $ Cladding +Y
119 0          +107 +108 +109 +110   fill=10 u=7 $ Void
C Cells - DFC Fuel Tube Absorber 1 Side (X) v1.0
120 0          -107 fill=10      u=8 $ Tube void
121 6 -7.9400 -108 +107       u=8 $ Tube
122 8 -2.6707 -111         u=8 $ Absorber +X
123 6 -7.9400 -112         u=8 $ Cladding +X
124 0          +107 +108 +111 +112   fill=10 u=8 $ Void
C Cells - DFC Fuel Tube No Absorber v1.0
125 0          -107 fill=10      u=9 $ Tube void
126 6 -7.9400 -108 +107       u=9 $ Tube
127 0          +107 +108      fill=10 u=9 $ Void
c Cell Cards - Disk Stack v1.0
201 6 -7.94 -203 trcl = ( 0.0000 0.0000 2.5400 )    u=4 $ Bottom weldment disk
202 6 -7.94 -201 trcl = ( 0.0000 0.0000 15.0368 )    u=4 $ Support disk 1
203 like 202 but   trcl = ( 0.0000 0.0000 24.7650 )    u=4 $ Support disk 2
204 like 202 but   trcl = ( 0.0000 0.0000 34.4932 )    u=4 $ Support disk 3
205 like 202 but   trcl = ( 0.0000 0.0000 44.2214 )    u=4 $ Support disk 4
206 like 202 but   trcl = ( 0.0000 0.0000 53.9496 )    u=4 $ Support disk 5
207 9 -2.70 -202 trcl = ( 0.0000 0.0000 58.9788 )    u=4 $ Heat transfer disk 1
208 like 202 but   trcl = ( 0.0000 0.0000 63.6778 )    u=4 $ Support disk 6
209 like 207 but   trcl = ( 0.0000 0.0000 68.7070 )    u=4 $ Heat transfer disk 2
210 like 202 but   trcl = ( 0.0000 0.0000 73.4060 )    u=4 $ Support disk 7
211 like 207 but   trcl = ( 0.0000 0.0000 78.4352 )    u=4 $ Heat transfer disk 3
212 like 202 but   trcl = ( 0.0000 0.0000 83.1342 )    u=4 $ Support disk 8
213 like 207 but   trcl = ( 0.0000 0.0000 88.1634 )    u=4 $ Heat transfer disk 4
214 like 202 but   trcl = ( 0.0000 0.0000 92.8624 )    u=4 $ Support disk 9
215 like 207 but   trcl = ( 0.0000 0.0000 97.8916 )    u=4 $ Heat transfer disk 5
216 like 202 but   trcl = ( 0.0000 0.0000 102.5906 )    u=4 $ Support disk 10
217 like 207 but   trcl = ( 0.0000 0.0000 107.6198 )    u=4 $ Heat transfer disk 6
218 like 202 but   trcl = ( 0.0000 0.0000 112.3188 )    u=4 $ Support disk 11
```

Figure 5.A.6-4 MPC-LACBWR MCNP Input File for Transfer Cask Wet Canister Top Axial Biasing – Fuel Neutron Source

```
219 like 207 but   trcl = ( 0.0000 0.0000 117.3480 )    u=4 $ Heat transfer disk 7
220 like 202 but   trcl = ( 0.0000 0.0000 122.0470 )    u=4 $ Support disk 12
221 like 207 but   trcl = ( 0.0000 0.0000 127.0762 )    u=4 $ Heat transfer disk 8
222 like 202 but   trcl = ( 0.0000 0.0000 131.7752 )    u=4 $ Support disk 13
223 like 207 but   trcl = ( 0.0000 0.0000 136.8044 )    u=4 $ Heat transfer disk 9
224 like 202 but   trcl = ( 0.0000 0.0000 141.5034 )    u=4 $ Support disk 14
225 like 207 but   trcl = ( 0.0000 0.0000 146.5326 )    u=4 $ Heat transfer disk 10
226 like 202 but   trcl = ( 0.0000 0.0000 151.2316 )    u=4 $ Support disk 15
227 like 207 but   trcl = ( 0.0000 0.0000 156.2608 )    u=4 $ Heat transfer disk 11
228 like 202 but   trcl = ( 0.0000 0.0000 160.9598 )    u=4 $ Support disk 16
229 like 207 but   trcl = ( 0.0000 0.0000 165.9890 )    u=4 $ Heat transfer disk 12
230 like 202 but   trcl = ( 0.0000 0.0000 170.6880 )    u=4 $ Support disk 1
231 like 207 but   trcl = ( 0.0000 0.0000 175.7172 )    u=4 $ Heat transfer disk 13
232 like 202 but   trcl = ( 0.0000 0.0000 180.4162 )    u=4 $ Support disk 18
233 like 207 but   trcl = ( 0.0000 0.0000 185.4454 )    u=4 $ Heat transfer disk 14
234 like 202 but   trcl = ( 0.0000 0.0000 190.1444 )    u=4 $ Support disk 19
235 like 202 but   trcl = ( 0.0000 0.0000 199.8726 )    u=4 $ Support disk 20
236 like 202 but   trcl = ( 0.0000 0.0000 209.6008 )    u=4 $ Support disk 21
237 like 202 but   trcl = ( 0.0000 0.0000 219.3290 )    u=4 $ Support disk 22
238 like 202 but   trcl = ( 0.0000 0.0000 229.0572 )    u=4 $ Support disk 23
239 like 202 but   trcl = ( 0.0000 0.0000 238.7854 )    u=4 $ Support disk 24
240 like 201 but   trcl = ( 0.0000 0.0000 255.8796 )    u=4 $ Top weldment disk
241 0                $ Outside Disks
      #201 #202 #203 #204 #205 #206 #207 #208 #209 #210
      #211 #212 #213 #214 #215 #216 #217 #218 #219 #220
      #221 #222 #223 #224 #225 #226 #227 #228 #229 #230
      #231 #232 #233 #234 #235 #236 #237 #238 #239
      #240        fill=10 u=4
c Cell Cards - Basket v1.0
301 0          -302 #302  fill=8 ( -8.8265 77.5233 0.0000 )      $ Tube/Disk 1
          trcl = ( -8.8265 77.5233 0.0000 )     u=3
302 0          -1  fill=11 trcl = ( -8.8265 77.5233 0.0000 )     u=3 $ Assembly 1
303 0          -302 #304  fill=9 ( 8.8265 77.5233 0.0000 )      $ Tube/Disk 2
          trcl = ( 8.8265 77.5233 0.0000 )     u=3
304 like 302 but     trcl = ( 8.8265 77.5233 0.0000 )     u=3 $ Assembly 2
305 0          -302 #306  fill=8 ( -44.1274 61.2699 0.0000 )      $ Tube/Disk 3
          trcl = ( -44.1274 61.2699 0.0000 )     u=3
306 like 302 but     trcl = ( -44.1274 61.2699 0.0000 )     u=3 $ Assembly 3
307 0          -302 #308  fill=8 ( -26.4770 59.8729 0.0000 )      $ Tube/Disk 4
          trcl = ( -26.4770 59.8729 0.0000 )     u=3
308 like 302 but     trcl = ( -26.4770 59.8729 0.0000 )     u=3 $ Assembly 4
309 0          -302 #310  fill=6 ( -8.8265 59.8729 0.0000 )      $ Tube/Disk 5
          trcl = ( -8.8265 59.8729 0.0000 )     u=3
310 like 302 but     trcl = ( -8.8265 59.8729 0.0000 )     u=3 $ Assembly 5
311 0          -302 #312  fill=6 ( 8.8265 59.8729 0.0000 )      $ Tube/Disk 6
          trcl = ( 8.8265 59.8729 0.0000 )     u=3
312 like 302 but     trcl = ( 8.8265 59.8729 0.0000 )     u=3 $ Assembly 6
313 0          -302 #314  fill=8 ( 26.4770 59.8729 0.0000 )      $ Tube/Disk 7
          trcl = ( 26.4770 59.8729 0.0000 )     u=3
314 like 302 but     trcl = ( 26.4770 59.8729 0.0000 )     u=3 $ Assembly 7
315 0          -302 #316  fill=9 ( 44.1274 61.2699 0.0000 )      $ Tube/Disk 8
          trcl = ( 44.1274 61.2699 0.0000 )     u=3
316 like 302 but     trcl = ( 44.1274 61.2699 0.0000 )     u=3 $ Assembly 8
317 0          -302 #318  fill=8 ( -61.2699 44.1274 0.0000 )      $ Tube/Disk 9
          trcl = ( -61.2699 44.1274 0.0000 )     u=3
318 like 302 but     trcl = ( -61.2699 44.1274 0.0000 )     u=3 $ Assembly 9
319 0          -301 #320  fill=5 ( -42.5399 42.5399 0.0000 )      $ Tube/Disk 10
          trcl = ( -42.5399 42.5399 0.0000 )     u=3
320 like 302 but     trcl = ( -42.5399 42.5399 0.0000 )     u=3 $ Assembly 10
321 0          -301 #322  fill=5 ( -25.5245 42.5399 0.0000 )      $ Tube/Disk 11
          trcl = ( -25.5245 42.5399 0.0000 )     u=3
322 like 302 but     trcl = ( -25.5245 42.5399 0.0000 )     u=3 $ Assembly 11
323 0          -301 #324  fill=5 ( -8.5090 42.5399 0.0000 )      $ Tube/Disk 12
          trcl = ( -8.5090 42.5399 0.0000 )     u=3
```

Figure 5.A.6-4 MPC-LACBWR MCNP Input File for Transfer Cask Wet Canister Top Axial Biasing – Fuel Neutron Source

```
324 like 302 but     trcl = ( -8.5090 42.5399 0.0000 )     u=3 $ Assembly 12
325 0          -301 #326  fill=5 ( 8.5090 42.5399 0.0000 )      $ Tube/Disk 13
           trcl = ( 8.5090 42.5399 0.0000 )      u=3
326 like 302 but     trcl = ( 8.5090 42.5399 0.0000 )     u=3 $ Assembly 13
327 0          -301 #328  fill=5 ( 25.5245 42.5399 0.0000 )      $ Tube/Disk 14
           trcl = ( 25.5245 42.5399 0.0000 )     u=3
328 like 302 but     trcl = ( 25.5245 42.5399 0.0000 )     u=3 $ Assembly 14
329 0          -301 #330  fill=5 ( 42.5399 42.5399 0.0000 )      $ Tube/Disk 15
           trcl = ( 42.5399 42.5399 0.0000 )     u=3
330 like 302 but     trcl = ( 42.5399 42.5399 0.0000 )     u=3 $ Assembly 15
331 0          -302 #332  fill=9 ( 61.2699 44.1274 0.0000 )      $ Tube/Disk 16
           trcl = ( 61.2699 44.1274 0.0000 )     u=3
332 like 302 but     trcl = ( 61.2699 44.1274 0.0000 )     u=3 $ Assembly 16
333 0          -302 #334  fill=6 ( -59.8729 26.4770 0.0000 )      $ Tube/Disk 17
           trcl = ( -59.8729 26.4770 0.0000 )     u=3
334 like 302 but     trcl = ( -59.8729 26.4770 0.0000 )     u=3 $ Assembly 17
335 0          -301 #336  fill=5 ( -42.5399 25.5245 0.0000 )      $ Tube/Disk 18
           trcl = ( -42.5399 25.5245 0.0000 )     u=3
336 like 302 but     trcl = ( -42.5399 25.5245 0.0000 )     u=3 $ Assembly 18
337 0          -301 #338  fill=5 ( -25.5245 25.5245 0.0000 )      $ Tube/Disk 19
           trcl = ( -25.5245 25.5245 0.0000 )     u=3
338 like 302 but     trcl = ( -25.5245 25.5245 0.0000 )     u=3 $ Assembly 19
339 0          -301 #340  fill=5 ( -8.5090 25.5245 0.0000 )      $ Tube/Disk 20
           trcl = ( -8.5090 25.5245 0.0000 )     u=3
340 like 302 but     trcl = ( -8.5090 25.5245 0.0000 )     u=3 $ Assembly 20
341 0          -301 #342  fill=5 ( 8.5090 25.5245 0.0000 )      $ Tube/Disk 21
           trcl = ( 8.5090 25.5245 0.0000 )     u=3
342 like 302 but     trcl = ( 8.5090 25.5245 0.0000 )     u=3 $ Assembly 21
343 0          -301 #344  fill=5 ( 25.5245 25.5245 0.0000 )      $ Tube/Disk 22
           trcl = ( 25.5245 25.5245 0.0000 )     u=3
344 like 302 but     trcl = ( 25.5245 25.5245 0.0000 )     u=3 $ Assembly 22
345 0          -301 #346  fill=5 ( 42.5399 25.5245 0.0000 )      $ Tube/Disk 23
           trcl = ( 42.5399 25.5245 0.0000 )     u=3
346 like 302 but     trcl = ( 42.5399 25.5245 0.0000 )     u=3 $ Assembly 23
347 0          -302 #348  fill=7 ( 59.8729 26.4770 0.0000 )      $ Tube/Disk 24
           trcl = ( 59.8729 26.4770 0.0000 )     u=3
348 like 302 but     trcl = ( 59.8729 26.4770 0.0000 )     u=3 $ Assembly 24
349 0          -302 #350  fill=8 ( -77.5233 8.8265 0.0000 )      $ Tube/Disk 25
           trcl = ( -77.5233 8.8265 0.0000 )     u=3
350 like 302 but     trcl = ( -77.5233 8.8265 0.0000 )     u=3 $ Assembly 25
351 0          -302 #352  fill=6 ( -59.8729 8.8265 0.0000 )      $ Tube/Disk 26
           trcl = ( -59.8729 8.8265 0.0000 )     u=3
352 like 302 but     trcl = ( -59.8729 8.8265 0.0000 )     u=3 $ Assembly 26
353 0          -301 #354  fill=5 ( -42.5399 8.5090 0.0000 )      $ Tube/Disk 27
           trcl = ( -42.5399 8.5090 0.0000 )     u=3
354 like 302 but     trcl = ( -42.5399 8.5090 0.0000 )     u=3 $ Assembly 27
355 0          -301 #356  fill=5 ( -25.5245 8.5090 0.0000 )      $ Tube/Disk 28
           trcl = ( -25.5245 8.5090 0.0000 )     u=3
356 like 302 but     trcl = ( -25.5245 8.5090 0.0000 )     u=3 $ Assembly 28
357 0          -301 #358  fill=5 ( -8.5090 8.5090 0.0000 )      $ Tube/Disk 29
           trcl = ( -8.5090 8.5090 0.0000 )     u=3
358 like 302 but     trcl = ( -8.5090 8.5090 0.0000 )     u=3 $ Assembly 29
359 0          -301 #360  fill=5 ( 8.5090 8.5090 0.0000 )      $ Tube/Disk 30
           trcl = ( 8.5090 8.5090 0.0000 )     u=3
360 like 302 but     trcl = ( 8.5090 8.5090 0.0000 )     u=3 $ Assembly 30
361 0          -301 #362  fill=5 ( 25.5245 8.5090 0.0000 )      $ Tube/Disk 31
           trcl = ( 25.5245 8.5090 0.0000 )     u=3
362 like 302 but     trcl = ( 25.5245 8.5090 0.0000 )     u=3 $ Assembly 31
363 0          -301 #364  fill=5 ( 42.5399 8.5090 0.0000 )      $ Tube/Disk 32
           trcl = ( 42.5399 8.5090 0.0000 )     u=3
364 like 302 but     trcl = ( 42.5399 8.5090 0.0000 )     u=3 $ Assembly 32
365 0          -302 #366  fill=6 ( 59.8729 8.8265 0.0000 )      $ Tube/Disk 33
           trcl = ( 59.8729 8.8265 0.0000 )     u=3
366 like 302 but     trcl = ( 59.8729 8.8265 0.0000 )     u=3 $ Assembly 33
```

Figure 5.A.6-4 MPC-LACBWR MCNP Input File for Transfer Cask Wet Canister Top Axial Biasing – Fuel Neutron Source

```
367 0        -302 #368  fill=9 ( 77.5233 8.8265 0.0000 )      $ Tube/Disk 34
         trcl = ( 77.5233 8.8265 0.0000 )     u=3
368 like 302 but     trcl = ( 77.5233 8.8265 0.0000 )     u=3 $ Assembly 34
369 0        -302 #370  fill=6 ( -77.5233 -8.8265 0.0000 )      $ Tube/Disk 35
         trcl = ( -77.5233 -8.8265 0.0000 )     u=3
370 like 302 but     trcl = ( -77.5233 -8.8265 0.0000 )     u=3 $ Assembly 35
371 0        -302 #372  fill=6 ( -59.8729 -8.8265 0.0000 )      $ Tube/Disk 36
         trcl = ( -59.8729 -8.8265 0.0000 )     u=3
372 like 302 but     trcl = ( -59.8729 -8.8265 0.0000 )     u=3 $ Assembly 36
373 0        -301 #374  fill=5 ( -42.5399 -8.5090 0.0000 )      $ Tube/Disk 37
         trcl = ( -42.5399 -8.5090 0.0000 )     u=3
374 like 302 but     trcl = ( -42.5399 -8.5090 0.0000 )     u=3 $ Assembly 37
375 0        -301 #376  fill=5 ( -25.5245 -8.5090 0.0000 )      $ Tube/Disk 38
         trcl = ( -25.5245 -8.5090 0.0000 )     u=3
376 like 302 but     trcl = ( -25.5245 -8.5090 0.0000 )     u=3 $ Assembly 38
377 0        -301 #378  fill=5 ( -8.5090 -8.5090 0.0000 )      $ Tube/Disk 39
         trcl = ( -8.5090 -8.5090 0.0000 )     u=3
378 like 302 but     trcl = ( -8.5090 -8.5090 0.0000 )     u=3 $ Assembly 39
379 0        -301 #380  fill=5 ( 8.5090 -8.5090 0.0000 )      $ Tube/Disk 40
         trcl = ( 8.5090 -8.5090 0.0000 )     u=3
380 like 302 but     trcl = ( 8.5090 -8.5090 0.0000 )     u=3 $ Assembly 40
381 0        -301 #382  fill=5 ( 25.5245 -8.5090 0.0000 )      $ Tube/Disk 41
         trcl = ( 25.5245 -8.5090 0.0000 )     u=3
382 like 302 but     trcl = ( 25.5245 -8.5090 0.0000 )     u=3 $ Assembly 41
383 0        -301 #384  fill=5 ( 42.5399 -8.5090 0.0000 )      $ Tube/Disk 42
         trcl = ( 42.5399 -8.5090 0.0000 )     u=3
384 like 302 but     trcl = ( 42.5399 -8.5090 0.0000 )     u=3 $ Assembly 42
385 0        -302 #386  fill=6 ( 59.8729 -8.8265 0.0000 )      $ Tube/Disk 43
         trcl = ( 59.8729 -8.8265 0.0000 )     u=3
386 like 302 but     trcl = ( 59.8729 -8.8265 0.0000 )     u=3 $ Assembly 43
387 0        -302 #388  fill=7 ( 77.5233 -8.8265 0.0000 )      $ Tube/Disk 44
         trcl = ( 77.5233 -8.8265 0.0000 )     u=3
388 like 302 but     trcl = ( 77.5233 -8.8265 0.0000 )     u=3 $ Assembly 44
389 0        -302 #390  fill=6 ( -59.8729 -26.4770 0.0000 )      $ Tube/Disk 45
         trcl = ( -59.8729 -26.4770 0.0000 )     u=3
390 like 302 but     trcl = ( -59.8729 -26.4770 0.0000 )     u=3 $ Assembly 45
391 0        -301 #392  fill=5 ( -42.5399 -25.5245 0.0000 )      $ Tube/Disk 46
         trcl = ( -42.5399 -25.5245 0.0000 )     u=3
392 like 302 but     trcl = ( -42.5399 -25.5245 0.0000 )     u=3 $ Assembly 46
393 0        -301 #394  fill=5 ( -25.5245 -25.5245 0.0000 )      $ Tube/Disk 47
         trcl = ( -25.5245 -25.5245 0.0000 )     u=3
394 like 302 but     trcl = ( -25.5245 -25.5245 0.0000 )     u=3 $ Assembly 47
395 0        -301 #396  fill=5 ( -8.5090 -25.5245 0.0000 )      $ Tube/Disk 48
         trcl = ( -8.5090 -25.5245 0.0000 )     u=3
396 like 302 but     trcl = ( -8.5090 -25.5245 0.0000 )     u=3 $ Assembly 48
397 0        -301 #398  fill=5 ( 8.5090 -25.5245 0.0000 )      $ Tube/Disk 49
         trcl = ( 8.5090 -25.5245 0.0000 )     u=3
398 like 302 but     trcl = ( 8.5090 -25.5245 0.0000 )     u=3 $ Assembly 49
399 0        -301 #400  fill=5 ( 25.5245 -25.5245 0.0000 )      $ Tube/Disk 50
         trcl = ( 25.5245 -25.5245 0.0000 )     u=3
400 like 302 but     trcl = ( 25.5245 -25.5245 0.0000 )     u=3 $ Assembly 50
401 0        -301 #402  fill=5 ( 42.5399 -25.5245 0.0000 )      $ Tube/Disk 51
         trcl = ( 42.5399 -25.5245 0.0000 )     u=3
402 like 302 but     trcl = ( 42.5399 -25.5245 0.0000 )     u=3 $ Assembly 51
403 0        -302 #404  fill=7 ( 59.8729 -26.4770 0.0000 )      $ Tube/Disk 52
         trcl = ( 59.8729 -26.4770 0.0000 )     u=3
404 like 302 but     trcl = ( 59.8729 -26.4770 0.0000 )     u=3 $ Assembly 52
405 0        -302 #406  fill=6 ( -61.2699 -44.1274 0.0000 )      $ Tube/Disk 53
         trcl = ( -61.2699 -44.1274 0.0000 )     u=3
406 like 302 but     trcl = ( -61.2699 -44.1274 0.0000 )     u=3 $ Assembly 53
407 0        -301 #408  fill=5 ( -42.5399 -42.5399 0.0000 )      $ Tube/Disk 54
         trcl = ( -42.5399 -42.5399 0.0000 )     u=3
408 like 302 but     trcl = ( -42.5399 -42.5399 0.0000 )     u=3 $ Assembly 54
409 0        -301 #410  fill=5 ( -25.5245 -42.5399 0.0000 )      $ Tube/Disk 55
```

Figure 5.A.6-4 MPC-LACBWR MCNP Input File for Transfer Cask Wet Canister Top Axial Biasing – Fuel Neutron Source

```
           trcl = ( -25.5245 -42.5399 0.0000 )     u=3
410 like 302 but     trcl = ( -25.5245 -42.5399 0.0000 )     u=3 $ Assembly 55
411 0          -301 #412  fill=5 ( -8.5090 -42.5399 0.0000 )      $ Tube/Disk 56
           trcl = ( -8.5090 -42.5399 0.0000 )     u=3
412 like 302 but     trcl = ( -8.5090 -42.5399 0.0000 )     u=3 $ Assembly 56
413 0          -301 #414  fill=5 ( 8.5090 -42.5399 0.0000 )      $ Tube/Disk 57
           trcl = ( 8.5090 -42.5399 0.0000 )     u=3
414 like 302 but     trcl = ( 8.5090 -42.5399 0.0000 )     u=3 $ Assembly 57
415 0          -301 #416  fill=5 ( 25.5245 -42.5399 0.0000 )      $ Tube/Disk 58
           trcl = ( 25.5245 -42.5399 0.0000 )     u=3
416 like 302 but     trcl = ( 25.5245 -42.5399 0.0000 )     u=3 $ Assembly 58
417 0          -301 #418  fill=5 ( 42.5399 -42.5399 0.0000 )      $ Tube/Disk 59
           trcl = ( 42.5399 -42.5399 0.0000 )     u=3
418 like 302 but     trcl = ( 42.5399 -42.5399 0.0000 )     u=3 $ Assembly 59
419 0          -302 #420  fill=7 ( 61.2699 -44.1274 0.0000 )      $ Tube/Disk 60
           trcl = ( 61.2699 -44.1274 0.0000 )     u=3
420 like 302 but     trcl = ( 61.2699 -44.1274 0.0000 )     u=3 $ Assembly 60
421 0          -302 #422  fill=6 ( -44.1274 -61.2699 0.0000 )      $ Tube/Disk 61
           trcl = ( -44.1274 -61.2699 0.0000 )     u=3
422 like 302 but     trcl = ( -44.1274 -61.2699 0.0000 )     u=3 $ Assembly 61
423 0          -302 #424  fill=6 ( -26.4770 -59.8729 0.0000 )      $ Tube/Disk 62
           trcl = ( -26.4770 -59.8729 0.0000 )     u=3
424 like 302 but     trcl = ( -26.4770 -59.8729 0.0000 )     u=3 $ Assembly 62
425 0          -302 #426  fill=6 ( -8.8265 -59.8729 0.0000 )      $ Tube/Disk 63
           trcl = ( -8.8265 -59.8729 0.0000 )     u=3
426 like 302 but     trcl = ( -8.8265 -59.8729 0.0000 )     u=3 $ Assembly 63
427 0          -302 #428  fill=6 ( 8.8265 -59.8729 0.0000 )      $ Tube/Disk 64
           trcl = ( 8.8265 -59.8729 0.0000 )     u=3
428 like 302 but     trcl = ( 8.8265 -59.8729 0.0000 )     u=3 $ Assembly 64
429 0          -302 #430  fill=6 ( 26.4770 -59.8729 0.0000 )      $ Tube/Disk 65
           trcl = ( 26.4770 -59.8729 0.0000 )     u=3
430 like 302 but     trcl = ( 26.4770 -59.8729 0.0000 )     u=3 $ Assembly 65
431 0          -302 #432  fill=7 ( 44.1274 -61.2699 0.0000 )      $ Tube/Disk 66
           trcl = ( 44.1274 -61.2699 0.0000 )     u=3
432 like 302 but     trcl = ( 44.1274 -61.2699 0.0000 )     u=3 $ Assembly 66
433 0          -302 #434  fill=7 ( -8.8265 -77.5233 0.0000 )      $ Tube/Disk 67
           trcl = ( -8.8265 -77.5233 0.0000 )     u=3
434 like 302 but     trcl = ( -8.8265 -77.5233 0.0000 )     u=3 $ Assembly 67
435 0          -302 #436  fill=7 ( 8.8265 -77.5233 0.0000 )      $ Tube/Disk 68
           trcl = ( 8.8265 -77.5233 0.0000 )     u=3
436 like 302 but     trcl = ( 8.8265 -77.5233 0.0000 )     u=3 $ Assembly 68
437 0          +303 +304          $ Canister Cavity Q1
      #303 #311 #313 #315 #325 #327 #329 #331 #341
      #304 #312 #314 #316 #326 #328 #330 #332 #342
      #343 #345 #347 #359 #361 #363 #365 #367
      #344 #346 #348 #360 #362 #364 #366 #368
          fill=4      u=3
438 0          +303 -304          $ Canister Cavity Q2
      #301 #305 #307 #309 #317 #319 #321 #323 #333
      #302 #306 #308 #310 #318 #320 #322 #324 #334
      #335 #337 #339 #349 #351 #353 #355 #357
      #336 #338 #340 #350 #352 #354 #356 #358
          fill=4      u=3
439 0          -303 -304          $ Canister Cavity Q3
      #369 #371 #373 #375 #377 #389 #391 #393 #395
      #370 #372 #374 #376 #378 #390 #392 #394 #396
      #405 #407 #409 #411 #421 #423 #425 #433
      #406 #408 #410 #412 #422 #424 #426 #434
          fill=4      u=3
440 0          -303 +304          $ Canister Cavity Q4
      #379 #381 #383 #385 #387 #397 #399 #401 #403
      #380 #382 #384 #386 #388 #398 #400 #402 #404
      #413 #415 #417 #419 #427 #429 #431 #435
      #414 #416 #418 #420 #428 #430 #432 #436
```

Figure 5.A.6-4 MPC-LACBWR MCNP Input File for Transfer Cask Wet Canister Top Axial Biasing – Fuel Neutron Source

```
          fill=4      u=3
C Cells - Canister w/o Port Covers v1.0
501 0          -501   fill=3    u=2 $ Cavity
502 6 -7.9400 -507 +501.3       u=2 $ Canister Bottom
503 0          -502 +501.2 -505 trcl = ( 72.8704 22.2787 0.0000 )    u=2 $ Bottom Drain Port
504 13 -3.9700 -503 +505 -506 trcl = ( 72.8704 22.2787 0.0000 )    u=2 $ Middle Drain Port
505 0          -504 +506 -507.2 trcl = ( 72.8704 22.2787 0.0000 )    u=2 $ Top Drain Port
506 like 503 but   trcl = ( -72.8704 -22.2787 0.0000 )    u=2 $ Bottom Vent Port
507 like 504 but   trcl = ( -72.8704 -22.2787 0.0000 )    u=2 $ Middle Vent Port
508 like 505 but   trcl = ( -72.8704 -22.2787 0.0000 )    u=2 $ Top Vent Port
509 6 -7.9400 -507 -501.3 +501.1     u=2 $ Canister Shell
510 6 -7.9400 -507 -501.1 +501.2 #503 #504 #505 #506 #507 #508     u=2 $ Lid
511 0          +507        u=2 $ Outside
C Transfer Cask Cells - v4.1
601 0          -601 -602  fill=2 ( 0.0000 0.0000 2.5400 )   u=1 $ Cavity
602 7 -7.8212 -601 +602 -606    u=1 $ Bottom forging
603 7 -7.8212 -603 +602 +606 -608 +614  u=1 $ Inner shell
604 10 -11.344 -604 +603 +606 -607 +614  u=1 $ Lead shell
605 11 -1.6316 -604 +603 +607 -608    u=1 $ NS-4-FR above Pb
606 11 -1.6316 -605 +604 +606 -608 +614  u=1 $ NS-4-FR
607 7 -7.8212 -601 +605 +606 -608 +614  u=1 $ Outer shell
608 7 -7.8212 -601 +602 +608    u=1 $ Top forging
609 7 -7.8212 -601 +602 -614    u=1 $ Trunnion
610 7 -7.8212 (-609 +610 -616) : (-609 -611 -616)      u=1 $ Door rail
611 7 -7.8212 -615 -612 +613 -616   u=1 $ Door steel
612 0          +601 #610  #611     u=1 $ Void
C Detector Cells - Axial Biasing
700  0  -700  fill=1  $ Surface
800  0  -800  +700  $ PortAzi
900  0  -900  +700  +800  $ AnnulusAzi
1000  0  -1000  +700  +800  +900  $ 1ft
1100  0  -1100  +700  +800  +900  +1000  $ 1m
1200  0  -1200  +700  +800  +900  +1000  +1100  $ 2m
1300  0  -1300  +700  +800  +900  +1000  +1100  +1200  $ 4m
1400  0  +700  +800  +900  +1000  +1100  +1200  +1300  $ Exterior

C Fuel Assembly Surfaces - v1.0
1 RPP -7.1247 7.1247 -7.1247 7.1247 0.0000 261.9502  $ Assy
2 PZ 27.2796        $ Lower Nozzle/Fuel
3 PZ 238.0996        $ Fuel/Upper Plenum
4 PZ 251.1298        $ Upper Plenum/Upper Nozzle
C Flood Elevation Surface
5 PZ 251.1297
C Surfaces - Standard Fuel Tube v1.0
101 RPP -7.3076 7.3076 -7.3076 7.3076 0.0000 274.4470    $ Tube void
102 RPP -7.4295 7.4295 -7.4295 7.4295 0.0000 249.5550    $ Tube
103 RPP -6.5913 6.5913 7.4295 7.6200 2.0320 245.8720    $ Absorber +Y
104 RPP -6.5913 6.5913 7.6200 7.6657 2.0320 245.8720    $ Cladding +Y
105 RPP 7.4295 7.6200 -6.5913 6.5913 2.0320 245.8720    $ Absorber +X
106 RPP 7.6200 7.6657 -6.5913 6.5913 2.0320 245.8720    $ Cladding +X
C Surfaces - DFC Fuel Tube v1.0
107 RPP -7.6251 7.6251 -7.6251 7.6251 0.0000 274.4470    $ Tube void
108 RPP -7.7470 7.7470 -7.7470 7.7470 0.0000 249.5550    $ Tube
109 RPP -6.5913 6.5913 7.7470 7.9375 2.0320 245.8720    $ Absorber +Y
110 RPP -6.5913 6.5913 7.9375 7.9832 2.0320 245.8720    $ Cladding +Y
111 RPP 7.7470 7.9375 -6.5913 6.5913 2.0320 245.8720    $ Absorber +X
112 RPP 7.9375 7.9832 -6.5913 6.5913 2.0320 245.8720    $ Cladding +X
c Surface Cards - Disk Stack  v1.0
201 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 1.5875 88.1380 $ Structural disk
202 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 1.2700 87.7951 $ Heat transfer disk
203 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 2.5400 88.0491 $ Weldment disk
c Surface Cards - Basket v1.0
301 RPP -7.7711 7.7711 -7.7711 7.7711 0.0000 274.4470  $ Std opening
302 RPP -8.0899 8.0899 -8.0899 8.0899 0.0000 274.4470  $ DFC opening
```

Figure 5.A.6-4 MPC-LACBWR MCNP Input File for Transfer Cask Wet Canister Top Axial Biasing – Fuel Neutron Source

```
303 PY 0.0000        $ Cut plane
304 PX 0.0000        $ Cut plane
C Surfaces - Canister v1.0
501 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 274.4470 88.4428   $ Cavity
502 CZ 1.3843          $ Bot Cylinder Radius
503 CZ 5.0800          $ Mid Cyclinder Radius
504 CZ 5.7150          $ Top Cylinder Radius
505 PZ 282.8798          $ Port plane bot/mid
506 PZ 289.3822          $ Port plane mid/top
507 RCC 0.0000 0.0000 -2.5400 0.0000 0.0000 294.7670 89.7128   $ Canister
C Transfer Cask Surfaces - v4.1
601 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 313.6900 109.8550  $ Cask
602 CZ 90.8050          $ Cavity
603 CZ 92.7100          $ Inner shell OR
604 CZ 101.6000          $ Lead shell OR
605 CZ 106.6800          $ Outer shell IR
606 PZ 2.5400          $ Bottom forging
607 PZ 298.4500          $ Top lead
608 PZ 308.6100          $ Top forging
609 RPP -110.1852 110.1852 -107.3150 107.3150 -24.1300 0.0000   $ Door container
610 PY 95.8850          $ Inside rail +y
611 PY -95.8850          $ Inside rail -y
612 PY 95.4024          $ Door +y
613 PY -95.4024          $ Door -y
614 RCC -109.8550 0.0000 275.5900 219.7100 0.0000 0.0000 12.7000  $ Trunnion
615 RHP 0.0000 0.0000 -24.1300 0.0000 0.0000 24.1300   $ Door prism
        109.6679 0.0000 0.0000 87.5826 -66.1670 0.0000
        -87.5826 -66.1670 0.0000
616 RCC 0.0000 0.0000 -24.1300 0.0000 0.0000 24.1300 109.8550  $ Door container
C Axial Detector DTA (Surface)
700  RCC  0.0000  0.0000  -24.2300  0.0000  0.0000  338.0200  109.9550
701  CZ  9.1629
702  CZ  18.3258
703  CZ  27.4888
704  CZ  36.6517
705  CZ  45.8146
706  CZ  54.9775
707  CZ  64.1404
708  CZ  73.3033
709  CZ  82.4663
710  CZ  91.6292
711  CZ  100.7921
C Axial Detector DTAA (PortAzi)
800  RCC  0.0000  0.0000  -24.2300  0.0000  0.0000  338.1200  81.9150
801  CZ  70.4850
802     PX  0.0000
803  1  PX  0.0000
804  2  PX  0.0000
805  3  PX  0.0000
806  4  PX  0.0000
807  5  PX  0.0000
808  6  PX  0.0000
809  7  PX  0.0000
810  8  PX  0.0000
811  9  PX  0.0000
812  10  PX  0.0000
813  11  PX  0.0000
814  12  PX  0.0000
815  13  PX  0.0000
816  14  PX  0.0000
817  15  PX  0.0000
818     PY  0.0000
819  16  PX  0.0000
820  17  PX  0.0000
```

Figure 5.A.6-4 MPC-LACBWR MCNP Input File for Transfer Cask Wet Canister Top Axial Biasing – Fuel Neutron Source

```
821  18  PX  0.0000
822  19  PX  0.0000
823  20  PX  0.0000
824  21  PX  0.0000
825  22  PX  0.0000
826  23  PX  0.0000
827  24  PX  0.0000
828  25  PX  0.0000
829  26  PX  0.0000
830  27  PX  0.0000
831  28  PX  0.0000
832  29  PX  0.0000
833  30  PX  0.0000
C Axial Detector DTAB (AnnulusAzi)
900  RCC  0.0000  0.0000  -24.2300  0.0000  0.0000  338.2200  90.8050
901  CZ  81.9150
902      PX  0.0000
903  8  PX  0.0000
904      PY  0.0000
905  23  PX  0.0000
C Axial Detector DTB (1ft)
1000  RCC  0.0000  0.0000  -24.2300  0.0000  0.0000  368.5000  140.4350
1001  CZ  11.7029
1002  CZ  23.4058
1003  CZ  35.1088
1004  CZ  46.8117
1005  CZ  58.5146
1006  CZ  70.2175
1007  CZ  81.9204
1008  CZ  93.6233
1009  CZ  105.3263
1010  CZ  117.0292
1011  CZ  128.7321
C Axial Detector DTC (1m)
1100  RCC  0.0000  0.0000  -24.2300  0.0000  0.0000  438.0200  209.9550
1101  CZ  17.4963
1102  CZ  34.9925
1103  CZ  52.4888
1104  CZ  69.9850
1105  CZ  87.4813
1106  CZ  104.9775
1107  CZ  122.4738
1108  CZ  139.9700
1109  CZ  157.4663
1110  CZ  174.9625
1111  CZ  192.4588
C Axial Detector DTD (2m)
1200  RCC  0.0000  0.0000  -24.2300  0.0000  0.0000  538.0200  309.9550
1201  CZ  25.8296
1202  CZ  51.6592
1203  CZ  77.4888
1204  CZ  103.3183
1205  CZ  129.1479
1206  CZ  154.9775
1207  CZ  180.8071
1208  CZ  206.6367
1209  CZ  232.4663
1210  CZ  258.2958
1211  CZ  284.1254
C Axial Detector DTE (4m)
1300  RCC  0.0000  0.0000  -24.2300  0.0000  0.0000  738.0200  509.9550
1301  CZ  42.4963
1302  CZ  84.9925
1303  CZ  127.4888
```

Figure 5.A.6-4 MPC-LACBWR MCNP Input File for Transfer Cask Wet Canister Top Axial Biasing – Fuel Neutron Source

```
1304  CZ  169.9850
1305  CZ  212.4813
1306  CZ  254.9775
1307  CZ  297.4738
1308  CZ  339.9700
1309  CZ  382.4663
1310  CZ  424.9625
1311  CZ  467.4588

C
C Materials List - Common Materials - v1.0
C
C Homogenized Lower Nozzle
m1     24000 -1.1867E-01
       25055 -1.2491E-02
       26000 -4.3407E-01
       28000 -5.9334E-02
        1001 -4.1715E-02
        8016 -3.3372E-01
C Homogenized UO2 Fuel
m2     24000 -2.5816E-02
       25055 -2.7175E-03
       26000 -9.4433E-02
       28000 -1.2908E-02
       92235 -2.3027E-02
       92238 -6.1661E-01
        8016 -2.0910E-01
        1001 -1.5390E-02
C Homogenized Upper Plenum
m3     24000 -1.1765E-01
       25055 -1.2384E-02
       26000 -4.3036E-01
       28000 -5.8826E-02
        1001 -4.2309E-02
        8016 -3.3847E-01
C Homogenized Upper Nozzle
m4     24000 -0.190 25055 -0.020 26000 -0.695
       28000 -0.095
C Water
m5     1001 2 8016 1
C Stainless Steel
m6     24000 -0.190 25055 -0.020 26000 -0.695
       28000 -0.095
C Carbon Steel
m7     26000 -0.99 6012 -0.01
C Neutron Poison
m8     13027 -0.8466  5010 -0.0216  5011 -0.0985
        6012 -0.0333
C Aluminum
m9     13027 -1.0
C Lead
m10    82000 -1.0
C NS-4-FR
m11     5010 -9.3127E-04 13027 -2.1420E-01  6012 -2.7627E-01
        5011 -3.7721E-03  1001 -6.0012E-02  7014 -1.9815E-02
        8016 -4.2500E-01
C Concrete
m12    26000 -0.014 20000 -0.044 14000 -0.337
        1001 -0.010  8016 -0.532 11023 -0.029
       13027 -0.034
C Vent Port Middle Cylinder
m13    24000 -0.190 25055 -0.020 26000 -0.695
       28000 -0.095
nonu                   $ Disable subcritical multiplication
```

Figure 5.A.6-4 MPC-LACBWR MCNP Input File for Transfer Cask Wet Canister Top Axial Biasing – Fuel Neutron Source

```
C
C Cell Importances
C
imp:n 1 244r 0
C
C BWR Source Definition - Fuel Neutron - Pref
C
sdef x=d1 y=d2 z=d3 erg=d4 cell=700:601:501:d5:2
si1   -7.1247 7.1247
sp1   0 1
si2   -7.1247 7.1247
sp2   0 1
si3   27.2796 48.3616 69.4436 90.5256 111.6076 132.6896 153.7716
      174.8536 195.9356 217.0176 238.0996
sp3   0.000E+00 2.205E-02 2.412E+00 3.660E+00 3.363E+00 3.065E+00 2.437E+00
      1.632E+00 1.047E+00 5.831E-01 1.009E-04
si4   1.000E-11 7.090E-08 5.500E-07 1.500E-06 4.000E-06 1.600E-05
      4.810E-05 1.660E-04 3.540E-04 9.610E-04 2.950E-03 9.120E-03
      2.480E-02 6.740E-02 1.100E-01 3.900E-01 6.400E-01 1.740E+00
      2.870E+00 3.680E+00 4.720E+00 6.070E+00 7.000E+00 8.250E+00
      1.000E+01 1.125E+01 1.250E+01 1.360E+01 1.460E+01
sp4   0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
      0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
      0.0000E+00 0.0000E+00 2.4850E+01 6.1350E+04 1.7620E+05 7.3960E+05
      6.2630E+05 2.6030E+05 1.4660E+05 7.8130E+04 2.3350E+04 1.3530E+04
      5.0380E+03 1.6060E+03 4.8350E+02 1.1600E+02 0.0000E+00
C Source Information
si5 1                  302 304
               306 308 310 312 314 316
           318 320 322 324 326 328 330 332
           334 336 338 340 342 344 346 348
       350 352 354 356 358 360 362 364 366 368
       370 372 374 376 378 380 382 384 386 388
           390 392 394 396 398 400 402 404
           406 408 410 412 414 416 418 420
               422 424 426 428 430 432
                       434 436
C Source Probability
sp5                       1.39 1.39
                1.39 1.39 1.39 1.39 1.39 1.39
           1.39 1.00 1.00 1.00 1.00 1.00 1.00 1.39
           1.39 1.00 1.00 1.00 1.00 1.00 1.00 1.39
      1.39 1.39 1.00 1.00 1.00 1.00 1.00 1.00 1.39 1.39
      1.39 1.39 1.00 1.00 1.00 1.00 1.00 1.00 1.39 1.39
           1.39 1.00 1.00 1.00 1.00 1.00 1.00 1.39
           1.39 1.00 1.00 1.00 1.00 1.00 1.00 1.39
                1.39 1.39 1.39 1.39 1.39 1.39
                          1.39 1.39
mode n
nps 30000000
C
C ANSI/ANS-6.1.1-1977 - Neutron Flux-to-Dose Conversion Factors
C (mrem/hr)/(neutrons/cm2-sec)
C
de0   2.5E-08 1E-07 1E-06 0.00001 0.0001 0.001 0.01
      0.1 0.5 1 2.5 5 7 10
      14 20
df0   3.67E-03 3.67E-03 4.46E-03 4.54E-03 4.18E-03 3.76E-03 3.56E-03
      2.17E-02 9.26E-02 1.32E-01 1.25E-01 1.56E-01 1.47E-01 1.47E-01
      2.08E-01 2.27E-01
C
C Weight Window Generation - Top Axial
C
wwg 2 0 0 0 0
```

Figure 5.A.6-4 MPC-LACBWR MCNP Input File for Transfer Cask Wet Canister Top Axial Biasing – Fuel Neutron Source

```
wwp:n 5 3 5 0 -1 0
mesh geom=cyl ref=9 9 240 origin=0.1 0.1 -25
     imesh 88.4 89.7 90.8 92.7 101.6 106.7 109.9 609.9
     iints 5 1 1 1 1 1 1 1
     jmesh 1 25 28 55 266 279 290 302 320 820
     jints 1 1 1 1 10 1 1 1 2 1
     kmesh 1
     kints 1
wwge:n  1e-5 1e-3 1 20
fc2 Axial Surface Tally
f2:n +700.2
fm2 4.5049E+09
fs2  -701  -702  -703  -704  -705  -706
     -707  -708  -709  -710  -711  T
tf2
fc12 Axial PortAzi Tally Q1 (+x+y)
f12:n +800.2
fm12 4.5049E+09
fs12 -801  -802  -818
     +817  +816  +815  +814  +813  +812
     +811  +810  +809  +808  +807  +806
     +805  +804  +803  T
sd12 1.5608E+04  2.7362E+03  1.3681E+03  8.5507E+01  15r  5.4724E+03
tf12
fc22 Axial PortAzi Tally Q2 (-x+y)
f22:n +800.2
fm22 4.5049E+09
fs22 -801  +802  -818
     -833  -832  -831  -830  -829  -828
     -827  -826  -825  -824  -823  -822
     -821  -820  -819  T
sd22 1.5608E+04  2.7362E+03  1.3681E+03  8.5507E+01  15r  5.4724E+03
tf22
fc32 Axial PortAzi Tally Q3 (-x-y)
f32:n +800.2
fm32 4.5049E+09
fs32 -801  +802  +818
     -817  -816  -815  -814  -813  -812
     -811  -810  -809  -808  -807  -806
     -805  -804  -803  T
sd32 1.5608E+04  2.7362E+03  1.3681E+03  8.5507E+01  15r  5.4724E+03
tf32
fc42 Axial PortAzi Tally Q4 (+x-y)
f42:n +800.2
fm42 4.5049E+09
fs42 -801  -802  +818
     +833  +832  +831  +830  +829  +828
     +827  +826  +825  +824  +823  +822
     +821  +820  +819  T
sd42 1.5608E+04  2.7362E+03  1.3681E+03  8.5507E+01  15r  5.4724E+03
tf42
fc52 Axial AnnulusAzi Tally Q1 (+x+y)
f52:n +900.2
fm52 4.5049E+09
fs52 -901  -902  -904
     +903  T
sd52 2.1080E+04  2.4119E+03  1.2060E+03  6.0298E+02  1r  4.8239E+03
tf52
fc62 Axial AnnulusAzi Tally Q2 (-x+y)
f62:n +900.2
fm62 4.5049E+09
fs62 -901  +902  -904
     -905  T
sd62 2.1080E+04  2.4119E+03  1.2060E+03  6.0298E+02  1r  4.8239E+03
```

Figure 5.A.6-4 MPC-LACBWR MCNP Input File for Transfer Cask Wet Canister Top Axial Biasing – Fuel Neutron Source

```
tf62
fc72 Axial AnnulusAzi Tally Q3 (-x-y)
f72:n +900.2
fm72 4.5049E+09
fs72 -901  +902  +904
     -903  T
sd72 2.1080E+04  2.4119E+03  1.2060E+03  6.0298E+02  1r  4.8239E+03
tf72
fc82 Axial AnnulusAzi Tally Q4 (+x-y)
f82:n +900.2
fm82 4.5049E+09
fs82 -901  -902  +904
     +905  T
sd82 2.1080E+04  2.4119E+03  1.2060E+03  6.0298E+02  1r  4.8239E+03
tf82
fc92 Axial 1ft Tally
f92:n +1000.2
fm92 4.5049E+09
fs92  -1001  -1002  -1003  -1004  -1005  -1006
     -1007  -1008  -1009  -1010  -1011  T
tf92
fc102 Axial 1m Tally
f102:n +1100.2
fm102 4.5049E+09
fs102  -1101  -1102  -1103  -1104  -1105  -1106
     -1107  -1108  -1109  -1110  -1111  T
tf102
fc112 Axial 2m Tally
f112:n +1200.2
fm112 4.5049E+09
fs112  -1201  -1202  -1203  -1204  -1205  -1206
     -1207  -1208  -1209  -1210  -1211  T
tf112
fc122 Axial 4m Tally
f122:n +1300.2
fm122 4.5049E+09
fs122  -1301  -1302  -1303  -1304  -1305  -1306
     -1307  -1308  -1309  -1310  -1311  T
tf122
C
C
C Print Control
C
prdmp -30 -60 1 2
print
C
C Random Number Generator
C
rand gen=2 seed=19073486328125 stride=152917 hist=1
C
C Rotation Matrix
C
C 5.625 degree rotation around z-axis
*TR1 0.0 0.0 0.0 5.625 95.625 90 -84.375 5.625 90 90 90 0
C 11.25 degree rotation around z-axis
*TR2 0.0 0.0 0.0 11.250 101.250 90 -78.750 11.250 90 90 90 0
C 16.875 degree rotation around z-axis
*TR3 0.0 0.0 0.0 16.875 106.875 90 -73.125 16.875 90 90 90 0
C 22.5 degree rotation around z-axis
*TR4 0.0 0.0 0.0 22.500 112.500 90 -67.500 22.500 90 90 90 0
C 28.125 degree rotation around z-axis
*TR5 0.0 0.0 0.0 28.125 118.125 90 -61.875 28.125 90 90 90 0
C 33.75 degree rotation around z-axis
*TR6 0.0 0.0 0.0 33.750 123.750 90 -56.250 33.750 90 90 90 0
```

Figure 5.A.6-4 MPC-LACBWR MCNP Input File for Transfer Cask Wet Canister Top Axial Biasing – Fuel Neutron Source

```
C 39.375 degree rotation around z-axis
*TR7 0.0 0.0 0.0 39.375 129.375 90 -50.625 39.375 90 90 90 0
C 45 degree rotation around z-axis
*TR8 0.0 0.0 0.0 45.000 135.000 90 -45.000 45.000 90 90 90 0
C 50.625 degree rotation around z-axis
*TR9 0.0 0.0 0.0 50.625 140.625 90 -39.375 50.625 90 90 90 0
C 56.25 degree rotation around z-axis
*TR10 0.0 0.0 0.0 56.250 146.250 90 -33.750 56.250 90 90 90 0
C 61.875 degree rotation around z-axis
*TR11 0.0 0.0 0.0 61.875 151.875 90 -28.125 61.875 90 90 90 0
C 67.5 degree rotation around z-axis
*TR12 0.0 0.0 0.0 67.500 157.500 90 -22.500 67.500 90 90 90 0
C 73.125 degree rotation around z-axis
*TR13 0.0 0.0 0.0 73.125 163.125 90 -16.875 73.125 90 90 90 0
C 78.75 degree rotation around z-axis
*TR14 0.0 0.0 0.0 78.750 168.750 90 -11.250 78.750 90 90 90 0
C 84.375 degree rotation around z-axis
*TR15 0.0 0.0 0.0 84.375 174.375 90 -5.625 84.375 90 90 90 0
C 95.625 degree rotation around z-axis
*TR16 0.0 0.0 0.0 95.625 185.625 90 5.625 95.625 90 90 90 0
C 101.25 degree rotation around z-axis
*TR17 0.0 0.0 0.0 101.250 191.250 90 11.250 101.250 90 90 90 0
C 106.875 degree rotation around z-axis
*TR18 0.0 0.0 0.0 106.875 196.875 90 16.875 106.875 90 90 90 0
C 112.5 degree rotation around z-axis
*TR19 0.0 0.0 0.0 112.500 202.500 90 22.500 112.500 90 90 90 0
C 118.125 degree rotation around z-axis
*TR20 0.0 0.0 0.0 118.125 208.125 90 28.125 118.125 90 90 90 0
C 123.75 degree rotation around z-axis
*TR21 0.0 0.0 0.0 123.750 213.750 90 33.750 123.750 90 90 90 0
C 129.375 degree rotation around z-axis
*TR22 0.0 0.0 0.0 129.375 219.375 90 39.375 129.375 90 90 90 0
C 135 degree rotation around z-axis
*TR23 0.0 0.0 0.0 135.000 225.000 90 45.000 135.000 90 90 90 0
C 140.625 degree rotation around z-axis
*TR24 0.0 0.0 0.0 140.625 230.625 90 50.625 140.625 90 90 90 0
C 146.25 degree rotation around z-axis
*TR25 0.0 0.0 0.0 146.250 236.250 90 56.250 146.250 90 90 90 0
C 151.875 degree rotation around z-axis
*TR26 0.0 0.0 0.0 151.875 241.875 90 61.875 151.875 90 90 90 0
C 157.5 degree rotation around z-axis
*TR27 0.0 0.0 0.0 157.500 247.500 90 67.500 157.500 90 90 90 0
C 163.125 degree rotation around z-axis
*TR28 0.0 0.0 0.0 163.125 253.125 90 73.125 163.125 90 90 90 0
C 168.75 degree rotation around z-axis
*TR29 0.0 0.0 0.0 168.750 258.750 90 78.750 168.750 90 90 90 0
C 174.375 degree rotation around z-axis
*TR30 0.0 0.0 0.0 174.375 264.375 90 84.375 174.375 90 90 90 0
```

Figure 5.A.6-5 MPC-LACBWR MCNP Input File for Transfer Cask Dry Canister Bottom Axial Biasing – Lower End Fitting Source

```
LACBWR Transfer Cask - trfShlDryBotLf_Pref
C Bottom Axial Biasing - Lower Nozzle Source
C Fuel Assembly Cells - v1.0
1 1 -1.3734 -1 -2    u=10 $ Lower Nozzle
2 2 -3.7790 -1 +2 -3   u=10 $ Fuel
3 3 -0.9880 -1 +3 -4   u=10 $ Upper Plenum
4 4 -0.6145 -1 +4    u=10 $ Upper Nozzle
5 0        +1     u=10 $ Outside
C Cells - Standard Fuel Tube  v1.0
101 0         -101       u=5 $ Tube void
102 6 -7.9400 -102 +101       u=5 $ Tube
103 8 -2.6707 -103       u=5 $ Absorber +Y
104 6 -7.9400 -104       u=5 $ Cladding +Y
105 8 -2.6707 -105       u=5 $ Absorber +X
106 6 -7.9400 -106       u=5 $ Cladding +X
107 0         +101 +102 +103 +104 +106 +105  u=5 $ Void
C Cells - DFC Fuel Tube Absorber 2 Sides v1.0
108 0         -107       u=6 $ Tube void
109 6 -7.9400 -108 +107       u=6 $ Tube
110 8 -2.6707 -109       u=6 $ Absorber +Y
111 6 -7.9400 -110       u=6 $ Cladding +Y
112 8 -2.6707 -111       u=6 $ Absorber +X
113 6 -7.9400 -112       u=6 $ Cladding +X
114 0         +107 +108 +109 +110 +112 +111  u=6 $ Void
C Cells - DFC Fuel Tube Absorber 1 Side (Y) v1.0
115 0         -107       u=7 $ Tube void
116 6 -7.9400 -108 +107       u=7 $ Tube
117 8 -2.6707 -109       u=7 $ Absorber +Y
118 6 -7.9400 -110       u=7 $ Cladding +Y
119 0         +107 +108 +109 +110    u=7 $ Void
C Cells - DFC Fuel Tube Absorber 1 Side (X) v1.0
120 0         -107       u=8 $ Tube void
121 6 -7.9400 -108 +107       u=8 $ Tube
122 8 -2.6707 -111       u=8 $ Absorber +X
123 6 -7.9400 -112       u=8 $ Cladding +X
124 0         +107 +108 +111 +112    u=8 $ Void
C Cells - DFC Fuel Tube No Absorber v1.0
125 0         -107       u=9 $ Tube void
126 6 -7.9400 -108 +107       u=9 $ Tube
127 0         +107 +108       u=9 $ Void
c Cell Cards - Disk Stack v1.0
201 6 -7.94 -203 trcl = ( 0.0000 0.0000 2.5400 )    u=4 $ Bottom weldment disk
202 6 -7.94 -201 trcl = ( 0.0000 0.0000 15.0368 )    u=4 $ Support disk 1
203 like 202 but   trcl = ( 0.0000 0.0000 24.7650 )    u=4 $ Support disk 2
204 like 202 but   trcl = ( 0.0000 0.0000 34.4932 )    u=4 $ Support disk 3
205 like 202 but   trcl = ( 0.0000 0.0000 44.2214 )    u=4 $ Support disk 4
206 like 202 but   trcl = ( 0.0000 0.0000 53.9496 )    u=4 $ Support disk 5
207 9 -2.70 -202 trcl = ( 0.0000 0.0000 58.9788 )    u=4 $ Heat transfer disk 1
208 like 202 but   trcl = ( 0.0000 0.0000 63.6778 )    u=4 $ Support disk 6
209 like 207 but   trcl = ( 0.0000 0.0000 68.7070 )    u=4 $ Heat transfer disk 2
210 like 202 but   trcl = ( 0.0000 0.0000 73.4060 )    u=4 $ Support disk 7
211 like 207 but   trcl = ( 0.0000 0.0000 78.4352 )    u=4 $ Heat transfer disk 3
212 like 202 but   trcl = ( 0.0000 0.0000 83.1342 )    u=4 $ Support disk 8
213 like 207 but   trcl = ( 0.0000 0.0000 88.1634 )    u=4 $ Heat transfer disk 4
214 like 202 but   trcl = ( 0.0000 0.0000 92.8624 )    u=4 $ Support disk 9
215 like 207 but   trcl = ( 0.0000 0.0000 97.8916 )    u=4 $ Heat transfer disk 5
216 like 202 but   trcl = ( 0.0000 0.0000 102.5906 )    u=4 $ Support disk 10
217 like 207 but   trcl = ( 0.0000 0.0000 107.6198 )    u=4 $ Heat transfer disk 6
218 like 202 but   trcl = ( 0.0000 0.0000 112.3188 )    u=4 $ Support disk 11
219 like 207 but   trcl = ( 0.0000 0.0000 117.3480 )    u=4 $ Heat transfer disk 7
220 like 202 but   trcl = ( 0.0000 0.0000 122.0470 )    u=4 $ Support disk 12
221 like 207 but   trcl = ( 0.0000 0.0000 127.0762 )    u=4 $ Heat transfer disk 8
```

Figure 5.A.6-5 MPC-LACBWR MCNP Input File for Transfer Cask Dry Canister Bottom Axial Biasing – Lower End Fitting Source

```
222 like 202 but   trcl = ( 0.0000 0.0000 131.7752 )    u=4 $ Support disk 13
223 like 207 but   trcl = ( 0.0000 0.0000 136.8044 )    u=4 $ Heat transfer disk 9
224 like 202 but   trcl = ( 0.0000 0.0000 141.5034 )    u=4 $ Support disk 14
225 like 207 but   trcl = ( 0.0000 0.0000 146.5326 )    u=4 $ Heat transfer disk 10
226 like 202 but   trcl = ( 0.0000 0.0000 151.2316 )    u=4 $ Support disk 15
227 like 207 but   trcl = ( 0.0000 0.0000 156.2608 )    u=4 $ Heat transfer disk 11
228 like 202 but   trcl = ( 0.0000 0.0000 160.9598 )    u=4 $ Support disk 16
229 like 207 but   trcl = ( 0.0000 0.0000 165.9890 )    u=4 $ Heat transfer disk 12
230 like 202 but   trcl = ( 0.0000 0.0000 170.6880 )    u=4 $ Support disk 17
231 like 207 but   trcl = ( 0.0000 0.0000 175.7172 )    u=4 $ Heat transfer disk 13
232 like 202 but   trcl = ( 0.0000 0.0000 180.4162 )    u=4 $ Support disk 18
233 like 207 but   trcl = ( 0.0000 0.0000 185.4454 )    u=4 $ Heat transfer disk 14
234 like 202 but   trcl = ( 0.0000 0.0000 190.1444 )    u=4 $ Support disk 19
235 like 202 but   trcl = ( 0.0000 0.0000 199.8726 )    u=4 $ Support disk 20
236 like 202 but   trcl = ( 0.0000 0.0000 209.6008 )    u=4 $ Support disk 21
237 like 202 but   trcl = ( 0.0000 0.0000 219.3290 )    u=4 $ Support disk 22
238 like 202 but   trcl = ( 0.0000 0.0000 229.0572 )    u=4 $ Support disk 23
239 like 202 but   trcl = ( 0.0000 0.0000 238.7854 )    u=4 $ Support disk 24
240 like 201 but   trcl = ( 0.0000 0.0000 255.8796 )    u=4 $ Top weldment disk
241 0                $ Outside Disks
      #201 #202 #203 #204 #205 #206 #207 #208 #209 #210
      #211 #212 #213 #214 #215 #216 #217 #218 #219 #220
      #221 #222 #223 #224 #225 #226 #227 #228 #229 #230
      #231 #232 #233 #234 #235 #236 #237 #238 #239
      #240        u=4
c Cell Cards - Basket v1.0
301 0          -302 #302  fill=8 ( -8.8265 77.5233 0.0000 )      $ Tube/Disk 1
           trcl = ( -8.8265 77.5233 0.0000 )     u=3
302 0          -1  fill=10 trcl = ( -8.8265 77.5233 0.0000 )     u=3 $ Assembly 1
303 0          -302 #304  fill=9 ( 8.8265 77.5233 0.0000 )     $ Tube/Disk 2
           trcl = ( 8.8265 77.5233 0.0000 )     u=3
304 like 302 but     trcl = ( 8.8265 77.5233 0.0000 )     u=3 $ Assembly 2
305 0          -302 #306  fill=8 ( -44.1274 61.2699 0.0000 )      $ Tube/Disk 3
           trcl = ( -44.1274 61.2699 0.0000 )     u=3
306 like 302 but     trcl = ( -44.1274 61.2699 0.0000 )     u=3 $ Assembly 3
307 0          -302 #308  fill=8 ( -26.4770 59.8729 0.0000 )      $ Tube/Disk 4
           trcl = ( -26.4770 59.8729 0.0000 )     u=3
308 like 302 but     trcl = ( -26.4770 59.8729 0.0000 )     u=3 $ Assembly 4
309 0          -302 #310  fill=6 ( -8.8265 59.8729 0.0000 )      $ Tube/Disk 5
           trcl = ( -8.8265 59.8729 0.0000 )     u=3
310 like 302 but     trcl = ( -8.8265 59.8729 0.0000 )     u=3 $ Assembly 5
311 0          -302 #312  fill=6 ( 8.8265 59.8729 0.0000 )      $ Tube/Disk 6
           trcl = ( 8.8265 59.8729 0.0000 )     u=3
312 like 302 but     trcl = ( 8.8265 59.8729 0.0000 )     u=3 $ Assembly 6
313 0          -302 #314  fill=8 ( 26.4770 59.8729 0.0000 )      $ Tube/Disk 7
           trcl = ( 26.4770 59.8729 0.0000 )     u=3
314 like 302 but     trcl = ( 26.4770 59.8729 0.0000 )     u=3 $ Assembly 7
315 0          -302 #316  fill=9 ( 44.1274 61.2699 0.0000 )      $ Tube/Disk 8
           trcl = ( 44.1274 61.2699 0.0000 )     u=3
316 like 302 but     trcl = ( 44.1274 61.2699 0.0000 )     u=3 $ Assembly 8
317 0          -302 #318  fill=8 ( -61.2699 44.1274 0.0000 )      $ Tube/Disk 9
           trcl = ( -61.2699 44.1274 0.0000 )     u=3
318 like 302 but     trcl = ( -61.2699 44.1274 0.0000 )     u=3 $ Assembly 9
319 0          -301 #320  fill=5 ( -42.5399 42.5399 0.0000 )      $ Tube/Disk 10
           trcl = ( -42.5399 42.5399 0.0000 )     u=3
320 like 302 but     trcl = ( -42.5399 42.5399 0.0000 )     u=3 $ Assembly 10
321 0          -301 #322  fill=5 ( -25.5245 42.5399 0.0000 )      $ Tube/Disk 11
           trcl = ( -25.5245 42.5399 0.0000 )     u=3
322 like 302 but     trcl = ( -25.5245 42.5399 0.0000 )     u=3 $ Assembly 11
323 0          -301 #324  fill=5 ( -8.5090 42.5399 0.0000 )      $ Tube/Disk 12
           trcl = ( -8.5090 42.5399 0.0000 )     u=3
324 like 302 but     trcl = ( -8.5090 42.5399 0.0000 )     u=3 $ Assembly 12
325 0          -301 #326  fill=5 ( 8.5090 42.5399 0.0000 )      $ Tube/Disk 13
           trcl = ( 8.5090 42.5399 0.0000 )     u=3
```

Figure 5.A.6-5 MPC-LACBWR MCNP Input File for Transfer Cask Dry Canister Bottom Axial Biasing – Lower End Fitting Source

```
326 like 302 but     trcl = ( 8.5090 42.5399 0.0000 )     u=3 $ Assembly 13
327 0          -301 #328  fill=5 ( 25.5245 42.5399 0.0000 )      $ Tube/Disk 14
          trcl = ( 25.5245 42.5399 0.0000 )      u=3
328 like 302 but     trcl = ( 25.5245 42.5399 0.0000 )     u=3 $ Assembly 14
329 0          -301 #330  fill=5 ( 42.5399 42.5399 0.0000 )      $ Tube/Disk 15
          trcl = ( 42.5399 42.5399 0.0000 )      u=3
330 like 302 but     trcl = ( 42.5399 42.5399 0.0000 )     u=3 $ Assembly 15
331 0          -302 #332  fill=9 ( 61.2699 44.1274 0.0000 )      $ Tube/Disk 16
          trcl = ( 61.2699 44.1274 0.0000 )      u=3
332 like 302 but     trcl = ( 61.2699 44.1274 0.0000 )     u=3 $ Assembly 16
333 0          -302 #334  fill=6 ( -59.8729 26.4770 0.0000 )      $ Tube/Disk 17
          trcl = ( -59.8729 26.4770 0.0000 )      u=3
334 like 302 but     trcl = ( -59.8729 26.4770 0.0000 )     u=3 $ Assembly 17
335 0          -301 #336  fill=5 ( -42.5399 25.5245 0.0000 )      $ Tube/Disk 18
          trcl = ( -42.5399 25.5245 0.0000 )      u=3
336 like 302 but     trcl = ( -42.5399 25.5245 0.0000 )     u=3 $ Assembly 18
337 0          -301 #338  fill=5 ( -25.5245 25.5245 0.0000 )      $ Tube/Disk 19
          trcl = ( -25.5245 25.5245 0.0000 )      u=3
338 like 302 but     trcl = ( -25.5245 25.5245 0.0000 )     u=3 $ Assembly 19
339 0          -301 #340  fill=5 ( -8.5090 25.5245 0.0000 )      $ Tube/Disk 20
          trcl = ( -8.5090 25.5245 0.0000 )      u=3
340 like 302 but     trcl = ( -8.5090 25.5245 0.0000 )     u=3 $ Assembly 20
341 0          -301 #342  fill=5 ( 8.5090 25.5245 0.0000 )      $ Tube/Disk 21
          trcl = ( 8.5090 25.5245 0.0000 )      u=3
342 like 302 but     trcl = ( 8.5090 25.5245 0.0000 )     u=3 $ Assembly 21
343 0          -301 #344  fill=5 ( 25.5245 25.5245 0.0000 )      $ Tube/Disk 22
          trcl = ( 25.5245 25.5245 0.0000 )      u=3
344 like 302 but     trcl = ( 25.5245 25.5245 0.0000 )     u=3 $ Assembly 22
345 0          -301 #346  fill=5 ( 42.5399 25.5245 0.0000 )      $ Tube/Disk 23
          trcl = ( 42.5399 25.5245 0.0000 )      u=3
346 like 302 but     trcl = ( 42.5399 25.5245 0.0000 )     u=3 $ Assembly 23
347 0          -302 #348  fill=7 ( 59.8729 26.4770 0.0000 )      $ Tube/Disk 24
          trcl = ( 59.8729 26.4770 0.0000 )      u=3
348 like 302 but     trcl = ( 59.8729 26.4770 0.0000 )     u=3 $ Assembly 24
349 0          -302 #350  fill=8 ( -77.5233 8.8265 0.0000 )      $ Tube/Disk 25
          trcl = ( -77.5233 8.8265 0.0000 )      u=3
350 like 302 but     trcl = ( -77.5233 8.8265 0.0000 )     u=3 $ Assembly 25
351 0          -302 #352  fill=6 ( -59.8729 8.8265 0.0000 )      $ Tube/Disk 26
          trcl = ( -59.8729 8.8265 0.0000 )      u=3
352 like 302 but     trcl = ( -59.8729 8.8265 0.0000 )     u=3 $ Assembly 26
353 0          -301 #354  fill=5 ( -42.5399 8.5090 0.0000 )      $ Tube/Disk 27
          trcl = ( -42.5399 8.5090 0.0000 )      u=3
354 like 302 but     trcl = ( -42.5399 8.5090 0.0000 )     u=3 $ Assembly 27
355 0          -301 #356  fill=5 ( -25.5245 8.5090 0.0000 )      $ Tube/Disk 28
          trcl = ( -25.5245 8.5090 0.0000 )      u=3
356 like 302 but     trcl = ( -25.5245 8.5090 0.0000 )     u=3 $ Assembly 28
357 0          -301 #358  fill=5 ( -8.5090 8.5090 0.0000 )      $ Tube/Disk 29
          trcl = ( -8.5090 8.5090 0.0000 )      u=3
358 like 302 but     trcl = ( -8.5090 8.5090 0.0000 )     u=3 $ Assembly 29
359 0          -301 #360  fill=5 ( 8.5090 8.5090 0.0000 )      $ Tube/Disk 30
          trcl = ( 8.5090 8.5090 0.0000 )      u=3
360 like 302 but     trcl = ( 8.5090 8.5090 0.0000 )     u=3 $ Assembly 30
361 0          -301 #362  fill=5 ( 25.5245 8.5090 0.0000 )      $ Tube/Disk 31
          trcl = ( 25.5245 8.5090 0.0000 )      u=3
362 like 302 but     trcl = ( 25.5245 8.5090 0.0000 )     u=3 $ Assembly 31
363 0          -301 #364  fill=5 ( 42.5399 8.5090 0.0000 )      $ Tube/Disk 32
          trcl = ( 42.5399 8.5090 0.0000 )      u=3
364 like 302 but     trcl = ( 42.5399 8.5090 0.0000 )     u=3 $ Assembly 32
365 0          -302 #366  fill=6 ( 59.8729 8.8265 0.0000 )      $ Tube/Disk 33
          trcl = ( 59.8729 8.8265 0.0000 )      u=3
366 like 302 but     trcl = ( 59.8729 8.8265 0.0000 )     u=3 $ Assembly 33
367 0          -302 #368  fill=9 ( 77.5233 8.8265 0.0000 )      $ Tube/Disk 34
          trcl = ( 77.5233 8.8265 0.0000 )      u=3
368 like 302 but     trcl = ( 77.5233 8.8265 0.0000 )     u=3 $ Assembly 34
```

Figure 5.A.6-5 MPC-LACBWR MCNP Input File for Transfer Cask Dry Canister Bottom Axial Biasing – Lower End Fitting Source

```
369 0          -302 #370  fill=6 ( -77.5233 -8.8265 0.0000 )       $ Tube/Disk 35
           trcl = ( -77.5233 -8.8265 0.0000 )      u=3
370 like 302 but     trcl = ( -77.5233 -8.8265 0.0000 )     u=3 $ Assembly 35
371 0          -302 #372  fill=6 ( -59.8729 -8.8265 0.0000 )       $ Tube/Disk 36
           trcl = ( -59.8729 -8.8265 0.0000 )      u=3
372 like 302 but     trcl = ( -59.8729 -8.8265 0.0000 )     u=3 $ Assembly 36
373 0          -301 #374  fill=5 ( -42.5399 -8.5090 0.0000 )       $ Tube/Disk 37
           trcl = ( -42.5399 -8.5090 0.0000 )      u=3
374 like 302 but     trcl = ( -42.5399 -8.5090 0.0000 )     u=3 $ Assembly 37
375 0          -301 #376  fill=5 ( -25.5245 -8.5090 0.0000 )       $ Tube/Disk 38
           trcl = ( -25.5245 -8.5090 0.0000 )      u=3
376 like 302 but     trcl = ( -25.5245 -8.5090 0.0000 )     u=3 $ Assembly 38
377 0          -301 #378  fill=5 ( -8.5090 -8.5090 0.0000 )      $ Tube/Disk 39
           trcl = ( -8.5090 -8.5090 0.0000 )      u=3
378 like 302 but     trcl = ( -8.5090 -8.5090 0.0000 )     u=3 $ Assembly 39
379 0          -301 #380  fill=5 ( 8.5090 -8.5090 0.0000 )      $ Tube/Disk 40
           trcl = ( 8.5090 -8.5090 0.0000 )      u=3
380 like 302 but     trcl = ( 8.5090 -8.5090 0.0000 )     u=3 $ Assembly 40
381 0          -301 #382  fill=5 ( 25.5245 -8.5090 0.0000 )      $ Tube/Disk 41
           trcl = ( 25.5245 -8.5090 0.0000 )      u=3
382 like 302 but     trcl = ( 25.5245 -8.5090 0.0000 )     u=3 $ Assembly 41
383 0          -301 #384  fill=5 ( 42.5399 -8.5090 0.0000 )      $ Tube/Disk 42
           trcl = ( 42.5399 -8.5090 0.0000 )      u=3
384 like 302 but     trcl = ( 42.5399 -8.5090 0.0000 )     u=3 $ Assembly 42
385 0          -302 #386  fill=6 ( 59.8729 -8.8265 0.0000 )      $ Tube/Disk 43
           trcl = ( 59.8729 -8.8265 0.0000 )      u=3
386 like 302 but     trcl = ( 59.8729 -8.8265 0.0000 )     u=3 $ Assembly 43
387 0          -302 #388  fill=7 ( 77.5233 -8.8265 0.0000 )      $ Tube/Disk 44
           trcl = ( 77.5233 -8.8265 0.0000 )      u=3
388 like 302 but     trcl = ( 77.5233 -8.8265 0.0000 )     u=3 $ Assembly 44
389 0          -302 #390  fill=6 ( -59.8729 -26.4770 0.0000 )      $ Tube/Disk 45
           trcl = ( -59.8729 -26.4770 0.0000 )      u=3
390 like 302 but     trcl = ( -59.8729 -26.4770 0.0000 )     u=3 $ Assembly 45
391 0          -301 #392  fill=5 ( -42.5399 -25.5245 0.0000 )      $ Tube/Disk 46
           trcl = ( -42.5399 -25.5245 0.0000 )      u=3
392 like 302 but     trcl = ( -42.5399 -25.5245 0.0000 )     u=3 $ Assembly 46
393 0          -301 #394  fill=5 ( -25.5245 -25.5245 0.0000 )      $ Tube/Disk 47
           trcl = ( -25.5245 -25.5245 0.0000 )      u=3
394 like 302 but     trcl = ( -25.5245 -25.5245 0.0000 )     u=3 $ Assembly 47
395 0          -301 #396  fill=5 ( -8.5090 -25.5245 0.0000 )      $ Tube/Disk 48
           trcl = ( -8.5090 -25.5245 0.0000 )      u=3
396 like 302 but     trcl = ( -8.5090 -25.5245 0.0000 )     u=3 $ Assembly 48
397 0          -301 #398  fill=5 ( 8.5090 -25.5245 0.0000 )      $ Tube/Disk 49
           trcl = ( 8.5090 -25.5245 0.0000 )      u=3
398 like 302 but     trcl = ( 8.5090 -25.5245 0.0000 )     u=3 $ Assembly 49
399 0          -301 #400  fill=5 ( 25.5245 -25.5245 0.0000 )      $ Tube/Disk 50
           trcl = ( 25.5245 -25.5245 0.0000 )      u=3
400 like 302 but     trcl = ( 25.5245 -25.5245 0.0000 )     u=3 $ Assembly 50
401 0          -301 #402  fill=5 ( 42.5399 -25.5245 0.0000 )      $ Tube/Disk 51
           trcl = ( 42.5399 -25.5245 0.0000 )      u=3
402 like 302 but     trcl = ( 42.5399 -25.5245 0.0000 )     u=3 $ Assembly 51
403 0          -302 #404  fill=7 ( 59.8729 -26.4770 0.0000 )      $ Tube/Disk 52
           trcl = ( 59.8729 -26.4770 0.0000 )      u=3
404 like 302 but     trcl = ( 59.8729 -26.4770 0.0000 )     u=3 $ Assembly 52
405 0          -302 #406  fill=6 ( -61.2699 -44.1274 0.0000 )      $ Tube/Disk 53
           trcl = ( -61.2699 -44.1274 0.0000 )      u=3
406 like 302 but     trcl = ( -61.2699 -44.1274 0.0000 )     u=3 $ Assembly 53
407 0          -301 #408  fill=5 ( -42.5399 -42.5399 0.0000 )      $ Tube/Disk 54
           trcl = ( -42.5399 -42.5399 0.0000 )      u=3
408 like 302 but     trcl = ( -42.5399 -42.5399 0.0000 )     u=3 $ Assembly 54
409 0          -301 #410  fill=5 ( -25.5245 -42.5399 0.0000 )      $ Tube/Disk 55
           trcl = ( -25.5245 -42.5399 0.0000 )      u=3
410 like 302 but     trcl = ( -25.5245 -42.5399 0.0000 )     u=3 $ Assembly 55
411 0          -301 #412  fill=5 ( -8.5090 -42.5399 0.0000 )      $ Tube/Disk 56
```

Figure 5.A.6-5 MPC-LACBWR MCNP Input File for Transfer Cask Dry Canister Bottom Axial Biasing – Lower End Fitting Source

```
           trcl = ( -8.5090 -42.5399 0.0000 )     u=3
412 like 302 but     trcl = ( -8.5090 -42.5399 0.0000 )     u=3 $ Assembly 56
413 0          -301 #414  fill=5 ( 8.5090 -42.5399 0.0000 )      $ Tube/Disk 57
           trcl = ( 8.5090 -42.5399 0.0000 )     u=3
414 like 302 but     trcl = ( 8.5090 -42.5399 0.0000 )     u=3 $ Assembly 57
415 0          -301 #416  fill=5 ( 25.5245 -42.5399 0.0000 )      $ Tube/Disk 58
           trcl = ( 25.5245 -42.5399 0.0000 )     u=3
416 like 302 but     trcl = ( 25.5245 -42.5399 0.0000 )     u=3 $ Assembly 58
417 0          -301 #418  fill=5 ( 42.5399 -42.5399 0.0000 )      $ Tube/Disk 59
           trcl = ( 42.5399 -42.5399 0.0000 )     u=3
418 like 302 but     trcl = ( 42.5399 -42.5399 0.0000 )     u=3 $ Assembly 59
419 0          -302 #420  fill=7 ( 61.2699 -44.1274 0.0000 )      $ Tube/Disk 60
           trcl = ( 61.2699 -44.1274 0.0000 )     u=3
420 like 302 but     trcl = ( 61.2699 -44.1274 0.0000 )     u=3 $ Assembly 60
421 0          -302 #422  fill=6 ( -44.1274 -61.2699 0.0000 )      $ Tube/Disk 61
           trcl = ( -44.1274 -61.2699 0.0000 )     u=3
422 like 302 but     trcl = ( -44.1274 -61.2699 0.0000 )     u=3 $ Assembly 61
423 0          -302 #424  fill=6 ( -26.4770 -59.8729 0.0000 )      $ Tube/Disk 62
           trcl = ( -26.4770 -59.8729 0.0000 )     u=3
424 like 302 but     trcl = ( -26.4770 -59.8729 0.0000 )     u=3 $ Assembly 62
425 0          -302 #426  fill=6 ( -8.8265 -59.8729 0.0000 )      $ Tube/Disk 63
           trcl = ( -8.8265 -59.8729 0.0000 )     u=3
426 like 302 but     trcl = ( -8.8265 -59.8729 0.0000 )     u=3 $ Assembly 63
427 0          -302 #428  fill=6 ( 8.8265 -59.8729 0.0000 )      $ Tube/Disk 64
           trcl = ( 8.8265 -59.8729 0.0000 )     u=3
428 like 302 but     trcl = ( 8.8265 -59.8729 0.0000 )     u=3 $ Assembly 64
429 0          -302 #430  fill=6 ( 26.4770 -59.8729 0.0000 )      $ Tube/Disk 65
           trcl = ( 26.4770 -59.8729 0.0000 )     u=3
430 like 302 but     trcl = ( 26.4770 -59.8729 0.0000 )     u=3 $ Assembly 65
431 0          -302 #432  fill=7 ( 44.1274 -61.2699 0.0000 )      $ Tube/Disk 66
           trcl = ( 44.1274 -61.2699 0.0000 )     u=3
432 like 302 but     trcl = ( 44.1274 -61.2699 0.0000 )     u=3 $ Assembly 66
433 0          -302 #434  fill=7 ( -8.8265 -77.5233 0.0000 )      $ Tube/Disk 67
           trcl = ( -8.8265 -77.5233 0.0000 )     u=3
434 like 302 but     trcl = ( -8.8265 -77.5233 0.0000 )     u=3 $ Assembly 67
435 0          -302 #436  fill=7 ( 8.8265 -77.5233 0.0000 )      $ Tube/Disk 68
           trcl = ( 8.8265 -77.5233 0.0000 )     u=3
436 like 302 but     trcl = ( 8.8265 -77.5233 0.0000 )     u=3 $ Assembly 68
437 0          +303 +304        $ Canister Cavity Q1
      #303 #311 #313 #315 #325 #327 #329 #331 #341
      #304 #312 #314 #316 #326 #328 #330 #332 #342
      #343 #345 #347 #359 #361 #363 #365 #367
      #344 #346 #348 #360 #362 #364 #366 #368
          fill=4      u=3
438 0          +303 -304        $ Canister Cavity Q2
      #301 #305 #307 #309 #317 #319 #321 #323 #333
      #302 #306 #308 #310 #318 #320 #322 #324 #334
      #335 #337 #339 #349 #351 #353 #355 #357
      #336 #338 #340 #350 #352 #354 #356 #358
          fill=4      u=3
439 0          -303 -304        $ Canister Cavity Q3
      #369 #371 #373 #375 #377 #389 #391 #393 #395
      #370 #372 #374 #376 #378 #390 #392 #394 #396
      #405 #407 #409 #411 #421 #423 #425 #433
      #406 #408 #410 #412 #422 #424 #426 #434
          fill=4      u=3
440 0          -303 +304        $ Canister Cavity Q4
      #379 #381 #383 #385 #387 #397 #399 #401 #403
      #380 #382 #384 #386 #388 #398 #400 #402 #404
      #413 #415 #417 #419 #427 #429 #431 #435
      #414 #416 #418 #420 #428 #430 #432 #436
          fill=4      u=3
C Cells - Canister v1.0
501 0          -501 fill=3      u=2 $ Cavity
```

Figure 5.A.6-5 MPC-LACBWR MCNP Input File for Transfer Cask Dry Canister Bottom Axial Biasing – Lower End Fitting Source

```
502 6 -7.9400 -507 +501.3      u=2 $ Canister Bottom
503 0         -502 +501.2 -505 trcl = ( 72.8704 22.2787 0.0000 )    u=2 $ Bottom Drain Port
504 0         -503 +505 -506 trcl = ( 72.8704 22.2787 0.0000 )    u=2 $ Middle Drain Port
505 6 -7.9400 -504 +506 -507.2 trcl = ( 72.8704 22.2787 0.0000 )    u=2 $ Top Drain Port
506 like 503 but   trcl = ( -72.8704 -22.2787 0.0000 )    u=2 $ Bottom Vent Port
507 like 504 but   trcl = ( -72.8704 -22.2787 0.0000 )    u=2 $ Middle Vent Port
508 like 505 but   trcl = ( -72.8704 -22.2787 0.0000 )    u=2 $ Top Vent Port
509 6 -7.9400 -507 -501.3 +501.1     u=2 $ Canister Shell
510 6 -7.9400 -507 -501.1 +501.2 #503 #504 #505 #506 #507 #508     u=2 $ Lid
511 0         +507       u=2 $ Outside
C Transfer Cask Cells - v4.1
601 0         -601 -602  fill=2 ( 0.0000 0.0000 2.5400 )   u=1 $ Cavity
602 7 -7.8212 -601 +602 -606    u=1 $ Bottom forging
603 7 -7.8212 -603 +602 +606 -608 +614  u=1 $ Inner shell
604 10 -11.344 -604 +603 +606 -607 +614  u=1 $ Lead shell
605 11 -1.6316 -604 +603 +607 -608   u=1 $ NS-4-FR above Pb
606 11 -1.6316 -605 +604 +606 -608 +614  u=1 $ NS-4-FR
607 7 -7.8212 -601 +605 +606 -608 +614  u=1 $ Outer shell
608 7 -7.8212 -601 +602 +608    u=1 $ Top forging
609 7 -7.8212 -601 +602 -614    u=1 $ Trunnion
610 7 -7.8212 (-609 +610 -616) : (-609 -611 -616)      u=1 $ Door rail
611 7 -7.8212 -615 -612 +613 -616   u=1 $ Door steel
612 0         +601 #610  #611     u=1 $ Void
C Detector Cells - Axial Biasing
700  0  -700  fill=1  $ Surface
800  0  -800  +700  $ 1ft
900  0  -900  +700  +800  $ 1m
1000  0  -1000  +700  +800  +900  $ 2m
1100  0  -1100  +700  +800  +900  +1000  $ 4m
1200  0  +700  +800  +900  +1000  +1100  $ Exterior

C Fuel Assembly Surfaces - v1.0
1 RPP -7.1247 7.1247 -7.1247 7.1247 0.0000 261.9502  $ Assy
2 PZ 27.2796        $ Lower Nozzle/Fuel
3 PZ 238.0996        $ Fuel/Upper Plenum
4 PZ 251.1298        $ Upper Plenum/Upper Nozzle
C Surfaces - Standard Fuel Tube v1.0
101 RPP -7.3076 7.3076 -7.3076 7.3076 0.0000 274.4470    $ Tube void
102 RPP -7.4295 7.4295 -7.4295 7.4295 0.0000 249.5550    $ Tube
103 RPP -6.5913 6.5913 7.4295 7.6200 2.0320 245.8720    $ Absorber +Y
104 RPP -6.5913 6.5913 7.6200 7.6657 2.0320 245.8720    $ Cladding +Y
105 RPP 7.4295 7.6200 -6.5913 6.5913 2.0320 245.8720    $ Absorber +X
106 RPP 7.6200 7.6657 -6.5913 6.5913 2.0320 245.8720    $ Cladding +X
C Surfaces - DFC Fuel Tube v1.0
107 RPP -7.6251 7.6251 -7.6251 7.6251 0.0000 274.4470    $ Tube void
108 RPP -7.7470 7.7470 -7.7470 7.7470 0.0000 249.5550    $ Tube
109 RPP -6.5913 6.5913 7.7470 7.9375 2.0320 245.8720    $ Absorber +Y
110 RPP -6.5913 6.5913 7.9375 7.9832 2.0320 245.8720    $ Cladding +Y
111 RPP 7.7470 7.9375 -6.5913 6.5913 2.0320 245.8720    $ Absorber +X
112 RPP 7.9375 7.9832 -6.5913 6.5913 2.0320 245.8720    $ Cladding +X
c Surface Cards - Disk Stack  v1.0
201 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 1.5875 88.1380 $ Structural disk
202 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 1.2700 87.7951 $ Heat transfer disk
203 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 2.5400 88.0491 $ Weldment disk
c Surface Cards - Basket v1.0
301 RPP -7.7711 7.7711 -7.7711 7.7711 0.0000 274.4470  $ Std opening
302 RPP -8.0899 8.0899 -8.0899 8.0899 0.0000 274.4470  $ DFC opening
303 PY 0.0000        $ Cut plane
304 PX 0.0000        $ Cut plane
C Surfaces - Canister v1.0
501 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 274.4470 88.4428   $ Cavity
502 CZ 1.3843         $ Bot Cylinder Radius
503 CZ 5.0800         $ Mid Cyclinder Radius
504 CZ 5.7150         $ Top Cylinder Radius
```

Figure 5.A.6-5 MPC-LACBWR MCNP Input File for Transfer Cask Dry Canister Bottom Axial Biasing – Lower End Fitting Source

```
505 PZ 282.8798          $ Port plane bot/mid
506 PZ 289.3822          $ Port plane mid/top
507 RCC 0.0000 0.0000 -2.5400 0.0000 0.0000 294.7670 89.7128   $ Canister
C Transfer Cask Surfaces - v4.1
601 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 313.6900 109.8550  $ Cask
602 CZ 90.8050          $ Cavity
603 CZ 92.7100          $ Inner shell OR
604 CZ 101.6000          $ Lead shell OR
605 CZ 106.6800          $ Outer shell IR
606 PZ 2.5400          $ Bottom forging
607 PZ 298.4500          $ Top lead
608 PZ 308.6100          $ Top forging
609 RPP -110.1852 110.1852 -107.3150 107.3150 -24.1300 0.0000   $ Door container
610 PY 95.8850          $ Inside rail +y
611 PY -95.8850          $ Inside rail -y
612 PY 95.4024          $ Door +y
613 PY -95.4024          $ Door -y
614 RCC -109.8550 0.0000 275.5900 219.7100 0.0000 0.0000 12.7000  $ Trunnion
615 RHP 0.0000 0.0000 -24.1300 0.0000 0.0000 24.1300   $ Door prism
        109.6679 0.0000 0.0000 87.5826 -66.1670 0.0000
        -87.5826 -66.1670 0.0000
616 RCC 0.0000 0.0000 -24.1300 0.0000 0.0000 24.1300 109.8550  $ Door container
C Axial Detector DBA (Surface)
700  RCC  0.0000  0.0000  -24.2300  0.0000  0.0000  338.0200  109.9550
701  CZ  10.9955
702  CZ  21.9910
703  CZ  32.9865
704  CZ  43.9820
705  CZ  54.9775
706  CZ  65.9730
707  CZ  76.9685
708  CZ  87.9640
709  CZ  98.9595
C Axial Detector DBB (1ft)
800  RCC  0.0000  0.0000  -54.7100  0.0000  0.0000  368.5000  140.4350
801  CZ  14.0435
802  CZ  28.0870
803  CZ  42.1305
804  CZ  56.1740
805  CZ  70.2175
806  CZ  84.2610
807  CZ  98.3045
808  CZ  112.3480
809  CZ  126.3915
C Axial Detector DBC (1m)
900  RCC  0.0000  0.0000  -124.2300  0.0000  0.0000  438.0200  209.9550
901  CZ  20.9955
902  CZ  41.9910
903  CZ  62.9865
904  CZ  83.9820
905  CZ  104.9775
906  CZ  125.9730
907  CZ  146.9685
908  CZ  167.9640
909  CZ  188.9595
C Axial Detector DBD (2m)
1000  RCC  0.0000  0.0000  -224.2300  0.0000  0.0000  538.0200  309.9550
1001  CZ  30.9955
1002  CZ  61.9910
1003  CZ  92.9865
1004  CZ  123.9820
1005  CZ  154.9775
1006  CZ  185.9730
1007  CZ  216.9685
```

Figure 5.A.6-5 MPC-LACBWR MCNP Input File for Transfer Cask Dry Canister Bottom Axial Biasing – Lower End Fitting Source

```
1008  CZ  247.9640
1009  CZ  278.9595
C Axial Detector DBE (4m)
1100  RCC  0.0000  0.0000  -424.2300  0.0000  0.0000  738.0200  509.9550
1101  CZ  50.9955
1102  CZ  101.9910
1103  CZ  152.9865
1104  CZ  203.9820
1105  CZ  254.9775
1106  CZ  305.9730
1107  CZ  356.9685
1108  CZ  407.9640
1109  CZ  458.9595

C
C Materials List - Common Materials - v1.0
C
C Homogenized Lower Nozzle
m1     24000 -1.9000E-01
       25055 -2.0000E-02
       26000 -6.9500E-01
       28000 -9.5000E-02
C Homogenized UO2 Fuel
m2     24000 -2.9967E-02
       25055 -3.1544E-03
       26000 -1.0961E-01
       28000 -1.4983E-02
       92235 -2.6729E-02
       92238 -7.1574E-01
        8016 -9.9810E-02
C Homogenized Upper Plenum
m3     24000 -1.9000E-01
       25055 -2.0000E-02
       26000 -6.9500E-01
       28000 -9.5000E-02
C Homogenized Upper Nozzle
m4     24000 -0.190 25055 -0.020 26000 -0.695
       28000 -0.095
C Water
m5     1001 2 8016 1
C Stainless Steel
m6     24000 -0.190 25055 -0.020 26000 -0.695
       28000 -0.095
C Carbon Steel
m7     26000 -0.99 6012 -0.01
C Neutron Poison
m8     13027 -0.8466  5010 -0.0216  5011 -0.0985
        6012 -0.0333
C Aluminum
m9     13027 -1.0
C Lead
m10    82000 -1.0
C NS-4-FR
m11     5010 -9.3127E-04 13027 -2.1420E-01  6012 -2.7627E-01
        5011 -3.7721E-03  1001 -6.0012E-02  7014 -1.9815E-02
        8016 -4.2500E-01
C Concrete
m12    26000 -0.014 20000 -0.044 14000 -0.337
        1001 -0.010  8016 -0.532 11023 -0.029
       13027 -0.034
C Vent Port Middle Cylinder
m13    24000 -0.190 25055 -0.020 26000 -0.695
       28000 -0.095
phys:p 100 0 0 0 1    $ Disable Doppler energy broadening
```

Figure 5.A.6-5 MPC-LACBWR MCNP Input File for Transfer Cask Dry Canister Bottom Axial Biasing – Lower End Fitting Source

```
C
C Cell Importances
C
imp:p 1 240r 0
C
C BWR Source Definition - Lower Nozzle - Pref
C
sdef x=d1 y=d2 z=d3 erg=d4 cell=700:601:501:d5:1
si1   -7.1247 7.1247
sp1   0 1
si2   -7.1247 7.1247
sp2   0 1
si3   0.0000 27.2796
sp3   0 1
si4   1.000E-02 2.000E-02 5.000E-02 1.000E-01 2.000E-01 3.000E-01
      4.000E-01 6.000E-01 8.000E-01 1.000E+00 1.220E+00 1.440E+00
      1.660E+00 2.000E+00 2.500E+00 3.000E+00 4.000E+00 5.000E+00
      6.500E+00 8.000E+00 1.000E+01 1.200E+01 1.400E+01
sp4   0.0000E+00 2.8706E+09 2.3122E+09 7.9407E+08 1.9153E+08 9.5103E+06
      1.2478E+07 7.8863E+05 2.7388E+05 1.0327E+07 1.5512E+11 1.4717E+11
      4.1293E-01 1.3627E-14 1.5535E+06 2.4089E+03 6.7528E-17 0.0000E+00
      0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
C Source Information
si5 1                  302 304
               306 308 310 312 314 316
           318 320 322 324 326 328 330 332
           334 336 338 340 342 344 346 348
       350 352 354 356 358 360 362 364 366 368
       370 372 374 376 378 380 382 384 386 388
           390 392 394 396 398 400 402 404
           406 408 410 412 414 416 418 420
               422 424 426 428 430 432
                       434 436
C Source Probability
sp5                       0.36 0.36
                0.36 0.36 0.36 0.36 0.36 0.36
           0.36 1.00 1.00 1.00 1.00 1.00 1.00 0.36
           0.36 1.00 1.00 1.00 1.00 1.00 1.00 0.36
      0.36 0.36 1.00 1.00 1.00 1.00 1.00 1.00 0.36 0.36
      0.36 0.36 1.00 1.00 1.00 1.00 1.00 1.00 0.36 0.36
           0.36 1.00 1.00 1.00 1.00 1.00 1.00 0.36
           0.36 1.00 1.00 1.00 1.00 1.00 1.00 0.36
                0.36 0.36 0.36 0.36 0.36 0.36
                          0.36 0.36
mode p
nps 9100000
C
C ANSI/ANS-6.1.1-1977 - Gamma Flux-to-Dose Conversion Factors
C (mrem/hr)/(photons/cm2-sec)
C
de0   0.01 0.03 0.05 0.07 0.1 0.15 0.2
      0.25 0.3 0.35 0.4 0.45 0.5 0.55
      0.6 0.65 0.7 0.8 1 1.4 1.8
      2.2 2.6 2.8 3.25 3.75 4.25 4.75
      5 5.25 5.75 6.25 6.75 7.5 9
      11 13 15
df0   3.96E-03 5.82E-04 2.90E-04 2.58E-04 2.83E-04 3.79E-04 5.01E-04
      6.31E-04 7.59E-04 8.78E-04 9.85E-04 1.08E-03 1.17E-03 1.27E-03
      1.36E-03 1.44E-03 1.52E-03 1.68E-03 1.98E-03 2.51E-03 2.99E-03
      3.42E-03 3.82E-03 4.01E-03 4.41E-03 4.83E-03 5.23E-03 5.60E-03
      5.80E-03 6.01E-03 6.37E-03 6.74E-03 7.11E-03 7.66E-03 8.77E-03
      1.03E-02 1.18E-02 1.33E-02
C
C Weight Window Generation - Bottom Axial
```

Figure 5.A.6-5 MPC-LACBWR MCNP Input File for Transfer Cask Dry Canister Bottom Axial Biasing – Lower End Fitting Source

```
C
wwg 2 0 0 0 0
wwp:p 5 3 5 0 -1 0
mesh geom=cyl ref=9 9 4 origin=0.1 0.1 -524
     imesh 88.4 89.7 90.8 92.7 101.6 106.7 109.9 609.9
     iints 5 1 1 1 3 1 1 1
     jmesh 500 524 527 554 765 778 789 801 819 1319
     jints 1 5 1 2 10 1 1 1 3 1
     kmesh 1
     kints 1
wwge:p  1e-3 1 20
fc2 Axial Surface Tally
f2:p +700.3
fm2 4.6382E+13
fs2  -701  -702  -703  -704  -705  -706
     -707  -708  -709  T
tf2
fc12 Axial 1ft Tally
f12:p +800.3
fm12 4.6382E+13
fs12  -801  -802  -803  -804  -805  -806
      -807  -808  -809  T
tf12
fc22 Axial 1m Tally
f22:p +900.3
fm22 4.6382E+13
fs22  -901  -902  -903  -904  -905  -906
      -907  -908  -909  T
tf22
fc32 Axial 2m Tally
f32:p +1000.3
fm32 4.6382E+13
fs32  -1001  -1002  -1003  -1004  -1005  -1006
      -1007  -1008  -1009  T
tf32
fc42 Axial 4m Tally
f42:p +1100.3
fm42 4.6382E+13
fs42  -1101  -1102  -1103  -1104  -1105  -1106
      -1107  -1108  -1109  T
tf42
C
C
C Print Control
C
prdmp -30 -60 1 2
print
C
C Random Number Generator
C
rand gen=2 seed=19073486328125 stride=152917 hist=1
C
C Rotation Matrix
C
C 5.625 degree rotation around z-axis
*TR1 0.0 0.0 0.0 5.625 95.625 90 -84.375 5.625 90 90 90 0
C 11.25 degree rotation around z-axis
*TR2 0.0 0.0 0.0 11.250 101.250 90 -78.750 11.250 90 90 90 0
C 16.875 degree rotation around z-axis
*TR3 0.0 0.0 0.0 16.875 106.875 90 -73.125 16.875 90 90 90 0
C 22.5 degree rotation around z-axis
*TR4 0.0 0.0 0.0 22.500 112.500 90 -67.500 22.500 90 90 90 0
C 28.125 degree rotation around z-axis
*TR5 0.0 0.0 0.0 28.125 118.125 90 -61.875 28.125 90 90 90 0
```

Figure 5.A.6-5 MPC-LACBWR MCNP Input File for Transfer Cask Dry Canister Bottom Axial Biasing – Lower End Fitting Source

```
C 33.75 degree rotation around z-axis
*TR6 0.0 0.0 0.0 33.750 123.750 90 -56.250 33.750 90 90 90 0
C 39.375 degree rotation around z-axis
*TR7 0.0 0.0 0.0 39.375 129.375 90 -50.625 39.375 90 90 90 0
C 45 degree rotation around z-axis
*TR8 0.0 0.0 0.0 45.000 135.000 90 -45.000 45.000 90 90 90 0
C 50.625 degree rotation around z-axis
*TR9 0.0 0.0 0.0 50.625 140.625 90 -39.375 50.625 90 90 90 0
C 56.25 degree rotation around z-axis
*TR10 0.0 0.0 0.0 56.250 146.250 90 -33.750 56.250 90 90 90 0
C 61.875 degree rotation around z-axis
*TR11 0.0 0.0 0.0 61.875 151.875 90 -28.125 61.875 90 90 90 0
C 67.5 degree rotation around z-axis
*TR12 0.0 0.0 0.0 67.500 157.500 90 -22.500 67.500 90 90 90 0
C 73.125 degree rotation around z-axis
*TR13 0.0 0.0 0.0 73.125 163.125 90 -16.875 73.125 90 90 90 0
C 78.75 degree rotation around z-axis
*TR14 0.0 0.0 0.0 78.750 168.750 90 -11.250 78.750 90 90 90 0
C 84.375 degree rotation around z-axis
*TR15 0.0 0.0 0.0 84.375 174.375 90 -5.625 84.375 90 90 90 0
C 95.625 degree rotation around z-axis
*TR16 0.0 0.0 0.0 95.625 185.625 90 5.625 95.625 90 90 90 0
C 101.25 degree rotation around z-axis
*TR17 0.0 0.0 0.0 101.250 191.250 90 11.250 101.250 90 90 90 0
C 106.875 degree rotation around z-axis
*TR18 0.0 0.0 0.0 106.875 196.875 90 16.875 106.875 90 90 90 0
C 112.5 degree rotation around z-axis
*TR19 0.0 0.0 0.0 112.500 202.500 90 22.500 112.500 90 90 90 0
C 118.125 degree rotation around z-axis
*TR20 0.0 0.0 0.0 118.125 208.125 90 28.125 118.125 90 90 90 0
C 123.75 degree rotation around z-axis
*TR21 0.0 0.0 0.0 123.750 213.750 90 33.750 123.750 90 90 90 0
C 129.375 degree rotation around z-axis
*TR22 0.0 0.0 0.0 129.375 219.375 90 39.375 129.375 90 90 90 0
C 135 degree rotation around z-axis
*TR23 0.0 0.0 0.0 135.000 225.000 90 45.000 135.000 90 90 90 0
C 140.625 degree rotation around z-axis
*TR24 0.0 0.0 0.0 140.625 230.625 90 50.625 140.625 90 90 90 0
C 146.25 degree rotation around z-axis
*TR25 0.0 0.0 0.0 146.250 236.250 90 56.250 146.250 90 90 90 0
C 151.875 degree rotation around z-axis
*TR26 0.0 0.0 0.0 151.875 241.875 90 61.875 151.875 90 90 90 0
C 157.5 degree rotation around z-axis
*TR27 0.0 0.0 0.0 157.500 247.500 90 67.500 157.500 90 90 90 0
C 163.125 degree rotation around z-axis
*TR28 0.0 0.0 0.0 163.125 253.125 90 73.125 163.125 90 90 90 0
C 168.75 degree rotation around z-axis
*TR29 0.0 0.0 0.0 168.750 258.750 90 78.750 168.750 90 90 90 0
C 174.375 degree rotation around z-axis
*TR30 0.0 0.0 0.0 174.375 264.375 90 84.375 174.375 90 90 90 0
```

Figure 5.A.6-6 MPC-LACBWR MCNP Input File for Storage Cask Inlet Biasing – Lower End Fitting Damaged Fuel Gamma Source

```
LACBWR VCC - strShlDryInlLfg_PrefD
C Inlet Biasing - Lower Nozzle Source
C Fuel Assembly Cells - v1.0
1 1 -1.3734 -1 -2    u=11 $ Lower Nozzle
2 2 -3.7790 -1 +2 -3   u=11 $ Fuel
3 3 -0.9880 -1 +3 -4   u=11 $ Upper Plenum
4 4 -0.6145 -1 +4    u=11 $ Upper Nozzle
5 0         +1     u=11 $ Outside
C Fuel Assembly Cells - v1.0
6 15 -9.5539 -1 -2    u=10 $ Lower Nozzle
7 2 -3.7790 -1 +2 -3   u=10 $ Fuel
8 3 -0.9880 -1 +3 -4   u=10 $ Upper Plenum
9 4 -0.6145 -1 +4    u=10 $ Upper Nozzle
10 0         +1     u=10 $ Outside
C Cells - Standard Fuel Tube  v1.0
101 0          -101       u=5 $ Tube void
102 6 -7.9400 -102 +101       u=5 $ Tube
103 8 -2.6707 -103       u=5 $ Absorber +Y
104 6 -7.9400 -104       u=5 $ Cladding +Y
105 8 -2.6707 -105       u=5 $ Absorber +X
106 6 -7.9400 -106       u=5 $ Cladding +X
107 0          +101 +102 +103 +104 +106 +105  u=5 $ Void
C Cells - DFC Fuel Tube Absorber 2 Sides v1.0
108 0          -107       u=6 $ Tube void
109 6 -7.9400 -108 +107       u=6 $ Tube
110 8 -2.6707 -109       u=6 $ Absorber +Y
111 6 -7.9400 -110       u=6 $ Cladding +Y
112 8 -2.6707 -111       u=6 $ Absorber +X
113 6 -7.9400 -112       u=6 $ Cladding +X
114 0          +107 +108 +109 +110 +112 +111  u=6 $ Void
C Cells - DFC Fuel Tube Absorber 1 Side (Y) v1.0
115 0          -107       u=7 $ Tube void
116 6 -7.9400 -108 +107       u=7 $ Tube
117 8 -2.6707 -109       u=7 $ Absorber +Y
118 6 -7.9400 -110       u=7 $ Cladding +Y
119 0          +107 +108 +109 +110    u=7 $ Void
C Cells - DFC Fuel Tube Absorber 1 Side (X) v1.0
120 0          -107       u=8 $ Tube void
121 6 -7.9400 -108 +107       u=8 $ Tube
122 8 -2.6707 -111       u=8 $ Absorber +X
123 6 -7.9400 -112       u=8 $ Cladding +X
124 0          +107 +108 +111 +112    u=8 $ Void
C Cells - DFC Fuel Tube No Absorber v1.0
125 0          -107       u=9 $ Tube void
126 6 -7.9400 -108 +107       u=9 $ Tube
127 0          +107 +108       u=9 $ Void
c Cell Cards - Disk Stack v1.0
201 6 -7.94 -203 trcl = ( 0.0000 0.0000 2.5400 )    u=4 $ Bottom weldment disk
202 6 -7.94 -201 trcl = ( 0.0000 0.0000 15.0368 )    u=4 $ Support disk 1
203 like 202 but   trcl = ( 0.0000 0.0000 24.7650 )    u=4 $ Support disk 2
204 like 202 but   trcl = ( 0.0000 0.0000 34.4932 )    u=4 $ Support disk 3
205 like 202 but   trcl = ( 0.0000 0.0000 44.2214 )    u=4 $ Support disk 4
206 like 202 but   trcl = ( 0.0000 0.0000 53.9496 )    u=4 $ Support disk 5
207 9 -2.70 -202 trcl = ( 0.0000 0.0000 58.9788 )    u=4 $ Heat transfer disk 1
208 like 202 but   trcl = ( 0.0000 0.0000 63.6778 )    u=4 $ Support disk 6
209 like 207 but   trcl = ( 0.0000 0.0000 68.7070 )    u=4 $ Heat transfer disk 2
210 like 202 but   trcl = ( 0.0000 0.0000 73.4060 )    u=4 $ Support disk 7
211 like 207 but   trcl = ( 0.0000 0.0000 78.4352 )    u=4 $ Heat transfer disk 3
212 like 202 but   trcl = ( 0.0000 0.0000 83.1342 )    u=4 $ Support disk 8
213 like 207 but   trcl = ( 0.0000 0.0000 88.1634 )    u=4 $ Heat transfer disk 4
214 like 202 but   trcl = ( 0.0000 0.0000 92.8624 )    u=4 $ Support disk 9
215 like 207 but   trcl = ( 0.0000 0.0000 97.8916 )    u=4 $ Heat transfer disk 5
```

Figure 5.A.6-6 MPC-LACBWR MCNP Input File for Storage Cask Inlet Biasing – Lower End Fitting Damaged Fuel Gamma Source

```
216 like 202 but   trcl = ( 0.0000 0.0000 102.5906 )    u=4 $ Support disk 10
217 like 207 but   trcl = ( 0.0000 0.0000 107.6198 )    u=4 $ Heat transfer disk 6
218 like 202 but   trcl = ( 0.0000 0.0000 112.3188 )    u=4 $ Support disk 11
219 like 207 but   trcl = ( 0.0000 0.0000 117.3480 )    u=4 $ Heat transfer disk 7
220 like 202 but   trcl = ( 0.0000 0.0000 122.0470 )    u=4 $ Support disk 12
221 like 207 but   trcl = ( 0.0000 0.0000 127.0762 )    u=4 $ Heat transfer disk 8
222 like 202 but   trcl = ( 0.0000 0.0000 131.7752 )    u=4 $ Support disk 13
223 like 207 but   trcl = ( 0.0000 0.0000 136.8044 )    u=4 $ Heat transfer disk 9
224 like 202 but   trcl = ( 0.0000 0.0000 141.5034 )    u=4 $ Support disk 14
225 like 207 but   trcl = ( 0.0000 0.0000 146.5326 )    u=4 $ Heat transfer disk 10
226 like 202 but   trcl = ( 0.0000 0.0000 151.2316 )    u=4 $ Support disk 15
227 like 207 but   trcl = ( 0.0000 0.0000 156.2608 )    u=4 $ Heat transfer disk 11
228 like 202 but   trcl = ( 0.0000 0.0000 160.9598 )    u=4 $ Support disk 16
229 like 207 but   trcl = ( 0.0000 0.0000 165.9890 )    u=4 $ Heat transfer disk 12
230 like 202 but   trcl = ( 0.0000 0.0000 170.6880 )    u=4 $ Support disk 17
231 like 207 but   trcl = ( 0.0000 0.0000 175.7172 )    u=4 $ Heat transfer disk 13
232 like 202 but   trcl = ( 0.0000 0.0000 180.4162 )    u=4 $ Support disk 18
233 like 207 but   trcl = ( 0.0000 0.0000 185.4454 )    u=4 $ Heat transfer disk 14
234 like 202 but   trcl = ( 0.0000 0.0000 190.1444 )    u=4 $ Support disk 19
235 like 202 but   trcl = ( 0.0000 0.0000 199.8726 )    u=4 $ Support disk 20
236 like 202 but   trcl = ( 0.0000 0.0000 209.6008 )    u=4 $ Support disk 21
237 like 202 but   trcl = ( 0.0000 0.0000 219.3290 )    u=4 $ Support disk 22
238 like 202 but   trcl = ( 0.0000 0.0000 229.0572 )    u=4 $ Support disk 23
239 like 202 but   trcl = ( 0.0000 0.0000 238.7854 )    u=4 $ Support disk 24
240 like 201 but   trcl = ( 0.0000 0.0000 255.8796 )    u=4 $ Top weldment disk
241 0                 $ Outside Disks
      #201 #202 #203 #204 #205 #206 #207 #208 #209 #210
      #211 #212 #213 #214 #215 #216 #217 #218 #219 #220
      #221 #222 #223 #224 #225 #226 #227 #228 #229 #230
      #231 #232 #233 #234 #235 #236 #237 #238 #239
      #240        u=4
c Cell Cards - Basket v1.0
301 0          -302 #302  fill=8 ( -8.8265 77.5233 0.0000 )     $ Tube/Disk 1
          trcl = ( -8.8265 77.5233 0.0000 )     u=3
302 0          -1  fill=10 trcl = ( -8.8265 77.5233 0.0000 )     u=3 $ Assembly 1
303 0          -302 #304  fill=9 ( 8.8265 77.5233 0.0000 )     $ Tube/Disk 2
          trcl = ( 8.8265 77.5233 0.0000 )     u=3
304 like 302 but    fill=10 trcl = ( 8.8265 77.5233 0.0000 )     u=3 $ Assembly 2
305 0          -302 #306  fill=8 ( -44.1274 61.2699 0.0000 )     $ Tube/Disk 3
          trcl = ( -44.1274 61.2699 0.0000 )     u=3
306 like 302 but    fill=10 trcl = ( -44.1274 61.2699 0.0000 )     u=3 $ Assembly 3
307 0          -302 #308  fill=8 ( -26.4770 59.8729 0.0000 )     $ Tube/Disk 4
          trcl = ( -26.4770 59.8729 0.0000 )     u=3
308 like 302 but    fill=10 trcl = ( -26.4770 59.8729 0.0000 )     u=3 $ Assembly 4
309 0          -302 #310  fill=6 ( -8.8265 59.8729 0.0000 )     $ Tube/Disk 5
          trcl = ( -8.8265 59.8729 0.0000 )     u=3
310 like 302 but    fill=10 trcl = ( -8.8265 59.8729 0.0000 )     u=3 $ Assembly 5
311 0          -302 #312  fill=6 ( 8.8265 59.8729 0.0000 )     $ Tube/Disk 6
          trcl = ( 8.8265 59.8729 0.0000 )     u=3
312 like 302 but    fill=10 trcl = ( 8.8265 59.8729 0.0000 )     u=3 $ Assembly 6
313 0          -302 #314  fill=8 ( 26.4770 59.8729 0.0000 )     $ Tube/Disk 7
          trcl = ( 26.4770 59.8729 0.0000 )     u=3
314 like 302 but    fill=10 trcl = ( 26.4770 59.8729 0.0000 )     u=3 $ Assembly 7
315 0          -302 #316  fill=9 ( 44.1274 61.2699 0.0000 )     $ Tube/Disk 8
          trcl = ( 44.1274 61.2699 0.0000 )     u=3
316 like 302 but    fill=10 trcl = ( 44.1274 61.2699 0.0000 )     u=3 $ Assembly 8
317 0          -302 #318  fill=8 ( -61.2699 44.1274 0.0000 )     $ Tube/Disk 9
          trcl = ( -61.2699 44.1274 0.0000 )     u=3
318 like 302 but    fill=10 trcl = ( -61.2699 44.1274 0.0000 )     u=3 $ Assembly 9
319 0          -301 #320  fill=5 ( -42.5399 42.5399 0.0000 )     $ Tube/Disk 10
          trcl = ( -42.5399 42.5399 0.0000 )     u=3
320 like 302 but    fill=11 trcl = ( -42.5399 42.5399 0.0000 )     u=3 $ Assembly 10
321 0          -301 #322  fill=5 ( -25.5245 42.5399 0.0000 )     $ Tube/Disk 11
          trcl = ( -25.5245 42.5399 0.0000 )     u=3
```

Figure 5.A.6-6 MPC-LACBWR MCNP Input File for Storage Cask Inlet Biasing – Lower End Fitting Damaged Fuel Gamma Source

```
322 like 302 but    fill=11 trcl = ( -25.5245 42.5399 0.0000 )     u=3 $ Assembly 11
323 0          -301 #324  fill=5 ( -8.5090 42.5399 0.0000 )     $ Tube/Disk 12
           trcl = ( -8.5090 42.5399 0.0000 )     u=3
324 like 302 but    fill=11 trcl = ( -8.5090 42.5399 0.0000 )     u=3 $ Assembly 12
325 0          -301 #326  fill=5 ( 8.5090 42.5399 0.0000 )     $ Tube/Disk 13
           trcl = ( 8.5090 42.5399 0.0000 )     u=3
326 like 302 but    fill=11 trcl = ( 8.5090 42.5399 0.0000 )     u=3 $ Assembly 13
327 0          -301 #328  fill=5 ( 25.5245 42.5399 0.0000 )     $ Tube/Disk 14
           trcl = ( 25.5245 42.5399 0.0000 )     u=3
328 like 302 but    fill=11 trcl = ( 25.5245 42.5399 0.0000 )     u=3 $ Assembly 14
329 0          -301 #330  fill=5 ( 42.5399 42.5399 0.0000 )     $ Tube/Disk 15
           trcl = ( 42.5399 42.5399 0.0000 )     u=3
330 like 302 but    fill=11 trcl = ( 42.5399 42.5399 0.0000 )     u=3 $ Assembly 15
331 0          -302 #332  fill=9 ( 61.2699 44.1274 0.0000 )     $ Tube/Disk 16
           trcl = ( 61.2699 44.1274 0.0000 )     u=3
332 like 302 but    fill=10 trcl = ( 61.2699 44.1274 0.0000 )     u=3 $ Assembly 16
333 0          -302 #334  fill=6 ( -59.8729 26.4770 0.0000 )     $ Tube/Disk 17
           trcl = ( -59.8729 26.4770 0.0000 )     u=3
334 like 302 but    fill=10 trcl = ( -59.8729 26.4770 0.0000 )     u=3 $ Assembly 17
335 0          -301 #336  fill=5 ( -42.5399 25.5245 0.0000 )     $ Tube/Disk 18
           trcl = ( -42.5399 25.5245 0.0000 )     u=3
336 like 302 but    fill=11 trcl = ( -42.5399 25.5245 0.0000 )     u=3 $ Assembly 18
337 0          -301 #338  fill=5 ( -25.5245 25.5245 0.0000 )     $ Tube/Disk 19
           trcl = ( -25.5245 25.5245 0.0000 )     u=3
338 like 302 but    fill=11 trcl = ( -25.5245 25.5245 0.0000 )     u=3 $ Assembly 19
339 0          -301 #340  fill=5 ( -8.5090 25.5245 0.0000 )     $ Tube/Disk 20
           trcl = ( -8.5090 25.5245 0.0000 )     u=3
340 like 302 but    fill=11 trcl = ( -8.5090 25.5245 0.0000 )     u=3 $ Assembly 20
341 0          -301 #342  fill=5 ( 8.5090 25.5245 0.0000 )     $ Tube/Disk 21
           trcl = ( 8.5090 25.5245 0.0000 )     u=3
342 like 302 but    fill=11 trcl = ( 8.5090 25.5245 0.0000 )     u=3 $ Assembly 21
343 0          -301 #344  fill=5 ( 25.5245 25.5245 0.0000 )     $ Tube/Disk 22
           trcl = ( 25.5245 25.5245 0.0000 )     u=3
344 like 302 but    fill=11 trcl = ( 25.5245 25.5245 0.0000 )     u=3 $ Assembly 22
345 0          -301 #346  fill=5 ( 42.5399 25.5245 0.0000 )     $ Tube/Disk 23
           trcl = ( 42.5399 25.5245 0.0000 )     u=3
346 like 302 but    fill=11 trcl = ( 42.5399 25.5245 0.0000 )     u=3 $ Assembly 23
347 0          -302 #348  fill=7 ( 59.8729 26.4770 0.0000 )     $ Tube/Disk 24
           trcl = ( 59.8729 26.4770 0.0000 )     u=3
348 like 302 but    fill=10 trcl = ( 59.8729 26.4770 0.0000 )     u=3 $ Assembly 24
349 0          -302 #350  fill=8 ( -77.5233 8.8265 0.0000 )     $ Tube/Disk 25
           trcl = ( -77.5233 8.8265 0.0000 )     u=3
350 like 302 but    fill=10 trcl = ( -77.5233 8.8265 0.0000 )     u=3 $ Assembly 25
351 0          -302 #352  fill=6 ( -59.8729 8.8265 0.0000 )     $ Tube/Disk 26
           trcl = ( -59.8729 8.8265 0.0000 )     u=3
352 like 302 but    fill=10 trcl = ( -59.8729 8.8265 0.0000 )     u=3 $ Assembly 26
353 0          -301 #354  fill=5 ( -42.5399 8.5090 0.0000 )     $ Tube/Disk 27
           trcl = ( -42.5399 8.5090 0.0000 )     u=3
354 like 302 but    fill=11 trcl = ( -42.5399 8.5090 0.0000 )     u=3 $ Assembly 27
355 0          -301 #356  fill=5 ( -25.5245 8.5090 0.0000 )     $ Tube/Disk 28
           trcl = ( -25.5245 8.5090 0.0000 )     u=3
356 like 302 but    fill=11 trcl = ( -25.5245 8.5090 0.0000 )     u=3 $ Assembly 28
357 0          -301 #358  fill=5 ( -8.5090 8.5090 0.0000 )     $ Tube/Disk 29
           trcl = ( -8.5090 8.5090 0.0000 )     u=3
358 like 302 but    fill=11 trcl = ( -8.5090 8.5090 0.0000 )     u=3 $ Assembly 29
359 0          -301 #360  fill=5 ( 8.5090 8.5090 0.0000 )     $ Tube/Disk 30
           trcl = ( 8.5090 8.5090 0.0000 )     u=3
360 like 302 but    fill=11 trcl = ( 8.5090 8.5090 0.0000 )     u=3 $ Assembly 30
361 0          -301 #362  fill=5 ( 25.5245 8.5090 0.0000 )     $ Tube/Disk 31
           trcl = ( 25.5245 8.5090 0.0000 )     u=3
362 like 302 but    fill=11 trcl = ( 25.5245 8.5090 0.0000 )     u=3 $ Assembly 31
363 0          -301 #364  fill=5 ( 42.5399 8.5090 0.0000 )     $ Tube/Disk 32
           trcl = ( 42.5399 8.5090 0.0000 )     u=3
364 like 302 but    fill=11 trcl = ( 42.5399 8.5090 0.0000 )     u=3 $ Assembly 32
```

Figure 5.A.6-6 MPC-LACBWR MCNP Input File for Storage Cask Inlet Biasing – Lower End Fitting Damaged Fuel Gamma Source

```
365 0         -302 #366  fill=6 ( 59.8729 8.8265 0.0000 )       $ Tube/Disk 33
           trcl = ( 59.8729 8.8265 0.0000 )     u=3
366 like 302 but    fill=10 trcl = ( 59.8729 8.8265 0.0000 )     u=3 $ Assembly 33
367 0         -302 #368  fill=9 ( 77.5233 8.8265 0.0000 )       $ Tube/Disk 34
           trcl = ( 77.5233 8.8265 0.0000 )     u=3
368 like 302 but    fill=10 trcl = ( 77.5233 8.8265 0.0000 )     u=3 $ Assembly 34
369 0         -302 #370  fill=6 ( -77.5233 -8.8265 0.0000 )      $ Tube/Disk 35
           trcl = ( -77.5233 -8.8265 0.0000 )     u=3
370 like 302 but    fill=10 trcl = ( -77.5233 -8.8265 0.0000 )     u=3 $ Assembly 35
371 0         -302 #372  fill=6 ( -59.8729 -8.8265 0.0000 )      $ Tube/Disk 36
           trcl = ( -59.8729 -8.8265 0.0000 )     u=3
372 like 302 but    fill=10 trcl = ( -59.8729 -8.8265 0.0000 )     u=3 $ Assembly 36
373 0         -301 #374  fill=5 ( -42.5399 -8.5090 0.0000 )      $ Tube/Disk 37
           trcl = ( -42.5399 -8.5090 0.0000 )     u=3
374 like 302 but    fill=11 trcl = ( -42.5399 -8.5090 0.0000 )     u=3 $ Assembly 37
375 0         -301 #376  fill=5 ( -25.5245 -8.5090 0.0000 )      $ Tube/Disk 38
           trcl = ( -25.5245 -8.5090 0.0000 )     u=3
376 like 302 but    fill=11 trcl = ( -25.5245 -8.5090 0.0000 )     u=3 $ Assembly 38
377 0         -301 #378  fill=5 ( -8.5090 -8.5090 0.0000 )      $ Tube/Disk 39
           trcl = ( -8.5090 -8.5090 0.0000 )     u=3
378 like 302 but    fill=11 trcl = ( -8.5090 -8.5090 0.0000 )     u=3 $ Assembly 39
379 0         -301 #380  fill=5 ( 8.5090 -8.5090 0.0000 )      $ Tube/Disk 40
           trcl = ( 8.5090 -8.5090 0.0000 )     u=3
380 like 302 but    fill=11 trcl = ( 8.5090 -8.5090 0.0000 )     u=3 $ Assembly 40
381 0         -301 #382  fill=5 ( 25.5245 -8.5090 0.0000 )      $ Tube/Disk 41
           trcl = ( 25.5245 -8.5090 0.0000 )     u=3
382 like 302 but    fill=11 trcl = ( 25.5245 -8.5090 0.0000 )     u=3 $ Assembly 41
383 0         -301 #384  fill=5 ( 42.5399 -8.5090 0.0000 )      $ Tube/Disk 42
           trcl = ( 42.5399 -8.5090 0.0000 )     u=3
384 like 302 but    fill=11 trcl = ( 42.5399 -8.5090 0.0000 )     u=3 $ Assembly 42
385 0         -302 #386  fill=6 ( 59.8729 -8.8265 0.0000 )      $ Tube/Disk 43
           trcl = ( 59.8729 -8.8265 0.0000 )     u=3
386 like 302 but    fill=10 trcl = ( 59.8729 -8.8265 0.0000 )     u=3 $ Assembly 43
387 0         -302 #388  fill=7 ( 77.5233 -8.8265 0.0000 )      $ Tube/Disk 44
           trcl = ( 77.5233 -8.8265 0.0000 )     u=3
388 like 302 but    fill=10 trcl = ( 77.5233 -8.8265 0.0000 )     u=3 $ Assembly 44
389 0         -302 #390  fill=6 ( -59.8729 -26.4770 0.0000 )      $ Tube/Disk 45
           trcl = ( -59.8729 -26.4770 0.0000 )     u=3
390 like 302 but    fill=10 trcl = ( -59.8729 -26.4770 0.0000 )     u=3 $ Assembly 45
391 0         -301 #392  fill=5 ( -42.5399 -25.5245 0.0000 )      $ Tube/Disk 46
           trcl = ( -42.5399 -25.5245 0.0000 )     u=3
392 like 302 but    fill=11 trcl = ( -42.5399 -25.5245 0.0000 )     u=3 $ Assembly 46
393 0         -301 #394  fill=5 ( -25.5245 -25.5245 0.0000 )      $ Tube/Disk 47
           trcl = ( -25.5245 -25.5245 0.0000 )     u=3
394 like 302 but    fill=11 trcl = ( -25.5245 -25.5245 0.0000 )     u=3 $ Assembly 47
395 0         -301 #396  fill=5 ( -8.5090 -25.5245 0.0000 )      $ Tube/Disk 48
           trcl = ( -8.5090 -25.5245 0.0000 )     u=3
396 like 302 but    fill=11 trcl = ( -8.5090 -25.5245 0.0000 )     u=3 $ Assembly 48
397 0         -301 #398  fill=5 ( 8.5090 -25.5245 0.0000 )      $ Tube/Disk 49
           trcl = ( 8.5090 -25.5245 0.0000 )     u=3
398 like 302 but    fill=11 trcl = ( 8.5090 -25.5245 0.0000 )     u=3 $ Assembly 49
399 0         -301 #400  fill=5 ( 25.5245 -25.5245 0.0000 )      $ Tube/Disk 50
           trcl = ( 25.5245 -25.5245 0.0000 )     u=3
400 like 302 but    fill=11 trcl = ( 25.5245 -25.5245 0.0000 )     u=3 $ Assembly 50
401 0         -301 #402  fill=5 ( 42.5399 -25.5245 0.0000 )      $ Tube/Disk 51
           trcl = ( 42.5399 -25.5245 0.0000 )     u=3
402 like 302 but    fill=11 trcl = ( 42.5399 -25.5245 0.0000 )     u=3 $ Assembly 51
403 0         -302 #404  fill=7 ( 59.8729 -26.4770 0.0000 )      $ Tube/Disk 52
           trcl = ( 59.8729 -26.4770 0.0000 )     u=3
404 like 302 but    fill=10 trcl = ( 59.8729 -26.4770 0.0000 )     u=3 $ Assembly 52
405 0         -302 #406  fill=6 ( -61.2699 -44.1274 0.0000 )      $ Tube/Disk 53
           trcl = ( -61.2699 -44.1274 0.0000 )     u=3
406 like 302 but    fill=10 trcl = ( -61.2699 -44.1274 0.0000 )     u=3 $ Assembly 53
407 0         -301 #408  fill=5 ( -42.5399 -42.5399 0.0000 )      $ Tube/Disk 54
```

Figure 5.A.6-6 MPC-LACBWR MCNP Input File for Storage Cask Inlet Biasing – Lower End Fitting Damaged Fuel Gamma Source

```
           trcl = ( -42.5399 -42.5399 0.0000 )      u=3
408 like 302 but    fill=11 trcl = ( -42.5399 -42.5399 0.0000 )     u=3 $ Assembly 54
409 0          -301 #410  fill=5 ( -25.5245 -42.5399 0.0000 )      $ Tube/Disk 55
           trcl = ( -25.5245 -42.5399 0.0000 )      u=3
410 like 302 but    fill=11 trcl = ( -25.5245 -42.5399 0.0000 )     u=3 $ Assembly 55
411 0          -301 #412  fill=5 ( -8.5090 -42.5399 0.0000 )      $ Tube/Disk 56
           trcl = ( -8.5090 -42.5399 0.0000 )      u=3
412 like 302 but    fill=11 trcl = ( -8.5090 -42.5399 0.0000 )     u=3 $ Assembly 56
413 0          -301 #414  fill=5 ( 8.5090 -42.5399 0.0000 )      $ Tube/Disk 57
           trcl = ( 8.5090 -42.5399 0.0000 )      u=3
414 like 302 but    fill=11 trcl = ( 8.5090 -42.5399 0.0000 )     u=3 $ Assembly 57
415 0          -301 #416  fill=5 ( 25.5245 -42.5399 0.0000 )      $ Tube/Disk 58
           trcl = ( 25.5245 -42.5399 0.0000 )      u=3
416 like 302 but    fill=11 trcl = ( 25.5245 -42.5399 0.0000 )     u=3 $ Assembly 58
417 0          -301 #418  fill=5 ( 42.5399 -42.5399 0.0000 )      $ Tube/Disk 59
           trcl = ( 42.5399 -42.5399 0.0000 )      u=3
418 like 302 but    fill=11 trcl = ( 42.5399 -42.5399 0.0000 )     u=3 $ Assembly 59
419 0          -302 #420  fill=7 ( 61.2699 -44.1274 0.0000 )      $ Tube/Disk 60
           trcl = ( 61.2699 -44.1274 0.0000 )      u=3
420 like 302 but    fill=10 trcl = ( 61.2699 -44.1274 0.0000 )     u=3 $ Assembly 60
421 0          -302 #422  fill=6 ( -44.1274 -61.2699 0.0000 )      $ Tube/Disk 61
           trcl = ( -44.1274 -61.2699 0.0000 )      u=3
422 like 302 but    fill=10 trcl = ( -44.1274 -61.2699 0.0000 )     u=3 $ Assembly 61
423 0          -302 #424  fill=6 ( -26.4770 -59.8729 0.0000 )      $ Tube/Disk 62
           trcl = ( -26.4770 -59.8729 0.0000 )      u=3
424 like 302 but    fill=10 trcl = ( -26.4770 -59.8729 0.0000 )     u=3 $ Assembly 62
425 0          -302 #426  fill=6 ( -8.8265 -59.8729 0.0000 )      $ Tube/Disk 63
           trcl = ( -8.8265 -59.8729 0.0000 )      u=3
426 like 302 but    fill=10 trcl = ( -8.8265 -59.8729 0.0000 )     u=3 $ Assembly 63
427 0          -302 #428  fill=6 ( 8.8265 -59.8729 0.0000 )      $ Tube/Disk 64
           trcl = ( 8.8265 -59.8729 0.0000 )      u=3
428 like 302 but    fill=10 trcl = ( 8.8265 -59.8729 0.0000 )     u=3 $ Assembly 64
429 0          -302 #430  fill=6 ( 26.4770 -59.8729 0.0000 )      $ Tube/Disk 65
           trcl = ( 26.4770 -59.8729 0.0000 )      u=3
430 like 302 but    fill=10 trcl = ( 26.4770 -59.8729 0.0000 )     u=3 $ Assembly 65
431 0          -302 #432  fill=7 ( 44.1274 -61.2699 0.0000 )      $ Tube/Disk 66
           trcl = ( 44.1274 -61.2699 0.0000 )      u=3
432 like 302 but    fill=10 trcl = ( 44.1274 -61.2699 0.0000 )     u=3 $ Assembly 66
433 0          -302 #434  fill=7 ( -8.8265 -77.5233 0.0000 )      $ Tube/Disk 67
           trcl = ( -8.8265 -77.5233 0.0000 )      u=3
434 like 302 but    fill=10 trcl = ( -8.8265 -77.5233 0.0000 )     u=3 $ Assembly 67
435 0          -302 #436  fill=7 ( 8.8265 -77.5233 0.0000 )      $ Tube/Disk 68
           trcl = ( 8.8265 -77.5233 0.0000 )      u=3
436 like 302 but    fill=10 trcl = ( 8.8265 -77.5233 0.0000 )     u=3 $ Assembly 68
437 0          +303 +304          $ Canister Cavity Q1
       #303 #311 #313 #315 #325 #327 #329 #331 #341
       #304 #312 #314 #316 #326 #328 #330 #332 #342
       #343 #345 #347 #359 #361 #363 #365 #367
       #344 #346 #348 #360 #362 #364 #366 #368
          fill=4      u=3
438 0          +303 -304          $ Canister Cavity Q2
       #301 #305 #307 #309 #317 #319 #321 #323 #333
       #302 #306 #308 #310 #318 #320 #322 #324 #334
       #335 #337 #339 #349 #351 #353 #355 #357
       #336 #338 #340 #350 #352 #354 #356 #358
          fill=4      u=3
439 0          -303 -304          $ Canister Cavity Q3
       #369 #371 #373 #375 #377 #389 #391 #393 #395
       #370 #372 #374 #376 #378 #390 #392 #394 #396
       #405 #407 #409 #411 #421 #423 #425 #433
       #406 #408 #410 #412 #422 #424 #426 #434
          fill=4      u=3
440 0          -303 +304          $ Canister Cavity Q4
       #379 #381 #383 #385 #387 #397 #399 #401 #403
```

Figure 5.A.6-6 MPC-LACBWR MCNP Input File for Storage Cask Inlet Biasing – Lower End Fitting Damaged Fuel Gamma Source

```
      #380 #382 #384 #386 #388 #398 #400 #402 #404
      #413 #415 #417 #419 #427 #429 #431 #435
      #414 #416 #418 #420 #428 #430 #432 #436
        fill=4     u=3
C Cells - Canister v1.0
501 0          -501 fill=3      u=2 $ Cavity
502 6 -7.9400 -507 +501.3      u=2 $ Canister Bottom
503 0          -502 +501.2 -505 trcl = ( 72.8704 22.2787 0.0000 )    u=2 $ Bottom Drain Port
504 0          -503 +505 -506 trcl = ( 72.8704 22.2787 0.0000 )    u=2 $ Middle Drain Port
505 6 -7.9400 -504 +506 -507.2 trcl = ( 72.8704 22.2787 0.0000 )    u=2 $ Top Drain Port
506 like 503 but   trcl = ( -72.8704 -22.2787 0.0000 )    u=2 $ Bottom Vent Port
507 like 504 but   trcl = ( -72.8704 -22.2787 0.0000 )    u=2 $ Middle Vent Port
508 like 505 but   trcl = ( -72.8704 -22.2787 0.0000 )    u=2 $ Top Vent Port
509 6 -7.9400 -507 -501.3 +501.1     u=2 $ Canister Shell
510 6 -7.9400 -507 -501.1 +501.2 #503 #504 #505 #506 #507 #508     u=2 $ Lid
511 0          +507       u=2 $ Outside
c Cell Cards - Storage Cask Geometry v4.0
601 7 -7.8212 -605        u=1 $ Base Plate
602 0          (-614 +612 -601          $ Air Inlet Channel Void
               +643 +644 +645 +646
               +651 +652 +653 +654) :
               (-614 +613 -612 +618)        u=1
603 7 -7.8212 -615 +614 +612 -601     u=1 $ Air Inlet Channel Mat
604 0          (-616 +612 -601          $ Air Inlet Channel Void
               +647 +648 +649 +650
               +655 +656 +657 +658) :
               (-616 +613 -612 +618)        u=1
605 7 -7.8212 -617 +616 +612 -601     u=1 $ Air Inlet Channel Mat
606 0          -619 -612 +613      u=1 $ Stand Cut-Out Top
607 like 606 but *trcl = (0 0 0 90 180 90 0 90 90 90 90 0)      u=1 $ Stand Cut-Out Top
608 7 -7.8212 -601 -612 +613 +618 +605 +614 +616 #606 #607  u=1 $ Stand Material
609 7 -7.8212 (-601 -612 -618) : (-601 +612 -618 +615 +617)       u=1 $ Bottom Plate
610 7 -7.8212 (-606 +607 +618 -610) : (-608 +609 +610 -611)       u=1 $ Baffle Cone Mat
611 0          (-607 +618 -610) : (-609 +610 -611)       u=1 $ Baffle Cone Int. Void
612 0          -613 +618 -611 +606 +608    u=1 $ Void inside stand - A
613 0          -601 -613 +611 +605     u=1 $ Void inside stand - B
614 0          -601 -603 +612 +618 +605 +615 +617  u=1 $ Void stand to liner
615 7 -7.8212 -601 -604 +603 +618 +615 +617   u=1 $ Liner
616 12 -2.3233 -601 +604 +618 +615 +617    u=1 $ Concrete
617 7 -7.8212 -620         u=1 $ VCC Lid
618 7 -7.8212 -621 +622        u=1 $ TopFlange
619 0          -621 -622 +603 +623      u=1 $ Void Cavity to Flange
620 12 -2.3233 -624         u=1 $ Lid Concrete
621 7 -7.8212 -623 +624        u=1 $ Lid Cover
622 12 -2.3233 (-626 +604) : (-627 -602 +628)        u=1 $ Concrete - Outlet Box
623 0          (-629 +630 +604) : (-631 +629 -602)        u=1 $ Air Outlet Void
624 7 -7.8212 -625 -602 +604 #622 #623      u=1 $ Air Outlet Steel
625 12 -2.3233 (-633 +604) : (-634 -602 +635)        u=1 $ Concrete - Outlet Box
626 0          (-636 +637 +604) : (-638 +636 -602)        u=1 $ Air Outlet Void
627 7 -7.8212 -632 -602 +604 #625 #626      u=1 $ Air Outlet Steel
628 12 -2.3233 -602 +604 +621 #622 #623 #624 #625 #626 #627    fill=12  u=1 $ Concrete
629 0          (-639 -641 +603) : (-640 -604 +641)        u=1 $ Air Outlet Liner Void
630 like 629 but *trcl = (0 0 0 90 180 90 0 90 90 90 90 0)      u=1 $ Air Outlet Liner Void
631 7 -7.8212 -602 -604 +603 +621 #629 #630      u=1 $ Liner Minus Voids
632 0          -602 -603 +623  fill=2 ( 0.0000 0.0000 2.5400 )     u=1 $ Cavity
633 12 -2.3233 -642         u=1 $ Concrete pad
634 7 -7.8212 -643 : -644 : -645 : -646        u=1 $ Air inlet pipes +x+y
635 7 -7.8212 -647 : -648 : -649 : -650        u=1 $ Air inlet pipes -x-y
636 7 -7.8212 -651 : -652 : -653 : -654        u=1 $ Air inlet pipes -x+y
637 7 -7.8212 -655 : -656 : -657 : -658        u=1 $ Air inlet pipes +x-y
638 0          +601 +602 +620 +642 #602 #603 #604 #605     u=1 $ Container
C VCC Rebar Cells - v4.0
639 7 -7.8212 -659      u=12 $ Inner hoop 1
640 7 -7.8212 -660      u=12 $ Inner hoop 2
```

Figure 5.A.6-6 MPC-LACBWR MCNP Input File for Storage Cask Inlet Biasing – Lower End Fitting Damaged Fuel Gamma Source

```
641 7 -7.8212 -661      u=12 $ Inner hoop 3
642 7 -7.8212 -662      u=12 $ Inner hoop 4
643 7 -7.8212 -663      u=12 $ Inner hoop 5
644 7 -7.8212 -664      u=12 $ Inner hoop 6
645 7 -7.8212 -665      u=12 $ Inner hoop 7
646 7 -7.8212 -666      u=12 $ Inner hoop 8
647 7 -7.8212 -667      u=12 $ Inner hoop 9
648 7 -7.8212 -668      u=12 $ Inner hoop 10
649 7 -7.8212 -669      u=12 $ Inner hoop 11
650 7 -7.8212 -670      u=12 $ Inner hoop 12
651 7 -7.8212 -671      u=12 $ Inner hoop 13
652 7 -7.8212 -672      u=12 $ Inner hoop 14
653 7 -7.8212 -673      u=12 $ Inner hoop 15
654 7 -7.8212 -674      u=12 $ Inner hoop 16
655 7 -7.8212 -675      u=12 $ Inner hoop 17
656 7 -7.8212 -676      u=12 $ Outer hoop 1
657 7 -7.8212 -677      u=12 $ Outer hoop 2
658 7 -7.8212 -678      u=12 $ Outer hoop 3
659 7 -7.8212 -679      u=12 $ Outer hoop 4
660 7 -7.8212 -680      u=12 $ Outer hoop 5
661 7 -7.8212 -681      u=12 $ Outer hoop 6
662 7 -7.8212 -682      u=12 $ Outer hoop 7
663 7 -7.8212 -683      u=12 $ Outer hoop 8
664 7 -7.8212 -684      u=12 $ Outer hoop 9
665 7 -7.8212 -685      u=12 $ Outer hoop 10
666 7 -7.8212 -686      u=12 $ Outer hoop 11
667 7 -7.8212 -687      u=12 $ Outer hoop 12
668 7 -7.8212 -688      u=12 $ Outer hoop 13
669 7 -7.8212 -689      u=12 $ Outer hoop 14
670 7 -7.8212 -690      u=12 $ Outer hoop 15
671 7 -7.8212 -691      u=12 $ Outer hoop 16
672 7 -7.8212 -692      u=12 $ Outer hoop 17
673 7 -7.8212 -693      u=12 $ Outer hoop 18
674 7 -7.8212 -694      u=12 $ Outer hoop 19
675 7 -7.8212 -695      u=12 $ Outer hoop 20
676 7 -7.8212 -696      u=12 $ Outer hoop 21
677 7 -7.8212 -697      u=12 $ Outer hoop 22
678 7 -7.8212 -698      u=12 $ Outer hoop 23
679 7 -7.8212 -699      u=12 $ Outer hoop 24
680 7 -7.8212 -700      u=12 $ Outer hoop 25
681 7 -7.8212 -701      u=12 $ Outer hoop 26
682 7 -7.8212 -702      u=12 $ Outer hoop 27
683 7 -7.8212 -703      u=12 $ Outer hoop 28
684 7 -7.8212 -704      u=12 $ Outer hoop 29
685 7 -7.8212 -705      u=12 $ Outer hoop 30
686 7 -7.8212 -706      u=12 $ Outer hoop 31
687 7 -7.8212 -707      u=12 $ Outer hoop 32
688 7 -7.8212 -708      u=12 $ Outer hoop 33
689 7 -7.8212 -709      u=12 $ Outer hoop 34
690 12 -2.3233 #639 #640 #641 #642 #643 #644 #645 #646 #647 #648       $ Concrete
               #649 #650 #651 #652 #653 #654 #655 #656 #657 #658
               #659 #660 #661 #662 #663 #664 #665 #666 #667 #668
               #669 #670 #671 #672 #673 #674 #675 #676 #677 #678
               #679 #680 #681 #682 #683 #684 #685 #686 #687 #688
               #689      fill=13 u=12
691 7 -7.8212 -710  trcl = ( 115.2525 0.0000 0.0000 )    u=13 $ Inner bar 1
692 like 691 but  trcl = ( 113.5016 20.0134 0.0000 )    u=13 $ Inner bar 2
693 like 691 but  trcl = ( 108.3019 39.4187 0.0000 )    u=13 $ Inner bar 3
694 like 691 but  trcl = ( 99.8116 57.6263 0.0000 )    u=13 $ Inner bar 4
695 like 691 but  trcl = ( 88.2885 74.0829 0.0000 )    u=13 $ Inner bar 5
696 like 691 but  trcl = ( 74.0829 88.2885 0.0000 )    u=13 $ Inner bar 6
697 like 691 but  trcl = ( 57.6263 99.8116 0.0000 )    u=13 $ Inner bar 7
698 like 691 but  trcl = ( 39.4187 108.3019 0.0000 )    u=13 $ Inner bar 8
699 like 691 but  trcl = ( 20.0134 113.5016 0.0000 )    u=13 $ Inner bar 9
```

Figure 5.A.6-6 MPC-LACBWR MCNP Input File for Storage Cask Inlet Biasing – Lower End Fitting Damaged Fuel Gamma Source

```
700 like 691 but  trcl = ( 0.0000 115.2525 0.0000 )    u=13 $ Inner bar 10
701 like 691 but  trcl = ( -20.0134 113.5016 0.0000 )    u=13 $ Inner bar 11
702 like 691 but  trcl = ( -39.4187 108.3019 0.0000 )    u=13 $ Inner bar 12
703 like 691 but  trcl = ( -57.6263 99.8116 0.0000 )    u=13 $ Inner bar 13
704 like 691 but  trcl = ( -74.0829 88.2885 0.0000 )    u=13 $ Inner bar 14
705 like 691 but  trcl = ( -88.2885 74.0829 0.0000 )    u=13 $ Inner bar 15
706 like 691 but  trcl = ( -99.8116 57.6263 0.0000 )    u=13 $ Inner bar 16
707 like 691 but  trcl = ( -108.3019 39.4187 0.0000 )    u=13 $ Inner bar 17
708 like 691 but  trcl = ( -113.5016 20.0134 0.0000 )    u=13 $ Inner bar 18
709 like 691 but  trcl = ( -115.2525 0.0000 0.0000 )    u=13 $ Inner bar 19
710 like 691 but  trcl = ( -113.5016 -20.0134 0.0000 )    u=13 $ Inner bar 20
711 like 691 but  trcl = ( -108.3019 -39.4187 0.0000 )    u=13 $ Inner bar 21
712 like 691 but  trcl = ( -99.8116 -57.6262 0.0000 )    u=13 $ Inner bar 22
713 like 691 but  trcl = ( -88.2885 -74.0829 0.0000 )    u=13 $ Inner bar 23
714 like 691 but  trcl = ( -74.0829 -88.2885 0.0000 )    u=13 $ Inner bar 24
715 like 691 but  trcl = ( -57.6263 -99.8116 0.0000 )    u=13 $ Inner bar 25
716 like 691 but  trcl = ( -39.4187 -108.3019 0.0000 )    u=13 $ Inner bar 26
717 like 691 but  trcl = ( -20.0134 -113.5016 0.0000 )    u=13 $ Inner bar 27
718 like 691 but  trcl = ( 0.0000 -115.2525 0.0000 )    u=13 $ Inner bar 28
719 like 691 but  trcl = ( 20.0134 -113.5016 0.0000 )    u=13 $ Inner bar 29
720 like 691 but  trcl = ( 39.4187 -108.3019 0.0000 )    u=13 $ Inner bar 30
721 like 691 but  trcl = ( 57.6262 -99.8116 0.0000 )    u=13 $ Inner bar 31
722 like 691 but  trcl = ( 74.0829 -88.2885 0.0000 )    u=13 $ Inner bar 32
723 like 691 but  trcl = ( 88.2885 -74.0829 0.0000 )    u=13 $ Inner bar 33
724 like 691 but  trcl = ( 99.8116 -57.6263 0.0000 )    u=13 $ Inner bar 34
725 like 691 but  trcl = ( 108.3019 -39.4187 0.0000 )    u=13 $ Inner bar 35
726 like 691 but  trcl = ( 113.5016 -20.0134 0.0000 )    u=13 $ Inner bar 36
727 like 691 but  trcl = ( 149.5425 0.0000 0.0000 )    u=13 $ Outer bar 1
728 like 691 but  trcl = ( 148.6022 16.7434 0.0000 )    u=13 $ Outer bar 2
729 like 691 but  trcl = ( 145.7932 33.2763 0.0000 )    u=13 $ Outer bar 3
730 like 691 but  trcl = ( 141.1507 49.3908 0.0000 )    u=13 $ Outer bar 4
731 like 691 but  trcl = ( 134.7331 64.8841 0.0000 )    u=13 $ Outer bar 5
732 like 691 but  trcl = ( 126.6213 79.5614 0.0000 )    u=13 $ Outer bar 6
733 like 691 but  trcl = ( 116.9170 93.2382 0.0000 )    u=13 $ Outer bar 7
734 like 691 but  trcl = ( 105.7425 105.7425 0.0000 )    u=13 $ Outer bar 8
735 like 691 but  trcl = ( 93.2382 116.9170 0.0000 )    u=13 $ Outer bar 9
736 like 691 but  trcl = ( 79.5614 126.6213 0.0000 )    u=13 $ Outer bar 10
737 like 691 but  trcl = ( 64.8841 134.7331 0.0000 )    u=13 $ Outer bar 11
738 like 691 but  trcl = ( 49.3908 141.1507 0.0000 )    u=13 $ Outer bar 12
739 like 691 but  trcl = ( 33.2763 145.7932 0.0000 )    u=13 $ Outer bar 13
740 like 691 but  trcl = ( 16.7434 148.6022 0.0000 )    u=13 $ Outer bar 14
741 like 691 but  trcl = ( 0.0000 149.5425 0.0000 )    u=13 $ Outer bar 15
742 like 691 but  trcl = ( -16.7434 148.6022 0.0000 )    u=13 $ Outer bar 16
743 like 691 but  trcl = ( -33.2763 145.7932 0.0000 )    u=13 $ Outer bar 17
744 like 691 but  trcl = ( -49.3908 141.1507 0.0000 )    u=13 $ Outer bar 18
745 like 691 but  trcl = ( -64.8841 134.7331 0.0000 )    u=13 $ Outer bar 19
746 like 691 but  trcl = ( -79.5614 126.6213 0.0000 )    u=13 $ Outer bar 20
747 like 691 but  trcl = ( -93.2382 116.9170 0.0000 )    u=13 $ Outer bar 21
748 like 691 but  trcl = ( -105.7425 105.7425 0.0000 )    u=13 $ Outer bar 22
749 like 691 but  trcl = ( -116.9170 93.2382 0.0000 )    u=13 $ Outer bar 23
750 like 691 but  trcl = ( -126.6213 79.5614 0.0000 )    u=13 $ Outer bar 24
751 like 691 but  trcl = ( -134.7331 64.8841 0.0000 )    u=13 $ Outer bar 25
752 like 691 but  trcl = ( -141.1507 49.3908 0.0000 )    u=13 $ Outer bar 26
753 like 691 but  trcl = ( -145.7932 33.2763 0.0000 )    u=13 $ Outer bar 27
754 like 691 but  trcl = ( -148.6022 16.7434 0.0000 )    u=13 $ Outer bar 28
755 like 691 but  trcl = ( -149.5425 0.0000 0.0000 )    u=13 $ Outer bar 29
756 like 691 but  trcl = ( -148.6022 -16.7434 0.0000 )    u=13 $ Outer bar 30
757 like 691 but  trcl = ( -145.7932 -33.2763 0.0000 )    u=13 $ Outer bar 31
758 like 691 but  trcl = ( -141.1507 -49.3908 0.0000 )    u=13 $ Outer bar 32
759 like 691 but  trcl = ( -134.7331 -64.8841 0.0000 )    u=13 $ Outer bar 33
760 like 691 but  trcl = ( -126.6213 -79.5614 0.0000 )    u=13 $ Outer bar 34
761 like 691 but  trcl = ( -116.9170 -93.2382 0.0000 )    u=13 $ Outer bar 35
762 like 691 but  trcl = ( -105.7425 -105.7425 0.0000 )    u=13 $ Outer bar 36
763 like 691 but  trcl = ( -93.2382 -116.9170 0.0000 )    u=13 $ Outer bar 37
```

Figure 5.A.6-6 MPC-LACBWR MCNP Input File for Storage Cask Inlet Biasing – Lower End Fitting Damaged Fuel Gamma Source

```
764 like 691 but  trcl = ( -79.5614 -126.6213 0.0000 )    u=13 $ Outer bar 38
765 like 691 but  trcl = ( -64.8841 -134.7331 0.0000 )    u=13 $ Outer bar 39
766 like 691 but  trcl = ( -49.3908 -141.1507 0.0000 )    u=13 $ Outer bar 40
767 like 691 but  trcl = ( -33.2763 -145.7932 0.0000 )    u=13 $ Outer bar 41
768 like 691 but  trcl = ( -16.7434 -148.6022 0.0000 )    u=13 $ Outer bar 42
769 like 691 but  trcl = ( 0.0000 -149.5425 0.0000 )   u=13 $ Outer bar 43
770 like 691 but  trcl = ( 16.7434 -148.6022 0.0000 )    u=13 $ Outer bar 44
771 like 691 but  trcl = ( 33.2763 -145.7932 0.0000 )    u=13 $ Outer bar 45
772 like 691 but  trcl = ( 49.3908 -141.1507 0.0000 )    u=13 $ Outer bar 46
773 like 691 but  trcl = ( 64.8841 -134.7331 0.0000 )    u=13 $ Outer bar 47
774 like 691 but  trcl = ( 79.5614 -126.6213 0.0000 )    u=13 $ Outer bar 48
775 like 691 but  trcl = ( 93.2382 -116.9170 0.0000 )    u=13 $ Outer bar 49
776 like 691 but  trcl = ( 105.7425 -105.7425 0.0000 )    u=13 $ Outer bar 50
777 like 691 but  trcl = ( 116.9170 -93.2382 0.0000 )    u=13 $ Outer bar 51
778 like 691 but  trcl = ( 126.6213 -79.5614 0.0000 )    u=13 $ Outer bar 52
779 like 691 but  trcl = ( 134.7331 -64.8841 0.0000 )    u=13 $ Outer bar 53
780 like 691 but  trcl = ( 141.1507 -49.3908 0.0000 )    u=13 $ Outer bar 54
781 like 691 but  trcl = ( 145.7932 -33.2763 0.0000 )    u=13 $ Outer bar 55
782 like 691 but  trcl = ( 148.6022 -16.7434 0.0000 )    u=13 $ Outer bar 56
783 12 -2.3233 #691 #692 #693 #694 #695 #696 #697 #698 #699        $ Concrete
               #700 #701 #702 #703 #704 #705 #706 #707 #708 #709
               #710 #711 #712 #713 #714 #715 #716 #717 #718 #719
               #720 #721 #722 #723 #724 #725 #726 #727 #728 #729
               #730 #731 #732 #733 #734 #735 #736 #737 #738 #739
               #740 #741 #742 #743 #744 #745 #746 #747 #748 #749
               #750 #751 #752 #753 #754 #755 #756 #757 #758 #759
               #760 #761 #762 #763 #764 #765 #766 #767 #768 #769
               #770 #771 #772 #773 #774 #775 #776 #777 #778 #779
               #780 #781 #782       u=13
C Detector Cells - Radial Biasing
799  0  -799  fill=1  $ Cask
800  0  -800  +799  $ Inlet
900  0  -900  +799  +800  $ Inlet+1ft
1000  0  +799  +800  +900  $ Exterior

C Fuel Assembly Surfaces - v1.0
1 RPP -7.1247 7.1247 -7.1247 7.1247 0.0000 261.9502  $ Assy
2 PZ 27.2796       $ Lower Nozzle/Fuel
3 PZ 238.0996       $ Fuel/Upper Plenum
4 PZ 251.1298       $ Upper Plenum/Upper Nozzle
C Surfaces - Standard Fuel Tube v1.0
101 RPP -7.3076 7.3076 -7.3076 7.3076 0.0000 274.4470    $ Tube void
102 RPP -7.4295 7.4295 -7.4295 7.4295 0.0000 249.5550    $ Tube
103 RPP -6.5913 6.5913 7.4295 7.6200 2.0320 245.8720    $ Absorber +Y
104 RPP -6.5913 6.5913 7.6200 7.6657 2.0320 245.8720    $ Cladding +Y
105 RPP 7.4295 7.6200 -6.5913 6.5913 2.0320 245.8720    $ Absorber +X
106 RPP 7.6200 7.6657 -6.5913 6.5913 2.0320 245.8720    $ Cladding +X
C Surfaces - DFC Fuel Tube v1.0
107 RPP -7.6251 7.6251 -7.6251 7.6251 0.0000 274.4470    $ Tube void
108 RPP -7.7470 7.7470 -7.7470 7.7470 0.0000 249.5550    $ Tube
109 RPP -6.5913 6.5913 7.7470 7.9375 2.0320 245.8720    $ Absorber +Y
110 RPP -6.5913 6.5913 7.9375 7.9832 2.0320 245.8720    $ Cladding +Y
111 RPP 7.7470 7.9375 -6.5913 6.5913 2.0320 245.8720    $ Absorber +X
112 RPP 7.9375 7.9832 -6.5913 6.5913 2.0320 245.8720    $ Cladding +X
c Surface Cards - Disk Stack  v1.0
201 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 1.5875 88.1380 $ Structural disk
202 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 1.2700 87.7951 $ Heat transfer disk
203 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 2.5400 88.0491 $ Weldment disk
c Surface Cards - Basket v1.0
301 RPP -7.7711 7.7711 -7.7711 7.7711 0.0000 274.4470  $ Std opening
302 RPP -8.0899 8.0899 -8.0899 8.0899 0.0000 274.4470  $ DFC opening
303 PY 0.0000       $ Cut plane
304 PX 0.0000       $ Cut plane
C Surfaces - Canister v1.0
```

Figure 5.A.6-6 MPC-LACBWR MCNP Input File for Storage Cask Inlet Biasing – Lower End Fitting Damaged Fuel Gamma Source

```
501 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 274.4470 88.4428   $ Cavity
502 CZ 1.3843          $ Bot Cylinder Radius
503 CZ 5.0800          $ Mid Cyclinder Radius
504 CZ 5.7150          $ Top Cylinder Radius
505 PZ 282.8798          $ Port plane bot/mid
506 PZ 289.3822          $ Port plane mid/top
507 RCC 0.0000 0.0000 -2.5400 0.0000 0.0000 294.7670 89.7128   $ Canister
c Surface Cards - Storage Cask Geometry v4.0
601  RCC 0.0000 0.0000 0.0000 0.0000 0.0000 -58.6740 162.5600 $ Bottom Section Container
602  RCC 0.0000 0.0000 0.0000 0.0000 0.0000 352.5520 162.5600 $ Top Section Container (Not VCC
Lid)
603  CZ 100.3300        $ VCC liner inner
604  CZ 106.6800        $ VCC liner outer
605  RCC 0.0000 0.0000 -5.7150 0.0000 0.0000 5.7150 91.4400 $ Base plate/cover
606  KZ 47.2803 0.1357 -1     $ Baffle weldment bot
607  KZ 45.4435 0.1357 -1     $ Baffle weldment bot void
608  KZ -111.2883 0.1357 1     $ Baffle weldment top
609  KZ -109.4515 0.1357 1     $ Baffle weldment top void
610  PZ -32.0040        $ Baffle middle cut surface
611  PZ -7.8740        $ Baffle top cut surface
612  CZ 63.5000        $ Stand outer
613  CZ 58.4200        $ Stand inner
614 1 RPP -162.5600 162.5600 -15.2400 15.2400 -58.6740 -25.6540  $ Air inlet void
615 1 RPP -162.5600 162.5600 -16.1925 16.1925 -58.6740 -23.1140  $ Air inlet channel
616 2 RPP -162.5600 162.5600 -15.2400 15.2400 -58.6740 -25.6540  $ Air inlet void
617 2 RPP -162.5600 162.5600 -16.1925 16.1925 -58.6740 -23.1140  $ Air inlet channel
618  PZ -56.1340        $ Bottom plate height
619  RPP -25.6540 25.6540 -63.5001 63.5001 -25.6540 -5.7150  $ Stand top cut box
620  RCC 0.0000 0.0000 352.5520 0.0000 0.0000 3.8100 116.2050 $ VCC lid
621  RCC 0.0000 0.0000 347.4720 0.0000 0.0000 5.0800 124.3330 $ Top flange cylinder
622  CZ 102.8700        $ Top flange inner cut cylinder
623  RCC 0.0000 0.0000 331.2668 0.0000 0.0000 21.2852 99.0600 $ Lid concrete enclosure
624  RCC 0.0000 0.0000 332.2193 0.0000 0.0000 20.3327 98.1075 $ Lid concrete
625  RPP -54.2290 54.2290 -162.5600 162.5600 303.6570 336.8040  $ Box for outlet structure
(outside liner)
626  RPP -54.2290 54.2290 -127.0635 127.0635 315.7220 336.8040  $ Upper portion concrete
627  RPP -54.2290 54.2290 -162.5600 162.5600 303.6570 324.7390  $ Lower portion concrete
628  RPP -54.2290 54.2290 -143.2560 143.2560 303.6570 324.7390  $ Lower portion concrete cut
surface
629  RPP -53.2765 53.2765 -138.1760 138.1760 304.6095 335.8515  $ Lower/middle outlet void
630  RPP -53.2765 53.2765 -128.0160 128.0160 314.7695 335.8515  $ Cut box for lower/middle void
631  RPP -53.2765 53.2765 -162.5600 162.5600 325.6915 335.8515  $ Upper void
632  RPP -162.5600 162.5600 -54.2290 54.2290 303.6570 336.8040  $ Box for outlet structure
(outside liner)
633  RPP -127.0635 127.0635 -54.2290 54.2290 315.7220 336.8040  $ Upper portion concrete
634  RPP -162.5600 162.5600 -54.2290 54.2290 303.6570 324.7390  $ Lower portion concrete
635  RPP -143.2560 143.2560 -54.2290 54.2290 303.6570 324.7390  $ Lower portion concrete cut
surface
636  RPP -138.1760 138.1760 -53.2765 53.2765 304.6095 335.8515  $ Lower/middle outlet void
637  RPP -128.0160 128.0160 -53.2765 53.2765 314.7695 335.8515  $ Cut box for lower/middle void
638  RPP -162.5600 162.5600 -53.2765 53.2765 325.6915 335.8515  $ Upper void
639  RPP -54.2290 54.2290 -106.6800 106.6800 303.6570 315.7220  $ Outlet cut in liner
640  RPP -53.2765 53.2765 -106.6800 106.6800 304.6095 314.7695  $ Portion of outlet in liner
641  CZ 104.1400       $ Air outlet inner radius
642  RCC 0.0000 0.0000 -158.6740 0.0000 0.0000 100.0000 162.5600 $ Concrete pad
643 1 RCC 130.8100 -15.2400 -48.5140 0.0000 30.4800 0.0000 5.0800 $ Air inlet pipe 1 +x+y
644 1 RCC 110.4900 -15.2400 -35.8140 0.0000 30.4800 0.0000 5.0800 $ Air inlet pipe 2 +x+y
645 1 RCC 90.1700 -15.2400 -48.5140 0.0000 30.4800 0.0000 5.0800 $ Air inlet pipe 3 +x+y
646 1 RCC 69.8500 -15.2400 -35.8140 0.0000 30.4800 0.0000 5.0800 $ Air inlet pipe 4 +x+y
647 2 RCC 130.8100 -15.2400 -48.5140 0.0000 30.4800 0.0000 5.0800 $ Air inlet pipe 1 -x-y
648 2 RCC 110.4900 -15.2400 -35.8140 0.0000 30.4800 0.0000 5.0800 $ Air inlet pipe 2 -x-y
649 2 RCC 90.1700 -15.2400 -48.5140 0.0000 30.4800 0.0000 5.0800 $ Air inlet pipe 3 -x-y
650 2 RCC 69.8500 -15.2400 -35.8140 0.0000 30.4800 0.0000 5.0800 $ Air inlet pipe 4 -x-y
651 3 RCC 130.8100 -15.2400 -48.5140 0.0000 30.4800 0.0000 5.0800 $ Air inlet pipe 1 -x+y
```

Figure 5.A.6-6 MPC-LACBWR MCNP Input File for Storage Cask Inlet Biasing – Lower End Fitting Damaged Fuel Gamma Source

```
652 3 RCC 110.4900 -15.2400 -35.8140 0.0000 30.4800 0.0000 5.0800 $ Air inlet pipe 2 -x+y
653 3 RCC 90.1700 -15.2400 -48.5140 0.0000 30.4800 0.0000 5.0800 $ Air inlet pipe 3 -x+y
654 3 RCC 69.8500 -15.2400 -35.8140 0.0000 30.4800 0.0000 5.0800 $ Air inlet pipe 4 -x+y
655 4 RCC 130.8100 -15.2400 -48.5140 0.0000 30.4800 0.0000 5.0800 $ Air inlet pipe 1 +x-y
656 4 RCC 110.4900 -15.2400 -35.8140 0.0000 30.4800 0.0000 5.0800 $ Air inlet pipe 2 +x-y
657 4 RCC 90.1700 -15.2400 -48.5140 0.0000 30.4800 0.0000 5.0800 $ Air inlet pipe 3 +x-y
658 4 RCC 69.8500 -15.2400 -35.8140 0.0000 30.4800 0.0000 5.0800 $ Air inlet pipe 4 +x-y
C VCC Rebar Surfaces - v4.0
659  TZ 0.0000 0.0000 2.2860 113.3475 0.9525 0.9525  $ Inner hoop 1
660  TZ 0.0000 0.0000 22.6060 113.3475 0.9525 0.9525  $ Inner hoop 2
661  TZ 0.0000 0.0000 42.9260 113.3475 0.9525 0.9525  $ Inner hoop 3
662  TZ 0.0000 0.0000 63.2460 113.3475 0.9525 0.9525  $ Inner hoop 4
663  TZ 0.0000 0.0000 83.5660 113.3475 0.9525 0.9525  $ Inner hoop 5
664  TZ 0.0000 0.0000 103.8860 113.3475 0.9525 0.9525  $ Inner hoop 6
665  TZ 0.0000 0.0000 124.2060 113.3475 0.9525 0.9525  $ Inner hoop 7
666  TZ 0.0000 0.0000 144.5260 113.3475 0.9525 0.9525  $ Inner hoop 8
667  TZ 0.0000 0.0000 164.8460 113.3475 0.9525 0.9525  $ Inner hoop 9
668  TZ 0.0000 0.0000 185.1660 113.3475 0.9525 0.9525  $ Inner hoop 10
669  TZ 0.0000 0.0000 205.4860 113.3475 0.9525 0.9525  $ Inner hoop 11
670  TZ 0.0000 0.0000 225.8060 113.3475 0.9525 0.9525  $ Inner hoop 12
671  TZ 0.0000 0.0000 246.1260 113.3475 0.9525 0.9525  $ Inner hoop 13
672  TZ 0.0000 0.0000 266.4460 113.3475 0.9525 0.9525  $ Inner hoop 14
673  TZ 0.0000 0.0000 286.7660 113.3475 0.9525 0.9525  $ Inner hoop 15
674  TZ 0.0000 0.0000 307.0860 113.3475 0.9525 0.9525  $ Inner hoop 16
675  TZ 0.0000 0.0000 327.4060 113.3475 0.9525 0.9525  $ Inner hoop 17
676  TZ 0.0000 0.0000 2.2860 151.4475 0.9525 0.9525  $ Outer hoop 1
677  TZ 0.0000 0.0000 12.4460 151.4475 0.9525 0.9525  $ Outer hoop 2
678  TZ 0.0000 0.0000 22.6060 151.4475 0.9525 0.9525  $ Outer hoop 3
679  TZ 0.0000 0.0000 32.7660 151.4475 0.9525 0.9525  $ Outer hoop 4
680  TZ 0.0000 0.0000 42.9260 151.4475 0.9525 0.9525  $ Outer hoop 5
681  TZ 0.0000 0.0000 53.0860 151.4475 0.9525 0.9525  $ Outer hoop 6
682  TZ 0.0000 0.0000 63.2460 151.4475 0.9525 0.9525  $ Outer hoop 7
683  TZ 0.0000 0.0000 73.4060 151.4475 0.9525 0.9525  $ Outer hoop 8
684  TZ 0.0000 0.0000 83.5660 151.4475 0.9525 0.9525  $ Outer hoop 9
685  TZ 0.0000 0.0000 93.7260 151.4475 0.9525 0.9525  $ Outer hoop 10
686  TZ 0.0000 0.0000 103.8860 151.4475 0.9525 0.9525  $ Outer hoop 11
687  TZ 0.0000 0.0000 114.0460 151.4475 0.9525 0.9525  $ Outer hoop 12
688  TZ 0.0000 0.0000 124.2060 151.4475 0.9525 0.9525  $ Outer hoop 13
689  TZ 0.0000 0.0000 134.3660 151.4475 0.9525 0.9525  $ Outer hoop 14
690  TZ 0.0000 0.0000 144.5260 151.4475 0.9525 0.9525  $ Outer hoop 15
691  TZ 0.0000 0.0000 154.6860 151.4475 0.9525 0.9525  $ Outer hoop 16
692  TZ 0.0000 0.0000 164.8460 151.4475 0.9525 0.9525  $ Outer hoop 17
693  TZ 0.0000 0.0000 175.0060 151.4475 0.9525 0.9525  $ Outer hoop 18
694  TZ 0.0000 0.0000 185.1660 151.4475 0.9525 0.9525  $ Outer hoop 19
695  TZ 0.0000 0.0000 195.3260 151.4475 0.9525 0.9525  $ Outer hoop 20
696  TZ 0.0000 0.0000 205.4860 151.4475 0.9525 0.9525  $ Outer hoop 21
697  TZ 0.0000 0.0000 215.6460 151.4475 0.9525 0.9525  $ Outer hoop 22
698  TZ 0.0000 0.0000 225.8060 151.4475 0.9525 0.9525  $ Outer hoop 23
699  TZ 0.0000 0.0000 235.9660 151.4475 0.9525 0.9525  $ Outer hoop 24
700  TZ 0.0000 0.0000 246.1260 151.4475 0.9525 0.9525  $ Outer hoop 25
701  TZ 0.0000 0.0000 256.2860 151.4475 0.9525 0.9525  $ Outer hoop 26
702  TZ 0.0000 0.0000 266.4460 151.4475 0.9525 0.9525  $ Outer hoop 27
703  TZ 0.0000 0.0000 276.6060 151.4475 0.9525 0.9525  $ Outer hoop 28
704  TZ 0.0000 0.0000 286.7660 151.4475 0.9525 0.9525  $ Outer hoop 29
705  TZ 0.0000 0.0000 296.9260 151.4475 0.9525 0.9525  $ Outer hoop 30
706  TZ 0.0000 0.0000 307.0860 151.4475 0.9525 0.9525  $ Outer hoop 31
707  TZ 0.0000 0.0000 317.2460 151.4475 0.9525 0.9525  $ Outer hoop 32
708  TZ 0.0000 0.0000 327.4060 151.4475 0.9525 0.9525  $ Outer hoop 33
709  TZ 0.0000 0.0000 337.5660 151.4475 0.9525 0.9525  $ Outer hoop 34
710  RCC 0.0000 0.0000 2.2860 0.0000 0.0000 332.7400 0.9525 $ Bar
C Storage Cask & Pad Container
799  RCC  0.0000  0.0000  -158.6740  0.0000  0.0000  515.0360  162.5601
C Radial Detector DIAA (Inlet)
800  RCC  0.0000  0.0000  -58.6740  0.0000  0.0000  33.0200  162.6601
```

Figure 5.A.6-6 MPC-LACBWR MCNP Input File for Storage Cask Inlet Biasing – Lower End Fitting Damaged Fuel Gamma Source

```
801      PX  0.0000
802   5  PX  0.0000
803   6  PX  0.0000
804   7  PX  0.0000
805   8  PX  0.0000
806   9  PX  0.0000
807   10  PX  0.0000
808   11  PX  0.0000
809   12  PX  0.0000
810      PY  0.0000
811   13  PX  0.0000
812   14  PX  0.0000
813   15  PX  0.0000
814   16  PX  0.0000
815   17  PX  0.0000
816   18  PX  0.0000
817   19  PX  0.0000
818   20  PX  0.0000
C Radial Detector DIBA (Inlet+1ft)
900  RCC  0.0000  0.0000  -58.6740  0.0000  0.0000  33.0200  193.1401
901      PX  0.0000
902   5  PX  0.0000
903   6  PX  0.0000
904   7  PX  0.0000
905   8  PX  0.0000
906   9  PX  0.0000
907   10  PX  0.0000
908   11  PX  0.0000
909   12  PX  0.0000
910      PY  0.0000
911   13  PX  0.0000
912   14  PX  0.0000
913   15  PX  0.0000
914   16  PX  0.0000
915   17  PX  0.0000
916   18  PX  0.0000
917   19  PX  0.0000
918   20  PX  0.0000

C
C Materials List - Common Materials - v1.0
C
C Homogenized Lower Nozzle
m1     24000 -1.9000E-01
       25055 -2.0000E-02
       26000 -6.9500E-01
       28000 -9.5000E-02
C Homogenized UO2 Fuel
m2     24000 -2.9967E-02
       25055 -3.1544E-03
       26000 -1.0961E-01
       28000 -1.4983E-02
       92235 -2.6729E-02
       92238 -7.1574E-01
        8016 -9.9810E-02
C Homogenized Upper Plenum
m3     24000 -1.9000E-01
       25055 -2.0000E-02
       26000 -6.9500E-01
       28000 -9.5000E-02
C Homogenized Upper Nozzle
m4     24000 -0.190 25055 -0.020 26000 -0.695
       28000 -0.095
C Water
```

Figure 5.A.6-6 MPC-LACBWR MCNP Input File for Storage Cask Inlet Biasing – Lower End Fitting Damaged Fuel Gamma Source

```
m5    1001 2 8016 1
C Stainless Steel
m6    24000 -0.190 25055 -0.020 26000 -0.695
      28000 -0.095
C Carbon Steel
m7    26000 -0.99 6012 -0.01
C Neutron Poison
m8    13027 -0.8466  5010 -0.0216  5011 -0.0985
       6012 -0.0333
C Aluminum
m9    13027 -1.0
C Lead
m10   82000 -1.0
C NS-4-FR
m11    5010 -9.3127E-04 13027 -2.1420E-01  6012 -2.7627E-01
       5011 -3.7721E-03  1001 -6.0012E-02  7014 -1.9815E-02
       8016 -4.2500E-01
C Concrete
m12   26000 -0.014 20000 -0.044 14000 -0.337
       1001 -0.010  8016 -0.532 11023 -0.029
      13027 -0.034
C Vent Port Middle Cylinder
m13   24000 -0.190 25055 -0.020 26000 -0.695
      28000 -0.095
C Damaged Lower Nozzle
m15   24000 -2.7312E-02
      25055 -2.8750E-03
      26000 -9.9905E-02
      28000 -1.3656E-02
      92235 -2.7172E-02
      92238 -7.2761E-01
       8016 -1.0147E-01
phys:p 100 0 0 0 1    $ Disable Doppler energy broadening
C
C Cell Importances
C
imp:p 1 414r 0
C
C BWR Source Definition - Lower Nozzle - DamagedGam - PrefD
C
sdef x=d1 y=d2 z=d3 erg=d4 cell=799:632:501:d5:6
si1   -7.1247 7.1247
sp1   0 1
si2   -7.1247 7.1247
sp2   0 1
si3   0.0000 27.2796
sp3   0 1
si4   1.000E-02 2.000E-02 5.000E-02 1.000E-01 2.000E-01 3.000E-01
      4.000E-01 6.000E-01 8.000E-01 1.000E+00 1.220E+00 1.440E+00
      1.660E+00 2.000E+00 2.500E+00 3.000E+00 4.000E+00 5.000E+00
      6.500E+00 8.000E+00 1.000E+01 1.200E+01 1.400E+01
sp4   0.0000E+00 3.9346E+13 5.1398E+13 2.4748E+13 1.5283E+13 4.7419E+12
      3.2789E+12 2.3939E+12 1.3546E+14 1.0605E+12 5.0505E+11 8.2048E+11
      7.5368E+10 8.4076E+09 4.2540E+08 2.8405E+07 1.8349E+05 6.1637E+04
      2.4653E+04 4.8213E+03 1.0215E+03 5.2748E+01 0.0000E+00
C Source Information
si5 1                  302  304
               306  308  310  312  314  316
           318        332
           334        348
       350  352        366  368
       370  372        386  388
           390        404
           406        420
```

Figure 5.A.6-6 MPC-LACBWR MCNP Input File for Storage Cask Inlet Biasing – Lower End Fitting Damaged Fuel Gamma Source

```
               422  424  426  428  430  432
                       434  436
C Source Probability
sp5                   0.36 0.36
              0.36 0.36 0.36 0.36 0.36 0.36
          0.36       0.36
          0.36       0.36
      0.36 0.36       0.36 0.36
      0.36 0.36       0.36 0.36
          0.36       0.36
          0.36       0.36
              0.36 0.36 0.36 0.36 0.36 0.36
                      0.36 0.36
mode p
nps 200000000
C
C ANSI/ANS-6.1.1-1977 - Gamma Flux-to-Dose Conversion Factors
C (mrem/hr)/(photons/cm2-sec)
C
de0   0.01 0.03 0.05 0.07 0.1 0.15 0.2
      0.25 0.3 0.35 0.4 0.45 0.5 0.55
      0.6 0.65 0.7 0.8 1 1.4 1.8
      2.2 2.6 2.8 3.25 3.75 4.25 4.75
      5 5.25 5.75 6.25 6.75 7.5 9
      11 13 15
df0   3.96E-03 5.82E-04 2.90E-04 2.58E-04 2.83E-04 3.79E-04 5.01E-04
      6.31E-04 7.59E-04 8.78E-04 9.85E-04 1.08E-03 1.17E-03 1.27E-03
      1.36E-03 1.44E-03 1.52E-03 1.68E-03 1.98E-03 2.51E-03 2.99E-03
      3.42E-03 3.82E-03 4.01E-03 4.41E-03 4.83E-03 5.23E-03 5.60E-03
      5.80E-03 6.01E-03 6.37E-03 6.74E-03 7.11E-03 7.66E-03 8.77E-03
      1.03E-02 1.18E-02 1.33E-02
C
C Weight Window Generation - Air Inlet
C
wwg 2 0 0 0 0
wwp:p 5 3 5 0 -1 0
mesh geom=cyl ref=78 9 4 origin=0.1 0.1 -160
     imesh 88.4 89.7 100.3 106.7 162.6 662.6
     iints 5 1 1 2 4 1
     jmesh 101 104 134 137 154 162 189 400 424 437 454 491 512 516 1016
     jints 1 1 1 1 1 2 2 10 1 1 3 1 2 1 1
     kmesh 0.11 0.14 0.36 0.39 0.61 0.64 0.86 0.89 1.00
     kints 1 1 1 1 1 1 1 1 1
wwge:p  1e-3 1 20
fc2 Radial Inlet Tally Q1 (+x+y)
f2:p +800.1
fm2 3.1267E+15
fs2 -801  -810
     +809  +808  +807  +806  +805  +804
     +803  +802  T
sd2 1.6874E+04  8.4368E+03  9.3742E+02  8r  3.3747E+04
tf2
fc12 Radial Inlet Tally Q2 (-x+y)
f12:p +800.1
fm12 3.1267E+15
fs12 +801  -810
     -818  -817  -816  -815  -814  -813
     -812  -811  T
sd12 1.6874E+04  8.4368E+03  9.3742E+02  8r  3.3747E+04
tf12
fc22 Radial Inlet Tally Q3 (-x-y)
f22:p +800.1
fm22 3.1267E+15
fs22 +801  +810
```

Figure 5.A.6-6 MPC-LACBWR MCNP Input File for Storage Cask Inlet Biasing – Lower End Fitting Damaged Fuel Gamma Source

```
     -809  -808  -807  -806  -805  -804
     -803  -802  T
sd22 1.6874E+04  8.4368E+03  9.3742E+02  8r  3.3747E+04
tf22
fc32 Radial Inlet Tally Q4 (+x-y)
f32:p +800.1
fm32 3.1267E+15
fs32 -801  +810
     +818  +817  +816  +815  +814  +813
     +812  +811  T
sd32 1.6874E+04  8.4368E+03  9.3742E+02  8r  3.3747E+04
tf32
fc42 Radial Inlet+1ft Tally Q1 (+x+y)
f42:p +900.1
fm42 3.1267E+15
fs42 -901  -910
     +909  +908  +907  +906  +905  +904
     +903  +902  T
sd42 2.0035E+04  1.0018E+04  1.1131E+03  8r  4.0071E+04
tf42
fc52 Radial Inlet+1ft Tally Q2 (-x+y)
f52:p +900.1
fm52 3.1267E+15
fs52 +901  -910
     -918  -917  -916  -915  -914  -913
     -912  -911  T
sd52 2.0035E+04  1.0018E+04  1.1131E+03  8r  4.0071E+04
tf52
fc62 Radial Inlet+1ft Tally Q3 (-x-y)
f62:p +900.1
fm62 3.1267E+15
fs62 +901  +910
     -909  -908  -907  -906  -905  -904
     -903  -902  T
sd62 2.0035E+04  1.0018E+04  1.1131E+03  8r  4.0071E+04
tf62
fc72 Radial Inlet+1ft Tally Q4 (+x-y)
f72:p +900.1
fm72 3.1267E+15
fs72 -901  +910
     +918  +917  +916  +915  +914  +913
     +912  +911  T
sd72 2.0035E+04  1.0018E+04  1.1131E+03  8r  4.0071E+04
tf72
C
C
C Print Control
C
prdmp -30 -60 1 2
print
C
C Random Number Generator
C
rand gen=2 seed=19073486328125 stride=152917 hist=1
C
C Rotation Matrix
C
C 45 degree rotation around z-axis
*TR1 0.0 0.0 0.0 45 135 90 -45 45 90 90 90 0
C 135 degree rotation around z-axis
*TR2 0.0 0.0 0.0 135 225 90 45 135 90 90 90 0
C 225 degree rotation around z-axis
*TR3 0.0 0.0 0.0 225 315 90 135 225 90 90 90 0
C 315 degree rotation around z-axis
```

Figure 5.A.6-6 MPC-LACBWR MCNP Input File for Storage Cask Inlet Biasing – Lower End Fitting Damaged Fuel Gamma Source

```
*TR4 0.0 0.0 0.0 315 405 90 225 315 90 90 90 0
C 10 degree rotation around z-axis
*TR5 0.0 0.0 0.0 10 100 90 -80 10 90 90 90 0
C 20 degree rotation around z-axis
*TR6 0.0 0.0 0.0 20 110 90 -70 20 90 90 90 0
C 30 degree rotation around z-axis
*TR7 0.0 0.0 0.0 30 120 90 -60 30 90 90 90 0
C 40 degree rotation around z-axis
*TR8 0.0 0.0 0.0 40 130 90 -50 40 90 90 90 0
C 50 degree rotation around z-axis
*TR9 0.0 0.0 0.0 50 140 90 -40 50 90 90 90 0
C 60 degree rotation around z-axis
*TR10 0.0 0.0 0.0 60 150 90 -30 60 90 90 90 0
C 70 degree rotation around z-axis
*TR11 0.0 0.0 0.0 70 160 90 -20 70 90 90 90 0
C 80 degree rotation around z-axis
*TR12 0.0 0.0 0.0 80 170 90 -10 80 90 90 90 0
C 100 degree rotation around z-axis
*TR13 0.0 0.0 0.0 100 190 90 10 100 90 90 90 0
C 110 degree rotation around z-axis
*TR14 0.0 0.0 0.0 110 200 90 20 110 90 90 90 0
C 120 degree rotation around z-axis
*TR15 0.0 0.0 0.0 120 210 90 30 120 90 90 90 0
C 130 degree rotation around z-axis
*TR16 0.0 0.0 0.0 130 220 90 40 130 90 90 90 0
C 140 degree rotation around z-axis
*TR17 0.0 0.0 0.0 140 230 90 50 140 90 90 90 0
C 150 degree rotation around z-axis
*TR18 0.0 0.0 0.0 150 240 90 60 150 90 90 90 0
C 160 degree rotation around z-axis
*TR19 0.0 0.0 0.0 160 250 90 70 160 90 90 90 0
C 170 degree rotation around z-axis
*TR20 0.0 0.0 0.0 170 260 90 80 170 90 90 90 0
C 18 degree rotation around z-axis
*TR21 0.0 0.0 0.0 18 108 90 -72 18 90 90 90 0
C 36 degree rotation around z-axis
*TR22 0.0 0.0 0.0 36 126 90 -54 36 90 90 90 0
C 54 degree rotation around z-axis
*TR23 0.0 0.0 0.0 54 144 90 -36 54 90 90 90 0
C 72 degree rotation around z-axis
*TR24 0.0 0.0 0.0 72 162 90 -18 72 90 90 90 0
C 108 degree rotation around z-axis
*TR25 0.0 0.0 0.0 108 198 90 18 108 90 90 90 0
C 126 degree rotation around z-axis
*TR26 0.0 0.0 0.0 126 216 90 36 126 90 90 90 0
C 144 degree rotation around z-axis
*TR27 0.0 0.0 0.0 144 234 90 54 144 90 90 90 0
C 162 degree rotation around z-axis
*TR28 0.0 0.0 0.0 162 252 90 72 162 90 90 90 0
```

Figure 5.A.6-7 MPC-LACBWR MCNP Input File for Transfer Cask Dry Canister Bottom Axial Biasing – Lower End Fitting Damaged Fuel Neutron Source

```
LACBWR Transfer Cask - trfShlDryBotLfn_PrefD
C Bottom Axial Biasing - Lower Nozzle Source
C Fuel Assembly Cells - v1.0
1 1 -1.3734 -1 -2    u=11 $ Lower Nozzle
2 2 -3.7790 -1 +2 -3   u=11 $ Fuel
3 3 -0.9880 -1 +3 -4   u=11 $ Upper Plenum
4 4 -0.6145 -1 +4    u=11 $ Upper Nozzle
5 0          +1     u=11 $ Outside
C Fuel Assembly Cells - v1.0
6 15 -9.5539 -1 -2    u=10 $ Lower Nozzle
7 2 -3.7790 -1 +2 -3   u=10 $ Fuel
8 3 -0.9880 -1 +3 -4   u=10 $ Upper Plenum
9 4 -0.6145 -1 +4    u=10 $ Upper Nozzle
10 0         +1     u=10 $ Outside
C Cells - Standard Fuel Tube  v1.0
101 0          -101        u=5 $ Tube void
102 6 -7.9400 -102 +101        u=5 $ Tube
103 8 -2.6707 -103        u=5 $ Absorber +Y
104 6 -7.9400 -104        u=5 $ Cladding +Y
105 8 -2.6707 -105        u=5 $ Absorber +X
106 6 -7.9400 -106        u=5 $ Cladding +X
107 0          +101 +102 +103 +104 +106 +105  u=5 $ Void
C Cells - DFC Fuel Tube Absorber 2 Sides v1.0
108 0          -107        u=6 $ Tube void
109 6 -7.9400 -108 +107        u=6 $ Tube
110 8 -2.6707 -109        u=6 $ Absorber +Y
111 6 -7.9400 -110        u=6 $ Cladding +Y
112 8 -2.6707 -111        u=6 $ Absorber +X
113 6 -7.9400 -112        u=6 $ Cladding +X
114 0          +107 +108 +109 +110 +112 +111  u=6 $ Void
C Cells - DFC Fuel Tube Absorber 1 Side (Y) v1.0
115 0          -107        u=7 $ Tube void
116 6 -7.9400 -108 +107        u=7 $ Tube
117 8 -2.6707 -109        u=7 $ Absorber +Y
118 6 -7.9400 -110        u=7 $ Cladding +Y
119 0          +107 +108 +109 +110    u=7 $ Void
C Cells - DFC Fuel Tube Absorber 1 Side (X) v1.0
120 0          -107        u=8 $ Tube void
121 6 -7.9400 -108 +107        u=8 $ Tube
122 8 -2.6707 -111        u=8 $ Absorber +X
123 6 -7.9400 -112        u=8 $ Cladding +X
124 0          +107 +108 +111 +112    u=8 $ Void
C Cells - DFC Fuel Tube No Absorber v1.0
125 0          -107        u=9 $ Tube void
126 6 -7.9400 -108 +107        u=9 $ Tube
127 0          +107 +108        u=9 $ Void
c Cell Cards - Disk Stack v1.0
201 6 -7.94 -203 trcl = ( 0.0000 0.0000 2.5400 )    u=4 $ Bottom weldment disk
202 6 -7.94 -201 trcl = ( 0.0000 0.0000 15.0368 )    u=4 $ Support disk 1
203 like 202 but   trcl = ( 0.0000 0.0000 24.7650 )    u=4 $ Support disk 2
204 like 202 but   trcl = ( 0.0000 0.0000 34.4932 )    u=4 $ Support disk 3
205 like 202 but   trcl = ( 0.0000 0.0000 44.2214 )    u=4 $ Support disk 4
206 like 202 but   trcl = ( 0.0000 0.0000 53.9496 )    u=4 $ Support disk 5
207 9 -2.70 -202 trcl = ( 0.0000 0.0000 58.9788 )    u=4 $ Heat transfer disk 1
208 like 202 but   trcl = ( 0.0000 0.0000 63.6778 )    u=4 $ Support disk 6
209 like 207 but   trcl = ( 0.0000 0.0000 68.7070 )    u=4 $ Heat transfer disk 2
210 like 202 but   trcl = ( 0.0000 0.0000 73.4060 )    u=4 $ Support disk 7
211 like 207 but   trcl = ( 0.0000 0.0000 78.4352 )    u=4 $ Heat transfer disk 3
212 like 202 but   trcl = ( 0.0000 0.0000 83.1342 )    u=4 $ Support disk 8
213 like 207 but   trcl = ( 0.0000 0.0000 88.1634 )    u=4 $ Heat transfer disk 4
214 like 202 but   trcl = ( 0.0000 0.0000 92.8624 )    u=4 $ Support disk 9
215 like 207 but   trcl = ( 0.0000 0.0000 97.8916 )    u=4 $ Heat transfer disk 5
```

Figure 5.A.6-7 MPC-LACBWR MCNP Input File for Transfer Cask Dry Canister Bottom Axial Biasing – Lower End Fitting Damaged Fuel Neutron Source

```
216 like 202 but   trcl = ( 0.0000 0.0000 102.5906 )    u=4 $ Support disk 10
217 like 207 but   trcl = ( 0.0000 0.0000 107.6198 )    u=4 $ Heat transfer disk 6
218 like 202 but   trcl = ( 0.0000 0.0000 112.3188 )    u=4 $ Support disk 11
219 like 207 but   trcl = ( 0.0000 0.0000 117.3480 )    u=4 $ Heat transfer disk 7
220 like 202 but   trcl = ( 0.0000 0.0000 122.0470 )    u=4 $ Support disk 12
221 like 207 but   trcl = ( 0.0000 0.0000 127.0762 )    u=4 $ Heat transfer disk 8
222 like 202 but   trcl = ( 0.0000 0.0000 131.7752 )    u=4 $ Support disk 13
223 like 207 but   trcl = ( 0.0000 0.0000 136.8044 )    u=4 $ Heat transfer disk 9
224 like 202 but   trcl = ( 0.0000 0.0000 141.5034 )    u=4 $ Support disk 14
225 like 207 but   trcl = ( 0.0000 0.0000 146.5326 )    u=4 $ Heat transfer disk 10
226 like 202 but   trcl = ( 0.0000 0.0000 151.2316 )    u=4 $ Support disk 15
227 like 207 but   trcl = ( 0.0000 0.0000 156.2608 )    u=4 $ Heat transfer disk 11
228 like 202 but   trcl = ( 0.0000 0.0000 160.9598 )    u=4 $ Support disk 16
229 like 207 but   trcl = ( 0.0000 0.0000 165.9890 )    u=4 $ Heat transfer disk 12
230 like 202 but   trcl = ( 0.0000 0.0000 170.6880 )    u=4 $ Support disk 17
231 like 207 but   trcl = ( 0.0000 0.0000 175.7172 )    u=4 $ Heat transfer disk 13
232 like 202 but   trcl = ( 0.0000 0.0000 180.4162 )    u=4 $ Support disk 18
233 like 207 but   trcl = ( 0.0000 0.0000 185.4454 )    u=4 $ Heat transfer disk 14
234 like 202 but   trcl = ( 0.0000 0.0000 190.1444 )    u=4 $ Support disk 19
235 like 202 but   trcl = ( 0.0000 0.0000 199.8726 )    u=4 $ Support disk 20
236 like 202 but   trcl = ( 0.0000 0.0000 209.6008 )    u=4 $ Support disk 21
237 like 202 but   trcl = ( 0.0000 0.0000 219.3290 )    u=4 $ Support disk 22
238 like 202 but   trcl = ( 0.0000 0.0000 229.0572 )    u=4 $ Support disk 23
239 like 202 but   trcl = ( 0.0000 0.0000 238.7854 )    u=4 $ Support disk 24
240 like 201 but   trcl = ( 0.0000 0.0000 255.8796 )    u=4 $ Top weldment disk
241 0              $ Outside Disks
      #201 #202 #203 #204 #205 #206 #207 #208 #209 #210
      #211 #212 #213 #214 #215 #216 #217 #218 #219 #220
      #221 #222 #223 #224 #225 #226 #227 #228 #229 #230
      #231 #232 #233 #234 #235 #236 #237 #238 #239
      #240      u=4
c Cell Cards - Basket v1.0
301 0         -302 #302  fill=8 ( -8.8265 77.5233 0.0000 )       $ Tube/Disk 1
          trcl = ( -8.8265 77.5233 0.0000 )     u=3
302 0         -1  fill=10 trcl = ( -8.8265 77.5233 0.0000 )     u=3 $ Assembly 1
303 0         -302 #304  fill=9 ( 8.8265 77.5233 0.0000 )      $ Tube/Disk 2
          trcl = ( 8.8265 77.5233 0.0000 )     u=3
304 like 302 but    fill=10 trcl = ( 8.8265 77.5233 0.0000 )     u=3 $ Assembly 2
305 0         -302 #306  fill=8 ( -44.1274 61.2699 0.0000 )      $ Tube/Disk 3
          trcl = ( -44.1274 61.2699 0.0000 )     u=3
306 like 302 but    fill=10 trcl = ( -44.1274 61.2699 0.0000 )     u=3 $ Assembly 3
307 0         -302 #308  fill=8 ( -26.4770 59.8729 0.0000 )      $ Tube/Disk 4
          trcl = ( -26.4770 59.8729 0.0000 )     u=3
308 like 302 but    fill=10 trcl = ( -26.4770 59.8729 0.0000 )     u=3 $ Assembly 4
309 0         -302 #310  fill=6 ( -8.8265 59.8729 0.0000 )      $ Tube/Disk 5
          trcl = ( -8.8265 59.8729 0.0000 )     u=3
310 like 302 but    fill=10 trcl = ( -8.8265 59.8729 0.0000 )     u=3 $ Assembly 5
311 0         -302 #312  fill=6 ( 8.8265 59.8729 0.0000 )      $ Tube/Disk 6
          trcl = ( 8.8265 59.8729 0.0000 )     u=3
312 like 302 but    fill=10 trcl = ( 8.8265 59.8729 0.0000 )     u=3 $ Assembly 6
313 0         -302 #314  fill=8 ( 26.4770 59.8729 0.0000 )      $ Tube/Disk 7
          trcl = ( 26.4770 59.8729 0.0000 )     u=3
314 like 302 but    fill=10 trcl = ( 26.4770 59.8729 0.0000 )     u=3 $ Assembly 7
315 0         -302 #316  fill=9 ( 44.1274 61.2699 0.0000 )      $ Tube/Disk 8
          trcl = ( 44.1274 61.2699 0.0000 )     u=3
316 like 302 but    fill=10 trcl = ( 44.1274 61.2699 0.0000 )     u=3 $ Assembly 8
317 0         -302 #318  fill=8 ( -61.2699 44.1274 0.0000 )      $ Tube/Disk 9
          trcl = ( -61.2699 44.1274 0.0000 )     u=3
318 like 302 but    fill=10 trcl = ( -61.2699 44.1274 0.0000 )     u=3 $ Assembly 9
319 0         -301 #320  fill=5 ( -42.5399 42.5399 0.0000 )      $ Tube/Disk 10
          trcl = ( -42.5399 42.5399 0.0000 )     u=3
320 like 302 but    fill=11 trcl = ( -42.5399 42.5399 0.0000 )     u=3 $ Assembly 10
321 0         -301 #322  fill=5 ( -25.5245 42.5399 0.0000 )      $ Tube/Disk 11
          trcl = ( -25.5245 42.5399 0.0000 )     u=3
```

Figure 5.A.6-7 MPC-LACBWR MCNP Input File for Transfer Cask Dry Canister Bottom Axial Biasing – Lower End Fitting Damaged Fuel Neutron Source

```
322 like 302 but    fill=11 trcl = ( -25.5245 42.5399 0.0000 )     u=3 $ Assembly 11
323 0          -301 #324  fill=5 ( -8.5090 42.5399 0.0000 )      $ Tube/Disk 12
           trcl = ( -8.5090 42.5399 0.0000 )      u=3
324 like 302 but    fill=11 trcl = ( -8.5090 42.5399 0.0000 )     u=3 $ Assembly 12
325 0          -301 #326  fill=5 ( 8.5090 42.5399 0.0000 )      $ Tube/Disk 13
           trcl = ( 8.5090 42.5399 0.0000 )      u=3
326 like 302 but    fill=11 trcl = ( 8.5090 42.5399 0.0000 )     u=3 $ Assembly 13
327 0          -301 #328  fill=5 ( 25.5245 42.5399 0.0000 )      $ Tube/Disk 14
           trcl = ( 25.5245 42.5399 0.0000 )      u=3
328 like 302 but    fill=11 trcl = ( 25.5245 42.5399 0.0000 )     u=3 $ Assembly 14
329 0          -301 #330  fill=5 ( 42.5399 42.5399 0.0000 )      $ Tube/Disk 15
           trcl = ( 42.5399 42.5399 0.0000 )      u=3
330 like 302 but    fill=11 trcl = ( 42.5399 42.5399 0.0000 )     u=3 $ Assembly 15
331 0          -302 #332  fill=9 ( 61.2699 44.1274 0.0000 )      $ Tube/Disk 16
           trcl = ( 61.2699 44.1274 0.0000 )      u=3
332 like 302 but    fill=10 trcl = ( 61.2699 44.1274 0.0000 )     u=3 $ Assembly 16
333 0          -302 #334  fill=6 ( -59.8729 26.4770 0.0000 )      $ Tube/Disk 17
           trcl = ( -59.8729 26.4770 0.0000 )      u=3
334 like 302 but    fill=10 trcl = ( -59.8729 26.4770 0.0000 )     u=3 $ Assembly 17
335 0          -301 #336  fill=5 ( -42.5399 25.5245 0.0000 )      $ Tube/Disk 18
           trcl = ( -42.5399 25.5245 0.0000 )      u=3
336 like 302 but    fill=11 trcl = ( -42.5399 25.5245 0.0000 )     u=3 $ Assembly 18
337 0          -301 #338  fill=5 ( -25.5245 25.5245 0.0000 )      $ Tube/Disk 19
           trcl = ( -25.5245 25.5245 0.0000 )      u=3
338 like 302 but    fill=11 trcl = ( -25.5245 25.5245 0.0000 )     u=3 $ Assembly 19
339 0          -301 #340  fill=5 ( -8.5090 25.5245 0.0000 )      $ Tube/Disk 20
           trcl = ( -8.5090 25.5245 0.0000 )      u=3
340 like 302 but    fill=11 trcl = ( -8.5090 25.5245 0.0000 )     u=3 $ Assembly 20
341 0          -301 #342  fill=5 ( 8.5090 25.5245 0.0000 )      $ Tube/Disk 21
           trcl = ( 8.5090 25.5245 0.0000 )      u=3
342 like 302 but    fill=11 trcl = ( 8.5090 25.5245 0.0000 )     u=3 $ Assembly 21
343 0          -301 #344  fill=5 ( 25.5245 25.5245 0.0000 )      $ Tube/Disk 22
           trcl = ( 25.5245 25.5245 0.0000 )      u=3
344 like 302 but    fill=11 trcl = ( 25.5245 25.5245 0.0000 )     u=3 $ Assembly 22
345 0          -301 #346  fill=5 ( 42.5399 25.5245 0.0000 )      $ Tube/Disk 23
           trcl = ( 42.5399 25.5245 0.0000 )      u=3
346 like 302 but    fill=11 trcl = ( 42.5399 25.5245 0.0000 )     u=3 $ Assembly 23
347 0          -302 #348  fill=7 ( 59.8729 26.4770 0.0000 )      $ Tube/Disk 24
           trcl = ( 59.8729 26.4770 0.0000 )      u=3
348 like 302 but    fill=10 trcl = ( 59.8729 26.4770 0.0000 )     u=3 $ Assembly 24
349 0          -302 #350  fill=8 ( -77.5233 8.8265 0.0000 )      $ Tube/Disk 25
           trcl = ( -77.5233 8.8265 0.0000 )      u=3
350 like 302 but    fill=10 trcl = ( -77.5233 8.8265 0.0000 )     u=3 $ Assembly 25
351 0          -302 #352  fill=6 ( -59.8729 8.8265 0.0000 )      $ Tube/Disk 26
           trcl = ( -59.8729 8.8265 0.0000 )      u=3
352 like 302 but    fill=10 trcl = ( -59.8729 8.8265 0.0000 )     u=3 $ Assembly 26
353 0          -301 #354  fill=5 ( -42.5399 8.5090 0.0000 )      $ Tube/Disk 27
           trcl = ( -42.5399 8.5090 0.0000 )      u=3
354 like 302 but    fill=11 trcl = ( -42.5399 8.5090 0.0000 )     u=3 $ Assembly 27
355 0          -301 #356  fill=5 ( -25.5245 8.5090 0.0000 )      $ Tube/Disk 28
           trcl = ( -25.5245 8.5090 0.0000 )      u=3
356 like 302 but    fill=11 trcl = ( -25.5245 8.5090 0.0000 )     u=3 $ Assembly 28
357 0          -301 #358  fill=5 ( -8.5090 8.5090 0.0000 )      $ Tube/Disk 29
           trcl = ( -8.5090 8.5090 0.0000 )      u=3
358 like 302 but    fill=11 trcl = ( -8.5090 8.5090 0.0000 )     u=3 $ Assembly 29
359 0          -301 #360  fill=5 ( 8.5090 8.5090 0.0000 )      $ Tube/Disk 30
           trcl = ( 8.5090 8.5090 0.0000 )      u=3
360 like 302 but    fill=11 trcl = ( 8.5090 8.5090 0.0000 )     u=3 $ Assembly 30
361 0          -301 #362  fill=5 ( 25.5245 8.5090 0.0000 )      $ Tube/Disk 31
           trcl = ( 25.5245 8.5090 0.0000 )      u=3
362 like 302 but    fill=11 trcl = ( 25.5245 8.5090 0.0000 )     u=3 $ Assembly 31
363 0          -301 #364  fill=5 ( 42.5399 8.5090 0.0000 )      $ Tube/Disk 32
           trcl = ( 42.5399 8.5090 0.0000 )      u=3
364 like 302 but    fill=11 trcl = ( 42.5399 8.5090 0.0000 )     u=3 $ Assembly 32
```

Figure 5.A.6-7 MPC-LACBWR MCNP Input File for Transfer Cask Dry Canister Bottom Axial Biasing – Lower End Fitting Damaged Fuel Neutron Source

```
365 0          -302 #366  fill=6 ( 59.8729 8.8265 0.0000 )      $ Tube/Disk 33
          trcl = ( 59.8729 8.8265 0.0000 )     u=3
366 like 302 but    fill=10 trcl = ( 59.8729 8.8265 0.0000 )     u=3 $ Assembly 33
367 0          -302 #368  fill=9 ( 77.5233 8.8265 0.0000 )      $ Tube/Disk 34
          trcl = ( 77.5233 8.8265 0.0000 )     u=3
368 like 302 but    fill=10 trcl = ( 77.5233 8.8265 0.0000 )     u=3 $ Assembly 34
369 0          -302 #370  fill=6 ( -77.5233 -8.8265 0.0000 )     $ Tube/Disk 35
          trcl = ( -77.5233 -8.8265 0.0000 )     u=3
370 like 302 but    fill=10 trcl = ( -77.5233 -8.8265 0.0000 )     u=3 $ Assembly 35
371 0          -302 #372  fill=6 ( -59.8729 -8.8265 0.0000 )     $ Tube/Disk 36
          trcl = ( -59.8729 -8.8265 0.0000 )     u=3
372 like 302 but    fill=10 trcl = ( -59.8729 -8.8265 0.0000 )     u=3 $ Assembly 36
373 0          -301 #374  fill=5 ( -42.5399 -8.5090 0.0000 )     $ Tube/Disk 37
          trcl = ( -42.5399 -8.5090 0.0000 )     u=3
374 like 302 but    fill=11 trcl = ( -42.5399 -8.5090 0.0000 )     u=3 $ Assembly 37
375 0          -301 #376  fill=5 ( -25.5245 -8.5090 0.0000 )     $ Tube/Disk 38
          trcl = ( -25.5245 -8.5090 0.0000 )     u=3
376 like 302 but    fill=11 trcl = ( -25.5245 -8.5090 0.0000 )     u=3 $ Assembly 38
377 0          -301 #378  fill=5 ( -8.5090 -8.5090 0.0000 )     $ Tube/Disk 39
          trcl = ( -8.5090 -8.5090 0.0000 )     u=3
378 like 302 but    fill=11 trcl = ( -8.5090 -8.5090 0.0000 )     u=3 $ Assembly 39
379 0          -301 #380  fill=5 ( 8.5090 -8.5090 0.0000 )     $ Tube/Disk 40
          trcl = ( 8.5090 -8.5090 0.0000 )     u=3
380 like 302 but    fill=11 trcl = ( 8.5090 -8.5090 0.0000 )     u=3 $ Assembly 40
381 0          -301 #382  fill=5 ( 25.5245 -8.5090 0.0000 )     $ Tube/Disk 41
          trcl = ( 25.5245 -8.5090 0.0000 )     u=3
382 like 302 but    fill=11 trcl = ( 25.5245 -8.5090 0.0000 )     u=3 $ Assembly 41
383 0          -301 #384  fill=5 ( 42.5399 -8.5090 0.0000 )     $ Tube/Disk 42
          trcl = ( 42.5399 -8.5090 0.0000 )     u=3
384 like 302 but    fill=11 trcl = ( 42.5399 -8.5090 0.0000 )     u=3 $ Assembly 42
385 0          -302 #386  fill=6 ( 59.8729 -8.8265 0.0000 )     $ Tube/Disk 43
          trcl = ( 59.8729 -8.8265 0.0000 )     u=3
386 like 302 but    fill=10 trcl = ( 59.8729 -8.8265 0.0000 )     u=3 $ Assembly 43
387 0          -302 #388  fill=7 ( 77.5233 -8.8265 0.0000 )     $ Tube/Disk 44
          trcl = ( 77.5233 -8.8265 0.0000 )     u=3
388 like 302 but    fill=10 trcl = ( 77.5233 -8.8265 0.0000 )     u=3 $ Assembly 44
389 0          -302 #390  fill=6 ( -59.8729 -26.4770 0.0000 )     $ Tube/Disk 45
          trcl = ( -59.8729 -26.4770 0.0000 )     u=3
390 like 302 but    fill=10 trcl = ( -59.8729 -26.4770 0.0000 )     u=3 $ Assembly 45
391 0          -301 #392  fill=5 ( -42.5399 -25.5245 0.0000 )     $ Tube/Disk 46
          trcl = ( -42.5399 -25.5245 0.0000 )     u=3
392 like 302 but    fill=11 trcl = ( -42.5399 -25.5245 0.0000 )     u=3 $ Assembly 46
393 0          -301 #394  fill=5 ( -25.5245 -25.5245 0.0000 )     $ Tube/Disk 47
          trcl = ( -25.5245 -25.5245 0.0000 )     u=3
394 like 302 but    fill=11 trcl = ( -25.5245 -25.5245 0.0000 )     u=3 $ Assembly 47
395 0          -301 #396  fill=5 ( -8.5090 -25.5245 0.0000 )     $ Tube/Disk 48
          trcl = ( -8.5090 -25.5245 0.0000 )     u=3
396 like 302 but    fill=11 trcl = ( -8.5090 -25.5245 0.0000 )     u=3 $ Assembly 48
397 0          -301 #398  fill=5 ( 8.5090 -25.5245 0.0000 )     $ Tube/Disk 49
          trcl = ( 8.5090 -25.5245 0.0000 )     u=3
398 like 302 but    fill=11 trcl = ( 8.5090 -25.5245 0.0000 )     u=3 $ Assembly 49
399 0          -301 #400  fill=5 ( 25.5245 -25.5245 0.0000 )     $ Tube/Disk 50
          trcl = ( 25.5245 -25.5245 0.0000 )     u=3
400 like 302 but    fill=11 trcl = ( 25.5245 -25.5245 0.0000 )     u=3 $ Assembly 50
401 0          -301 #402  fill=5 ( 42.5399 -25.5245 0.0000 )     $ Tube/Disk 51
          trcl = ( 42.5399 -25.5245 0.0000 )     u=3
402 like 302 but    fill=11 trcl = ( 42.5399 -25.5245 0.0000 )     u=3 $ Assembly 51
403 0          -302 #404  fill=7 ( 59.8729 -26.4770 0.0000 )     $ Tube/Disk 52
          trcl = ( 59.8729 -26.4770 0.0000 )     u=3
404 like 302 but    fill=10 trcl = ( 59.8729 -26.4770 0.0000 )     u=3 $ Assembly 52
405 0          -302 #406  fill=6 ( -61.2699 -44.1274 0.0000 )     $ Tube/Disk 53
          trcl = ( -61.2699 -44.1274 0.0000 )     u=3
406 like 302 but    fill=10 trcl = ( -61.2699 -44.1274 0.0000 )     u=3 $ Assembly 53
407 0          -301 #408  fill=5 ( -42.5399 -42.5399 0.0000 )     $ Tube/Disk 54
```

Figure 5.A.6-7 MPC-LACBWR MCNP Input File for Transfer Cask Dry Canister Bottom Axial Biasing – Lower End Fitting Damaged Fuel Neutron Source

```
           trcl = ( -42.5399 -42.5399 0.0000 )      u=3
408 like 302 but    fill=11 trcl = ( -42.5399 -42.5399 0.0000 )     u=3 $ Assembly 54
409 0          -301 #410  fill=5 ( -25.5245 -42.5399 0.0000 )     $ Tube/Disk 55
           trcl = ( -25.5245 -42.5399 0.0000 )      u=3
410 like 302 but    fill=11 trcl = ( -25.5245 -42.5399 0.0000 )     u=3 $ Assembly 55
411 0          -301 #412  fill=5 ( -8.5090 -42.5399 0.0000 )     $ Tube/Disk 56
           trcl = ( -8.5090 -42.5399 0.0000 )      u=3
412 like 302 but    fill=11 trcl = ( -8.5090 -42.5399 0.0000 )     u=3 $ Assembly 56
413 0          -301 #414  fill=5 ( 8.5090 -42.5399 0.0000 )     $ Tube/Disk 57
           trcl = ( 8.5090 -42.5399 0.0000 )      u=3
414 like 302 but    fill=11 trcl = ( 8.5090 -42.5399 0.0000 )     u=3 $ Assembly 57
415 0          -301 #416  fill=5 ( 25.5245 -42.5399 0.0000 )     $ Tube/Disk 58
           trcl = ( 25.5245 -42.5399 0.0000 )      u=3
416 like 302 but    fill=11 trcl = ( 25.5245 -42.5399 0.0000 )     u=3 $ Assembly 58
417 0          -301 #418  fill=5 ( 42.5399 -42.5399 0.0000 )     $ Tube/Disk 59
           trcl = ( 42.5399 -42.5399 0.0000 )      u=3
418 like 302 but    fill=11 trcl = ( 42.5399 -42.5399 0.0000 )     u=3 $ Assembly 59
419 0          -302 #420  fill=7 ( 61.2699 -44.1274 0.0000 )     $ Tube/Disk 60
           trcl = ( 61.2699 -44.1274 0.0000 )      u=3
420 like 302 but    fill=10 trcl = ( 61.2699 -44.1274 0.0000 )     u=3 $ Assembly 60
421 0          -302 #422  fill=6 ( -44.1274 -61.2699 0.0000 )     $ Tube/Disk 61
           trcl = ( -44.1274 -61.2699 0.0000 )      u=3
422 like 302 but    fill=10 trcl = ( -44.1274 -61.2699 0.0000 )     u=3 $ Assembly 61
423 0          -302 #424  fill=6 ( -26.4770 -59.8729 0.0000 )     $ Tube/Disk 62
           trcl = ( -26.4770 -59.8729 0.0000 )      u=3
424 like 302 but    fill=10 trcl = ( -26.4770 -59.8729 0.0000 )     u=3 $ Assembly 62
425 0          -302 #426  fill=6 ( -8.8265 -59.8729 0.0000 )     $ Tube/Disk 63
           trcl = ( -8.8265 -59.8729 0.0000 )      u=3
426 like 302 but    fill=10 trcl = ( -8.8265 -59.8729 0.0000 )     u=3 $ Assembly 63
427 0          -302 #428  fill=6 ( 8.8265 -59.8729 0.0000 )     $ Tube/Disk 64
           trcl = ( 8.8265 -59.8729 0.0000 )      u=3
428 like 302 but    fill=10 trcl = ( 8.8265 -59.8729 0.0000 )     u=3 $ Assembly 64
429 0          -302 #430  fill=6 ( 26.4770 -59.8729 0.0000 )     $ Tube/Disk 65
           trcl = ( 26.4770 -59.8729 0.0000 )      u=3
430 like 302 but    fill=10 trcl = ( 26.4770 -59.8729 0.0000 )     u=3 $ Assembly 65
431 0          -302 #432  fill=7 ( 44.1274 -61.2699 0.0000 )     $ Tube/Disk 66
           trcl = ( 44.1274 -61.2699 0.0000 )      u=3
432 like 302 but    fill=10 trcl = ( 44.1274 -61.2699 0.0000 )     u=3 $ Assembly 66
433 0          -302 #434  fill=7 ( -8.8265 -77.5233 0.0000 )     $ Tube/Disk 67
           trcl = ( -8.8265 -77.5233 0.0000 )      u=3
434 like 302 but    fill=10 trcl = ( -8.8265 -77.5233 0.0000 )     u=3 $ Assembly 67
435 0          -302 #436  fill=7 ( 8.8265 -77.5233 0.0000 )     $ Tube/Disk 68
           trcl = ( 8.8265 -77.5233 0.0000 )      u=3
436 like 302 but    fill=10 trcl = ( 8.8265 -77.5233 0.0000 )     u=3 $ Assembly 68
437 0          +303 +304         $ Canister Cavity Q1
      #303 #311 #313 #315 #325 #327 #329 #331 #341
      #304 #312 #314 #316 #326 #328 #330 #332 #342
      #343 #345 #347 #359 #361 #363 #365 #367
      #344 #346 #348 #360 #362 #364 #366 #368
          fill=4      u=3
438 0          +303 -304         $ Canister Cavity Q2
      #301 #305 #307 #309 #317 #319 #321 #323 #333
      #302 #306 #308 #310 #318 #320 #322 #324 #334
      #335 #337 #339 #349 #351 #353 #355 #357
      #336 #338 #340 #350 #352 #354 #356 #358
          fill=4      u=3
439 0          -303 -304         $ Canister Cavity Q3
      #369 #371 #373 #375 #377 #389 #391 #393 #395
      #370 #372 #374 #376 #378 #390 #392 #394 #396
      #405 #407 #409 #411 #421 #423 #425 #433
      #406 #408 #410 #412 #422 #424 #426 #434
          fill=4      u=3
440 0          -303 +304         $ Canister Cavity Q4
      #379 #381 #383 #385 #387 #397 #399 #401 #403
```

Figure 5.A.6-7 MPC-LACBWR MCNP Input File for Transfer Cask Dry Canister Bottom Axial Biasing – Lower End Fitting Damaged Fuel Neutron Source

```
      #380 #382 #384 #386 #388 #398 #400 #402 #404
      #413 #415 #417 #419 #427 #429 #431 #435
      #414 #416 #418 #420 #428 #430 #432 #436
          fill=4     u=3
C Cells - Canister v1.0
501 0         -501 fill=3      u=2 $ Cavity
502 6 -7.9400 -507 +501.3      u=2 $ Canister Bottom
503 0         -502 +501.2 -505 trcl = ( 72.8704 22.2787 0.0000 )    u=2 $ Bottom Drain Port
504 0         -503 +505 -506 trcl = ( 72.8704 22.2787 0.0000 )    u=2 $ Middle Drain Port
505 6 -7.9400 -504 +506 -507.2 trcl = ( 72.8704 22.2787 0.0000 )    u=2 $ Top Drain Port
506 like 503 but   trcl = ( -72.8704 -22.2787 0.0000 )    u=2 $ Bottom Vent Port
507 like 504 but   trcl = ( -72.8704 -22.2787 0.0000 )    u=2 $ Middle Vent Port
508 like 505 but   trcl = ( -72.8704 -22.2787 0.0000 )    u=2 $ Top Vent Port
509 6 -7.9400 -507 -501.3 +501.1     u=2 $ Canister Shell
510 6 -7.9400 -507 -501.1 +501.2 #503 #504 #505 #506 #507 #508     u=2 $ Lid
511 0         +507      u=2 $ Outside
C Transfer Cask Cells - v4.0
601 0         -601 -602  fill=2 ( 0.0000 0.0000 2.5400 )   u=1 $ Cavity
602 7 -7.8212 -601 +602 -606    u=1 $ Bottom forging
603 7 -7.8212 -603 +602 +606 -607 +613  u=1 $ Inner shell
604 10 -11.344 -604 +603 +606 -607 +613  u=1 $ Lead shell
605 11 -1.6316 -605 +604 +606 -607 +613  u=1 $ NS-4-FR
606 7 -7.8212 -601 +605 +606 -607 +613  u=1 $ Outer shell
607 7 -7.8212 -601 +602 +607    u=1 $ Top forging
608 7 -7.8212 -601 +602 -613    u=1 $ Trunnion
609 7 -7.8212 (-608 +609 -615) : (-608 -610 -615)      u=1 $ Door rail
610 7 -7.8212 -614 -611 +612 -615   u=1 $ Door steel
611 0         +601 #609  #610     u=1 $ Void
C Detector Cells - Axial Biasing
700  0  -700  fill=1  $ Surface
800  0  -800  +700  $ 1ft
900  0  -900  +700  +800  $ 1m
1000  0  -1000  +700  +800  +900  $ 2m
1100  0  -1100  +700  +800  +900  +1000  $ 4m
1200  0  +700  +800  +900  +1000  +1100  $ Exterior

C Fuel Assembly Surfaces - v1.0
1 RPP -7.1247 7.1247 -7.1247 7.1247 0.0000 261.9502  $ Assy
2 PZ 27.2796       $ Lower Nozzle/Fuel
3 PZ 238.0996       $ Fuel/Upper Plenum
4 PZ 251.1298       $ Upper Plenum/Upper Nozzle
C Surfaces - Standard Fuel Tube v1.0
101 RPP -7.3076 7.3076 -7.3076 7.3076 0.0000 274.4470    $ Tube void
102 RPP -7.4295 7.4295 -7.4295 7.4295 0.0000 249.5550    $ Tube
103 RPP -6.5913 6.5913 7.4295 7.6200 2.0320 245.8720    $ Absorber +Y
104 RPP -6.5913 6.5913 7.6200 7.6657 2.0320 245.8720    $ Cladding +Y
105 RPP 7.4295 7.6200 -6.5913 6.5913 2.0320 245.8720    $ Absorber +X
106 RPP 7.6200 7.6657 -6.5913 6.5913 2.0320 245.8720    $ Cladding +X
C Surfaces - DFC Fuel Tube v1.0
107 RPP -7.6251 7.6251 -7.6251 7.6251 0.0000 274.4470    $ Tube void
108 RPP -7.7470 7.7470 -7.7470 7.7470 0.0000 249.5550    $ Tube
109 RPP -6.5913 6.5913 7.7470 7.9375 2.0320 245.8720    $ Absorber +Y
110 RPP -6.5913 6.5913 7.9375 7.9832 2.0320 245.8720    $ Cladding +Y
111 RPP 7.7470 7.9375 -6.5913 6.5913 2.0320 245.8720    $ Absorber +X
112 RPP 7.9375 7.9832 -6.5913 6.5913 2.0320 245.8720    $ Cladding +X
c Surface Cards - Disk Stack  v1.0
201 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 1.5875 88.1380 $ Structural disk
202 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 1.2700 87.7951 $ Heat transfer disk
203 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 2.5400 88.0491 $ Weldment disk
c Surface Cards - Basket v1.0
301 RPP -7.7711 7.7711 -7.7711 7.7711 0.0000 274.4470  $ Std opening
302 RPP -8.0899 8.0899 -8.0899 8.0899 0.0000 274.4470  $ DFC opening
303 PY 0.0000       $ Cut plane
304 PX 0.0000       $ Cut plane
```

Figure 5.A.6-7 MPC-LACBWR MCNP Input File for Transfer Cask Dry Canister Bottom Axial Biasing – Lower End Fitting Damaged Fuel Neutron Source

```
C Surfaces - Canister v1.0
501 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 274.4470 88.4428   $ Cavity
502 CZ 1.3843          $ Bot Cylinder Radius
503 CZ 5.0800          $ Mid Cyclinder Radius
504 CZ 5.7150          $ Top Cylinder Radius
505 PZ 282.8798          $ Port plane bot/mid
506 PZ 289.3822          $ Port plane mid/top
507 RCC 0.0000 0.0000 -2.5400 0.0000 0.0000 294.7670 89.7128   $ Canister
C Transfer Cask Surfaces - v4.0
601 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 313.6900 109.8550  $ Cask
602 CZ 90.8050         $ Cavity
603 CZ 92.7100         $ Inner shell OR
604 CZ 101.6000         $ Lead shell OR
605 CZ 106.6800         $ Outer shell IR
606 PZ 2.5400         $ Bottom forging
607 PZ 308.6100         $ Top forging
608 RPP -110.1852 110.1852 -107.3150 107.3150 -24.1300 0.0000   $ Door container
609 PY 95.8850         $ Inside rail +y
610 PY -95.8850         $ Inside rail -y
611 PY 95.4024         $ Door +y
612 PY -95.4024         $ Door -y
613 RCC -109.8550 0.0000 275.5900 219.7100 0.0000 0.0000 12.7000  $ Trunnion
614 RHP 0.0000 0.0000 -24.1300 0.0000 0.0000 24.1300   $ Door prism
        109.6679 0.0000 0.0000 87.5826 -66.1670 0.0000
        -87.5826 -66.1670 0.0000
615 RCC 0.0000 0.0000 -24.1300 0.0000 0.0000 24.1300 109.8550  $ Door container
C Axial Detector DBA (Surface)
700  RCC  0.0000  0.0000  -24.2300  0.0000  0.0000  338.0200  109.9550
701  CZ  10.9955
702  CZ  21.9910
703  CZ  32.9865
704  CZ  43.9820
705  CZ  54.9775
706  CZ  65.9730
707  CZ  76.9685
708  CZ  87.9640
709  CZ  98.9595
C Axial Detector DBB (1ft)
800  RCC  0.0000  0.0000  -54.7100  0.0000  0.0000  368.5000  140.4350
801  CZ  14.0435
802  CZ  28.0870
803  CZ  42.1305
804  CZ  56.1740
805  CZ  70.2175
806  CZ  84.2610
807  CZ  98.3045
808  CZ  112.3480
809  CZ  126.3915
C Axial Detector DBC (1m)
900  RCC  0.0000  0.0000  -124.2300  0.0000  0.0000  438.0200  209.9550
901  CZ  20.9955
902  CZ  41.9910
903  CZ  62.9865
904  CZ  83.9820
905  CZ  104.9775
906  CZ  125.9730
907  CZ  146.9685
908  CZ  167.9640
909  CZ  188.9595
C Axial Detector DBD (2m)
1000  RCC  0.0000  0.0000  -224.2300  0.0000  0.0000  538.0200  309.9550
1001  CZ  30.9955
1002  CZ  61.9910
1003  CZ  92.9865
```

Figure 5.A.6-7 MPC-LACBWR MCNP Input File for Transfer Cask Dry Canister Bottom Axial Biasing – Lower End Fitting Damaged Fuel Neutron Source

```
1004  CZ  123.9820
1005  CZ  154.9775
1006  CZ  185.9730
1007  CZ  216.9685
1008  CZ  247.9640
1009  CZ  278.9595
C Axial Detector DBE (4m)
1100  RCC  0.0000  0.0000  -424.2300  0.0000  0.0000  738.0200  509.9550
1101  CZ  50.9955
1102  CZ  101.9910
1103  CZ  152.9865
1104  CZ  203.9820
1105  CZ  254.9775
1106  CZ  305.9730
1107  CZ  356.9685
1108  CZ  407.9640
1109  CZ  458.9595

C
C Materials List - Common Materials - v1.0
C
C Homogenized Lower Nozzle
m1    24000 -1.9000E-01
      25055 -2.0000E-02
      26000 -6.9500E-01
      28000 -9.5000E-02
C Homogenized UO2 Fuel
m2    24000 -2.9967E-02
      25055 -3.1544E-03
      26000 -1.0961E-01
      28000 -1.4983E-02
      92235 -2.6729E-02
      92238 -7.1574E-01
       8016 -9.9810E-02
C Homogenized Upper Plenum
m3    24000 -1.9000E-01
      25055 -2.0000E-02
      26000 -6.9500E-01
      28000 -9.5000E-02
C Homogenized Upper Nozzle
m4    24000 -0.190 25055 -0.020 26000 -0.695
      28000 -0.095
C Water
m5    1001 2 8016 1
C Stainless Steel
m6    24000 -0.190 25055 -0.020 26000 -0.695
      28000 -0.095
C Carbon Steel
m7    26000 -0.99 6012 -0.01
C Neutron Poison
m8    13027 -0.8466  5010 -0.0216  5011 -0.0985
       6012 -0.0333
C Aluminum
m9    13027 -1.0
C Lead
m10   82000 -1.0
C NS-4-FR
m11    5010 -9.3127E-04 13027 -2.1420E-01  6012 -2.7627E-01
       5011 -3.7721E-03  1001 -6.0012E-02  7014 -1.9815E-02
       8016 -4.2500E-01
C Concrete
m12   26000 -0.014 20000 -0.044 14000 -0.337
       1001 -0.010  8016 -0.532 11023 -0.029
      13027 -0.034
```

Figure 5.A.6-7 MPC-LACBWR MCNP Input File for Transfer Cask Dry Canister Bottom Axial Biasing – Lower End Fitting Damaged Fuel Neutron Source

```
C Vent Port Middle Cylinder
m13   24000 -0.190 25055 -0.020 26000 -0.695
      28000 -0.095
C Damaged Lower Nozzle
m15   24000 -2.7312E-02
      25055 -2.8750E-03
      26000 -9.9905E-02
      28000 -1.3656E-02
      92235 -2.7172E-02
      92238 -7.2761E-01
      8016 -1.0147E-01
nonu                  $ Disable subcritical multiplication
C
C Cell Importances
C
imp:n 1 244r 0
C
C BWR Source Definition - Lower Nozzle - DamagedNut - PrefD
C
sdef x=d1 y=d2 z=d3 erg=d4 cell=700:601:501:d5:6
si1   -7.1247 7.1247
sp1   0 1
si2   -7.1247 7.1247
sp2   0 1
si3   0.0000 27.2796
sp3   0 1
si4   1.000E-11 7.090E-08 5.500E-07 1.500E-06 4.000E-06 1.600E-05
      4.810E-05 1.660E-04 3.540E-04 9.610E-04 2.950E-03 9.120E-03
      2.480E-02 6.740E-02 1.100E-01 3.900E-01 6.400E-01 1.740E+00
      2.870E+00 3.680E+00 4.720E+00 6.070E+00 7.000E+00 8.250E+00
      1.000E+01 1.125E+01 1.250E+01 1.360E+01 1.460E+01
sp4   0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
      0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
      0.0000E+00 0.0000E+00 2.4850E+01 6.1350E+04 1.7620E+05 7.3960E+05
      6.2630E+05 2.6030E+05 1.4660E+05 7.8130E+04 2.3350E+04 1.3530E+04
      5.0380E+03 1.6060E+03 4.8350E+02 1.1600E+02 0.0000E+00
C Source Information
si5 1                  302  304
               306  308  310  312  314  316
           318        332
           334        348
       350  352        366  368
       370  372        386  388
           390        404
           406        420
               422  424  426  428  430  432
                       434  436
C Source Probability
sp5                   0.36 0.36
              0.36 0.36 0.36 0.36 0.36 0.36
          0.36       0.36
          0.36       0.36
      0.36 0.36       0.36 0.36
      0.36 0.36       0.36 0.36
          0.36       0.36
          0.36       0.36
              0.36 0.36 0.36 0.36 0.36 0.36
                      0.36 0.36
mode n
nps 9100000
C
C ANSI/ANS-6.1.1-1977 - Neutron Flux-to-Dose Conversion Factors
C (mrem/hr)/(neutrons/cm2-sec)
C
```

Figure 5.A.6-7 MPC-LACBWR MCNP Input File for Transfer Cask Dry Canister Bottom Axial Biasing – Lower End Fitting Damaged Fuel Neutron Source

```
de0   2.5E-08 1E-07 1E-06 0.00001 0.0001 0.001 0.01
      0.1 0.5 1 2.5 5 7 10
      14 20
df0   3.67E-03 3.67E-03 4.46E-03 4.54E-03 4.18E-03 3.76E-03 3.56E-03
      2.17E-02 9.26E-02 1.32E-01 1.25E-01 1.56E-01 1.47E-01 1.47E-01
      2.08E-01 2.27E-01
c
c Weight Window Generation - Bottom Axial
c
wwg 2 0 0 0 0
wwp:n 5 3 5 0 -1 0
mesh geom=cyl ref=9 9 4 origin=0.1 0.1 -524
     imesh 88.4 89.7 90.8 92.7 101.6 106.7 109.9 609.9
     iints 5 1 1 1 1 1 1 1
     jmesh 500 524 527 554 765 778 789 801 819 1319
     jints 1 1 1 1 10 1 1 1 2 1
     kmesh 1
     kints 1
wwge:n  1e-5 1e-3 1 20
fc2 Axial Surface Tally
f2:n +700.3
fm2 7.2567E+07
fs2  -701  -702  -703  -704  -705  -706
     -707  -708  -709  T
tf2
fc12 Axial 1ft Tally
f12:n +800.3
fm12 7.2567E+07
fs12  -801  -802  -803  -804  -805  -806
     -807  -808  -809  T
tf12
fc22 Axial 1m Tally
f22:n +900.3
fm22 7.2567E+07
fs22  -901  -902  -903  -904  -905  -906
     -907  -908  -909  T
tf22
fc32 Axial 2m Tally
f32:n +1000.3
fm32 7.2567E+07
fs32  -1001  -1002  -1003  -1004  -1005  -1006
     -1007  -1008  -1009  T
tf32
fc42 Axial 4m Tally
f42:n +1100.3
fm42 7.2567E+07
fs42  -1101  -1102  -1103  -1104  -1105  -1106
     -1107  -1108  -1109  T
tf42
c
c
c Print Control
c
prdmp -30 -60 1 2
print
c
c Random Number Generator
c
rand gen=2 seed=19073486328125 stride=152917 hist=1
c
c Rotation Matrix
c
c 5.625 degree rotation around z-axis
*TR1 0.0 0.0 0.0 5.625 95.625 90 -84.375 5.625 90 90 90 0
```

Figure 5.A.6-7 MPC-LACBWR MCNP Input File for Transfer Cask Dry Canister Bottom Axial Biasing – Lower End Fitting Damaged Fuel Neutron Source

```
C 11.25 degree rotation around z-axis
*TR2 0.0 0.0 0.0 11.250 101.250 90 -78.750 11.250 90 90 90 0
C 16.875 degree rotation around z-axis
*TR3 0.0 0.0 0.0 16.875 106.875 90 -73.125 16.875 90 90 90 0
C 22.5 degree rotation around z-axis
*TR4 0.0 0.0 0.0 22.500 112.500 90 -67.500 22.500 90 90 90 0
C 28.125 degree rotation around z-axis
*TR5 0.0 0.0 0.0 28.125 118.125 90 -61.875 28.125 90 90 90 0
C 33.75 degree rotation around z-axis
*TR6 0.0 0.0 0.0 33.750 123.750 90 -56.250 33.750 90 90 90 0
C 39.375 degree rotation around z-axis
*TR7 0.0 0.0 0.0 39.375 129.375 90 -50.625 39.375 90 90 90 0
C 45 degree rotation around z-axis
*TR8 0.0 0.0 0.0 45.000 135.000 90 -45.000 45.000 90 90 90 0
C 50.625 degree rotation around z-axis
*TR9 0.0 0.0 0.0 50.625 140.625 90 -39.375 50.625 90 90 90 0
C 56.25 degree rotation around z-axis
*TR10 0.0 0.0 0.0 56.250 146.250 90 -33.750 56.250 90 90 90 0
C 61.875 degree rotation around z-axis
*TR11 0.0 0.0 0.0 61.875 151.875 90 -28.125 61.875 90 90 90 0
C 67.5 degree rotation around z-axis
*TR12 0.0 0.0 0.0 67.500 157.500 90 -22.500 67.500 90 90 90 0
C 73.125 degree rotation around z-axis
*TR13 0.0 0.0 0.0 73.125 163.125 90 -16.875 73.125 90 90 90 0
C 78.75 degree rotation around z-axis
*TR14 0.0 0.0 0.0 78.750 168.750 90 -11.250 78.750 90 90 90 0
C 84.375 degree rotation around z-axis
*TR15 0.0 0.0 0.0 84.375 174.375 90 -5.625 84.375 90 90 90 0
C 95.625 degree rotation around z-axis
*TR16 0.0 0.0 0.0 95.625 185.625 90 5.625 95.625 90 90 90 0
C 101.25 degree rotation around z-axis
*TR17 0.0 0.0 0.0 101.250 191.250 90 11.250 101.250 90 90 90 0
C 106.875 degree rotation around z-axis
*TR18 0.0 0.0 0.0 106.875 196.875 90 16.875 106.875 90 90 90 0
C 112.5 degree rotation around z-axis
*TR19 0.0 0.0 0.0 112.500 202.500 90 22.500 112.500 90 90 90 0
C 118.125 degree rotation around z-axis
*TR20 0.0 0.0 0.0 118.125 208.125 90 28.125 118.125 90 90 90 0
C 123.75 degree rotation around z-axis
*TR21 0.0 0.0 0.0 123.750 213.750 90 33.750 123.750 90 90 90 0
C 129.375 degree rotation around z-axis
*TR22 0.0 0.0 0.0 129.375 219.375 90 39.375 129.375 90 90 90 0
C 135 degree rotation around z-axis
*TR23 0.0 0.0 0.0 135.000 225.000 90 45.000 135.000 90 90 90 0
C 140.625 degree rotation around z-axis
*TR24 0.0 0.0 0.0 140.625 230.625 90 50.625 140.625 90 90 90 0
C 146.25 degree rotation around z-axis
*TR25 0.0 0.0 0.0 146.250 236.250 90 56.250 146.250 90 90 90 0
C 151.875 degree rotation around z-axis
*TR26 0.0 0.0 0.0 151.875 241.875 90 61.875 151.875 90 90 90 0
C 157.5 degree rotation around z-axis
*TR27 0.0 0.0 0.0 157.500 247.500 90 67.500 157.500 90 90 90 0
C 163.125 degree rotation around z-axis
*TR28 0.0 0.0 0.0 163.125 253.125 90 73.125 163.125 90 90 90 0
C 168.75 degree rotation around z-axis
*TR29 0.0 0.0 0.0 168.750 258.750 90 78.750 168.750 90 90 90 0
C 174.375 degree rotation around z-axis
*TR30 0.0 0.0 0.0 174.375 264.375 90 84.375 174.375 90 90 90 0
```

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6.0 CRITICALITY EVALUATION

This chapter provides the criticality evaluation of the NAC-MPC storage system and demonstrates that the NAC-MPC storage system is subcritical in accordance with the requirements of 10 CFR 72.124(a), 10 CFR 72.236(c) and Chapter 6 of NUREG-1536. The evaluations show that the effective neutron multiplication factor of the NAC-MPC system is less than 0.95, including biases and uncertainties under normal, off-normal and accident conditions.

The NAC-MPC storage system is comprised of a transportable storage canister (canister), a transfer cask and a vertical concrete cask (storage cask). The canister comprises a stainless steel canister and a basket. The basket comprises fuel tubes held in place with stainless steel support disks and tie rods. The transfer cask containing the canister and basket is loaded underwater in the spent fuel pool. Once loaded with fuel, the canister is drained, dried, inerted, and welded shut. The transfer cask is then used to transfer the canister to the storage cask where it is stored until transported off-site.

Under normal conditions, such as loading in a spent fuel pool, moderator (water) is present in the canister while it is in the transfer cask. Also, during draining and drying operations, the moderator is present and its density will vary. Thus, the criticality evaluation of the transfer cask includes a variation in moderator density and a determination of optimum moderator density. Assuming the most reactive mechanical basket configuration, moderator intrusion into the canister and moderator intrusion into the fuel cladding (100% fuel failure) bounds all normal, off-normal and accident conditions.

Under normal storage conditions, moderator is not present in the canister. However, access to the environment is possible via the air inlets in the storage cask and the convective heat transfer annulus between the canister and the storage cask steel liner. This provides paths for moderator intrusion during a flood. Under off-normal conditions, moderator intrusion into the convective heat transfer annulus is evaluated. Under accident conditions of the cask loaded with intact fuel, it is hypothetically assumed that the canister confinement fails, and moderator intrusion into the canister and into the fuel cladding (100% fuel failure) is evaluated. This is a highly conservative assumption, since, as shown in Chapters 3 and 11, there are no design basis normal, off-normal or accident conditions that result in the failure of the canister confinement boundary that would allow the intrusion of water.

The NAC-MPC is provided in three configurations. The first is designed to store up to 36 Yankee Class spent fuel assemblies and is referred to as the Yankee-MPC. The second is designed to store up to 26 Connecticut Yankee (CY) spent fuel assemblies and is referred to as the CY-MPC. The third, MPC-LACBWR, is designed to store up to 68 Dairyland Power Cooperative La Crosse Boiling Water Reactor(LACBWR) spent fuel assemblies, including up to 32 LACBWR damaged fuel cans. The transportable storage canister (canister) configurations differ primarily in fuel basket design, but also differ in overall length and weight. There are corresponding differences in the principal dimensions and weights of the transfer cask and vertical concrete casks used with each of these NAC-MPC storage systems.

6.1 Discussion and Results

A description of the Yankee Class fuel and a summary of the results of the Yankee-MPC criticality evaluation are presented in Section 6.1.1. The description of the Connecticut Yankee fuel and a summary of the CY-MPC criticality results are presented in Section 6.1.2. The description of the LACBWR fuel and a summary of the MPC-LACBWR criticality results are presented in Appendix 6.A.

The Yankee-MPC criticality evaluation is performed using the SCALE 4.3 Criticality Safety Analysis Sequence (CSAS). This sequence uses KENO-Va Monte Carlo analysis to determine the effective neutron multiplication factor, k_{eff}. The CY-MPC configurations are evaluated using the MONK8A Monte Carlo Program. Consequently, these configurations are evaluated using different modeling and analysis techniques, but similar fuel and system assumptions are conservatively established. These conservative assumptions include:

1. No fuel burnup (fresh fuel assumption).
2. No fission product build up as a poison.
3. Fuel assemblies of the most reactive type.
4. UO_2 fuel density at 95% of theoretical.
5. No dissolved boron in the spent fuel pool water (water temperature 293°K).
6. Infinite cask array.
7. Moderator intrusion into the intact fuel rod clad/pellet gap under accident conditions.
8. A most reactive mechanical configuration.

In addition, consistent with Section 6, Part IV of NUREG-1536, 75% of the specified minimum ^{10}B loading in the BORAL plates is assumed.

The evaluation of the two NAC-MPC storage systems, the spent fuel stored in these two systems, and the criticality evaluation methods used are described separately in the appropriate sections and/or appendix of this chapter.

6.1.1 Yankee-MPC System Criticality Discussion and Results

The criticality evaluation of the Yankee-MPC is performed with the SCALE 4.3 (ORNL) Criticality Safety Analysis Sequence (CSAS)(Landers). This sequence includes KENO-Va (Petrie) Monte Carlo analysis to determine the effective neutron multiplication factor (k_{eff}). The 27-group ENDF/B-IV neutron library (Jordan) is used in all calculations. CSAS with the 27-group library is benchmarked by comparison to 63 critical experiments relevant to Light Water Reactor fuel in storage and transport casks.

Criticality control in the Yankee-MPC canister basket is achieved using a flux trap principle. The flux trap principle controls the reactivity in the interior of each of the three basket configurations. In the first of the configurations, all fuel tubes are separated by a flux trap that is formed by surrounding the tube with stainless steel support disks and four 0.01g $^{10}B/cm^2$ (minimum) areal density BORAL sheets, which are held in place by stainless steel covers. In the second configuration, the size of the four fuel tubes (one outer tube in each quadrant of the basket, as shown in Figure 6.3.1-4) is increased by removing the BORAL sheets from the outside of the tubes. The remainder of the tubes have BORAL sheets on each of the four sides. In the third configuration, the four enlarged fuel tubes, which do not have BORAL sheets, are replaced with screened damaged fuel cans. The remainder of the fuel tubes have BORAL sheets on all four sides. The spacing of the fuel tubes is maintained by the stainless steel support disks. These disks provide water gap spacings between tubes of 0.875, 0.810, or 0.750 inches, depending on the position of the fuel tube in the basket. When the canister is flooded with water, fast neutrons leaking from the fuel assemblies are thermalized in the water gaps and are absorbed in the BORAL sheets before causing a fission in an adjacent fuel assembly. The Yankee-MPC basket can accommodate up to 36 Yankee Class Zircaloy-clad assemblies with a nominal initial enrichment of 4.0 wt % ^{235}U or 36 Yankee Class stainless steel-clad assemblies with a nominal initial enrichment of 4.94 wt % ^{235}U.

Criticality evaluations are performed for both the transfer and storage casks under normal, off-normal and accident conditions applying the conservative conditions and assumptions described in Section 6.1. As specified, these consider the most reactive fuel assembly type, worst case mechanical basket configuration and variations in moderator density. The maximum effective neutron multiplication factor with bias and uncertainties for the transfer cask is 0.9021. The maximum multiplication factor with bias and uncertainties for the storage cask is 0.4503 under normal dry storage conditions and 0.9018 under the hypothetical accident conditions involving full moderator intrusion. The maximum bias and uncertainty adjusted reactivities for the basket containing the four enlarged fuel tubes are slightly higher at 0.9175 for transfer conditions and 0.9182 for a hypothetical storage accident condition involving full moderator intrusion.

Analysis of simultaneous moderator density variation inside and outside either the transfer or storage casks shows a monotonic decrease in reactivity with decreasing moderator density. Thus, the full moderator density condition bounds any off-normal or accident situation. Analysis of moderator intrusion into the storage cask heat transfer annulus with the canister dry shows a slight decrease in reactivity from the completely dry condition.

Appendix 6.A CRITICALITY EVALUATION – MPC-LACBWR MPC STORAGE SYSTEM FOR DAIRYLAND POWER COOPERATIVE LA CROSSE BOILING WATER REACTOR

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6.A CRITICALITY EVALUATION OF THE MPC-LACBWR STORAGE SYSTEM

This appendix documents the method, input, and result of the criticality analysis of the LACBWR payload in the NAC-MPC system. The results demonstrate that the effective neutron multiplication factor, k_{eff}, of the system under normal conditions, or off-normal and accident events, is less than 0.95 including biases and uncertainties. The MPC-LACBWR system design meets the criticality requirements of 10 CFR 72 [A1] and Chapter 6 of NUREG-1536 [A2].

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6.A.1 Discussion and Results

The cask system consists of a TSC (Transportable Storage Canister), a transfer cask, and a concrete cask. The system is designed to safely store up to 68 LACBWR fuel assemblies of which up to 32 may be classified as damaged and be placed into damaged fuel cans (DFCs). The TSC is comprised of a stainless steel canister and a basket within which fuel is loaded. The DFC provides a screened container to prevent gross fissile material release into the TSC cavity from failed fuel rod clad. The TSC is loaded into the concrete cask for storage. A transfer cask is used for handling the TSC during loading of spent fuel. Fuel is loaded into the TSC contained within the transfer cask underwater in the spent fuel pool. Once loaded with fuel, the TSC closure lid is welded and the TSC is drained, dried and backfilled with helium. The transfer cask is then used to move the TSC into or out of the concrete cask. The transfer cask provides shielding during the TSC loading and transfer operations.

Under normal conditions, such as loading in a spent fuel pool, moderator (water) is present in the TSC during the initial stages of fuel transfer. During draining and drying operations, moderator with varying density is present. Thus, the criticality evaluation of the transfer cask includes a variation in moderator density and a determination of optimum moderator density. Cask accident conditions are bounded by inclusion in the analysis of the most reactive mechanical basket configuration as well as moderator intrusion into the fuel cladding, and preferential flooding of the DFCs.

Structural analyses demonstrate that the TSC confinement boundary remains intact through all storage operating conditions. Therefore, moderator is not present in the TSC while it is in the concrete cask. However, access to the concrete cask interior environment is possible via the air inlets and outlets and the heat transfer annulus between the TSC and the cask steel liner. This access provides paths for moderator intrusion during a flood. Under off-normal and accident conditions, moderator intrusion into the convective heat transfer annulus is evaluated.

System criticality control is achieved through the use of neutron absorber sheets (BORAL®) attached to the exterior faces of the fuel tubes. Individual fuel assemblies are held in place by stainless steel structural disks. The basket design includes 68 fuel tubes, one tube per fuel assembly or DFC, with the DFC tubes having a slightly larger (oversized) opening.

Criticality evaluations rely on modeled neutron absorber ^{10}B loadings of 0.015 g/cm^2. The modeled areal density is arrived at by multiplying the minimum 0.02 g/cm^2 ^{10}B areal density specified for the absorber by a 75% efficiency factor.

MCNP [A3], a three-dimensional Monte Carlo code, is used in the system criticality analysis. Evaluations are primarily based on the ENDF/B-VI continuous energy neutron cross-section library [A4] available in the MCNP distribution. Nuclides for which no ENDF/B-VI data is available are set to the latest cross-section sets available in the code distribution. The code and cross-section libraries are benchmarked by comparison to a range of critical experiments relevant to light water reactor fuel in storage and transport casks. An upper subcritical limit (USL) for the system is determined based on guidance given in NUREG/CR-6361 [A9].

Key assembly physical characteristics and maximum initial enrichment for the loading of the two LACBWR fuel assembly types are shown in Table 6.A.1-1, with the allowed loading configuration shown in Figure 6.A.1-1. Maximum enrichment is defined as planar-average enrichment for the variably enriched Exxon (EX) assemblies.

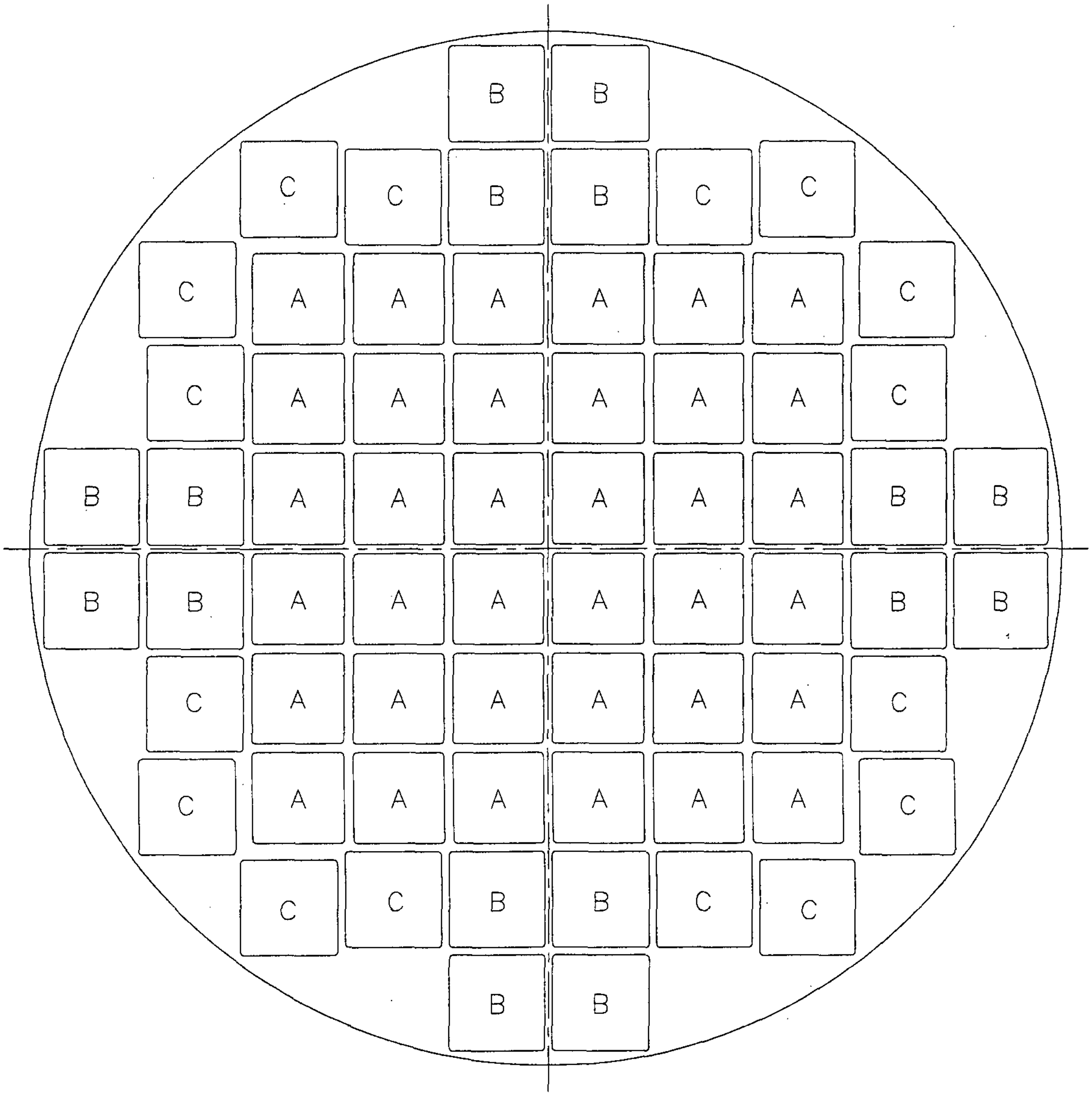
Undamaged fuel assemblies are evaluated with a full, nominal set of fuel rods. Fuel rod (lattice) locations may contain filler rods. A filler rod must occupy, at a minimum, a volume equivalent to the fuel rod it displaces. Filler rods may be placed into the lattice after assembly in-core use or be designed to replace fuel rods prior to use. The undamaged Exxon assembly must contain its nominal set of inert rods.

The maximum multiplication factors (k_{eff} +2σ) are calculated, using conservative assumptions, for the transfer and concrete casks. The USL applied to the analysis results is 0.9372 per Section 6.A.5. Maximum reactivities are produced by the damaged fuel payloads. The results of the analyses are presented in detail in Section 6.A.4.4 and are summarized as follows.

		Water Density (g/cc)			
Cask Body	**Operating Condition**	**TSC Interior**	**DFC Interior**	**TSC Exterior**	**k_{eff}+2σ**
Transfer	--	0.0001	0.0001	0.0001	0.35333
Transfer	--	0.9982	0.9982	0.0001	0.87655
Transfer	--	0.9982	0.9982	0.9982	0.87636
Transfer	--	0.0001	0.9982	0.9982	0.91423
Transfer	--	0.0001	0.9982	0.0001	0.93014
Storage	Normal	0.0001	0.0001	0.0001	0.34222
Storage	Accident	0.0001	0.0001	0.9982	0.33691

Analysis of moderator density in the canister shows a monotonic decrease in reactivity with decreasing moderator density for undamaged fuel. The full moderator density TSC interior condition bounds any off-normal or accident condition with the exception of the preferentially flooded DFC case. Analysis of moderator intrusion into the concrete cask heat transfer annulus with the dry TSC shows a slight decrease in reactivity from the completely dry condition.

Figure 6.A.1-1 Allowed Loading Configuration for LACBWR Fuel



Slot A: Undamaged Exxon fuel maximum planar average enrichment 3.71 wt % ^{235}U.

Slot B: Undamaged or damaged Exxon fuel maximum planar average enrichment 3.71 wt % ^{235}U.

Damaged Allis Chalmers fuel maximum enrichment 3.64 wt % ^{235}U.

Slot C: Undamaged or damaged Exxon fuel maximum planar average enrichment 3.71 wt % ^{235}U.

Damaged Allis Chalmers fuel maximum enrichment 3.94 wt % ^{235}U.

Table 6.A.1-1 Bounding Fuel Assembly Loading Criteria

Fuel ID		AC	EX
Array		10×10	10×10
Number of Fuel Rods		100	96
Max. Active Length	[in]	83	83
Rod Pitch	[in]	0.565	0.557
Rod Diameter	[in]	0.396	0.394
Pellet Diameter	[in]	0.350	0.343
Clad Thickness	[in]	0.020	0.0220
Max. MTU(5)	[MTU]	0.1214	0.1119
Number of Inert Rods(1,2)		0	4
Listed Inert Rod OD	[in]	N/A	0.3940
Max. Enrichment	[wt.% ^{235}U]	3.64/3.94(4)	3.71(3)

Notes:

(1) Not required for fuel assemblies located in DFC.

(2) Inert rods comprised of stainless steel clad tube containing zirconium alloy slug.

(3) Planar average enrichment.

(4) Two AC fuel types, Type 1 at an enrichment of 3.64 wt % ^{235}U and Type 2 at 3.94 wt % ^{235}U.

(5) Damaged fuel cans are allowed to contain an additional 5% fissile material to account for loose pellets not necessarily associated with the as-built assembly.

General Note: All dimensions represent nominal, cold, unirradiated values.

6.A.2 Spent Fuel Loading

There are two primary fuel types with distinct physical characteristics, Allis Chalmers (AC) and Exxon Nuclear Corporation (EX) fuel. AC fuel was constructed at two different enrichments while EX fuel contains a radial enrichment pattern. Relevant fuel characteristics are shown in Table 6.A.2-1.

Table 6.A.2-1 Fuel Assembly Characteristics

Fuel ID		AC	EX
Array		10×10	10×10
Number of Fuel Rods		100	96
Active Length	[in]	83.0	83.0
Rod Pitch	[in]	0.5650	0.5570
Rod Diameter	[in]	0.396	0.394
Pellet Diameter	[in]	0.3500	0.3430
Clad Thickness	[in]	0.0200	0.0220
Fuel Assembly Width	[in]	5.603	5.614
Fuel Assembly Height	[in]	102.34	102.45
Fuel Rod Height	[in]	87.820	88.03
Upper Nozzle Height	[in]	4.260	3.76
Top End-Cap Height	[in]	1.280	0.386
Upper Plenum Region Height	[in]	3.670	3.890
Lower Plenum Region Height	[in]	0.000	0.000
Bottom End-Cap Height	[in]	0.660	0.575
Gap Fuel Rod To Bottom Nozzle	[in]	0.0	0.0
Lower Nozzle Height	[in]	10.0	10.00
Number of Inert Rods		0	4
Listed Inert Rod OD	[in]	0.0000	0.3940
Listed Inert Rod Thickness	[in]	0.0000	0.0220
Upper Nozzle SS/Inconel Mass	[kg]	1.950	1.350
Lower Nozzle SS/Inconel Mass	[kg]	6.550	10.460
Enrichment	[wt% ^{235}U]	3.64,3.94[1]	3.71[2]
Uranium Loading	[kg]	120.5	108.3

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[1] Represents Type I and Type II fuel.

[2] Represents the bounding planar average enrichment. Manufacturer input lists 12 rods at 3.12 wt % ^{235}U, 36 rods at 3.43 wt % ^{235}U, and 48 rods at 4.05 wt % ^{235}U.

6.A.3 Model Specification

6.A.3.1 Description of Calculation Model

The MCNP code is used to model the storage and transfer casks containing a full load of fuel assemblies. The system contains up to 68 fuel assemblies, with up to 32 assemblies being damaged. The MCNP code package uses combinatorial geometry, with the option to divide the model into self-contained Universes. The self-contained Universe structure can be used to separate canister, cask, and fuel into individual components that can be easily modified and checked.

The basic component of the geometry package is a set of general surfaces. To reduce the required user input MCNP includes simplified expressions for cylinders and planes perpendicular to system axes and "macrobodies" (cubes, finite cylinders, wedges, etc). Models are constructed by combining geometry components (surfaces) into cells. Cells may be embedded in individual Universes to simplify modeling. A given Universe may be included in different positions within the geometry by translation. Translation allows movement in the x, y, and z directions and rotation using direction cosines.

Finite cask/canister/basket/fuel models (termed cask model henceforth) are constructed for the storage and transfer system. The cask models are constructed in a set of distinct phases. In the first phase a fuel assembly is constructed from the basic components of the fuel assembly, i.e., fuel rod, inert rod (Exxon fuel), and nozzle (end-fitting). Next the basket structure is placed within the canister cavity. The basket structure is comprised of a set of stainless steel tubes and aluminum/B_4C (BORAL®) neutron absorber panels within a stacked set of stainless steel and aluminum disks. Fuel assemblies are placed into the canister cavity with the basket structure superimposed on the cavity surrounding the assemblies using the Universe structure. The canister shell and lid are placed around the loaded basket. The complete canister is then placed into either the transfer or storage cask overpack. For damaged fuel models an additional phase is the construction of the damaged fuel can (DFC) which surrounds the fuel material in the outer 32 fuel tubes.

Components within the fuel region are evaluated for manufacturing tolerance effects.

6.A.3.1.1 Fuel Assembly Models

Fuel assemblies are constructed of a top and bottom end-fitting, also referred to as top and bottom nozzles, inert rods (EX fuel only), and fuel rods that are held via grid spacers between the top and bottom nozzles. LACBWR assemblies do not contain channels.

The majority of fuel rods are not attached to either the top or bottom end-fitting. A limited number of fuel rods function as tie rods that connect the top and bottom end-fittings. Fuel rods may also be segmented. To simplify model construction all fuel rods are modeled as "floating" between the top and bottom end-fittings. All fuel rods are modeled at the full active fuel length. The number of fuel rods depends on the fuel design being evaluated. A fuel rod consists of: (1) a bottom end cap, (2) an active fuel region (including clad), (4) a top plenum, and (5) a top end cap. Spacing associated with the insulator disks is included in the end-cap definition. As stated in the assumptions, grid spacers are not modeled.

For each fuel assembly type selected a set of Universes is constructed. Assembly Universes are typically fuel rod, inert rod, tube/rod array, and the complete fuel assembly. Table 6.A.3-1 shows the geometry input summary sheet for the AC fuel type. Similar data is developed for the EX model with inert rods replacing four interior fuel rods.

Partial flooding evaluations are limited to cases with a void region above the active fuel region and canister cavity moderator from the top of the active fuel region to the canister bottom. This configuration allows a potential reactivity increase by neutron reflection from the steel lid, while minimizing neutron leakage in the moderated canister volume.

6.A.3.1.2 Fuel Tube Model

The basket contains 68 fuel tubes, 36 standard size tubes and 32 DFC tubes. Each standard tube contains up to two absorber sheets, each held to a tube face by a stainless steel cover sheet. One standard size fuel tube is modeled for each absorber configuration which is then replicated using the MCNP "fill" option to fill the basket. DFCs contain either three or four absorbers. Similarly, one DFC tube is modeled for each required absorber configuration and duplicated using the "fill" option. A sketch of a fuel tube is shown in Figure 6.A.3-1.

Key dimensions for the fuel tube are shown in shown in Table 6.A.3-2. Manufacturing tolerances are applied within the calculated parameters.

6.A.3.1.3 DFC Model

The basket may contain up to 32 DFCs. Each DFC is comprised of a stainless steel rectangular box with a lid and bottom plate structure. The DFC is designed to freely drain and fill, thereby avoiding the potential of preferentially flooding the DFC. Key dimensions for the DFC are shown in Table 6.A.3-3.

DFC contents included in these evaluations are:

- Undamaged clad fuel assemblies with functional grids (i.e., fuel assemblies retaining clad and fuel rods in their as-designed configuration);
- A hypothetical fuel configuration, where the clad (stainless steel) is conservatively removed from the model and rods are allowed to achieve increased pitch; and
- A homogenized fuel/water mixture model.

For modeling the unclad array the fuel assembly input structure is repeated, this time with no clad or end-fitting. Homogenized fuel is modeled as a simple rectangular volume with the maximum mixture elevations set as a variable (compact fuel to full DFC cavity height). Material composition is then calculated based on the fuel mass within the DFC, DFC cross-section, and moderator density within the mixture volume.

6.A.3.1.4 Basket Model

Key dimensions for the basket are shown in shown in Table 6.A.3-4. A sketch of a support disk is shown in Figure 6.A.3-2. Manufacturing tolerances are applied within the calculated parameters. An MCNP Universe composed of the basket disks is constructed with no fuel or openings. Into this Universe the disk opening, tube, DFC (if required), and payload are inserted. Up to three fuel types may be implemented within the analysis, one for interior assemblies and up to two in the exterior DFC slots.

The fuel assemblies (or DFC payload) are placed into the basket at their respective radial and axial locations via the "fill" option. Fuel assembly location, DFC location, and disk opening locations and sizes may be adjusted to any desired manufacturing tolerance and shift direction.

6.A.3.1.5 Canister Model

Criticality evaluations for the storage and transfer configurations model the system with lid and port covers in place. A sketch of the canister model, composed of a canister cavity body, surrounded by lid, canister shell weldment and bottom plate, is shown in Figure 6.A.3-3. To simplify the geometry, the lid is modeled as a single cylinder with no penetrations. Parameters required in the canister model are listed in Table 6.A.3-5.

6.A.3.1.6 Transfer Cask Model

Model parameters for the transfer cask shown in Figure 6.A.3-4 are listed in Table 6.A.3-6. The cask body model is an arrangement of cylindrical shells. The origin of the transfer cask Universe (Universe 0) is the top of the shield door in the center of the cask, corresponding to the center bottom of the canister bottom plate. The canister filling the cask cavity must, therefore, be raised by the canister bottom thickness. The shield door is modeled by a combination of macro bodies (RHP and RPP). The retaining ring is not included in the model. Since the transfer cask is open to the cask exterior the cask exterior material is employed in the canister-to-cask gap.

6.A.3.1.7 Storage Cask Model

Model parameters for the storage cask shown in Figure 6.A.3-5 are listed in Table 6.A.3-7. The cask body model is an arrangement of a cylindrical carbon steel shell surrounded by concrete. Cask model complexity is associated with the pedestal stand and the air inlet and outlet structure. The cask body is composed of a lower section, housing the canister and air inlet structure, and an upper section composed of the cask lid and air outlet structure. The origin of the concrete cask Universe (Universe 0) is set to the top of the bottom weldment pedestal plate in the center of the cask, corresponding to the center bottom of the canister bottom plate. The canister filling the cask cavity must, therefore, be raised by the canister bottom thickness. Since the storage cask is open to the cask exterior the cask exterior material is employed in the canister-to-cask gap and air inlet and outlet structure.

6.A.3.1.8 Monte Carlo Sampling and Result Convergence

To assure proper spatial fission site distribution, 30 inactive generations (cycles) are tracked prior to starting the active cycles employed in the eigenvalue calculation. The standard deviation (σ) for all cases will be less than 0.002. Upon completion of the analysis, a reactivity comparison is made to the upper subcritical limit (USL). These comparisons are made using the reported "final estimated combined collision/absorption/track-length k_{eff}" identified in each output. Each output is checked for sampling of fissile material areas in the model and normal distribution of the k_{eff} values.

6.A.3.1.9 Sample Model Files

Sample input files for the transfer cask and storage cask models for undamaged and damaged fuel are provided in Section 6.A.7. The inputs provided represent the maximum reactivity configuration case and additional transfer and storage cases.

6.A.3.2 Model Assumptions

Key assumptions for the analytical models are as follows.

6.A.3.2.1 Fuel Modeling

a) All fuel assemblies are conservatively modeled at a fuel density of 96% theoretical. (0.96×10.96 g/cm^3 = 10.52 g/cm^3).

Basis: Calculated fuel mass bounds LACBWR fuel assembly material mass.

b) Fuel assembly grid spacers are not included in the model.

Basis: Removing material in the active fuel region raises reactivity by removing parasitic absorber material and increasing fuel assembly moderation in a typically under-moderated fuel assembly.

c) Stainless steel and inconel hardware are modeled as stainless steel.

Basis: The total hardware mass is homogenized into end-fitting volumes. There is no neutronically significant difference in the materials. Furthermore, the components modeled are outside the active fuel region and therefore do not affect basket neutronics significantly.

d) The exact geometry of the top and bottom nozzles is unknown, therefore, they are modeled as solid boxes with the width of the fuel assembly.

Basis: The material density in this region is adjusted to account for the volume of the box modeled. Since the material is outside the active fuel region, this simplifying assumption will not affect system reactivity significantly.

e) DFC fuel material is increased by 5% over that of an undamaged assembly.

Basis: In-core clad failure leads to the potential of fuel releasing during assembly movement in the spent fuel pool. This could result in a limited quantity of loose pellets/fuel debris to transfer to the structure of another fuel assembly.

f) No fuel-related burnable absorbers are included in the fuel assembly.

Basis: LACBWR fuel assemblies did not contain integral absorbers. Further, removing any fuel integral absorbers from the model increases fresh fuel reactivity.

6.A.3.2.2 Basket and Canister Modeling

a) Neutron absorber ^{10}B density is reduced to 75%.

Basis: The Part 72 Standard Review Plan (NUREG-1536) indicates in Section IV.c that a 75% credit represents the standard accepted value.

b) To simplify modeling, the basket/fuel model ignores small steel masses in the basket such as nuts, washers and tie rods.

   Basis: This modeling assumption does not have a statistically significant effect on subsequent analyses due to the small amount of material involved.

c) Basket components may not be listed with symmetric (i.e., ±x) tolerance bands. For component tolerances that are not symmetric the maximum tolerance is applied symmetrically.

   Basis: Applying the largest band symmetrically will produce bounding results.

d) The basket structure, including neutron absorber panels and fuel assemblies, is assumed to rest at the lowest possible position in the basket cavity, which is at the bottom of the bottom weldment.

   Basis: All storage and transfer cask operating conditions are vertical. There are no design basis tip-over events.

e) Aluminum sheet on DFC is not modeled.

   Basis: The aluminum sheet is 0.075 inch of neutron transparent material that is facing the periphery of the basket.

f) Top weldment is modeled as a 0.625 inch plate with a 69.33-inch OD.

   Basis: Due to structural concerns the top plate was increased to 1 inch thickness with a 69.35 inch OD. The top plate is outside the fissile material region in storage and transfer calculations. Difference in geometry in this region does not affect system reactivity significantly.

g) The canister lid location is modeled at 7 inches from the canister top.

   Basis: Actual location is 6.97 inches from the top to assure that the lid is not below the shell wall. While potentially affecting transport calculations due to the change in calculated cavity length, and the corresponding component axial shift, there is no effect on storage calculations as fissile material is located at the bottom of the canister cavity.

h) The DFC canister lid bottom plate is modeled as 0.25 inch.

   Basis: Actual thickness is 0.325 inch. The difference in plate thickness slightly decreases the cavity height inside the DFC from the modeled value. As various content locations and mixture heights are evaluated, a larger cavity height bounds the as-designed DFC.

6.A.3.2.3 Criticality Analysis

a) Code input will be in centimeters to four or five decimals.

   Basis: Input dimensions are provided in a variety of significant figures and decimals down to 1/1000th (0.001) inch. Based on reasonable engineering judgment, the affects of smaller dimensions cannot be resolved within the statistical uncertainties of the Monte Carlo analysis and do not have a significant effect on system reactivity.

b) Changes in reactivity are considered to be significant if the Δk_{eff} exceeds three times the standard deviation (3σ).

   Basis: The 3σ level represents the 99% confidence band on a normally distributed result set. Exceeding this interval would therefore present a high likelihood that the result change is statistically significant.

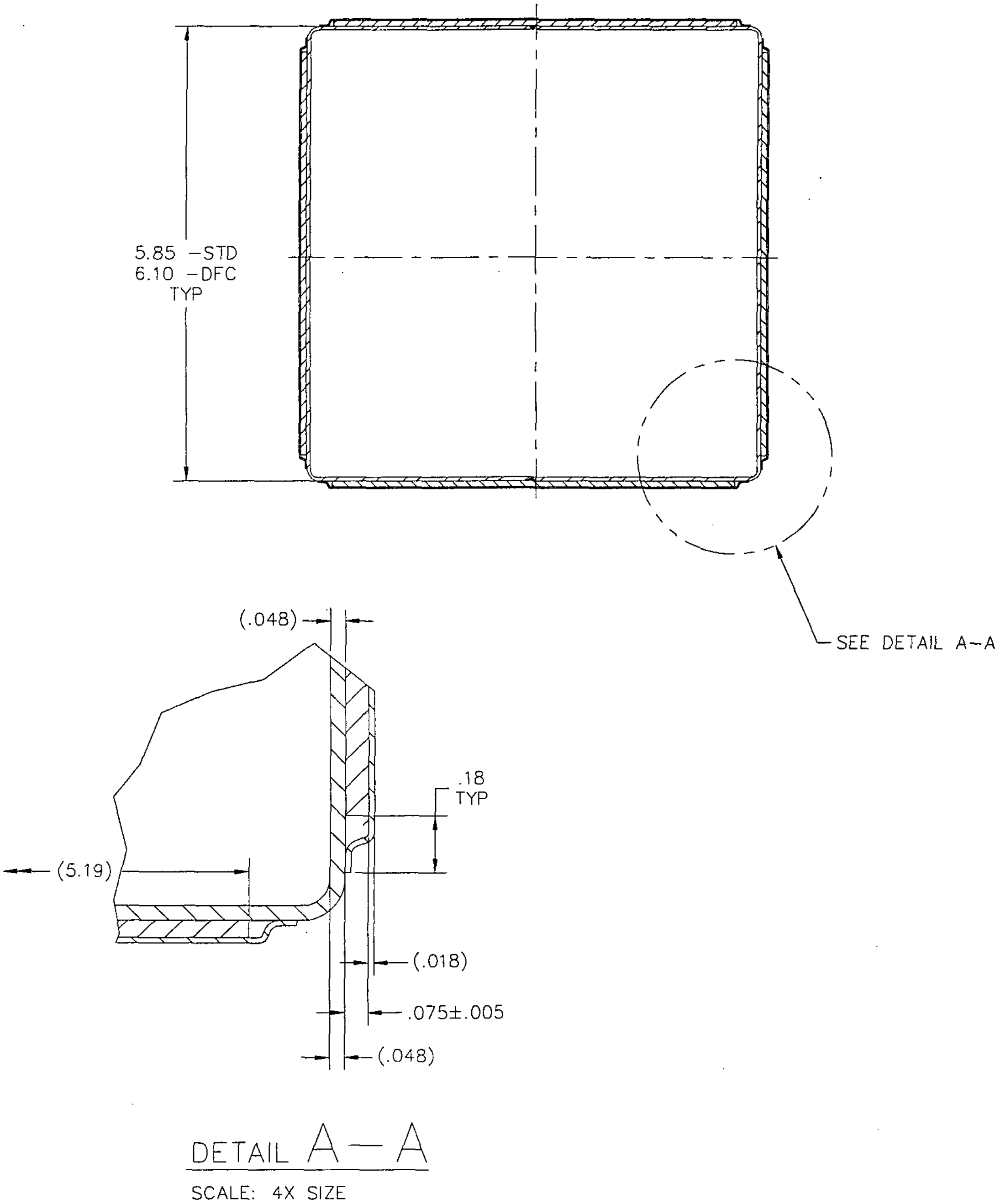
c) Base analyses are performed with DFC fuel material located axially lined up with the undamaged fuel.

   Basis: Assembly nozzles are expected to provide axial offset for any loose fuel material within the DFCs. Fuel exposure analysis, neglecting assembly hardware, is included in the DFC studies to confirm the most reactivity axial DFC material configuration.

6.A.3.3 Cask Regional Densities

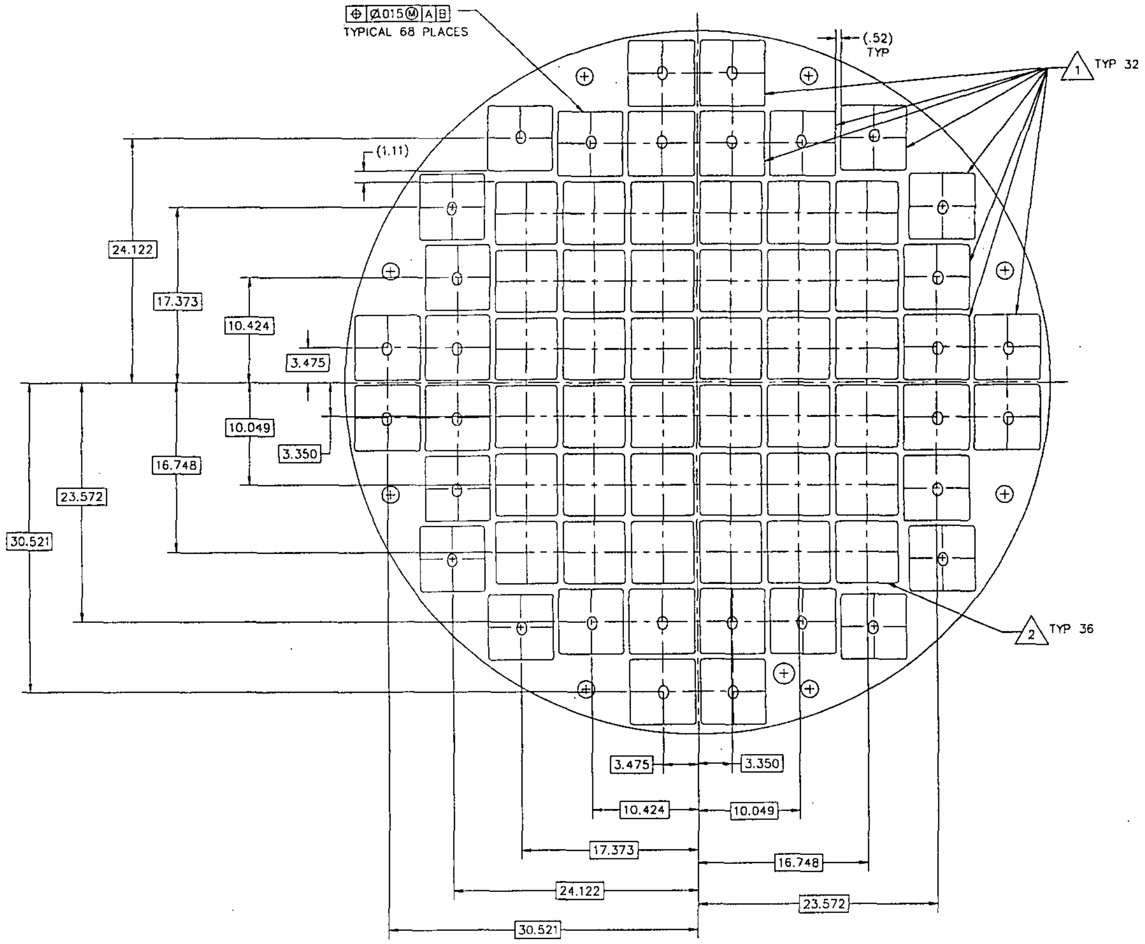
The densities used in the criticality analyses are primarily SCALE 4.3 default densities [A5]. NS-4-FR is a proprietary material and the listed information reflects values defined by the material information data sheet. Fuel assembly materials are listed in Table 6.A.3-8. Basket, TSC, and cask material definitions are shown in Table 6.A.3-9.

Figure 6.A.3-1 Fuel Tube Sketch



Note: Absorber number varies.

Figure 6.A.3-2 Support Disk Sketch

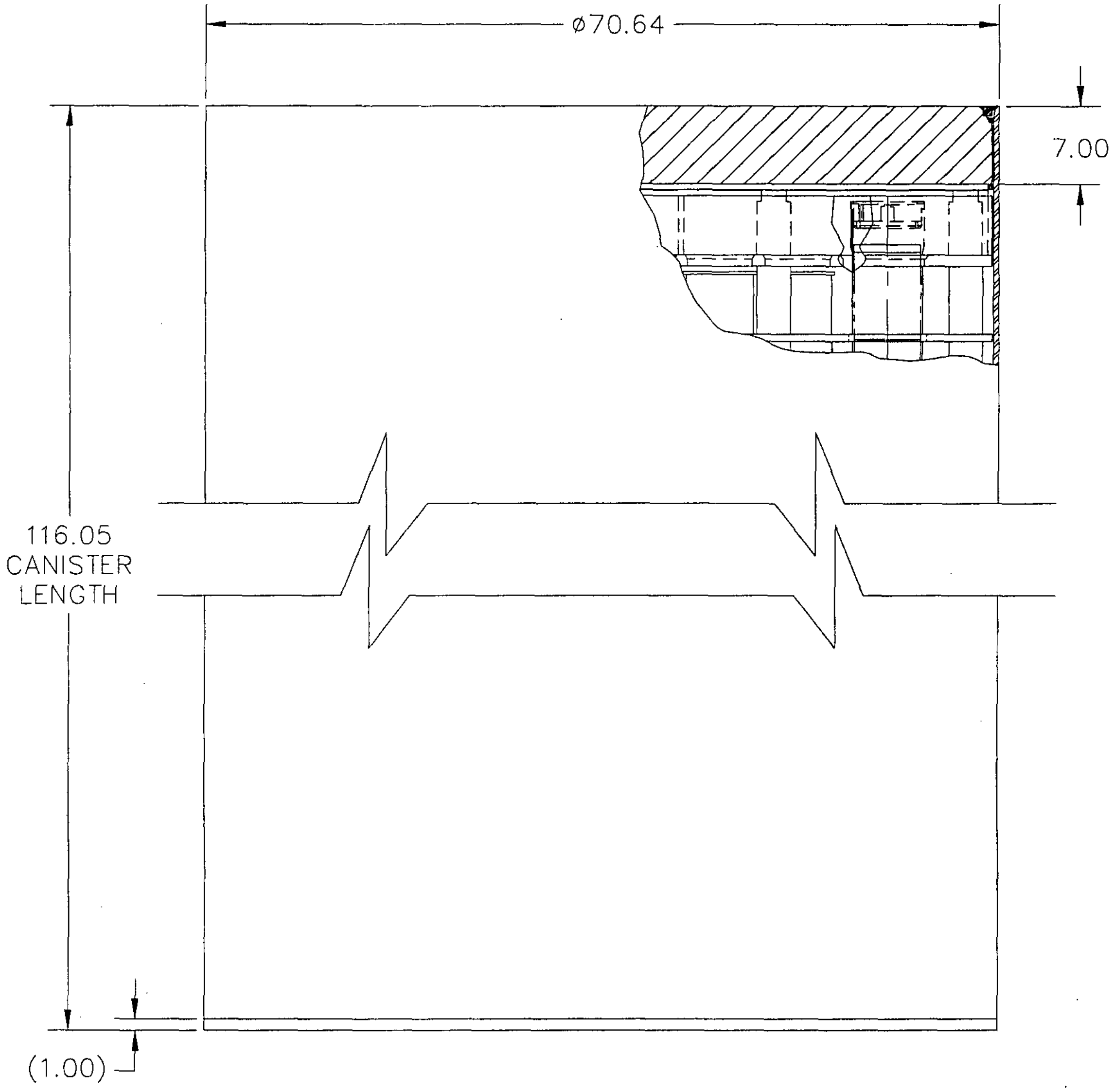


△2 THIS OPENING SHALL BE 6.089±.015 X 6.089±.015.

△1 THIS OPENING SHALL BE 6.433±.015 X 6.433±.015.

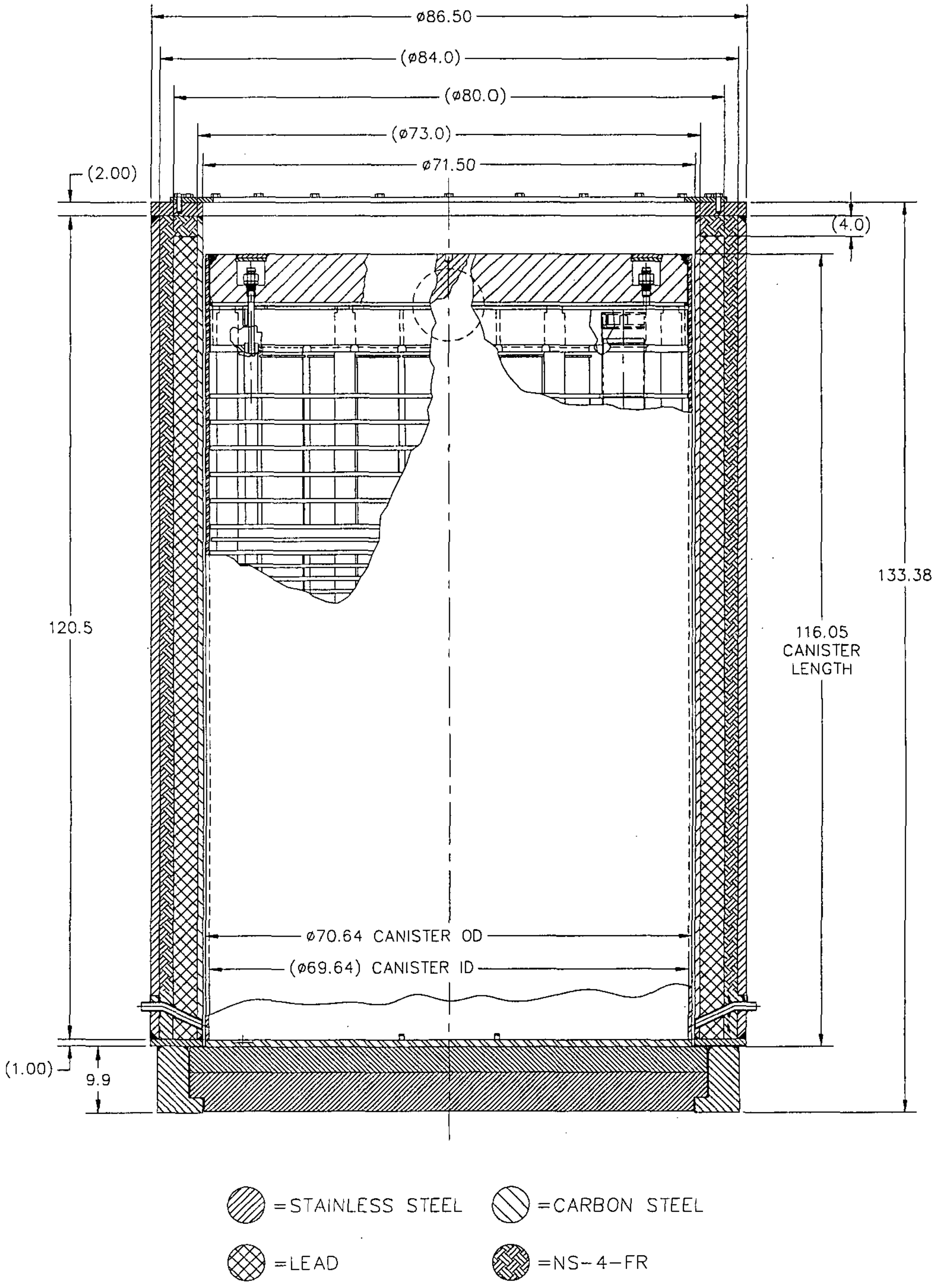
Note: Dimensions in inches

Figure 6.A.3-3 TSC Model Sketch



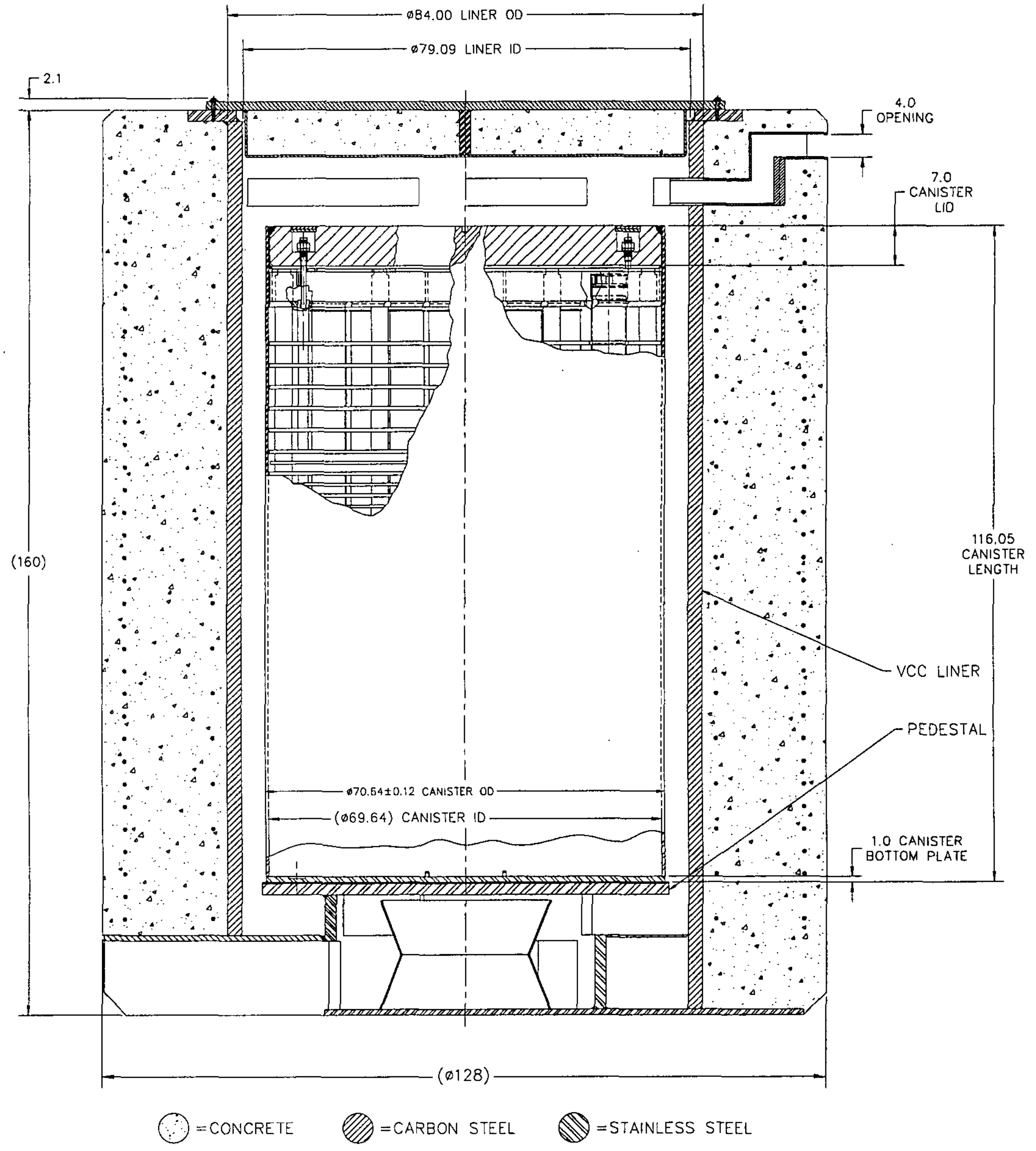
Note: Dimensions in inches

Figure 6.A.3-4 Transfer Cask Model Sketch



Note: Dimensions in inches

Figure 6.A.3-5 Storage Cask Model Sketch



Note: Dimensions in inches

Table 6.A.3-1 Fuel Assembly Configuration (AC)

Description	Value [in]
Fuel Rod Height	87.820
Top End-Cap Height	1.280
Bottom End-Cap Height	0.660
Upper Plenum Region Height	3.670
Active Length	83.000
Rod Diameter	0.3960
Clad Thickness	0.0200
Pellet Diameter	0.3500
Array	10
Pitch	0.5650
Fuel Assembly Height	102.340
Lower Nozzle Height	10.000
Upper Nozzle Height	4.260
Gap Fuel Rod to Bottom Nozzle	0.000
Number of Fuel Rods	100
Lower Nozzle SS/Inconel Mass (kg)	6.550
Upper Nozzle SS/Inconel Mass (kg)	1.950
Fuel Assembly Width	5.603
Number of Inert Rods	0
Inert Rod OD	N/A
Inert Rod Clad Thickness	N/A
Fuel Assembly Width	5.603

Table 6.A.3-2 Fuel Tube Model Parameters (Nominal Configuration)

Description	**Dimension [in]**
DFC tube outer width	6.10
DFC tube width tolerance	0.03
Standard tube outer width	5.85
Standard Tube outer width tolerance	0.02
Tube thickness	0.048
Tube thickness tolerance (+0.03, -0.01)	0.03
Absorber thickness	0.075
Tolerance on absorber thickness	0.005
Absorber width	5.19
Tolerance on absorber width	0.08
Minimum ^{10}B content (g/cm^2)	0.020
Cover sheet thickness	0.018
Fuel Tube height (min)	98.15
Absorber length (min)	95.88
Distance to bottom of absorber cover	0.8

Table 6.A.3-3 DFC Model Parameters

Description	**Dimension [in]**
Damaged fuel can opening width	5.750
Damaged fuel can wall thickness	0.048
Damaged fuel can bottom plate thickness	0.500
Damaged fuel can height	106.750
DFC lid handle height	1.500
DFC lid bottom plate thickness	0.250
DFC lid top plate thickness	0.375

Table 6.A.3-4 Basket Structure Model Parameters

Description	Dimension [in]	Description	Dimension [in]
Bottom weld. height	2.00	No. of structural disks	24
Bottom weld. OD	69.33	No. of structural B disks	1
Bottom weld. thick.	1.00	No. of structural C disks	1
Top weld. height	6.75	No. of aluminum disks	14
Top weld. OD	69.33	Split spacer height	1.60
Top weld. thick.	0.625	Split spacer tol.	0.02
Structural disk thick.	0.625	Spacer height	3.21
Structural thick. tol.	0.055	Spacer tol.	0.02
Structural disk OD	69.40	Spacer B height	1.31
Structural B disk thick..	1.250	Spacer B tol.	0.02
Structural B thick. tol.	0.055	Bottom spacer height	1.86
Structural C disk thick.	0.750	top spacer height	1.65
Structural C thick. tol.	0.055	Tube to Top Weldment gap	0.50
Std opening location 1	3.350	Basket height	107.40
Std opening location 2	10.049		
Std opening location 3	16.748		
Std opening location 4	23.572		
Dfc opening location 1	3.475		
Dfc opening location 2	10.424		
Dfc opening location 3	17.373		
Dfc opening location 4	24.122		
Dfc opening location 5	30.521		
Disk Op. location tol.	0.015		
Std opening width	6.089		
Std opening width tol.	0.015		
Dfc opening width	6.433		
Dfc opening width tol.	0.015		
Al. disk thick.	0.500		
Al. disk thick. tol.	0.027		
Aluminum disk OD	69.13		

Table 6.A.3-5 Canister Model Parameters

Description	Dimension [in]
Canister Outer Diameter	70.64
Canister Wall Thickness	0.50
Canister Length	116.05
Canister Lid Recess	7.00
Canister Bottom Plate	1.00
Canister Lid	7.00

T able 6.A.3-6 Transfer Cask Model Parameters

Description	Dimension [in]
Transfer cask OD	86.50
Bottom plate height	1.00
Inner shell height	120.50
Inner shell inner diameter	71.50
Inner shell thickness	0.75
Lead inner radius	36.5
Lead outer radius	40.0
Outer shell thickness	1.25
Top plate height	2.00
Shield door height	9.50
Shield door rail inner dimension	75.50
Shield door rail width	6.50
Shield door rail overlap	2.00
Shield door boundary total y-axis length	75.12
Shield door boundary base y-axis length	29.08
Shield door boundary x-axis length	45.38
Shield door boundary base x-axis length	17.39
Shield door overlap	4.00
Shield door trapezoidal angle (degree)	50.564
Lead shell thickness	3.500
Shield door boundary triangle y-axis length	23.020
Shield door boundary triangle x-axis length	27.990

Table 6.A.3-7 Key Storage Cask Model Parameters

Description	Dimension [in]
VCC shell height	158.9
VCC shell ID	79.0
VCC shell thickness	2.5
Top flange OD	97.9
Top flange ID	81.0
Top flange thickness	2.0
Bottom plate thickness	1.0
Baffle weldment height	19.0
Baffle weldment major diameter	30.0
Baffle weldment minor diameter	23.0
Baffle weldment plate thickness	0.25
Base weldment height without bottom plate	22.1
Air inlet vertical opening	12.0
Air inlet horizontal opening	12.0
Air inlet side plate thickness	0.375
Air inlet top plate thickness	1.0
Base plate thickness	2.0
Base plate outer diameter	72.0
Base plate cover thickness	0.25
Stand OD	50.0
Stand thickness	2.0
Stand cut dimension	20.2
VCC lid OD	91.5
VCC lid top thickness	1.5
VCC lid overall height	9.7
VCC lid concrete plate OD	78.0
VCC lid concrete plate thickness	0.375
Concrete OD	128.0

Table 6.A.3-8 Fuel Assembly Material Densities and Compositions

Material	**Density g/cm^3**	**Element/ Isotope**	**Density atom/barn-cm**
UO_2 (3.71 wt % ^{235}U)[1]	10.522	^{235}U	8.82E-03
96% theoretical density		^{238}U	2.26E-02
		O	4.69E-02
Water	0.9982	H	6.67E-02
Full Density		O	3.34E-02
Stainless Steel	7.94	Cr	1.75E-02
		Fe	5.95E-02
		Ni	7.74E-03
		Mn	1.74E-03

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[1] System is evaluated at varying enrichment levels. Sample data is provided.

Table 6.A.3-9 Basket, TSC, and Cask Material Densities and Compositions

Material	**Density g/cm^3**	**Element/ Isotope**	**Density atom/barn-cm**
Carbon Steel	7.821	Fe	8.35E-02
		C	3.92E-03
Stainless Steel	7.94	Cr	1.75E-02
		Fe	5.95E-02
		Ni	7.74E-03
		Mn	1.74E-03
Aluminum	2.702	Al	6.03E-02
Lead	11.344	Pb	3.30E-02
NS-4-FR	1.632	H	5.8508E-02
		^{10}B	9.1385E-05
		^{11}B	3.3665E-04
		C	2.2600E-02
		N	1.3904E-03
		O	2.6107E-02
		Al	7.8003E-03
Concrete	2.322	H	1.3879E-02
(145 lb/ft^3)		O	4.6522E-02
		Na	1.7643E-03
		Al	1.7625E-03
		Si	1.6783E-02
		Ca	1.5356E-03
		Fe	3.5063E-04
Neutron Absorber	1.965	^{10}B	7.10E-03
(Core)	(75% of	^{11}B	3.01E-02
	Actual)	C	9.29E-02
		Al	2.48E-02

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6.A.4 Criticality Calculation

6.A.4.1 Calculation Method

System reactivity evaluations are performed with the MCNP5 three-dimensional Monte Carlo code and continuous neutron energy cross-sections [A3, A4]. The Monte Carlo code and neutron cross-section libraries are validated for use in fuel transport and storage cask applications through a series of calculations based on critical experiments. Validation detail is presented in Section 6.A.4.4.

The criticality analysis of the system is performed in several steps.

- For Undamaged Fuel
    - Establish initial reactivities effects of gap conditions and fuel types for LACBWR fuel assemblies and justify the use of planar average versus heterogeneous enrichments.
    - Evaluate basket mechanical perturbations and basket geometric tolerances.
    - Construct optimum moderator density curve(s).
    - Based on the maximum reactivity configuration, demonstrate that the system reactivity remains below the USL.
- For Damaged Fuel
    - Establish maximum reactivity configuration for damaged fuel.
    - Evaluate optimum moderator density considering preferential flooding of DFC.
    - Justify that maximum reactivity configuration for undamaged fuel applies to the damaged fuel configuration.
    - Demonstrate that the reactivity for the maximum reactivity damaged fuel configuration remains below the USL.

6.A.4.2 Fuel Loading Optimization

The fuel loading is optimized in the criticality models using the following:

- Fresh fuel at 96% theoretical density
- Bounding fuel assembly characterization
- The most reactive cask configuration

The maximum reactivity cask configuration considers basket fabrication tolerances, component shifting, and moderator density evaluations. Each of these effects is evaluated individually and in combination to assure that the highest reactivity configuration is documented. Fabrication tolerances and shift effect are evaluated for each of the LACBWR fuel types.

Casks are evaluated at various interior and exterior flood conditions with reflective boundary conditions. Reflective boundary conditions are applied to an independently generated cylindrical body surrounding the cask body. This allows the modeling of infinite cask arrays at various cask spacings. Space between the cask surface and the reflecting body may be flooded at various moderator densities. Given the low neutron fluxes of either concrete or transfer cask bodies, no significant effect is observed from conditions outside the cask body.

The cask reactivity evaluation is divided into two primary sections. The first section details the determination of the maximum reactivity configuration for a payload of undamaged fuel assemblies. The maximum reactivity configuration is a function of the bounding parameters of the fuel, fuel location within the basket, manufacturing tolerances of the basket, and optimum moderator level. The second section details the extension of the analysis to consider damaged fuel cans (DFCs).

6.A.4.2.1 Undamaged Fuel

The maximum reactivity configuration is the result of fabrication tolerances, component shifting, and moderator density evaluations. Each of these effects is initially evaluated separately to determine the highest reactivity basket configuration. An evaluation combining tolerance and shift effects builds on the individual evaluations. These analyses are performed with the canister placed into the transfer cask. Fabrication tolerances and shift effects are evaluated using each of the primary fuel types.

Fuel Type and Enrichment Variation Study

LACBWR fuel is composed of two primary fuel types: Allis Chalmers (AC) fuel that was produced as Type I with a uniform enrichment of 3.64 wt% ^{235}U and as a Type II with a 3.94 wt% ^{235}U enrichment, and Exxon fuel with radial enrichment variations. Radial enrichments varied from 3.12 to 4.05 wt% ^{235}U, with an average enrichment of 3.70 wt% ^{235}U. A maximum planar average enrichment of 3.71 wt% ^{235}U is evaluated. Each of the fuel types is individually evaluated to determine their relative reactivity within the LACBWR cask system. Wet and dry pellet to clad gaps are evaluated to demonstrate the effect of minor clad failure on system reactivity. Radial enrichments were discretely modeled to allow a comparison to a homogenized enrichment.

Fabrication Tolerances

The basket is composed of a set of fuel tubes, held in place by disks which in turn are held in place by a set of tie rods, spacers and washers. Tube location in the basket is controlled by the disk opening cut-out in the structural disk. Moderator space between fuel tubes is controlled by a number of items including: fuel tube size, fuel tube thickness, absorber thickness and width, and locations of the disk opening and tube within the disk opening.

Component Shift

In addition to the component tolerances, a reactivity study on component shifts is required. Based on the tube in disk arrangement the radial shifts evaluated are the movement of the fuel assembly within the tubes, and the tubes within the disk opening.

Combined Basket Tolerances and Shift

In addition to the individual effect studies, the combination of the various basket tolerances with the maximum reactivity shift configuration (center shift) are considered in the results section of the chapter.

Moderator Density Study

Optimum moderator density is evaluated by considering TSC uniform water density variations ranging from void (0.0001 g/cm^3) to full density (0.9982 g/cm^3). More moderator density evaluations are performed with a void interior and various exterior water densities, and simultaneous variations in interior and exterior water densities, for the damaged fuel evaluations.

6.A.4.3 Damaged Fuel Evaluations

Starting with the most reactive basket configuration determined for undamaged fuel, various damaged fuel configurations are evaluated. Base evaluations for DFC designs are comprised of undamaged EX assemblies in the basket interior with EX or AC fuel assemblies in the DFCs. No AC assemblies are allowed in the non DFC basket locations.

To bound the potential of additional fissile material in the DFCs the total fissile mass in each DFC is increased by 5%. For mixture cases, the mass is increased by adjusting the fuel volume in the mixture. For pellet stack cases, the active fuel height is increased. As demonstrated in the various moderator density and rod pitch evaluations, the fuel rod lattice is under-moderated. Placing additional fissile material within the active fuel region displaces moderator and reduces reactivity. An increased active fuel height configuration was chosen.

Clad Rods – Grid Undamaged

DFC evaluations are initiated by placing undamaged fuel assemblies into the DFC to demonstrate the effect of the additional stainless steel shell. Table 6.A.4-8 demonstrates that starting from an all EX fuel payload, the DFC material results in a minor decrease in system reactivity. Next, fuel rods are removed from the lattice to evaluate various "missing rod geometries."

Unclad Rods – Loose Pellet Stack

Damaged fuel is postulated to lose its cladding. As stainless steel presents a significant parasitic absorber within the fuel region, the removal of cladding from the array is evaluated. The next stage in the analysis is an increase in pitch for the unclad array. As the assembly array showed an increase in reactivity as a function of moderator density, increased rod pitches are also evaluated.

Fuel/Water Mixture

In addition to the heterogeneous (rod array) evaluations, a set of mixture analysis are run. Mixtures are designed to fill various fractions of the DFC canister and simulate small fuel rubble inside the canister.

Optimum Moderator

In the final stage of the maximum reactivity configurations analysis, moderator density variations are considered. Including the damaged fuel optimum moderator configuration studies, a preferential flooding of the damaged fuel cans is evaluated (i.e., DFCs may be flooded with a dry canister cavity and vice versa).

Maximum Reactivity Configuration Confirmation Studies

Maximum reactivity geometry for undamaged fuel was based on a fully flooded TSC. For preferentially flooded geometry, the fissile material shift and tolerance studies are repeated. Additional evaluations to assess the movement of the active fuel towards the top and bottom of the DFCs must also be included for damaged fuel contents.

6.A.4.3.1 Storage Cask Evaluations

Additional runs for the maximum reactivity assembly are performed for the single storage cask and array of casks under normal and accident conditions. These studies evaluate the effects of differences in reflector material on canister reactivity.

6.A.4.4 Criticality Results

The cask reactivity evaluation is divided into two primary sections. The first section details the results of undamaged fuel elevations with the second section detailing the extension of the analysis to consider damaged fuel cans (DFCs).

6.A.4.4.1 Undamaged Fuel Maximum Reactivity Basket Configuration

The maximum reactivity configuration is the result of fabrication tolerances, component shifting, and moderator density evaluations. Each of these effects is initially evaluated separately to determine the highest reactivity basket configuration. An evaluation combining tolerance and shift effects builds on the individual evaluations. As stated in the assumptions, these analyses are performed with the canister placed into the transfer cask.

Fabrication tolerances and shift effects are evaluated using each of the primary fuel types.

Fuel Type and Enrichment Variation Study

Each of the fuel types is individually evaluated to determine their relative reactivity within the LACBWR cask system. Radial enrichments were discretely modeled to allow a comparison to a homogenized enrichment. Results for the individual cases are shown in Table 6.A.4-1 and indicate a substantially higher reactivity for the AC fuel type. Wet and dry pellet to clad gaps are evaluated with a wet clad being bounding.

As shown in the result table, the radial and homogenized enrichment results are statistically identical. The variable enriched fuel may therefore be represented by the homogenized "average" enrichment description.

Fabrication Tolerances – Centered Components

The results of the tolerance evaluation for centered fuel assemblies and tubes are included in Table 6.A.4-2 and Table 6.A.4-3. As indicated in the tables, little statistically significant information is available from this study. Viewed independently, none of the fabrication related tolerance studies with the exception of fuel tube thickness produce significant reactivity increases across both fuel types. A combined model is therefore constructed based on theoretical maximum reactivity configuration. Maximum reactivity configuration is one that minimizes the amount of moderator and neutron absorber (BORAL and tube material) within the radial plane between disks (i.e., maximum tube opening, minimum tube wall thickness, minimum absorber width and maximum absorber thickness). Disk thickness increase and decreased disk pitch increases the amount of parasitic absorber within the center (axial) fuel region while simultaneously decreasing water space between fuel tubes, thereby reducing the BORAL effectiveness. Structural disk thickness and pitch tolerances, therefore, invoke offsetting effects. A reduced flux trap (maximum disk thickness and minimum disk pitch) configuration is chosen for the maximum reactivity model. As shown in the tolerance study result tables, the combined tolerance model significantly increases system reactivity and produces the maximum reactivity configuration. Further evaluations of the component tolerance evaluation are performed in conjunction with the shifted component configuration.

Component Shift – Nominal Basket Configuration

The results of the shift evaluation are shown in Table 6.A.4-4 and Table 6.A.4-5 for Allis Chalmers (AC) and Exxon (EX) fuel and indicate that moving the fuel assembly and tube towards the basket center ("in" shift) clearly increases system reactivity.

Combined Basket Tolerances and Shift

Previous sections evaluated basket tolerances and fuel shifts as separate effects. This section evaluates the effect of combining various basket tolerances with the maximum reactivity shift configuration (center shift). The results for these evaluations are shown in Table 6.A.4-6 and Table 6.A.4-7. Similar to the results of the independent basket tolerance evaluations, applying fabrication tolerances to the basket components provides limited statistically significant change in system reactivity. A combined shifted/toleranced model is, therefore, constructed containing minimum absorber/flux trap space.

The maximum reactivity configuration is, therefore, based on:

a) Minimum absorber width and maximum absorber thickness
b) Maximum tube width and minimum tube thickness;
c) Maximum size disk openings at their minimum radial location;
d) Minimum disk pitch at maximum disk thickness

The minimum fuel assembly separation modeled in this configuration reduces the amount of moderation and the corresponding effectiveness of the absorber sheet, which depend on the ^{10}B neutron capture cross-section in the thermal energy range.

Moderator Density Study

The moderator density variation studies are limited to the AC (most reactive) fuel assembly type as it produces maximum system reactivity. The results of these analyses are shown in Figure 6.A.4-1. Maximum reactivity occurs at full density water inside the canister cavity. This analysis also demonstrates the low reactivity, $k_{eff}<0.4$, for the dry basket system.

More moderator density evaluations are performed with a void interior and various exterior water densities, and simultaneous variations in interior and exterior water densities, for the damaged fuel can evaluations.

6.A.4.4.2 Damaged Fuel Can (DFC) Evaluations

Starting with the most reactive basket configuration determined for undamaged fuel, various damaged fuel configurations are evaluated. Base evaluations for DFC designs are comprised of undamaged EX assemblies in the basket interior with EX or AC fuel assemblies in the DFCs. No AC assemblies are allowed in the non DFC basket locations.

Clad Rods – Grid Undamaged

Table 6.A.4-8 demonstrates that starting from an all EX fuel payload, the DFC material results in a minor decrease in system reactivity. Next, fuel rods are removed from the lattice to evaluate

various "missing rod geometries." System reactivity for the AC and EX elements is not significantly affected by the removal of fuel rods.

Unclad Rods – Loose Pellet Stack

As listed in Table 6.A.4-9, system reactivity increases with rod pitch. A significant increase occurs for the midpoint pitch (midpoint between nominal assembly pitch and maximum pitch in the DFC) for both fuel types. Rod removal from the unclad rod maximum pitch array does not statistically affect or reduce system reactivity for either fuel type.

Fuel/Water Mixture

Shown in Table 6.A.4-10 are the results of the mixture analysis. Results for the homogenous mixture cases are lower than those of the rod array studies.

Optimum Moderator

In the final stage of the maximum reactivity configurations, analysis moderator density variations are considered for damaged fuel canisters. Similar to the undamaged fuel analysis, a uniform reduction in moderator density reduces reactivity. Maximum reactivity is achieved with maximum density moderator within the DFC and void (low density moderator) in the TSC cavity. This configuration reduces neutron absorber effectiveness by hardening the neutron spectrum. Moderator density cases are illustrated in Figure 6.A.4-2. Maximum reactivity plus two sigma for a 3.71 wt % ^{235}U Exxon interior loading and 3.94 wt % ^{235}U AC exterior DFC pattern is 0.9373, which is above the USL. To reduce system reactivity, the AC fuel is divided between 3.64 and 3.94 wt % ^{235}U enriched assemblies. The optimum moderator density study is repeated for a loading pattern of 16 high and 16 low enriched AC assemblies, with the lower enriched material restricted to the "on-axis" locations. The "off-axis" higher, 3.94 wt % ^{235}U enriched AC loading bounds a payload of either 3.64 or 3.94 wt % ^{235}U AC fuel since the higher enrichment increases reactivity. Maximum reactivity (k_{eff}+2σ) of 0.92636 is below the USL and represents the allowed loading configuration as illustrated in Figure 6.A.4-3. Figure 6.A.4-4 illustrates the allowed loading configuration. Within the scope of the moderator density evaluations, a partial drain-down of the TSC is evaluated. Draining the cask to the top of the active fuel region changes the axial reflection from water to steel TSC lid. The reactivity change for this configuration is not statistically resolvable at Δk of 0.003 for the wet TSC case (k_{eff} 0.879) and -0.002 (k_{eff} 0.9250) for the dry TSC and wet DFC case. Justification for loading Exxon fuel in the DFCs is included in the following section.

Maximum Reactivity Configuration Confirmation Studies

As maximum reactivity geometry was based on a fully flooded TSC, the fissile material shift and tolerance studies are repeated at the preferential flood configuration. Shift models contain two additional options. The additional options move DFC fissile material into close contact with each other. Results from studies, shown in Table 6.A.4-11, demonstrate that the shifted radial towards canister center ("in") pattern represents the most reactive fissile material configuration. Since the dry TSC removes the inter-assembly moderator, the minor geometry variations do not significantly affect system reactivity. Similarly, the small manufacturing tolerances on the system do not significantly affect system reactivity in the dry TSC cavity, see Table 6.A.4-12.

While all Exxon fuel is expected to be undamaged, the potential exists for Exxon assemblies to be characterized as damaged prior to placement in the TSC. Table 6.A.4-13 contains the reactivities for models containing Exxon fuel in some or all DFC locations. There is no increase in system reactivity when considering Exxon assemblies in DFCs.

All previous evaluations rely on models where the active fuel region in the DFCs is aligned with the active fuel region of the undamaged fuel in the basket interior locations. Evaluations to assess the movement of the active fuel towards the top and bottom of the DFCs are considered. These evaluations expose small amounts of fissile material outside the axial absorber coverage. As shown in Table 6.A.4-14, the effect of the fuel location within the DFC is minor for the dry TSC and insignificant for the wet TSC models. Maximum uncertainty adjusted (2σ) reactivity for the transfer cask is 0.93014. This model represents a partially flooded DFC with DFC fuel material arranged in an unclad pellet array at the bottom of the DFC.

6.A.4.4.3 Storage Cask Evaluations

Additional runs for the maximum reactivity assembly are performed for the single storage cask and array of casks under normal and accident conditions. Results of these evaluations are shown in Table 6.A.4-15. Results include a comparison to the single transfer cask evaluations. Both axially aligned fuel and DFC bottom models are evaluated for the storage cask. Transfer cask results are significantly higher than those of the storage cask at identical TSC configuration.

6.A.4.4.4 Allowed Fuel Specifications and Comparison to USL Range of Applicability

Fuel assembly characteristics evaluated for content within the MPC-LACBWR system are listed within Table 6.A.4-16. The variables are based on the maximum reactivity model for a preferentially flooded DFC with a maximum reactivity configuration payload. A comparison of the maximum reactivity case parameters to the MCNP range of applicability is shown in Table 6.A.4-17.

Figure 6.A.4-1 Undamaged Fuel Reactivity versus Water Density (AC Fuel, 3.94 wt % ^{235}U)

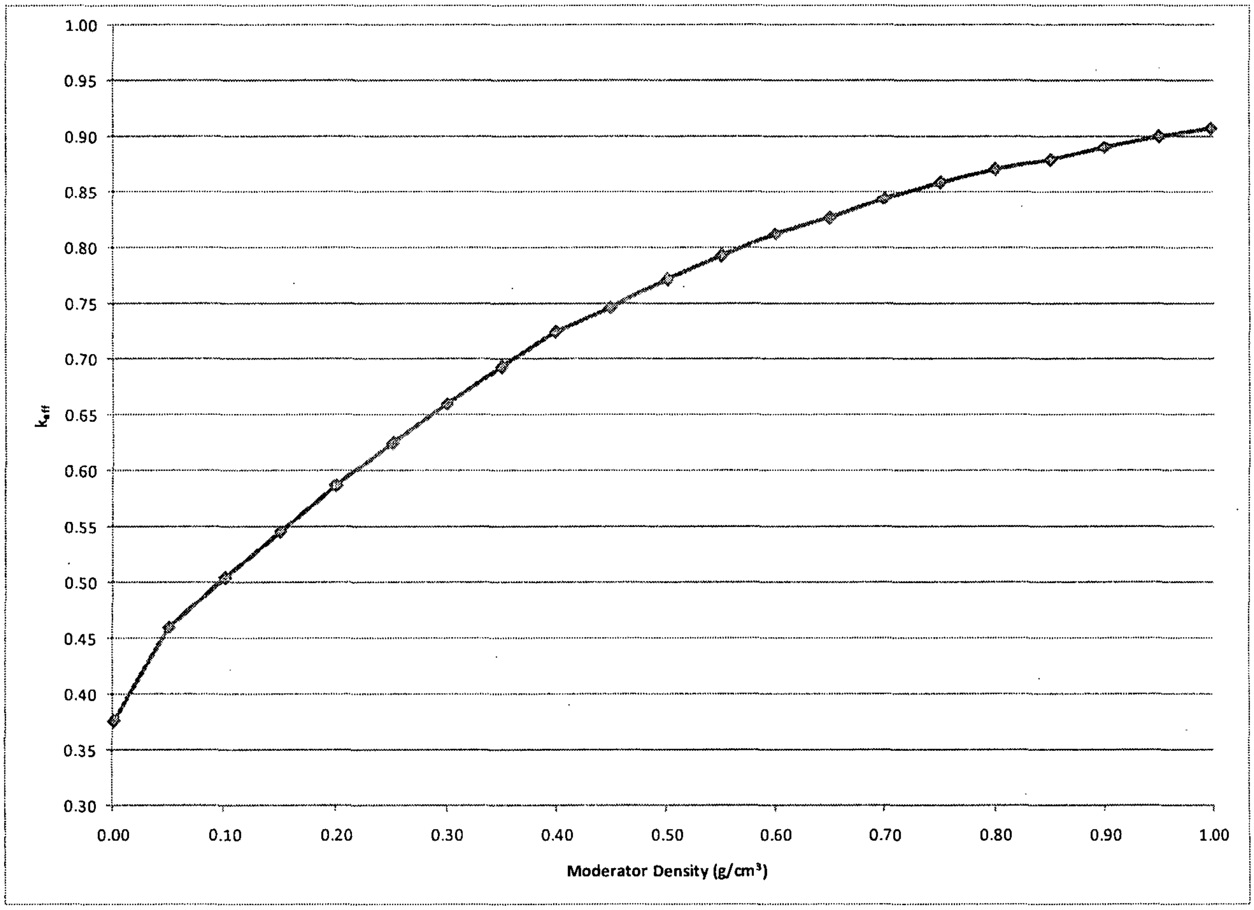


Figure 6.A.4-2 DFC Cask System Reactivity versus Water Density (3.71 wt % EX Interior Locations, 3.94 wt % ^{235}U AC DFC Locations)

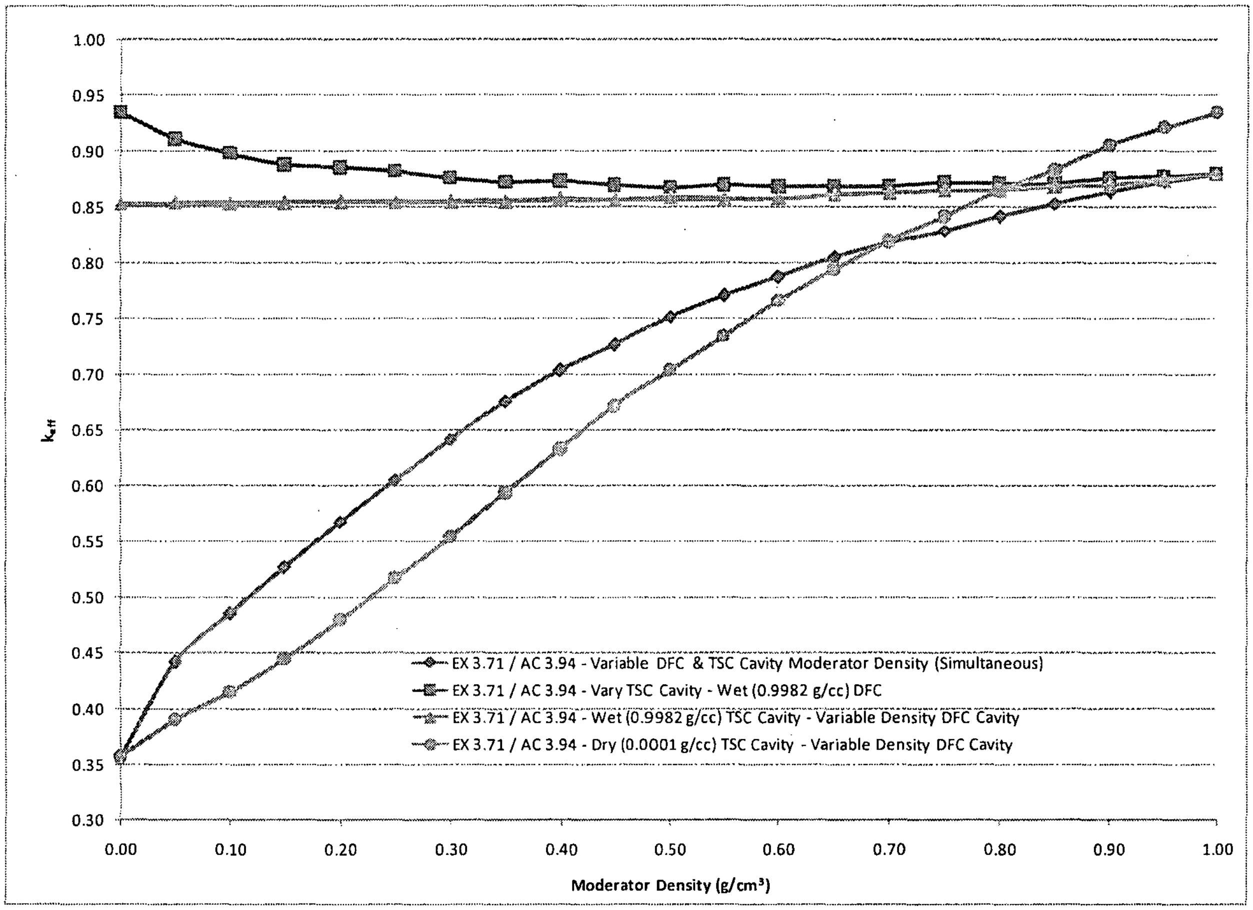


Figure 6.A.4-3 DFC Cask System Reactivity versus Water Density (3.71 wt % EX Interior Locations, 3.94/3.64 wt % ^{235}U AC DFC Locations)

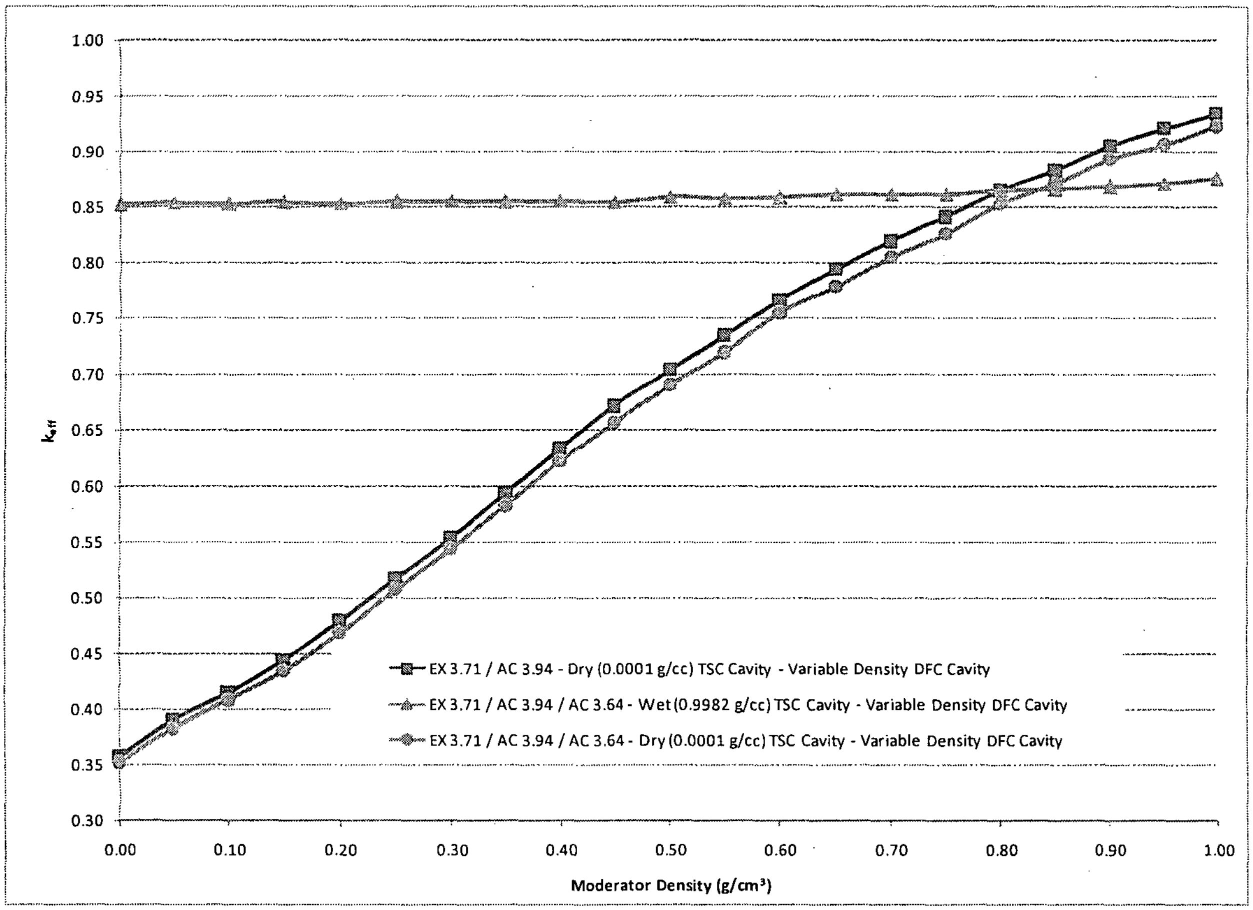
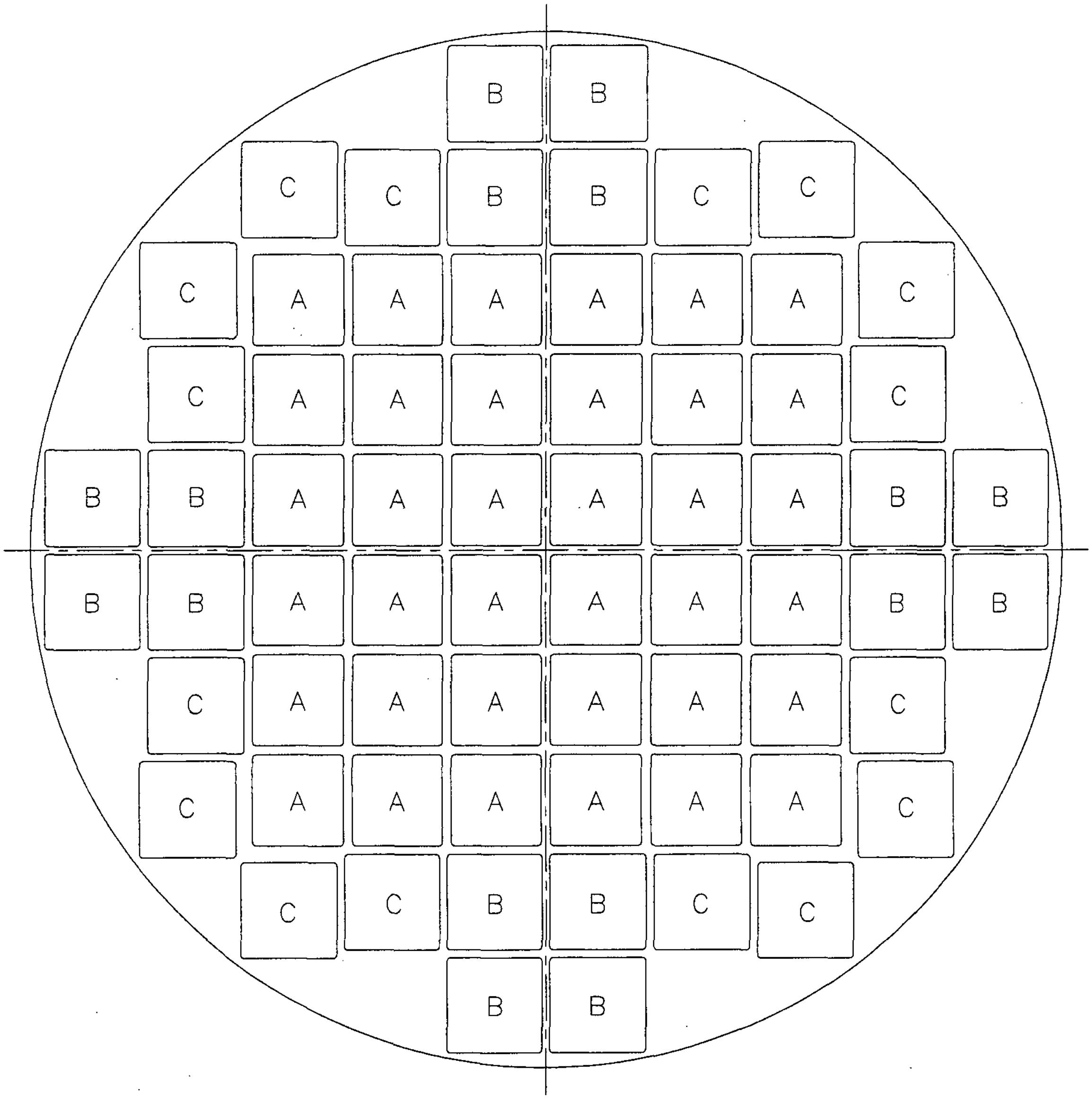


Figure 6.A.4-4 Allowed Loading Configuration for LACBWR Fuel



Slot A: Undamaged Exxon fuel maximum planar average enrichment 3.71 wt % ^{235}U.

Slot B: Undamaged or damaged Exxon fuel maximum planar average enrichment 3.71 wt % ^{235}U.

Damaged Allis Chalmers fuel maximum enrichment 3.64 wt % ^{235}U.

Slot C: Undamaged or damaged Exxon fuel maximum planar average enrichment 3.71 wt % ^{235}U.

Damaged Allis Chalmers fuel maximum enrichment 3.94 wt % ^{235}U.

Table 6.A.4-1 Baseline Reactivity Evaluation Results – Typical Tube and Disk Basket Maximum Reactivity Configuration

Fuel Type	Discrete Enrichment	Pellet / Clad Gap	Enrichment %^{235}U	k_{eff}	Δk
AC	N/A	Dry	3.64	0.88298	--
AC	N/A	Dry	3.94	0.90521	--
EX	N/A	Dry	3.71	0.85525	--
EX	N/A	Dry	3.70	0.85365	--
EX	Yes	Dry	3.70	0.85313	-0.00052
AC	N/A	Wet	3.64	0.88704	--
AC	N/A	Wet	3.94	0.90794	--
EX	N/A	Wet	3.71	0.86033	--

Table 6.A.4-2 Component Tolerance Study – No Shift – Allis Chalmers Fuel (AC) at 3.94 wt % ^{235}U

Tube Tol.		**Absorber Tol.**		**Disk Tol.**						
Outer Width	**Thickness**	**Width**	**Thickness**	**Op_Width**	**Location**	**Thickness**	**Spacing**	**k_{eff}**	**Δk**	**Δk/σ**
Nom	Nom	Nom	Nom	Nom	Nom	Nom	Nom	0.88983	--	--
Min	Nom	Nom	Nom	Nom	Nom	Nom	Nom	0.88980	-0.00003	0.0
Max	Nom	Nom	Nom	Nom	Nom	Nom	Nom	0.89144	0.00161	1.4
Nom	Min	Nom	Nom	Nom	Nom	Nom	Nom	0.89662	0.00679	6.0
Nom	Max	Nom	Nom	Nom	Nom	Nom	Nom	0.88524	-0.00459	-4.0
Nom	Nom	Min	Nom	Nom	Nom	Nom	Nom	0.89243	0.00260	2.3
Nom	Nom	Max	Nom	Nom	Nom	Nom	Nom	0.88889	-0.00094	-0.9
Nom	Nom	Nom	Min	Nom	Nom	Nom	Nom	0.89041	0.00058	0.5
Nom	Nom	Nom	Max	Nom	Nom	Nom	Nom	0.89027	0.00044	0.4
Nom	Nom	Nom	Nom	Min	Nom	Nom	Nom	0.88937	-0.00046	-0.4
Nom	Nom	Nom	Nom	Max	Nom	Nom	Nom	0.89041	0.00058	0.5
Nom	Nom	Nom	Nom	Nom	Min	Nom	Nom	0.88911	-0.00072	-0.6
Nom	Nom	Nom	Nom	Nom	Max	Nom	Nom	0.88988	0.00005	0.0
Nom	Nom	Nom	Nom	Nom	Nom	Min	Nom	0.88959	-0.00024	-0.2
Nom	Nom	Nom	Nom	Nom	Nom	Max	Nom	0.88931	-0.00052	-0.5
Nom	Nom	Nom	Nom	Nom	Nom	Nom	Min	0.89031	0.00048	0.4
Nom	Nom	Nom	Nom	Nom	Nom	Nom	Max	0.89061	0.00078	0.7
Max	Min	Min	Max	Max	Min	Max	Min	0.90051	0.01068	9.6

Table 6.A.4-3 Component Tolerance Study – No Shift – Exxon Fuel (EX) at 3.71 wt % ^{235}U

Tube Tol.		**Absorber Tol.**		**Disk Tol.**						
Outer Width	**Thickness**	**Width**	**Thickness**	**Op_Width**	**Location**	**Thickness**	**Spacing**	**k_{eff}**	**Δk**	**Δk/σ**
Nom	Nom	Nom	Nom	Nom	Nom	Nom	Nom	0.84195	--	--
Min	Nom	Nom	Nom	Nom	Nom	Nom	Nom	0.84009	-0.00186	-1.6
Max	Nom	Nom	Nom	Nom	Nom	Nom	Nom	0.84328	0.00133	1.2
Nom	Min	Nom	Nom	Nom	Nom	Nom	Nom	0.84800	0.00605	5.6
Nom	Max	Nom	Nom	Nom	Nom	Nom	Nom	0.83573	-0.00622	-5.5
Nom	Nom	Min	Nom	Nom	Nom	Nom	Nom	0.84201	0.00006	0.1
Nom	Nom	Max	Nom	Nom	Nom	Nom	Nom	0.83957	-0.00238	-2.1
Nom	Nom	Nom	Min	Nom	Nom	Nom	Nom	0.83924	-0.00271	-2.5
Nom	Nom	Nom	Max	Nom	Nom	Nom	Nom	0.84288	0.00093	0.8
Nom	Nom	Nom	Nom	Min	Nom	Nom	Nom	0.84140	-0.00055	-0.5
Nom	Nom	Nom	Nom	Max	Nom	Nom	Nom	0.84149	-0.00046	-0.4
Nom	Nom	Nom	Nom	Nom	Min	Nom	Nom	0.84094	-0.00101	-0.9
Nom	Nom	Nom	Nom	Nom	Max	Nom	Nom	0.84121	-0.00074	-0.6
Nom	Nom	Nom	Nom	Nom	Nom	Min	Nom	0.84150	-0.00045	-0.4
Nom	Nom	Nom	Nom	Nom	Nom	Max	Nom	0.84342	0.00147	1.3
Nom	Nom	Nom	Nom	Nom	Nom	Nom	Min	0.84181	-0.00014	-0.1
Nom	Nom	Nom	Nom	Nom	Nom	Nom	Max	0.84073	-0.00122	-1.1
Max	Min	Min	Max	Max	Min	Max	Min	0.85141	0.00946	8.4

Table 6.A.4-4 Component Shift Study – No Tolerance Applied – Allis Chalmers Fuel (AC) at 3.94 wt % ^{235}U

Comp. Radial Shift				
Fuel	**Tube**	k_{eff}	Δk	Δk/σ
Centered	Centered	0.88983	--	--
Centered	Top	0.88874	-0.00109	-1.0
Centered	Bottom	0.88951	-0.00032	-0.3
Centered	Right	0.88977	-0.00006	-0.1
Centered	Left	0.88928	-0.00055	-0.5
Centered	Corner	0.88995	0.00012	0.1
Centered	In	0.89618	0.00635	5.6
Centered	Out	0.88445	-0.00538	-4.8
Centered	Custom	0.88866	-0.00117	-1.0
Top	Centered	0.89067	0.00084	0.7
Top	Top	0.88932	-0.00051	-0.5
Bottom	Centered	0.89094	0.00111	1.0
Bottom	Bottom	0.88929	-0.00054	-0.5
Right	Centered	0.88994	0.00011	0.1
Right	Right	0.88984	0.00001	0.0
Left	Centered	0.89233	0.00250	2.2
Left	Left	0.88972	-0.00011	-0.1
Corner	Centered	0.88965	-0.00018	-0.2
Corner	Corner	0.89040	0.00057	0.5
In	Centered	0.89248	0.00265	2.3
In	In	0.89765	0.00782	6.9
Out	Centered	0.88705	-0.00278	-2.5
Out	Out	0.88181	-0.00802	-7.2

Table 6.A.4-5 Component Shift Study – No Tolerance Applied – Exxon Fuel (EX) at 3.71 wt % ^{235}U

Comp. Radial Shift				
Fuel	**Tube**	**k_{eff}**	**Δk**	**$\Delta k/\sigma$**
Centered	Centered	0.84195	--	--
Centered	Top	0.84142	-0.00053	-0.5
Centered	Bottom	0.84128	-0.00067	-0.6
Centered	Right	0.84094	-0.00101	-0.9
Centered	Left	0.84025	-0.00170	-1.5
Centered	Corner	0.84256	0.00061	0.6
Centered	In	0.84580	0.00385	3.5
Centered	Out	0.83437	-0.00758	-6.8
Centered	Custom	0.84188	-0.00007	-0.1
Top	Centered	0.84185	-0.00010	-0.1
Top	Top	0.84227	0.00032	0.3
Bottom	Centered	0.84096	-0.00099	-0.9
Bottom	Bottom	0.84099	-0.00096	-0.9
Right	Centered	0.84210	0.00015	0.1
Right	Right	0.83924	-0.00271	-2.4
Left	Centered	0.84188	-0.00007	-0.1
Left	Left	0.83911	-0.00284	-2.7
Corner	Centered	0.84070	-0.00125	-1.1
Corner	Corner	0.84220	0.00025	0.2
In	Centered	0.84182	-0.00013	-0.1
In	In	0.84753	0.00558	4.9
Out	Centered	0.84047	-0.00148	-1.3
Out	Out	0.83438	-0.00757	-6.9

Table 6.A.4-6 Component Tolerance Study – In Shift Allis Chalmers Fuel (AC) at 3.94 wt % ^{235}U

Tube Tol.		**Absorber Tol.**		**Disk Tol.**						
Outer Width	**Thickness**	**Width**	**Thickness**	**Op_Width**	**Location**	**Thickness**	**Spacing**	**k_{eff}**	**Δk**	**Δk/σ**
Nom	Nom	Nom	Nom	Nom	Nom	Nom	Nom	0.89765	--	--
Min	Nom	Nom	Nom	Nom	Nom	Nom	Nom	0.89728	-0.00037	-0.3
Max	Nom	Nom	Nom	Nom	Nom	Nom	Nom	0.89960	0.00195	1.7
Nom	Min	Nom	Nom	Nom	Nom	Nom	Nom	0.90312	0.00547	4.8
Nom	Max	Nom	Nom	Nom	Nom	Nom	Nom	0.89114	-0.00651	-5.7
Nom	Nom	Min	Nom	Nom	Nom	Nom	Nom	0.89853	0.00088	0.8
Nom	Nom	Max	Nom	Nom	Nom	Nom	Nom	0.89477	-0.00288	-2.5
Nom	Nom	Nom	Min	Nom	Nom	Nom	Nom	0.89727	-0.00038	-0.3
Nom	Nom	Nom	Max	Nom	Nom	Nom	Nom	0.89679	-0.00086	-0.7
Nom	Nom	Nom	Nom	Min	Nom	Nom	Nom	0.89797	0.00032	0.3
Nom	Nom	Nom	Nom	Max	Nom	Nom	Nom	0.89666	-0.00099	-0.9
Nom	Nom	Nom	Nom	Nom	Min	Nom	Nom	0.89715	-0.00050	-0.5
Nom	Nom	Nom	Nom	Nom	Max	Nom	Nom	0.89735	-0.00030	-0.3
Nom	Nom	Nom	Nom	Nom	Nom	Min	Nom	0.89625	-0.00140	-1.3
Nom	Nom	Nom	Nom	Nom	Nom	Max	Nom	0.89615	-0.00150	-1.3
Nom	Nom	Nom	Nom	Nom	Nom	Nom	Min	0.89713	-0.00052	-0.5
Nom	Nom	Nom	Nom	Nom	Nom	Nom	Max	0.89683	-0.00082	-0.7
Max	Min	Min	Max	Max	Min	Max	Min	0.90794	0.01029	9.1

Table 6.A.4-7 Component Tolerance Study – In Shift Exxon Fuel (EX) at 3.71 wt % ^{235}U

Tube Tol.		**Absorber Tol.**		**Disk Tol.**						
Outer Width	**Thickness**	**Width**	**Thickness**	**Op_Width**	**Location**	**Thickness**	**Spacing**	**k_{eff}**	**Δk**	**$\Delta k/\sigma$**
Nom	Nom	Nom	Nom	Nom	Nom	Nom	Nom	0.84753	--	--
Min	Nom	Nom	Nom	Nom	Nom	Nom	Nom	0.84771	0.00018	0.2
Max	Nom	Nom	Nom	Nom	Nom	Nom	Nom	0.85028	0.00275	2.4
Nom	Min	Nom	Nom	Nom	Nom	Nom	Nom	0.85547	0.00794	6.9
Nom	Max	Nom	Nom	Nom	Nom	Nom	Nom	0.84325	-0.00428	-3.8
Nom	Nom	Min	Nom	Nom	Nom	Nom	Nom	0.84929	0.00176	1.6
Nom	Nom	Max	Nom	Nom	Nom	Nom	Nom	0.84789	0.00036	0.3
Nom	Nom	Nom	Min	Nom	Nom	Nom	Nom	0.84925	0.00172	1.5
Nom	Nom	Nom	Max	Nom	Nom	Nom	Nom	0.84800	0.00047	0.4
Nom	Nom	Nom	Nom	Min	Nom	Nom	Nom	0.84621	-0.00132	-1.2
Nom	Nom	Nom	Nom	Max	Nom	Nom	Nom	0.84798	0.00045	0.4
Nom	Nom	Nom	Nom	Nom	Min	Nom	Nom	0.84824	0.00071	0.6
Nom	Nom	Nom	Nom	Nom	Max	Nom	Nom	0.84717	-0.00036	-0.3
Nom	Nom	Nom	Nom	Nom	Nom	Min	Nom	0.84801	0.00048	0.4
Nom	Nom	Nom	Nom	Nom	Nom	Max	Nom	0.84796	0.00043	0.4
Nom	Nom	Nom	Nom	Nom	Nom	Nom	Min	0.84936	0.00183	1.6
Nom	Nom	Nom	Nom	Nom	Nom	Nom	Max	0.84810	0.00057	0.5
Max	Min	Min	Max	Max	Min	Max	Min	0.86033	0.01280	11.4

Table 6.A.4-8 DFC Undamaged Assembly and Missing Rod Study Results

Primary Fuel (Interior)		Secondary Fuel (Exterior)							
Type	Enrichment wt % ^{235}U	Type	Enrichment wt % ^{235}U	DFC Model	DFC Content	Missing Rods #	k_{eff}	Δk	$\Delta k/\sigma$
EX	3.71	N/A	N/A	No	N/A	N/A	0.86033	--	--
EX	3.71	N/A	N/A	Yes	IAA	N/A	0.85806	--	--
EX	3.71	N/A	N/A	Yes	IAA	1	0.86003	0.00197	1.8
EX	3.71	N/A	N/A	Yes	IAA	4	0.85946	0.00140	1.3
EX	3.71	N/A	N/A	Yes	IAA	8	0.85741	-0.00065	-0.6
EX	3.71	N/A	N/A	Yes	IAA	12	0.85886	0.00080	0.7
EX	3.71	N/A	N/A	Yes	IAA	16	0.85972	0.00166	1.5
EX	3.71	N/A	N/A	Yes	IAA	20	0.85883	0.00077	0.7
EX	3.71	AC	3.94	Yes	IAA	N/A	0.86144	--	--
EX	3.71	AC	3.94	Yes	IAA	1	0.86068	-0.00076	-0.7
EX	3.71	AC	3.94	Yes	IAA	4	0.86033	-0.00111	-1.0
EX	3.71	AC	3.94	Yes	IAA	8	0.86081	-0.00063	-0.6
EX	3.71	AC	3.94	Yes	IAA	12	0.86111	-0.00033	-0.3
EX	3.71	AC	3.94	Yes	IAA	16	0.86129	-0.00015	-0.1
EX	3.71	AC	3.94	Yes	IAA	20	0.86198	0.00054	0.5

Table 6.A.4-9 DFC Damaged Assembly – No Clad, Modified Pitch, Missing Rod Study Results

Primary Fuel		Secondary Fuel								
Type	Enrichment wt %^{235}U	Type	Enrichment wt %^{235}U	DFC Model	DFC Content	Pitch [in]	Missing Rods #	k_{eff}	Δk	Δk/σ
EX	3.71	AC	3.94	Yes	URA	--	N/A	0.87209	--	--
EX	3.71	AC	3.94	Yes	URA	0.5825	N/A	0.87595	0.00386	3.6
EX	3.71	AC	3.94	Yes	URA	0.5999	N/A	0.87930	0.00721	6.4
EX	3.71	AC	3.94	Yes	URA	0.5999	N/A	0.87930	--	--
EX	3.71	AC	3.94	Yes	URA	0.5999	1	0.88051	0.00121	1.1
EX	3.71	AC	3.94	Yes	URA	0.5999	4	0.87886	-0.00044	-0.4
EX	3.71	AC	3.94	Yes	URA	0.5999	8	0.87760	-0.00170	-1.5
EX	3.71	AC	3.94	Yes	URA	0.5999	12	0.87747	-0.00183	-1.6
EX	3.71	EX	3.71	Yes	URA	0.557	N/A	0.86752	--	--
EX	3.71	EX	3.71	Yes	URA	0.5789	N/A	0.87208	0.00456	4.2
EX	3.71	EX	3.71	Yes	URA	0.6007	N/A	0.87275	0.00523	4.6
EX	3.71	EX	3.71	Yes	URA	0.6007	N/A	0.87275	--	--
EX	3.71	EX	3.71	Yes	URA	0.6007	1	0.87319	0.00044	0.4
EX	3.71	EX	3.71	Yes	URA	0.6007	4	0.87174	-0.00101	-0.9
EX	3.71	EX	3.71	Yes	URA	0.6007	8	0.87075	-0.00200	-1.8
EX	3.71	EX	3.71	Yes	URA	0.6007	12	0.86867	-0.00408	-3.6

Table 6.A.4-10 DFC Damaged Assembly – Fuel Mixture Study Results

Primary Fuel		Secondary Fuel							
Type	**Enrichment wt % ^{235}U**	**Type**	**Enrichment wt % ^{235}U**	**DFC Model**	**DFC Content**	**Mix. Height**	**k_{eff}**	**Δk**	**$\Delta k/\sigma$**
EX	3.71	N/A	N/A	No	N/A	N/A	0.86033	--	--
EX	3.71	N/A	N/A	Yes	MIX	0.23	0.85102	-0.00931	-8.3
EX	3.71	N/A	N/A	Yes	MIX	0.3	0.85200	-0.00833	-7.8
EX	3.71	N/A	N/A	Yes	MIX	0.4	0.85778	-0.00255	-2.3
EX	3.71	N/A	N/A	Yes	MIX	0.5	0.85994	-0.00039	-0.3
EX	3.71	N/A	N/A	Yes	MIX	0.6	0.86369	0.00336	2.9
EX	3.71	N/A	N/A	Yes	MIX	0.7	0.86599	0.00566	5.1
EX	3.71	N/A	N/A	Yes	MIX	0.9	0.86621	0.00588	5.3
EX	3.71	N/A	N/A	Yes	MIX	0.9	0.86521	0.00488	4.2
EX	3.71	N/A	N/A	Yes	MIX	1	0.86485	0.00452	4.0
EX	3.71	AC	3.94	Yes	MIX	0.25	0.85118	-0.00915	-8.3
EX	3.71	AC	3.94	Yes	MIX	0.3	0.85096	-0.00937	-8.5
EX	3.71	AC	3.94	Yes	MIX	0.4	0.85511	-0.00522	-4.8
EX	3.71	AC	3.94	Yes	MIX	0.5	0.86074	0.00041	0.4
EX	3.71	AC	3.94	Yes	MIX	0.6	0.86393	0.00360	3.2
EX	3.71	AC	3.94	Yes	MIX	0.7	0.86783	0.00750	6.6
EX	3.71	AC	3.94	Yes	MIX	0.8	0.86864	0.00831	7.2
EX	3.71	AC	3.94	Yes	MIX	0.9	0.86780	0.00747	6.7
EX	3.71	AC	3.94	Yes	MIX	1	0.86659	0.00626	5.7

Table 6.A.4-11 Preferentially Flooded System Shift Study – (AC Fuel, 3.94/3.64 wt % ^{235}U DFC Locations, EX Fuel, 3.71 wt % ^{235}U Interior Locations)

Comp. Radial Shift				
Fuel	**Tube**	**k_{eff}**	**Δk**	**Δk/σ**
In	In	0.92286	--	--
DFC_Close_A	DFC_Close_A	0.92045	-0.00241	-1.0
DFC_Close_B	DFC_Close_B	0.92183	-0.00103	-0.4

Table 6.A.4-12 DFC Shift Study – Preferential Flood Tolerance Evaluations Based on DFC_Close_B Shift Pattern

Tube Tol.		**Absorber Tol.**		**Disk Tol.**						
Outer Width	**Thickness**	**Width**	**Thickness**	**Op_Width**	**Location**	**Thickness**	**Spacing**	k_{eff}	Δk	$\Delta k/\sigma$
Nom	Nom	Nom	Nom	Nom	Nom	Nom	Nom	0.92414	--	--
Min	Nom	Nom	Nom	Nom	Nom	Nom	Nom	0.92371	-0.00043	-0.2
Max	Nom	Nom	Nom	Nom	Nom	Nom	Nom	0.92117	-0.00297	-1.3
Nom	Min	Nom	Nom	Nom	Nom	Nom	Nom	0.91849	-0.00565	-2.5
Nom	Max	Nom	Nom	Nom	Nom	Nom	Nom	0.92373	-0.00041	-0.2
Nom	Nom	Min	Nom	Nom	Nom	Nom	Nom	0.92429	0.00015	0.1
Nom	Nom	Max	Nom	Nom	Nom	Nom	Nom	0.92288	-0.00126	-0.5
Nom	Nom	Nom	Min	Nom	Nom	Nom	Nom	0.92149	-0.00265	-1.2
Nom	Nom	Nom	Max	Nom	Nom	Nom	Nom	0.92201	-0.00213	-0.9
Nom	Nom	Nom	Nom	Min	Nom	Nom	Nom	0.92180	-0.00234	-1.0
Nom	Nom	Nom	Nom	Max	Nom	Nom	Nom	0.92311	-0.00103	-0.5
Nom	Nom	Nom	Nom	Nom	Min	Nom	Nom	0.92550	0.00136	0.6
Nom	Nom	Nom	Nom	Nom	Max	Nom	Nom	0.92160	-0.00254	-1.1
Nom	Nom	Nom	Nom	Nom	Nom	Min	Nom	0.92189	-0.00225	-1.0
Nom	Nom	Nom	Nom	Nom	Nom	Max	Nom	0.92253	-0.00161	-0.7
Nom	Nom	Nom	Nom	Nom	Nom	Nom	Min	0.92638	0.00224	1.0
Nom	Nom	Nom	Nom	Nom	Nom	Nom	Max	0.92124	-0.00290	-1.3

Table 6.A.4-13 Exxon Placement in DFC

Primary Fuel		Secondary Fuel		Third Fuel				
Type	Enrichment wt %^{235}U	Type	Enrichment wt %^{235}U	Type	Enrichment wt %^{235}U	k_{eff}	Δk	$\Delta k/\sigma$
EX	3.71	AC	3.94	AC	3.64	0.92286	--	--
EX	3.71	AC	3.94	EX	3.71	0.92175	-0.00123	-0.5
EX	3.71	EX	3.71	AC	3.64	0.90577	-0.01753	-7.5
EX	3.71	N/A	N/A	N/A	N/A	0.91357	-0.00977	-4.2

Table 6.A.4-14 Active Fuel Location Study for Wet TSC and Dry TSC

DFC Fuel Location	TSC	k_{eff}	Δk	$\Delta k/\sigma$
Active Fuel	Dry	0.92286	--	--
Bottom	Dry	0.92680	0.00394	1.6
Top	Dry	0.92502	0.00216	0.9
Active Fuel	Wet	0.87505	--	--
Bottom	Wet	0.87601	0.00096	0.8
Top	Wet	0.87254	-0.00251	-2.3

Table 6.A.4-15 Storage Cask Analyses Results

DFC Fuel Loc.Axial	**Cask Model**	**Cask Array**	**Density (H_2O)**			**k_{eff}**	**σ**	**$k_{eff}+2\sigma$**	**Δk**
			Lattice	**Exterior**	**DFC**				
Active Fuel	Transfer	SC[1]	0.0001	0.0001	0.9982	0.92286	0.00175	0.92636	--
Active Fuel	Storage	SC	0.0001	0.0001	0.9982	0.90915	0.00161	0.91237	-0.01371
Active Fuel	Storage	SC	0.0001	0.0001	N/A	0.33965	0.00054	0.34073	-0.56950
Active Fuel	Storage	InfArray	0.9982	0.0001	N/A	0.87621	0.00083	0.87787	-0.04665
Active Fuel	Storage	InfArray	0.0001	0.0001	0.9982	0.91159	0.00163	0.91485	-0.01127
Active Fuel	Storage	InfArray	0.0001	0.0001	N/A	0.33869	0.00057	0.33983	-0.58417
Active Fuel	Storage	InfArray	0.0001	0.9982	N/A	0.33438	0.00069	0.33576	-0.58848
Active Fuel	Storage	InfArray	0.9982	0.9982	N/A	0.87447	0.00082	0.87611	-0.04839
Bottom	Transfer	SC	0.0001	0.0001	0.9982	0.92680	0.00167	0.93014	--
Bottom	Storage	SC	0.0001	0.0001	0.9982	0.91418	0.00170	0.91758	-0.01262
Bottom	Storage	SC	0.0001	0.0001	N/A	0.33994	0.00057	0.34108	-0.57424
Bottom	Storage	InfArray	0.9982	0.0001	N/A	0.87578	0.00082	0.87742	-0.05102
Bottom	Storage	InfArray	0.0001	0.0001	0.9982	0.91571	0.00164	0.91899	-0.01109
Bottom	Storage	InfArray	0.0001	0.0001	N/A	0.34100	0.00061	0.34222	-0.58580
Bottom	Storage	InfArray	0.0001	0.9982	N/A	0.33553	0.00069	0.33691	-0.59127
Bottom	Storage	InfArray	0.9982	0.9982	N/A	0.87363	0.00076	0.87515	-0.05317

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[1] Single cask model.

Table 6.A.4-16 Fuel Assembly Limiting Characteristics

Fuel ID		AC	EX
Array		10×10	10×10
Number of Fuel Rods		100	96
Max. Active Length	[in]	83	83
Rod Pitch	[in]	0.565	0.557
Rod Diameter	[in]	0.396	0.394
Pellet Diameter	[in]	0.350	0.343
Clad Thickness	[in]	0.020	0.0220
Max. MTU(5)	[MTU]	0.1214	0.1119
Number of Inert Rods(1,2)		0	4
Listed Inert Rod OD	[in]	N/A	0.3940
Enrichment	[wt % ^{235}U]	3.64/3.94(4)	3.71(3)

Notes:
(1) Not required for fuel assemblies located in DFC.
(2) Inert rods comprised of stainless steel clad tube containing zirconium alloy slug.
(3) Planar average enrichment.
(4) Two AC fuel types, Type 1 at an enrichment of 3.64 wt % ^{235}U and Type 2 at 3.94 wt % ^{235}U.
(5) Damaged fuel cans are allowed to contain an additional 5% spent fuel rod material to account for loose pellets not necessarily associated with the as-built assembly.

Table 6.A.4-17 MCNP Validation – Range of Applicability

Parameter	Minimum	Maximum	MPC-LACBWR
Enrichment (wt % ^{235}U)	2.350%	4.738%	3.94%
Fuel rod pitch (cm)	1.30	2.54	1.524 (AC Loose Pellets)
Fuel pellet outer diameter (cm)	0.790	1.265	0.889 (AC Loose Pellets)
Fuel rod diameter (cm)	0.9400	1.4172	N/A
H/^{235}U atom ratio	72.7	403.9	195 (AC Loose Pellets)
Soluble boron (ppm by weight)	0	4986	0
Cluster Gap (cm)	1.206	13.750	1.2(1)
Boron (^{10}B) plate loading (g/cm^2)	0.0000	0.0670	0.020
EALCF (eV)	0.09781	0.77219	0.4215

Note: (1) Represents minimum flux trap between DFCs. Corner DFCs are separated by up to 2.8 cm. The maximum reactivity payload cluster gap is less than 1% lower than the range evaluated. This will not affect the USL applicability to the MPC-LACBWR basket.

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6.A.5 Critical Benchmark Experiments

Criticality code validation is performed for the Monte Carlo evaluation code and neutron cross-section libraries. Criticality validation is required by the criticality safety standards ANSI/ANS-8.1 [A6].

6.A.5.1 Benchmark Experiments and Applicability

NUREG/CR-6361, "Criticality Benchmark Guide for Light-Water-Reactor Fuel in Transportation and Storage Packages" (NUREG), provides a guide to LWR criticality benchmark calculations and the determination of bias and subcritical limits in critical safety evaluations. In Section 2 of the NUREG, a series of LWR critical experiments are described in sufficient detail for independent modeling. In Section 3, the critical experiments are modeled, and the results (k_{eff} values) are presented. The method utilized in the NUREG is KENO-Va with the 44-group ENDF/B-V cross-section library embedded in SCALE 4.3. In Section 4, a guide for the determination of bias and subcritical safety limits is provided based on ANSI/ANS-8.17 [A7] and statistical analysis of the trending in the bias. Finally, guidelines for experiment selection and applicability are presented in Section 5. The approach outlined in Section 4 of the NUREG is described in detail herein and is implemented for MCNP5 with continuous energy ENDF/B-VI cross-sections.

The NUREG/CR-6361 implements ANSI/ANS-8.17 criticality safety criterion as follows.

$$k_s \leq k_c - \Delta k_s - \Delta k_c - \Delta k_m \qquad \text{(Equation 1)}$$

where:

k_s = calculated allowable maximum multiplication factor, k_{eff}, of the system being evaluated for all normal or credible abnormal conditions or events.

k_c = mean k_{eff} that results from a calculation of benchmark criticality experiments using a particular calculation method. If the calculated k_{eff} values for the criticality experiments exhibit a trend with an independent parameter, then k_c shall be determined by extrapolation based on best fit to calculated values. Criticality experiments used as benchmarks in computing k_c should have physical compositions, configurations, and nuclear characteristics (including reflectors) similar to those of the system being evaluated.

Δk_s = allowance for the following.

- statistical or convergence uncertainties, or both, in computation of k_s
- material and fabrication tolerances
- geometric or material representations used in computational method

Δk_c = margin for uncertainty in k_c, which includes allowance for the following.

- uncertainties in critical experiments
- statistical or convergence uncertainties, or both, in computation of k_c
- uncertainties resulting from extrapolation of k_c outside range of experimental data
- uncertainties resulting from limitations in geometrical or material representations used in the computational method

Δk_m = arbitrary administrative margin to ensure subcriticality of k_s

The various uncertainties are combined statistically if they are independent. Correlated uncertainties are combined by addition.

Equation 1 can be rewritten as shown.

$$k_s \leq 1 - \Delta k_m - \Delta k_s - (1 - k_c) - \Delta k_c \qquad \text{(Equation 2)}$$

Noting that the definition of the bias is $\beta = 1 - k_c$, Equation 2 can be written as shown.

$$k_s + \Delta k_s \leq 1 - \Delta k_m - \beta - \Delta\beta \qquad \text{(Equation 3)}$$

where:

$$\Delta\beta = \Delta k_c$$

Thus, the maximum allowable value for k_{eff} plus uncertainties in the system being analyzed must be below 1 minus an administrative margin (typically 0.05), which includes the bias and the uncertainty in the bias. This can also be written as shown.

$$k_s + \Delta k_s \leq \text{Upper Subcritical Limit (USL)} \qquad \text{(Equation 4)}$$

where:

$$\text{USL} \equiv 1 - \Delta k_m - \beta - \Delta\beta \qquad \text{(Equation 5)}$$

This is the USL criterion as described in Section 4 of NUREG/CR-6361. Two methods are prescribed for the statistical determination of the USL. The “Confidence Band with Administrative Margin (USL-1)” approach is implemented here and is referred to generically as USL. A $\Delta k_m = 0.05$ and a lower confidence band are specified based on a linear regression of k_{eff} as a function of some system parameter. As recommended in NUREG/CR-6361, a simple linear regression is performed on each system parameter, and the line with the greatest correlation is used to functionalize β.

Section 6.A.5.2 contains the extensive list of LWR critical benchmarks employed in the validation of MCNP with its continuous energy neutron cross-section libraries. The range of parameters included in the benchmarks is shown in Table 6.A.5-1.

Included in Section 6.A.5.2 are linear fits of reactivity (k_{eff}) to each of the system parameters. Experiments were chosen to reflect the fuel and basket geometry and materials, and the spent fuel cask criticality control mechanism. This includes the use of square pitched, low enriched uranium oxide fuel rods, a rectangular arrangement of assembles, light water moderation, and criticality control by spacing, borated moderator, and/or borated absorber panels and tubes. Trending in k_{eff} was evaluated for the following independent variables: wt % ^{235}U, rod pitch, H/U volume ratio, energy of the average neutron lethargy causing fission (EALCF), ^{10}B loading of the absorber sheet, and soluble boron loading. No statistically significant trends were found for any of the system parameters. USLs are, therefore, generated for each of the independent variables. A minimum USL covering the range of applicability of the benchmark set is determined as detailed in Section 6.A.5.2.

6.A.5.2 Results of Benchmark Calculations

To evaluate the relative importance of the trend analysis to the upper subcritical limits, correlation coefficients are required for all independent parameters. The linear correlation coefficient, R, is calculated by taking the square root of the R^2 value. In particular, the correlation coefficient, R, is a measure of the linear relationship between k_{eff} and a critical experiment parameter. If R is +1, a perfect linear relationship with a positive slope is indicated; and if R is -1, a perfect linear relationship with a negative slope is indicated. When R is 0, no linear relationship is indicated.

Table 6.A.5-2 contains the correlation coefficient, R, for each linear fit of k_{eff} versus experimental parameter. Linear fits and correlation constants are based on the 183 data-point evaluation sets plotted in Section 6.A.5-3. The cluster gap plot is limited to the 137 data points for experiments containing multiple fuel rod clusters. Single fuel rod cluster experiments documented in LEU-COMP-THERM sets 06, 14, 35 and 50, in addition to LEU-COMP-THERM experiments 01-01, 02-01 to -03, and 08-01 to -15, were therefore excluded from the cluster gap study. The 183 data points evaluated for the remaining parameters represent the complete set of experiments listed in Section 6.A.5-3 minus the three high energy lethargy experiments above 0.35 eV (Experiments LEU-COMP-THERM 14-05, -06 and -07). Addition of these points, while not resulting in a significant linear fit, produces a noticeable slope to the

USL correlation not representative of the remaining data fits. As this increased slope results in a higher USL, it is acceptable to discard these data points. The three higher energy points are removed from all independent variables for consistency.

As there is no significant correlation to any of the independent variables, the USL for each independent variable is calculated and shown with its range of applicability in Table 6.A.5-2. A sample output for EALCF is shown in Figure 6.A.5-1. Uncertainties included in the USLSTATS evaluation are the Monte Carlo uncertainty associated with the reactivity calculation and experimental uncertainty that was provided in the literature for each of the cases.

Based on all the independent variable correlations, a lower limit constant USL of 0.9376 may be applied. The range of applicability (area of applicability) of this limit may be extended to 5 wt % enriched fuel, as the correlation shows no significant trend with enrichment between 2.35 and 4.74 wt %, and that the limited trending observed increases the USL. Extending the range of applicability for the average neutron lethargy is based on a minimal, but positive, trend of the USL versus EALCF. Studies, including additional data points up to 0.7722 eV, indicate that the trending continues to the higher energy levels.

6.A.5.3 Critical Benchmarks

From the International Handbook of Evaluated Criticality Safety Benchmark Experiments [A8], 186 experiments are selected as basis of the MCNP benchmarking. Experiments were selected for compatibility of materials and geometry with the spent fuel casks. Of particular interest are benchmarks with rectangular arrays of low enriched uranium oxide fuel rods in which reactivity is controlled by soluble boron or borated plates (tubes).

MCNP benchmark cases represent a collection of files composed of inputs directly obtained from references (with cross-section sets adjusted to those used in the cask analysis), NAC modified input files representing unique geometries based on reference input files, and input files constructed from the experimental material and geometry information. All cases were reviewed on a "preparer/checker" principle for modeling consistency with the cask models and the choice of code options. Due to large variations in the benchmark complexities, not all options employed in the cask models are reflected in each of the benchmarks (e.g., UNIVERSE structure). A review of the criticality results did not indicate any result trend due to particular modeling choices (e.g., using the UNIVERSE structure versus a single universe, or employing KSRC versus SDEF sampling).

Key system parameters, the experimental uncertainty, and calculated k_{eff} and σ for each experiment are shown in Table 6.A.5-3. Stochastic Monte Carlo error is kept within ±0.2% and each output is checked to assure that the MCNP build-in statistical checks on the results are passed and that all fissile material is sampled.

Scatter plots of k_{eff} versus system parameters for 183 data point sets (full set minus three high lethargy points above 0.35 eV) are created (see Figure 6.A.5-2 through Figure 6.A.5-10). Included in these scatter plots are linear regression lines with a corresponding correlation coefficient (R^2) to statistically indicate any trend or lack thereof. Scatter plates are created for k_{eff} versus the following.

Enrichment in ^{235}U (wt % ^{235}U)
Fuel rod pitch (cm)
Fuel pellet outer diameter (cm)
Fuel rod outer diameter (cm)
Hydrogen/uranium (^{235}U) atom ratio
Soluble boron (ppm by weight)
Cluster gap spacing (spacing between assemblies in cm)
Boron (^{10}B) plate loading (g/cm^2)
Energy of average neutron lethargy causing fission (eV)

Figure 6.A.5-1 USLSTATS Output for EALCF

```
************************************************************************
                        Version 1.4, April 23, 2003
                       Oak Ridge National Laboratory
************************************************************************
 Input to statistical treatment from file:enrich-183.in
 Title: keff vs enrichment
 Proportion of the population = .995
 Confidence of fit            = .950
 Confidence on proportion     = .950
 Number of observations       =  183
 Minimum value of closed band =    0.00
 Maximum value of closed band =    0.00
 Administrative margin        =    0.05

 independent      dependent        deviation               independent      dependent        deviation
 variable - x     variable - y      in y                   variable - x     variable - y      in y
  2.35000E+00      9.94910E-01     3.42000E-03              2.35000E+00      9.95090E-01     3.46000E-03
  2.35000E+00      9.92830E-01     3.38000E-03              2.35000E+00      9.92520E-01     3.47000E-03
  2.35000E+00      9.98060E-01     3.38000E-03              2.35000E+00      9.95620E-01     3.50000E-03
  2.35000E+00      9.96550E-01     3.42000E-03              2.35000E+00      9.93130E-01     3.55000E-03
  2.35000E+00      9.89310E-01     3.44000E-03              2.35000E+00      9.98130E-01     3.58000E-03
  2.35000E+00      9.95340E-01     3.41000E-03              2.35000E+00      9.96700E-01     3.56000E-03
  2.35000E+00      9.93880E-01     3.44000E-03              2.35000E+00      9.93830E-01     3.55000E-03
  2.35000E+00      9.89690E-01     3.36000E-03              2.35000E+00      9.92770E-01     3.47000E-03
  4.30600E+00      9.95160E-01     2.79000E-03              2.35000E+00      9.92920E-01     3.50000E-03
  4.30600E+00      9.93670E-01     2.54000E-03              2.35000E+00      9.96410E-01     3.46000E-03
  4.30600E+00      9.96340E-01     2.76000E-03              2.35000E+00      9.93060E-01     3.49000E-03
  4.30600E+00      9.93110E-01     2.64000E-03              2.35000E+00      9.96500E-01     3.45000E-03
  4.30600E+00      9.93000E-01     2.49000E-03              2.35000E+00      9.94680E-01     3.50000E-03
  2.59600E+00      9.92680E-01     2.10000E-03              2.35000E+00      9.93300E-01     3.47000E-03
  2.59600E+00      9.93190E-01     2.14000E-03              2.35000E+00      9.91810E-01     3.46000E-03
  2.59600E+00      9.92990E-01     2.13000E-03              2.35000E+00      9.93920E-01     3.47000E-03
  2.59600E+00      9.94790E-01     2.13000E-03              2.35000E+00      9.95560E-01     3.55000E-03
  2.59600E+00      9.93100E-01     2.12000E-03              2.35000E+00      9.94540E-01     3.51000E-03
  2.59600E+00      9.93240E-01     2.12000E-03              2.35000E+00      9.94490E-01     3.47000E-03
  2.59600E+00      9.91990E-01     2.12000E-03              2.35000E+00      9.91300E-01     3.52000E-03
  2.59600E+00      9.93820E-01     2.12000E-03              2.35000E+00      9.94800E-01     3.47000E-03
  2.59600E+00      9.94450E-01     2.12000E-03              2.35000E+00      9.93500E-01     3.60000E-03
  2.59600E+00      9.95440E-01     2.13000E-03              2.35000E+00      9.94000E-01     3.45000E-03
  2.59600E+00      9.94410E-01     2.12000E-03              2.35000E+00      9.96280E-01     3.53000E-03
  2.59600E+00      9.93920E-01     2.15000E-03              2.35000E+00      9.92620E-01     3.45000E-03
  2.59600E+00      9.95090E-01     2.14000E-03              2.35000E+00      9.94100E-01     3.53000E-03
  2.59600E+00      9.93780E-01     2.12000E-03              2.35000E+00      9.96470E-01     3.52000E-03
  2.59600E+00      9.95040E-01     2.14000E-03              2.35000E+00      9.93600E-01     3.47000E-03
  2.59600E+00      9.94380E-01     2.11000E-03              2.35000E+00      9.97020E-01     3.49000E-03
  2.59600E+00      9.95730E-01     2.12000E-03              2.35000E+00      9.94970E-01     3.50000E-03
  2.59600E+00      9.94270E-01     2.14000E-03              2.35000E+00      9.91950E-01     3.55000E-03
  2.45900E+00      9.98350E-01     1.34000E-03              2.59600E+00      9.93410E-01     1.93000E-03
  2.45900E+00      9.96860E-01     1.36000E-03              2.59600E+00      9.91310E-01     2.05000E-03
  2.45900E+00      9.99310E-01     1.24000E-03              4.73800E+00      9.95860E-01     4.36000E-03
  2.45900E+00      9.97950E-01     1.36000E-03              4.73800E+00      9.93580E-01     4.53000E-03
  2.45900E+00      9.97650E-01     1.38000E-03              4.73800E+00      9.95390E-01     4.58000E-03
  2.45900E+00      9.96990E-01     1.35000E-03              4.73800E+00      9.92370E-01     4.54000E-03
  2.45900E+00      9.97230E-01     1.37000E-03              4.73800E+00      9.91440E-01     4.62000E-03
  2.45900E+00      9.96590E-01     1.40000E-03              4.73800E+00      9.98780E-01     4.82000E-03
  2.45900E+00      9.95260E-01     1.40000E-03              4.73800E+00      9.94180E-01     4.94000E-03
  2.45900E+00      9.97450E-01     1.36000E-03              4.73800E+00      9.92400E-01     4.90000E-03
  2.45900E+00      9.97590E-01     1.38000E-03              4.73800E+00      9.96930E-01     4.98000E-03
  2.45900E+00      9.97650E-01     1.36000E-03              4.73800E+00      9.91370E-01     5.05000E-03
  2.45900E+00      9.98880E-01     1.39000E-03              2.35000E+00      9.92500E-01     2.34000E-03
  2.45900E+00      9.97350E-01     1.37000E-03              2.35000E+00      9.95140E-01     2.43000E-03
  2.45900E+00      9.97580E-01     1.39000E-03              2.35000E+00      9.92190E-01     2.33000E-03
  2.45900E+00      9.97720E-01     1.39000E-03              2.35000E+00      9.94760E-01     2.40000E-03
  2.45900E+00      9.96910E-01     1.35000E-03              2.35000E+00      9.94690E-01     3.67000E-03
  4.30600E+00      9.95480E-01     2.84000E-03              2.35000E+00      9.94340E-01     2.49000E-03
  4.30600E+00      9.93430E-01     2.78000E-03              2.35000E+00      9.93190E-01     2.39000E-03
  4.30600E+00      9.93300E-01     2.81000E-03              4.73800E+00      9.93300E-01     1.28000E-03
  4.30600E+00      9.93710E-01     2.85000E-03              4.73800E+00      9.93400E-01     1.23000E-03
  4.30600E+00      9.95930E-01     2.73000E-03              4.73800E+00      9.94890E-01     1.25000E-03
  4.30600E+00      9.92950E-01     2.85000E-03              4.73800E+00      9.93190E-01     1.25000E-03
  4.30600E+00      9.96160E-01     2.89000E-03              4.73800E+00      9.93060E-01     1.28000E-03
  4.30600E+00      9.93890E-01     2.73000E-03              2.45900E+00      9.91330E-01     2.03000E-03
  4.30600E+00      9.95710E-01     2.96000E-03              2.45900E+00      9.95970E-01     2.43000E-03
  4.30600E+00      9.93190E-01     2.60000E-03              2.45900E+00      9.95550E-01     2.42000E-03
  4.30600E+00      9.93780E-01     2.75000E-03              2.45900E+00      9.94860E-01     2.42000E-03
  4.30600E+00      9.92630E-01     2.84000E-03              2.45900E+00      9.95040E-01     2.42000E-03
  4.30600E+00      9.95660E-01     2.75000E-03              2.45900E+00      9.95420E-01     2.42000E-03
```

Figure 6.A.5-1 USLSTATS Output for EALCF

```
   4.30600E+00     9.94310E-01     2.82000E-03                4.45900E+00     9.95300E-01     2.42000E-03
```

```
    4.30600E+00     9.94310E-01     2.82000E-03                2.45900E+00     9.95300E-01     2.42000E-03
    4.30600E+00     9.96390E-01     2.95000E-03                2.45900E+00     9.95070E-01     2.42000E-03
    4.30600E+00     9.96860E-01     2.79000E-03                2.45900E+00     9.93680E-01     1.93000E-03
    4.30600E+00     9.97160E-01     2.68000E-03                2.45900E+00     9.92100E-01     1.93000E-03
    4.30600E+00     9.92370E-01     2.86000E-03                2.45900E+00     9.94470E-01     1.93000E-03
    4.30600E+00     9.97190E-01     2.81000E-03                2.45900E+00     9.90730E-01     1.93000E-03
    4.30600E+00     9.94340E-01     2.76000E-03                2.45900E+00     9.86520E-01     2.23000E-03
    4.30600E+00     9.96920E-01     2.79000E-03                2.45900E+00     9.86340E-01     1.93000E-03
    4.30600E+00     9.96060E-01     2.83000E-03                2.45900E+00     9.90420E-01     2.42000E-03
    4.30600E+00     9.97400E-01     2.94000E-03                2.45900E+00     9.89740E-01     2.03000E-03
    4.30600E+00     9.92810E-01     2.69000E-03                2.45900E+00     9.91520E-01     2.72000E-03
    4.30600E+00     9.92560E-01     2.88000E-03                2.45900E+00     9.90290E-01     2.13000E-03
    4.30600E+00     9.93650E-01     2.88000E-03                2.45900E+00     9.89270E-01     1.93000E-03
    4.30600E+00     9.94970E-01     2.85000E-03                2.60000E+00     9.95710E-01     1.42000E-03
    2.45900E+00     9.94820E-01     3.21000E-03                2.60000E+00     9.96180E-01     1.42000E-03
    2.45900E+00     9.94940E-01     3.21000E-03                2.60000E+00     9.95340E-01     1.52000E-03
    2.45900E+00     9.95140E-01     3.21000E-03                2.60000E+00     9.95470E-01     1.52000E-03
    2.45900E+00     9.95640E-01     3.21000E-03                2.60000E+00     9.96910E-01     1.42000E-03
    2.45900E+00     9.95080E-01     3.21000E-03                2.60000E+00     9.96140E-01     1.42000E-03
    2.45900E+00     9.95260E-01     3.21000E-03                2.60000E+00     9.95890E-01     1.42000E-03
    2.45900E+00     9.95200E-01     3.21000E-03                2.60000E+00     9.96240E-01     1.62000E-03
    4.30600E+00     9.94020E-01     1.92000E-03                2.60000E+00     9.96670E-01     1.52000E-03
    4.30600E+00     9.94460E-01     1.91000E-03                2.60000E+00     9.96760E-01     1.62000E-03
    4.30600E+00     9.93550E-01     1.91000E-03                2.60000E+00     9.96370E-01     1.62000E-03
    4.30600E+00     9.94010E-01     1.91000E-03                2.60000E+00     9.96430E-01     1.72000E-03
    4.30600E+00     9.92810E-01     3.27000E-03                2.60000E+00     9.97010E-01     1.62000E-03
    4.30600E+00     9.94960E-01     1.91000E-03                2.60000E+00     9.96500E-01     1.62000E-03
    4.30600E+00     9.93780E-01     1.90000E-03                2.60000E+00     9.96340E-01     1.62000E-03
    4.30600E+00     9.96680E-01     1.95000E-03                2.60000E+00     9.96580E-01     1.71000E-03
    4.30600E+00     9.85950E-01     7.71000E-03                2.60000E+00     9.96450E-01     1.62000E-03
    2.35000E+00     9.94940E-01     3.54000E-03
  chi =  2.5464 (upper bound = 9.49). The data tests normal.
        Output from statistical treatment
  keff vs enrichment
   Number of data points (n)                          183
   Linear regression, k(X)                            0.9950 + (-1.5719E-04)*X
   Confidence on fit (1-gamma) [input]                 95.0%
   Confidence on proportion (alpha) [input]            95.0%
   Proportion of population falling above
   lower tolerance interval (rho) [input]              99.5%
   Minimum value of X                                  2.3500E+00
   Maximum value of X                                  4.7380E+00
   Average value of X                                  3.0597E+00
   Average value of k                                   0.99453
   Minimum value of k                                   0.98595
   Variance of fit, s(k,X)^2                           5.0408E-06
   Within variance, s(w)^2                             7.8633E-06
   Pooled variance, s(p)^2                             1.2904E-05
   Pooled std. deviation, s(p)                         3.5922E-03
   C(alpha,rho)*s(p)                                   1.5554E-02
   student-t @ (n-2,1-gamma)                           1.64500E+00
   Confidence band width, W                            5.9793E-03
   Minimum margin of subcriticality, C*s(p)-W          9.5746E-03

   Upper subcritical limits: (  2.3500     <= X <=    4.7380    )
   ***** *********** *******
   USL Method 1 (Confidence Band with
   Administrative Margin)               USL1 = 0.9390 + (-1.5719E-04)*X
   USL Method 2 (Single-Sided Uniform
   Width Closed Interval Approach)      USL2 = 0.9795 + (-1.5719E-04)*X
   USLs Evaluated Over Range of Parameter X:
   **** ********* **** ***** ** ********* **

   X:  2.35E+0  2.69E+0  3.03E+0  3.37E+0  3.71E+0  4.06E+0  4.40E+0  4.74E+0
       ----------------------------------------------------------------------------
USL-1:   0.9387   0.9386   0.9386   0.9385   0.9385   0.9384   0.9383   0.9383
USL-2:   0.9791   0.9790   0.9790   0.9789   0.9789   0.9788   0.9788   0.9787
       ----------------------------------------------------------------------------
```

Figure 6.A.5-2 k_{eff} versus Fuel Enrichment

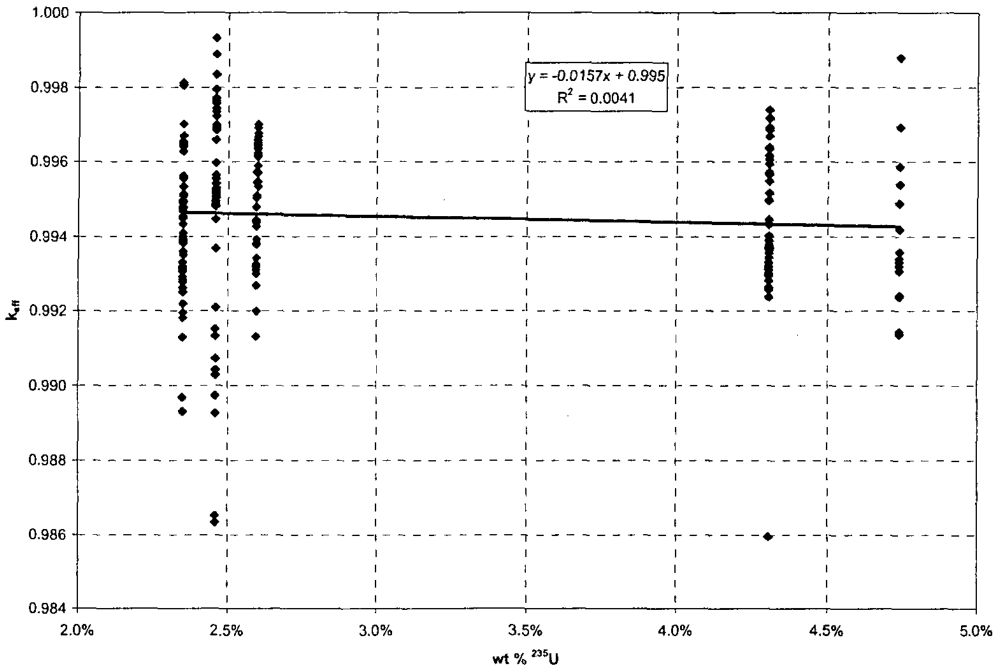

Figure 6.A.5-3 k_{eff} versus Rod Pitch

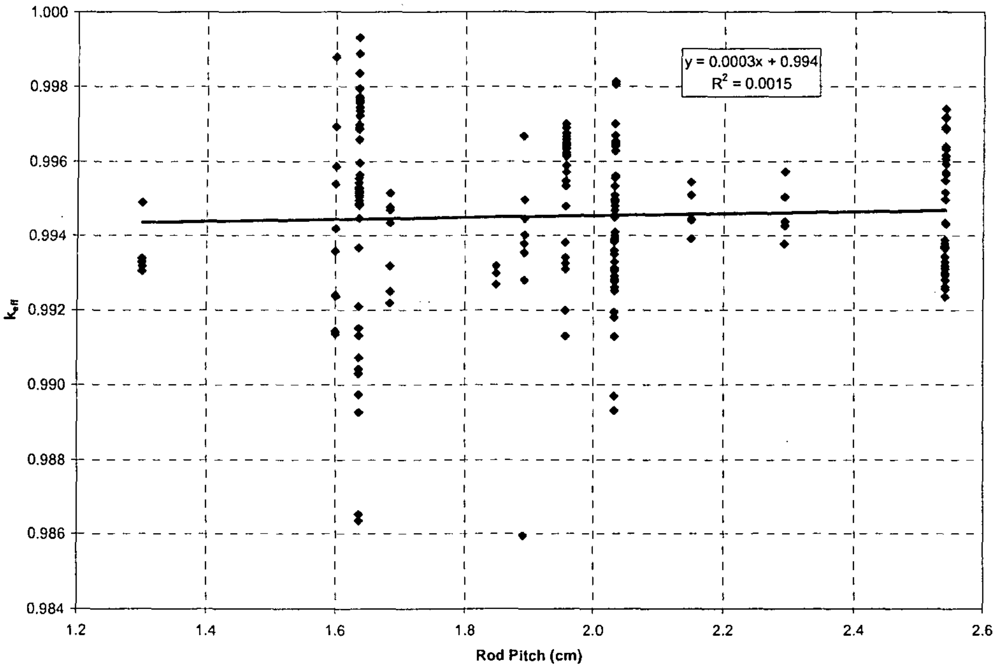

Figure 6.A.5-4 k_{eff} versus Fuel Pellet Diameter

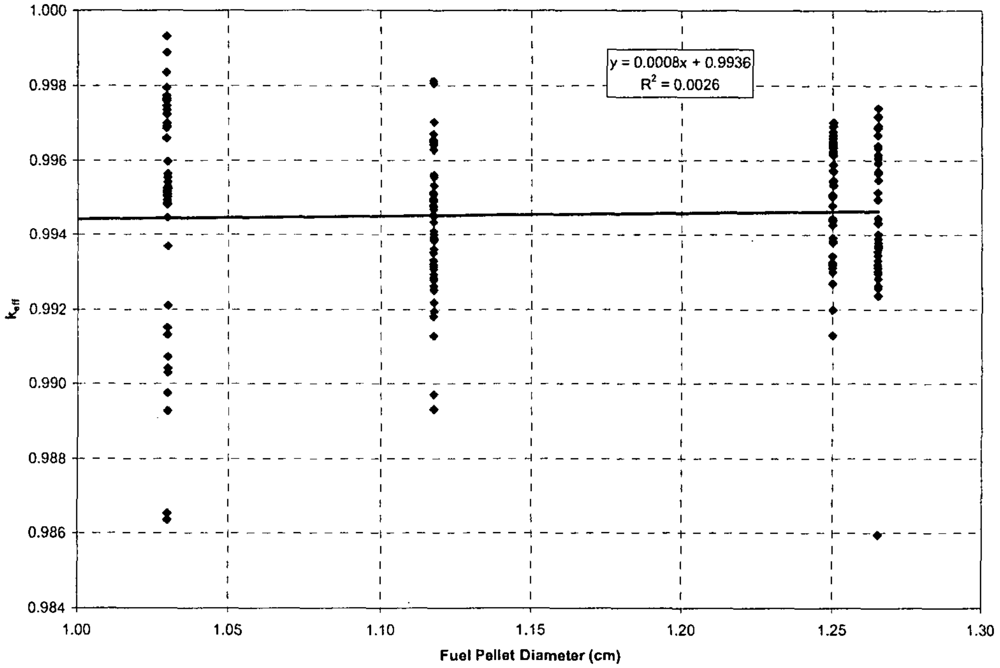

Figure 6.A.5-5 k_{eff} versus Fuel Rod Outside Diameter

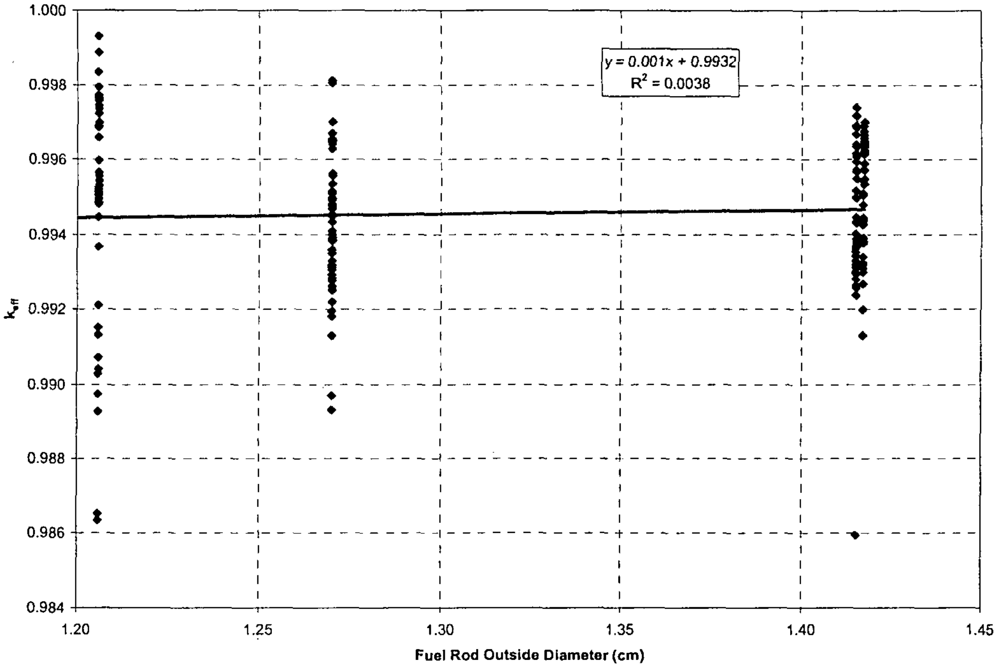

Figure 6.A.5-6 k_{eff} versus Hydrogen/^{235}U Atom Ratio

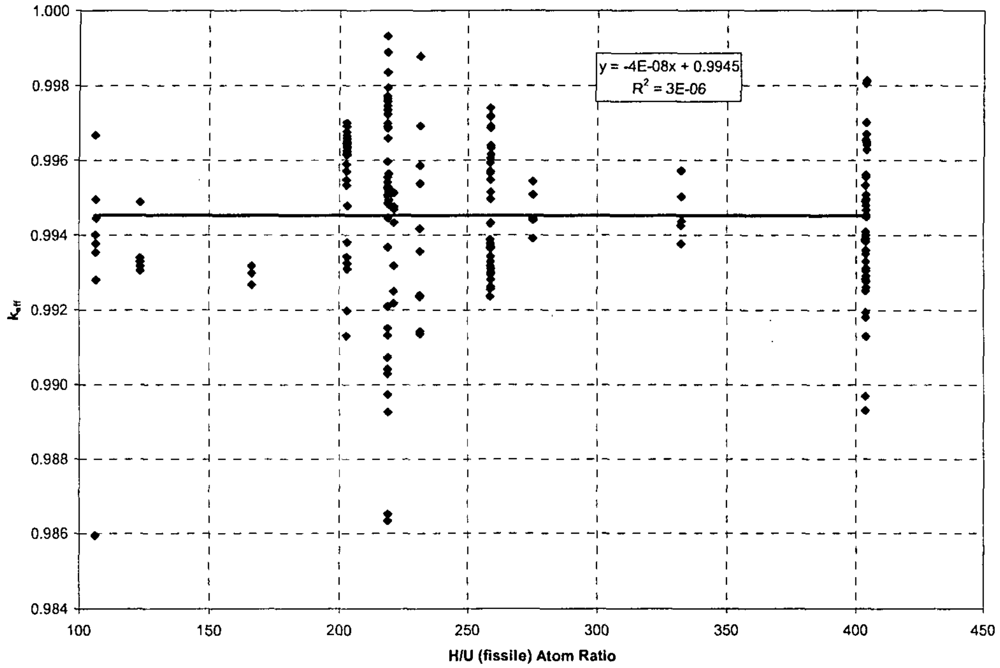

Figure 6.A.5-7 k_{eff} versus Soluble Boron Concentration

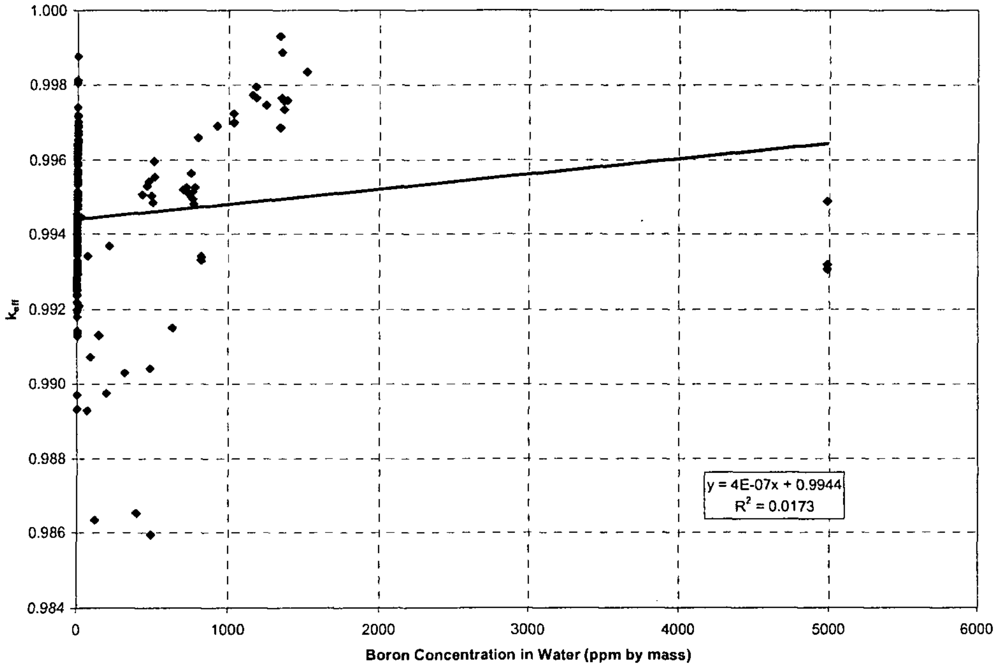

Figure 6.A.5-8 k_{eff} versus Cluster Gap Thickness

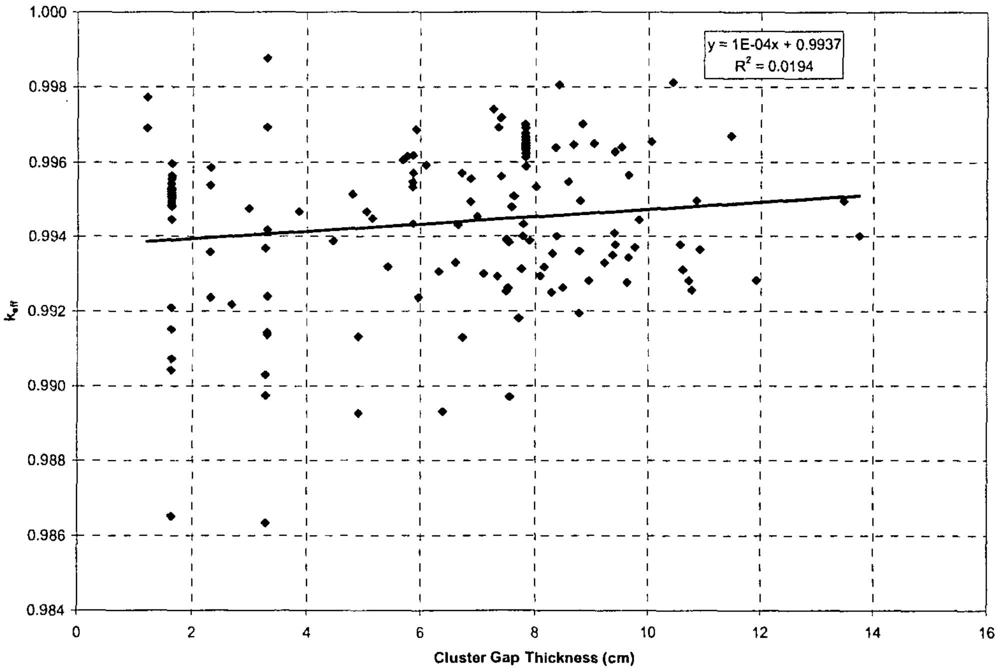

Figure 6.A.5-9 k_{eff} versus ^{10}B Plate Loading

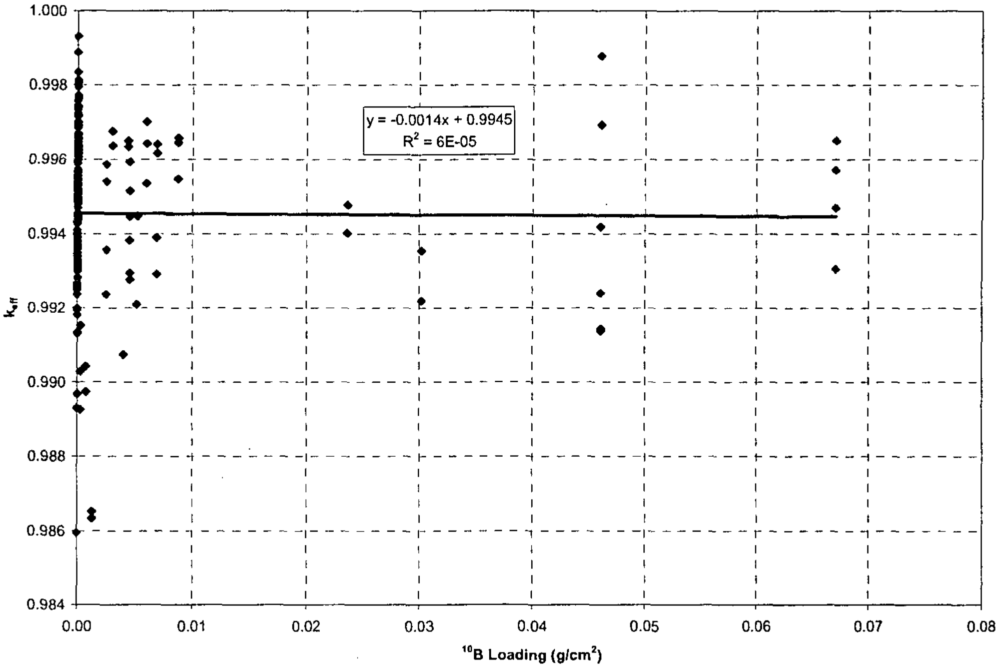

Figure 6.A.5-10 k_{eff} versus Energy of Average Neutron Lethargy Causing Fission

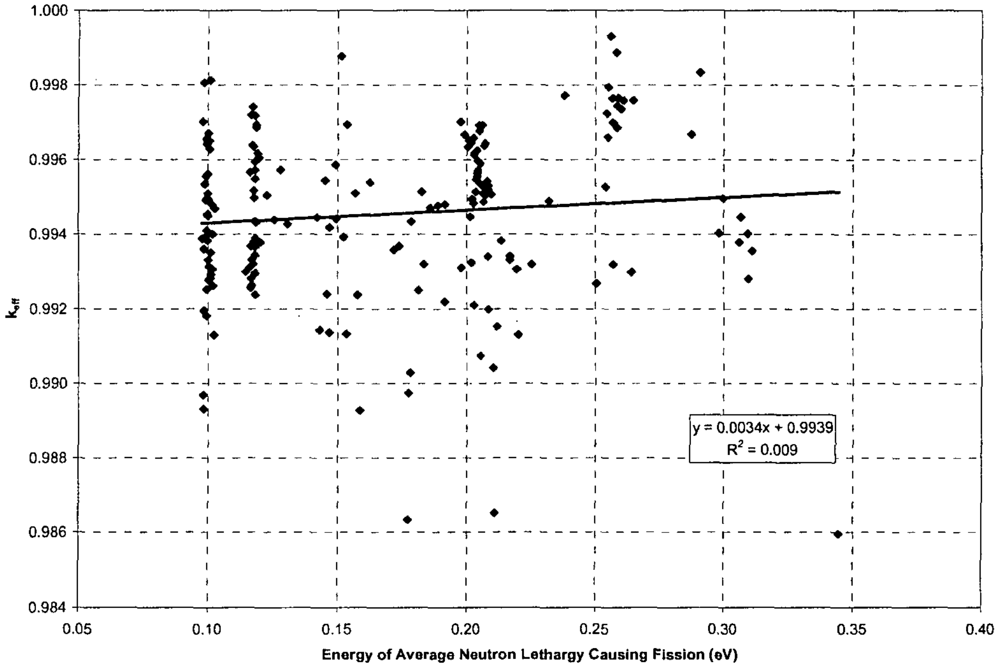

Table 6.A.5-1 Range of Applicability for Complete Set of 186 Benchmark Experiments

Parameter	Minimum	Maximum
Enrichment (wt % ^{235}U)	2.350%	4.738%
Fuel rod pitch (cm)	1.30	2.54
Fuel pellet outer diameter (cm)	0.790	1.265
Fuel rod diameter (cm)	0.9400	1.4172
H/^{235}U atom ratio	72.7	403.9
Soluble boron (ppm by weight)	0	4986
Cluster Gap (cm)	1.206	13.750
Boron (^{10}B) plate loading (g/cm^2)	0.0000	0.0670
Energy of average neutron lethargy causing fission (eV)	0.09781	0.77219

Table 6.A.5-2 Correlation Coefficients and USLs for Benchmark Experiments

Variable	R^2	R	Range of Applicability	USLSTATS Correlation	USL Low	USL High
Enrichment (wt% ^{235}U)	0.00410	0.064	2.35<=X<=4.738	0.9390+-1.57E-04X	0.9382	0.9386
Fuel rod pitch (cm)	0.00150	0.039	1.3<=X<=2.54	0.9380+2.64E-04X	0.9383	0.9386
Fuel pellet outer diameter (cm)	0.00260	0.051	0.79<=X<=1.265	0.9376+8.25E-04X	0.9382	0.9386
Fuel rod diameter (cm)	0.00380	0.062	0.94<=X<=1.4172	0.9372+1.01E-03X	0.9381	0.9386
H/^{235}U atom ratio	3.00E-06	0.002	106.2<=X<=403.9	0.9386-4.74E-08X	0.9385	0.9385
Soluble boron (ppm by weight)	0.01730	0.132	0<=X<=4986	0.9379+3.96E-07X	0.9379	0.9398
Cluster gap (cm)	0.01940	0.139	1.2<=X<=13.8	0.9375+9.82E-05X	0.9376	0.9388
Boron (^{10}B) plate loading (g/cm^2)	0.00006	0.008	0<=X<=0.067	0.9382-1.37E-03X	0.9381	0.9382
Energy of average neutron lethargy causing fission (eV)	0.00900	0.095	0.09781<=X<=0.3447	0.9379+3.45E-03X	0.9382	0.9390

Table 6.A.5-3 MCNP Validation Statistics

Case	1.01	1.02	1.03	1.04	1.05	1.06	1.07	1.08
Clusters	1	3	3	3	3	3	3	3
Enrichment (wt %^{235}U)	2.35%	2.35%	2.35%	2.35%	2.35%	2.35%	2.35%	2.35%
Pitch (cm)	2.032	2.032	2.032	2.032	2.032	2.032	2.032	2.032
Fuel OD (cm)	1.118	1.118	1.118	1.118	1.118	1.118	1.118	1.118
Clad OD (cm)	1.270	1.270	1.270	1.270	1.270	1.270	1.270	1.270
Clad Mat'l	Al	Al	Al	Al	Al	Al	Al	Al
H/U (fissile)	404	404	404	404	404	404	404	404
Soluble B (ppm)	-	-	-	-	-	-	-	-
Absorber Type	-	-	-	-	-	-	-	-
Cluster Gap (cm)	-	11.9	8.4	10.1	6.4	8.0	4.5	7.6
Reflector	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O
Plate Loading (g^{10}B /cm^2)	-	-	-	-	-	-	-	-
EALCF (MeV)	9.916E-8	1.010E-7	9.838E-8	9.933E-8	9.837E-8	9.874E-8	9.781E-8	9.826E-8
Exp. σ	0.0030	0.0030	0.0030	0.0030	0.0030	0.0030	0.0031	0.0030
k_{eff}	0.99491	0.99283	0.99806	0.99655	0.98931	0.99534	0.99388	0.98969
σ	0.00165	0.00155	0.00155	0.00165	0.00169	0.00162	0.00150	0.00152

Table 6.A.5-3 MCNP Validation Statistics (continued)

Case	2.01	2.02	2.03	2.04	2.05
Clusters	1	1	1	3	3
Enrichment (wt %^{235}U)	4.31%	4.31%	4.31%	4.31%	4.31%
Pitch (cm)	2.540	2.540	2.540	2.540	2.540
Fuel OD (cm)	1.265	1.265	1.265	1.265	1.265
Clad OD (cm)	1.415	1.415	1.415	1.415	1.415
Clad Material	Al	Al	Al	Al	Al
H/U (fissile)	259	259	259	259	259
Soluble B (ppm)	-	-	-	-	-
Absorber Type	-	-	-	-	-
Cluster Gap (cm)	-	-	-	10.6	7.1
Reflector	H_2O	H_2O	H_2O	H_2O	H_2O
Plate Loading (g^{10}B /cm^2)	-	-	-	-	-
EALCF (MeV)	1.177E-7	1.164E-7	1.175E-7	1.161E-7	1.146E-7
Exp. σ	0.0020	0.0020	0.0020	0.0018	0.0019
k_{eff}	0.99516	0.99367	0.99634	0.99311	0.99300
σ	0.00195	0.00157	0.00190	0.00193	0.00161

Table 6.A.5-3 MCNP Validation Statistics (continued)

Case	6.01	6.02	6.03	6.04	6.05	6.06	6.07	6.08	6.09
Clusters	1	1	1	1	1	1	1	1	1
Enrichment (wt %^{235}U)	2.60%	2.60%	2.60%	2.60%	2.60%	2.60%	2.60%	2.60%	2.60%
Pitch (cm)	1.849	1.849	1.849	1.956	1.956	1.956	1.956	1.956	2.150
Fuel OD (cm)	1.250	1.250	1.250	1.250	1.250	1.250	1.250	1.250	1.250
Clad OD (cm)	1.417	1.417	1.417	1.417	1.417	1.417	1.417	1.417	1.417
Clad Material	Al	Al	Al	Al	Al	Al	Al	Al	Al
H/U (fissile)	166	166	166	203	203	203	203	203	275
Soluble B (ppm)	-	-	-	-	-	-	-	-	-
Absorber Type	-	-	-	-	-	-	-	-	-
Cluster Gap (cm)	-	-	-	-	-	-	-	-	-
Reflector	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O
Plate Loading (g^{10}B /cm^2)	-	-	-	-	-	-	-	-	-
EALCF (MeV)	2.506E-7	2.568E-7	2.642E-7	1.915E-7	1.978E-7	2.018E-7	2.085E-7	2.136E-7	1.422E-7
Exp. σ	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020
k_{eff}	0.99268	0.99319	0.99299	0.99479	0.99310	0.99324	0.99199	0.99382	0.99445
σ	0.00065	0.00076	0.00074	0.00074	0.00069	0.00070	0.00071	0.00071	0.00069

Table 6.A.5-3 MCNP Validation Statistics (continued)

Case	6.10	6.11	6.12	6.13	6.14	6.15	6.16	6.17	6.18
Clusters	1	1	1	1	1	1	1	1	1
Enrichment (wt %^{235}U)	2.60%	2.60%	2.60%	2.60%	2.60%	2.60%	2.60%	2.60%	2.60%
Pitch (cm)	2.150	2.150	2.150	2.150	2.293	2.293	2.293	2.293	2.293
Fuel OD (cm)	1.250	1.250	1.250	1.250	1.250	1.250	1.250	1.250	1.250
Clad OD (cm)	1.417	1.417	1.417	1.417	1.417	1.417	1.417	1.417	1.417
Clad Material	Al	Al	Al	Al	Al	Al	Al	Al	Al
H/U (fissile)	275	275	275	275	332	332	332	332	332
Soluble B (ppm)	-	-	-	-	-	-	-	-	-
Absorber Type	-	-	-	-	-	-	-	-	-
Cluster Gap (cm)	-	-	-	-	-	-	-	-	-
Reflector	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O
Plate Loading (g^{10}B /cm^2)	-	-	-	-	-	-	-	-	-
EALCF (MeV)	1.453E-7	1.496E-7	1.523E-7	1.568E-7	1.202E-7	1.227E-7	1.257E-7	1.280E-7	1.306E-7
Exp. σ	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020
k_{eff}	0.99544	0.99441	0.99392	0.99509	0.99378	0.99504	0.99438	0.99573	0.99427
σ	0.00073	0.00071	0.00078	0.00076	0.00070	0.00075	0.00067	0.00070	0.00076

Table 6.A.5-3 MCNP Validation Statistics (continued)

Case	8.01	8.02	8.03	8.04	8.05	8.06	8.07	8.08
Clusters	3 x 3	3 x 3	3 x 3	3 x 3	3 x 3	3 x 3	3 x 3	3 x 3
Enrichment (wt %^{235}U)	2.46%	2.46%	2.46%	2.46%	2.46%	2.46%	2.46%	2.46%
Pitch (cm)	1.636	1.636	1.636	1.636	1.636	1.636	1.636	1.636
Fuel OD (cm)	1.030	1.030	1.030	1.030	1.030	1.030	1.030	1.030
Clad OD (cm)	1.206	1.206	1.206	1.206	1.206	1.206	1.206	1.206
Clad Material	Al	Al	Al	Al	Al	Al	Al	Al
H/U (fissile)	219	219	219	219	219	219	219	219
Soluble B (ppm)	1511	1336	1336	1182	1182	1033	1033	794
Absorber Type	-	-	-	-	-	-	-	-
Cluster Gap (cm)	-	-	-	-	-	-	-	-
Reflector	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O
Plate Loading (g^{10}B /cm^2)	-	-	-	-	-	-	-	-
EALCF (MeV)	2.907E-7	2.583E-7	2.559E-7	2.548E-7	2.566E-7	2.568E-7	2.544E-7	2.548E-7
Exp. σ	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012
k_{eff}	0.99835	0.99686	0.99931	0.99795	0.99765	0.99699	0.99723	0.99659
σ	0.00060	0.00063	0.00032	0.00063	0.00069	0.00061	0.00066	0.00073

Table 6.A.5-3 MCNP Validation Statistics (continued)

Case	8.09	8.10	8.11	8.12	8.13	8.14	8.15	8.16	8.17
Clusters	3 x 3	3 x 3	3 x 3	3 x 3	3 x 3	3 x 3	3 x 3	5	5 x 5
Enrichment (wt %^{235}U)	2.46%	2.46%	2.46%	2.46%	2.46%	2.46%	2.46%	2.46%	2.46%
Pitch (cm)	1.636	1.636	1.636	1.636	1.636	1.636	1.636	1.636	1.636
Fuel OD (cm)	1.030	1.030	1.030	1.030	1.030	1.030	1.030	1.030	1.030
Clad OD (cm)	1.206	1.206	1.206	1.206	1.206	1.206	1.206	1.206	1.206
Clad Material	Al	Al	Al	Al	Al	Al	Al	Al	Al
H/U (fissile)	219	219	219	219	219	219	219	219	219
Soluble B (ppm)	779	1245	1384	1348	1348	1363	1363	1158	921
Absorber Type	-	-	-	-	-	-	-	-	-
Cluster Gap (cm)	-	-	-	-	-	-	-	1.2	1.2
Reflector	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O
Plate Loading (g^{10}B /cm^2)	-	-	-	-	-	-	-	-	-
EALCF (MeV)	2.538E-7	2.586E-7	2.647E-7	2.587E-7	2.582E-7	2.600E-7	2.609E-7	2.379E-7	2.063E-7
Exp. σ	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012
k_{eff}	0.99526	0.99745	0.99759	0.99765	0.99888	0.99735	0.99758	0.99772	0.99691
σ	0.00072	0.00065	0.00068	0.00065	0.00070	0.00067	0.00071	0.00070	0.00062

Table 6.A.5-3 MCNP Validation Statistics (continued)

Case	9.01	9.02	9.03	9.04	9.05	9.06	9.07	9.08	9.09	9.10	9.11	9.12	9.13
Clusters	3	3	3	3	3	3	3	3	3	3	3	3	3
Enrichment (wt %^{235}U)	4.31%	4.31%	4.31%	4.31%	4.31%	4.31%	4.31%	4.31%	4.31%	4.31%	4.31%	4.31%	4.31%
Pitch (cm)	2.540	2.540	2.540	2.540	2.540	2.540	2.540	2.540	2.540	2.540	2.540	2.540	2.540
Fuel OD (cm)	1.265	1.265	1.265	1.265	1.265	1.265	1.265	1.265	1.265	1.265	1.265	1.265	1.265
Clad OD (cm)	1.415	1.415	1.415	1.415	1.415	1.415	1.415	1.415	1.415	1.415	1.415	1.415	1.415
Clad Material	Al	Al	Al	Al	Al	Al	Al	Al	Al	Al	Al	Al	Al
H/U (fissile)	259	259	259	259	259	259	259	259	259	259	259	259	259
Soluble B (ppm)	-	-	-	-	-	-	-	-	-	-	-	-	-
Absorber Type	304L SS (no B)	304L SS (no B)	304L SS (no B)	304L SS (no B)	304L SS (1.05% B)	304L SS (1.05% B)	304L SS (1.62% B)	304L SS (1.62% B)	Boral	Cu	Cu	Cu	Cu
Cluster Gap (cm)	8.6	9.7	9.2	9.8	6.1	8.1	5.8	7.9	6.7	8.2	9.4	8.5	9.6
Reflector	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O
Plate Loading (g^{10}B /cm^2)	0.00000	0.00000	0.00000	0.00000	0.00455	0.00455	0.00690	0.00690	0.06704	-	-	-	-
EALCF(MeV)	1.183E-7	1.181E-7	1.168E-7	1.179E-7	1.182E-7	1.182E-7	1.191E-7	1.182E-7	1.183E-7	1.173E-7	1.176E-7	1.169E-7	1.163E-7
Exp. σ	0.0021	0.0021	0.0021	0.0021	0.0021	0.0021	0.0021	0.0021	0.0021	0.0021	0.0021	0.0021	0.0021
k_{eff}	0.99548	0.99343	0.99330	0.99371	0.99593	0.99295	0.99616	0.99389	0.99571	0.99319	0.99378	0.99263	0.99566
σ	0.00191	0.00182	0.00187	0.00192	0.00174	0.00193	0.00198	0.00175	0.00209	0.00153	0.00178	0.00191	0.00177

Table 6.A.5-3 MCNP Validation Statistics (continued)

Case	9.14	9.15	9.16	9.17	9.18	9.19	9.20	9.21	9.22	9.23	9.24	9.25	9.26	9.27
Clusters	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Enrichment (wt %^{235}U)	4.31%	4.31%	4.31%	4.31%	4.31%	4.31%	4.31%	4.31%	4.31%	4.31%	4.31%	4.31%	4.31%	4.31%
Pitch (cm)	2.540	2.540	2.540	2.540	2.540	2.540	2.540	2.540	2.540	2.540	2.540	2.540	2.540	2.540
Fuel OD (cm)	1.265	1.265	1.265	1.265	1.265	1.265	1.265	1.265	1.265	1.265	1.265	1.265	1.265	1.265
Clad OD (cm)	1.415	1.415	1.415	1.415	1.415	1.415	1.415	1.415	1.415	1.415	1.415	1.415	1.415	1.415
Clad Material	Al	Al	Al	Al	Al	Al	Al	Al	Al	Al	Al	Al	Al	Al
H/U (fissile)	259	259	259	259	259	259	259	259	259	259	259	259	259	259
Soluble B (ppm)	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Absorber Type	Cu (0.989 wt % Cd)	Cu (0.989 wt % Cd)	Cd	Cd	Cd	Cd	Cd	Cd	Cd	Cd	Al (no B)	Al (no B)	Zircaloy-4	Zircaloy-4
Cluster Gap (cm)	6.7	8.4	5.9	7.4	6.0	7.4	5.9	7.4	5.7	7.3	10.7	10.8	10.9	10.9
Reflector	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O
Plate Loading ($g^{10}B/cm^2$)	-	-	-	-	-	-	-	-	-	-	0.00000	0.00000	-	-
EALCF(MeV)	1.186E-7	1.171E-7	1.186E-7	1.183E-7	1.183E-7	1.168E-7	1.182E-7	1.187E-7	1.199E-7	1.173E-7	1.167E-7	1.165E-7	1.181E-7	1.177E-7
Exp. σ	0.0021	0.0021	0.0021	0.0021	0.0021	0.0021	0.0021	0.0021	0.0021	0.0021	0.0021	0.0021	0.0021	0.0021
k_{eff}	0.99431	0.99639	0.99686	0.99716	0.99237	0.99719	0.99434	0.99692	0.99606	0.99740	0.99281	0.99256	0.99365	0.99497
σ	0.00188	0.00207	0.00183	0.00166	0.00194	0.00187	0.00179	0.00183	0.00189	0.00206	0.00168	0.00197	0.00197	0.00193

Table 6.A.5-3 MCNP Validation Statistics (continued)

Case	11.03	11.04	11.05	11.06	11.07	11.08	11.09
Clusters	3	3	3	3	3	3	3
Enrichment (wt %^{235}U)	2.46%	2.46%	2.46%	2.46%	2.46%	2.46%	2.46%
Pitch (cm)	1.636	1.636	1.636	1.636	1.636	1.636	1.636
Fuel OD (cm)	1.030	1.030	1.030	1.030	1.030	1.030	1.030
Clad OD (cm)	1.206	1.206	1.206	1.206	1.206	1.206	1.206
Clad Material	Al	Al	Al	Al	Al	Al	Al
H/U (fissile)	219	219	219	219	219	219	219
Soluble B (ppm)	769	764	762	753	739	721	702
Absorber Type	-	-	-	-	-	-	-
Cluster Gap (cm)	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Reflector	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O
Plate Loading (g^{10}B /cm^2)	-	-	-	-	-	-	-
EALCF [MeV]	2.027E-7	2.020E-7	2.035E-7	2.044E-7	2.065E-7	2.068E-7	2.085E-7
Exp. σ	0.0032	0.0032	0.0032	0.0032	0.0032	0.0032	0.0032
k_{eff}	0.99482	0.99494	0.99514	0.99564	0.99508	0.99526	0.99520
σ	0.00031	0.00030	0.00030	0.00030	0.00031	0.00030	0.00031

Table 6.A.5-3 MCNP Validation Statistics (continued)

Case	13.01	13.02	13.03	13.04	13.05	13.06	13.07
Clusters	3	3	3	3	3	3	3
Enrichment (wt %^{235}U)	4.31%	4.31%	4.31%	4.31%	4.31%	4.31%	4.31%
Pitch (cm)	1.892	1.892	1.892	1.892	1.892	1.892	1.892
Fuel OD (cm)	1.265	1.265	1.265	1.265	1.265	1.265	1.265
Clad OD (cm)	1.415	1.415	1.415	1.415	1.415	1.415	1.415
Clad Material	Al	Al	Al	Al	Al	Al	Al
H/U (fissile)	107	107	107	107	107	107	107
Soluble B (ppm)	-	-	-	-	-	-	-
Absorber Type	304L SS (no B)	304L SS (1.05% B)	Boral B	Boroflex	Cd	Cu	Cu (0.989 wt % Cd)
Cluster Gap (cm)	13.8	9.8	8.3	8.4	8.9	13.5	10.6
Reflector	Steel	Steel	Steel	Steel	Steel	Steel	Steel
Plate Loading (g^{10}B /cm^2)	0.00000	0.00455	0.03022	0.02361	-	-	-
EALCF (MeV)	2.982E-7	3.068E-7	3.111E-7	3.094E-7	3.097E-7	2.998E-7	3.061E-7
Exp. σ	0.0018	0.0018	0.0018	0.0018	0.0032	0.0018	0.0018
k_{eff}	0.99402	0.99446	0.99355	0.99401	0.99281	0.99496	0.99378
σ	0.00068	0.00064	0.00064	0.00064	0.00066	0.00063	0.00062

Table 6.A.5-3 MCNP Validation Statistics (continued)

Case	14.01	14.02	14.05	14.06	14.07
Clusters	1	1	1	1	1
Enrichment (wt %^{235}U)	4.31%	4.31%	4.31%	4.31%	4.31%
Pitch (cm)	1.890	1.890	1.890	1.715	1.715
Fuel OD (cm)	1.265	1.265	1.265	1.265	1.265
Clad OD (cm)	1.415	1.415	1.415	1.415	1.415
Clad Material	Al	Al	Al	Al	Al
H/U (fissile)	106	106	106	73	73
Soluble B (ppm)	0	491	2539	0	1030
Absorber Type	-	-	-	-	-
Cluster Gap (cm)	-	-	-	-	-
Reflector	H_2O	H_2O	H_2O	H_2O	H_2O
Plate Loading (g^{10}B /cm^2)	-	-	-	-	-
EALCF (MeV)	2.873E-7	3.447E-7	6.003E-7	5.175E-7	7.722E-7
Exp. σ	0.0019	0.0077	0.0069	0.0033	0.0051
k_{eff}	0.99668	0.98595	1.00221	1.00245	0.99973
σ	0.00044	0.00045	0.00043	0.00045	0.00044

Table 6.A.5-3 MCNP Validation Statistics (continued)

Case	16.01	16.02	16.03	16.04	16.05	16.06	16.07	16.08	16.09	16.10
Clusters	3	3	3	3	3	3	3	3	3	3
Enrichment [wt %^{235}U]	2.35%	2.35%	2.35%	2.35%	2.35%	2.35%	2.35%	2.35%	2.35%	2.35%
Pitch (cm)	2.032	2.032	2.032	2.032	2.032	2.032	2.032	2.032	2.032	2.032
Fuel OD (cm)	1.118	1.118	1.118	1.118	1.118	1.118	1.118	1.118	1.118	1.118
Clad OD (cm)	1.270	1.270	1.270	1.270	1.270	1.270	1.270	1.270	1.270	1.270
Clad Material	Al	Al	Al	Al	Al	Al	Al	Al	Al	Al
H/U (fissile)	404	404	404	404	404	404	404	404	404	404
Soluble B (ppm)	-	-	-	-	-	-	-	-	-	-
Absorber Type	304L SS (no B)	304L SS (no B)	304L SS (no B)	304L SS (no B)	304L SS (no B)	304L SS (no B)	304L SS (no B)	304L SS (1.05% B)	304L SS (1.05% B)	304L SS (1.62% B)
Cluster Gap (cm)	6.9	7.6	7.5	7.4	7.8	10.4	11.5	7.6	9.6	7.4
Reflector	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O
Plate Loading (g^{10}B /cm^2)	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00455	0.00455	0.00690
EALCF (MeV)	1.000E-7	9.983E-8	9.947E-8	1.001E-7	1.002E-7	1.009E-7	1.001E-7	9.993E-8	1.004E-7	1.012E-7
Exp. σ	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031
k_{eff}	0.99494	0.99509	0.99252	0.99562	0.99313	0.99813	0.99670	0.99383	0.99277	0.99292
σ	0.00171	0.00153	0.00157	0.00162	0.00173	0.00179	0.00175	0.00172	0.00157	0.00162

Table 6.A.5-3 MCNP Validation Statistics (continued)

Case	16.11	16.12	16.13	16.14	16.15	16.16	16.17	16.18	16.19	16.20	16.21	16.22
Clusters	3	3	3	3	3	3	3	3	3	3	3	3
Enrichment [wt %^{235}U]	2.35%	2.35%	2.35%	2.35%	2.35%	2.35%	2.35%	2.35%	2.35%	2.35%	2.35%	2.35%
Pitch(cm)	2.032	2.032	2.032	2.032	2.032	2.032	2.032	2.032	2.032	2.032	2.032	2.032
Fuel OD (cm)	1.118	1.118	1.118	1.118	1.118	1.118	1.118	1.118	1.118	1.118	1.118	1.118
Clad OD (cm)	1.270	1.270	1.270	1.270	1.270	1.270	1.270	1.270	1.270	1.270	1.270	1.270
Clad Material	Al	Al	Al	Al	Al	Al	Al	Al	Al	Al	Al	Al
H/U (fissile)	404	404	404	404	404	404	404	404	404	404	404	404
Soluble B (ppm)	-	-	-	-	-	-	-	-	-	-	-	-
Absorber Type	304L SS (1.62% B)	Boral	Boral	Boral	Cu	Cu	Cu	Cu	Cu	Cu (0.989 wt % Cd)	Cd	Cd
Cluster Gap (cm)	9.5	6.3	9.0	5.1	6.6	7.7	7.5	6.9	7.0	5.2	6.7	7.6
Reflector	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O
Plate Loading (g^{10}B /cm^2)	0.00690	0.06704	0.06704	0.06704	-	-	-	-	-	-	-	-
EALCF (MeV)	9.962E-8	1.016E-7	1.006E-7	1.025E-7	1.000E-7	9.944E-8	9.904E-8	9.919E-8	9.971E-8	1.001E-7	1.024E-7	1.014E-7
Exp. σ	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031
k_{eff}	0.99641	0.99306	0.99650	0.99468	0.99330	0.99181	0.99392	0.99556	0.99454	0.99449	0.99130	0.99480
σ	0.00154	0.00161	0.00152	0.00162	0.00157	0.00153	0.00155	0.00172	0.00165	0.00155	0.00166	0.00157

Table 6.A.5-3 MCNP Validation Statistics (continued)

Case	16.23	16.24	16.25	16.26	16.27	16.28	16.29	16.30	16.31	16.32
Clusters	3	3	3	3	3	3	3	3	3	3
Enrichment [wt %^{235}U]	2.35%	2.35%	2.35%	2.35%	2.35%	2.35%	2.35%	2.35%	2.35%	2.35%
Pitch(cm)	2.032	2.032	2.032	2.032	2.032	2.032	2.032	2.032	2.032	2.032
Fuel OD (cm)	1.118	1.118	1.118	1.118	1.118	1.118	1.118	1.118	1.118	1.118
Clad OD (cm)	1.270	1.270	1.270	1.270	1.270	1.270	1.270	1.270	1.270	1.270
Clad Material	Al	Al	Al	Al	Al	Al	Al	Al	Al	Al
H/U (fissile)	404	404	404	404	404	404	404	404	404	404
Soluble B (ppm)	-	-	-	-	-	-	-	-	-	-
Absorber Type	Cd	Cd	Cd	Cd	Cd	Al (no B)	Al (no B)	Al (no B)	Zircaloy-4	Zircaloy-4
Cluster Gap cm)	9.4	7.8	9.4	7.5	9.4	8.7	8.8	8.8	8.8	8.8
Reflector	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O
Plate Loading (g^{10}B /cm^2)	-	-	-	-	-	0.00000	0.00000	0.00000	-	-
EALCF (MeV)	1.010E-7	1.018E-7	1.006E-7	1.019E-7	9.948E-8	9.991E-8	9.843E-8	9.807E-8	9.964E-8	9.834E-8
Exp. σ	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031
k_{eff}	0.99350	0.99400	0.99628	0.99262	0.99410	0.99647	0.99360	0.99702	0.99497	0.99195
σ	0.00184	0.00152	0.00169	0.00151	0.00168	0.00166	0.00157	0.00160	0.00163	0.00172

Table 6.A.5-3 MCNP Validation Statistics (continued)

Case	35.01	35.02	40.01	40.02	40.03	40.04	40.05	40.06	40.07	40.08	40.09	40.10
Clusters	1	1	4	4	4	4	4	4	4	4	4	4
Enrichment (wt %^{235}U)	2.60%	2.60%	4.74%	4.74%	4.74%	4.74%	4.74%	4.74%	4.74%	4.74%	4.74%	4.74%
Pitch (cm)	1.956	1.956	1.600	1.600	1.600	1.600	1.600	1.600	1.600	1.600	1.600	1.600
Fuel OD (cm)	1.250	1.250	0.790	0.790	0.790	0.790	0.790	0.790	0.790	0.790	0.790	0.790
Clad OD (cm)	1.417	1.417	0.940	0.940	0.940	0.940	0.940	0.940	0.940	0.940	0.940	0.940
Clad Material	Al	Al	Al alloy	Al alloy	Al alloy	Al alloy	Al alloy	Al alloy	Al alloy	Al alloy	Al alloy	Al alloy
H/U (fissile)	203	203	231	231	231	231	231	231	231	231	231	231
Soluble B (ppm)	70	148	-	-	-	-	-	-	-	-	-	-
Absorber Type	-	-	Z2 CN18/10 SS (1.10% B)	Z2 CN18/10 SS (1.10% B)	Z2 CN18/10 SS (1.10% B)	Z2 CN18/10 SS (1.10% B)	Boral	Boral	Boral	Boral	Boral	Boral
Cluster Gap (cm)	-	-	2.3	2.3	2.3	2.3	3.3	3.3	3.3	3.3	3.3	3.3
Reflector	H_2O	H_2O	H_2O	Lead	Lead	Lead	H_2O	Lead	Lead	Lead	Steel	Steel
Plate Loading (g^{10}B /cm^2)	-	-	0.00252	0.00252	0.00252	0.00252	0.04608	0.04608	0.04608	0.04608	0.04608	0.04608
EALCF (MeV)	2.170E-7	2.202E-7	1.493E-7	1.717E-7	1.625E-7	1.576E-7	1.432E-7	1.515E-7	1.470E-7	1.459E-7	1.537E-7	1.469E-7
Exp. σ	0.0018	0.0019	0.0039	0.0041	0.0041	0.0041	0.0042	0.0044	0.0044	0.0044	0.0046	0.0046
k_{eff}	0.99341	0.99131	0.99586	0.99358	0.99539	0.99237	0.99144	0.99878	0.99418	0.99240	0.99693	0.99137
σ	0.00070	0.00078	0.00195	0.00192	0.00203	0.00194	0.00193	0.00196	0.00224	0.00216	0.00190	0.00208

Table 6.A.5-3 MCNP Validation Statistics (continued)

Case	42.01	42.02	42.03	42.04	42.05	42.06	42.07
Clusters	3	3	3	3	3	3	3
Enrichment (wt %^{235}U)	2.35%	2.35%	2.35%	2.35%	2.35%	2.35%	2.35%
Pitch (cm)	1.684	1.684	1.684	1.684	1.684	1.684	1.684
Fuel OD (cm)	1.118	1.118	1.118	1.118	1.118	1.118	1.118
Clad OD (cm)	1.270	1.270	1.270	1.270	1.270	1.270	1.270
Clad Materiall	Al	Al	Al	Al	Al	Al	Al
H/U (fissile)	221	221	221	221	221	221	221
Soluble B (ppm)	-	-	-	-	-	-	-
Absorber Type	304L SS (no B)	304L SS (1.05% B)	Boral B	Boroflex	Cd	Cu	Cu-Cd
Cluster Gap (cm)	8.3	4.8	2.7	3.0	3.9	7.8	5.4
Reflector	Steel	Steel	Steel	Steel	Steel	Steel	Steel
Plate Loading (g^{10}B /cm^2)	0.00000	0.00455	0.03022	0.02361	-	-	-
EALCF (MeV)	1.813E-7	1.824E-7	1.915E-7	1.887E-7	1.857E-7	1.786E-7	1.833E-7
Exp. σ	0.0016	0.0016	0.0016	0.0017	0.0033	0.0016	0.0018
k_{eff}	0.99250	0.99514	0.99219	0.99476	0.99469	0.99434	0.99319
σ	0.00171	0.00183	0.00169	0.00169	0.00161	0.00191	0.00157

Table 6.A.5-3 MCNP Validation Statistics (continued)

Case	50.03	50.03	50.03	50.03	50.03
Clusters	1	1	1	1	1
Enrichment (wt %^{235}U)	4.74%	4.74%	4.74%	4.74%	4.74%
Pitch (cm)	1.300	1.300	1.300	1.300	1.300
Fuel OD (cm)	0.790	0.790	0.790	0.790	0.790
Clad OD (cm)	0.940	0.940	0.940	0.940	0.940
Clad Material	Al alloy	Al alloy	Al alloy	Al alloy	Al alloy
H/U (fissile)	124	124	124	124	124
Soluble B (ppm)	821	821	4986	4986	4986
Absorber Type	-	-	-	-	-
Cluster Gap (cm)	-	-	-	-	-
Reflector	Borated H_2O	Borated H_2O	Borated H_2O	Borated H_2O	Borated H_2O
Plate Loading (g^{10}B /cm^2)	-	-	-	-	-
EALCF (MeV)	2.170E-7	2.083E-7	2.318E-7	2.252E-7	2.195E-7
Exp. σ	0.0010	0.0010	0.0010	0.0010	0.0010
k_{eff}	0.99330	0.99340	0.99489	0.99319	0.99306
σ	0.00080	0.00071	0.00075	0.00075	0.00080

Table 6.A.5-3 MCNP Validation Statistics (continued)

Case	51.01	51.02	51.03	51.04	51.05	51.06	51.07	51.08	51.09
Clusters	9	9	9	9	9	9	9	9	9
Enrichment (wt %^{235}U)	2.46%	2.46%	2.46%	2.46%	2.46%	2.46%	2.46%	2.46%	2.46%
Pitch (cm)	1.636	1.636	1.636	1.636	1.636	1.636	1.636	1.636	1.636
Fuel OD (cm)	1.030	1.030	1.030	1.030	1.030	1.030	1.030	1.030	1.030
Clad OD (cm)	1.206	1.206	1.206	1.206	1.206	1.206	1.206	1.206	1.206
Clad Material	Al	Al	Al	Al	Al	Al	Al	Al	Al
H/U (fissile)	219	219	219	219	219	219	219	219	219
Soluble B (ppm)	143	510	514	501	493	474	462	432	217
Absorber Type	none	SS	SS	SS	SS	SS	SS	SS	SS
Cluster Gap (cm)	4.9	1.6	1.6	1.6	1.6	1.6	1.6	1.6	3.3
Reflector	Borated H_2O	Borated H_2O	Borated H_2O	Borated H_2O	Borated H_2O	Borated H_2O	Borated H_2O	Borated H_2O	Borated H_2O
Plate Loading (g^{10}B /cm^2)	0.00000	-	-	-	-	-	-	-	-
EALCF (MeV)	1.535E-7	2.045E-7	2.043E-7	2.067E-7	2.074E-7	2.083E-7	2.085E-7	2.098E-7	1.737E-7
Exp. σ	0.0020	0.0024	0.0024	0.0024	0.0024	0.0024	0.0024	0.0024	0.0019
k_{eff}	0.99133	0.99597	0.99555	0.99486	0.99504	0.99542	0.99530	0.99507	0.99368
σ	0.00033	0.00035	0.00033	0.00034	0.00034	0.00034	0.00034	0.00034	0.00033

Table 6.A.5-3 MCNP Validation Statistics (continued)

Case	51.10	51.11	51.12	51.13	51.14	51.15	51.16	51.17	51.18	51.19
Clusters	9	9	9	9	9	9	9	9	9	9
Enrichment (wt %^{235}U)	2.46%	2.46%	2.46%	2.46%	2.46%	2.46%	2.46%	2.46%	2.46%	2.46%
Pitch (cm)	1.636	1.636	1.636	1.636	1.636	1.636	1.636	1.636	1.636	1.636
Fuel OD (cm)	1.030	1.030	1.030	1.030	1.030	1.030	1.030	1.030	1.030	1.030
Clad OD (cm)	1.206	1.206	1.206	1.206	1.206	1.206	1.206	1.206	1.206	1.206
Clad Material	Al	Al	Al	Al	Al	Al	Al	Al	Al	Al
H/U (fissile)	219	219	219	219	219	219	219	219	219	219
Soluble B (ppm)	15	28	92	395	121	487	197	634	320	72
Absorber Type	B/Al Set 5	B/Al Set 5A	B/Al Set 4	B/Al Set 3	B/Al Set 3	B/Al Set 2	B/Al Set 2	B/Al Set 1	B/Al Set 1	B/Al Set 1
Cluster Gap (cm)	1.6	1.6	1.6	1.6	3.3	1.6	3.3	1.6	3.3	4.9
Reflector	Borated H_2O	Borated H_2O	Borated H_2O	Borated H_2O	Borated H_2O	Borated H_2O	Borated H_2O	Borated H_2O	Borated H_2O	Borated H_2O
Plate Loading (g^{10}B /cm^2)	0.00517	0.00519	0.00403	0.00128	0.00128	0.00078	0.00078	0.00032	0.00032	0.00032
EALCF (MeV)	2.029E-7	2.015E-7	2.056E-7	2.112E-7	1.773E-7	2.106E-7	1.775E-7	2.119E-7	1.780E-7	1.587E-7
p. σ	0.0019	0.0019	0.0019	0.0022	0.0019	0.0024	0.0020	0.0027	0.0021	0.0019
keff	0.99210	0.99447	0.99073	0.98652	0.98634	0.99042	0.98974	0.99152	0.99029	0.98927
σ	0.00034	0.00034	0.00034	0.00034	0.00034	0.00034	0.00034	0.00034	0.00035	0.00035

Table 6.A.5-3 MCNP Validation Statistics (continued)

Case	65.01	65.02	65.03	65.04	65.05	65.06	65.07	65.08
Clusters	2	2	2	2	2	2	2	2
Enrichment (wt %^{235}U)	2.60%	2.60%	2.60%	2.60%	2.60%	2.60%	2.60%	2.60%
Pitch (cm)	1.956	1.956	1.956	1.956	1.956	1.956	1.956	1.956
Fuel OD (cm)	1.250	1.250	1.250	1.250	1.250	1.250	1.250	1.250
Clad OD (cm)	1.417	1.417	1.417	1.417	1.417	1.417	1.417	1.417
Clad Material	Al	Al	Al	Al	Al	Al	Al	Al
H/U (fissile)	203	203	203	203	203	203	203	203
Soluble B (ppm)	-	-	-	-	-	-	-	-
Absorber Type	none	304L SS (No B)	304L SS (0.67% B)	304L SS (0.98% B)	none	304L SS (No B)	304L SS (No B)	304L SS (No B)
Cluster Gap (cm)	5.9	5.9	5.9	5.9	7.8	7.8	7.8	7.8
Reflector	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O
Plate Loading (g^{10}B /cm^2)	-	0.00000	0.00599	0.00875	-	0.00000	0.00000	0.00000
EALCF [MeV]	2.045E-7	2.030E-7	2.054E-7	2.038E-7	2.049E-7	2.030E-7	2.055E-7	2.040E-7
Exp. σ	0.0014	0.0014	0.0015	0.0015	0.0014	0.0014	0.0014	0.0016
k_{eff}	0.99571	0.99618	0.99534	0.99547	0.99691	0.99614	0.99589	0.99624
σ	0.00023	0.00022	0.00023	0.00023	0.00023	0.00023	0.00023	0.00023

Table 6.A.5-3 MCNP Validation Statistics (continued)

Case	65.09	65.10	65.11	65.12	65.13	65.14	65.15	65.16	65.17
Clusters	2	2	2	2	2	2	2	2	2
Enrichment (wt %^{235}U)	2.60%	2.60%	2.60%	2.60%	2.60%	2.60%	2.60%	2.60%	2.60%
Pitch (cm)	1.956	1.956	1.956	1.956	1.956	1.956	1.956	1.956	1.956
Fuel OD (cm)	1.250	1.250	1.250	1.250	1.250	1.250	1.250	1.250	1.250
Clad OD (cm)	1.417	1.417	1.417	1.417	1.417	1.417	1.417	1.417	1.417
Clad Material	Al	Al	Al	Al	Al	Al	Al	Al	Al
H/U (fissile)	203	203	203	203	203	203	203	203	203
Soluble B (ppm)	-	-	-	-	-	-	-	-	-
Absorber Type	304L SS (No B)	304L SS (0.67% B)	304L SS (0.67% B)	304L SS (0.67% B)	304L SS (0.67% B)	304L SS (0.98% B)	304L SS (0.98% B)	304L SS (0.98% B)	304L SS (0.98% B)
Cluster Gap (cm)	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8
Reflector	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O	H_2O
Plate Loading (g^{10}B /cm^2)	0.00000	0.00299	0.00299	0.00599	0.00599	0.00438	0.00438	0.00875	0.00875
EALCF [MeV]	1.993E-7	2.050E-7	2.069E-7	2.072E-7	1.977E-7	2.010E-7	2.004E-7	2.027E-7	2.017E-7
Exp. σ	0.0015	0.0016	0.0016	0.0017	0.0016	0.0016	0.0016	0.0017	0.0016
k_{eff}	0.99667	0.99676	0.99637	0.99643	0.99701	0.99650	0.99634	0.99658	0.99645
σ	0.00022	0.00022	0.00023	0.00023	0.00022	0.00023	0.00023	0.00022	0.00023

6.A.6 References

[A1] 10 CFR 72, "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste and Reactor-Related Greater Than Class C Waste," Code of Federal Regulations, US Government, Washington, DC.

[A2] NUREG-1536, "Standard Review Plan for Dry Cask Storage Systems," US Nuclear Regulatory Commission, Washington, DC, January 1997.

[A3] "MCNP – A General Monte Carlo N-Particle Transport Code, Version 5," X-5 Monte Carlo Team, Los Alamos National Laboratory, Los Alamos, NM, April 24, 2003.

[A4] CC-710/MCNP: Data Libraries for MCNP5, "MCNP5 DATA: Standard Neutron, Photoatomic, Photonuclear, and Electron Data Libraries for MCNP5," February 2003.

[A5] CCC-545-NUREG/CR-0200, "Standard Composition Library," Petrie, L.M., et al., Rev. 6, Volume 3 Section M8, September 1998.

[A6] ANSI/ANS - 8.1-1983, "Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors," American Nuclear Society, La Grange Park, IL.

[A7] ANSI/ANS - 8.17-1984, "Criticality Safety Criteria for the Handling, Storage, and of LWR Fuel Outside Reactors," American Nuclear Society, La Grange Park, IL.

[A8] International Handbook of Evaluated Criticality Safety Benchmark Experiments, NEA/NSC/DOC(95)03, September 2003.

[A9] NUREG/CR-6361, "Criticality Benchmark Guide for Light-Water-Reactor Fuel in Transportation and Storage Packages," US Nuclear Regulatory Commission, Washington, DC, March 1997.

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6.A.7 Sample Inputs

This section contains sample input files for the MCNP model. Included are sample input files for undamaged and damaged LACBWR fuel in the MPC-LACBWR transfer cask and damaged LACBWR fuel in the MPC-LACBWR storage cask.

6.A.7.1 Transfer Cask

Input files are presented for undamaged AC 3.94 wt % enriched material at the maximum reactivity configuration. Also included is the maximum reactivity preferentially flooded input case for damaged fuel.

Figure 6.A.7.1-1 AC Undamaged Fuel Transfer Cask Sample Input

```
LACBWR Transfer Cask Model -  Fuel Assembly Type: AC - BWR_10x10_0 WR
c
c Model Revision 3.4
c
c Single Cask Model
c
c Partial Flood: No
c
c Damaged Fuel Can Option:  No
c
c
c
c
c Primary Fuel Tye Enrichment:  3.94 wt%
c
c Secondary Fuel Type:  None
c Seondary Fuel Enrichment:  None
c
c Thrid Fuel Type:  None
c Seondary Fuel Enrichment:  None
c
c Density (H2O) (g/cc)
c              Lattice DFC Exterior
c              0.9982  N/A 0.0001
c
c Tube
c      Outer_Width Thickness
c      Max         Min
c
c Absorber
c          Width Thickness
c          Min   Max
c
c Disk
c      Op_Width Location Thickness Spacing
c      Max      Min      Max       Min
c
c Shift Patterns
c  Rad Fuel Rad Tube Axial Fuel Axial Basket
c  In       In       Bottom     Bottom
c Cells - Fuel Rod - AC - BWR_10x10_0 WR
10 1 -10.522 -10     u=22 $ Fuel
11 3 -0.9982 -11 +10    u=22 $ Plenum + Fuel to Clad Gap
12 2 -7.94 -12 +11    u=22 $ Clad + End Plugs
13 3 -0.9982 +12     u=22 $ Outside Fuel Rod
c Array_10x10_0
40 3 -0.9982 -40 +41 -42 +43
      trcl=(0.71755 0.71755 25.4)    lat=1 u=21 fill=-5:4 -5:4 0:0
      22 22 22 22 22 22 22 22 22 22
      22 22 22 22 22 22 22 22 22 22
      22 22 22 22 22 22 22 22 22 22
      22 22 22 22 22 22 22 22 22 22
      22 22 22 22 22 22 22 22 22 22
      22 22 22 22 22 22 22 22 22 22
      22 22 22 22 22 22 22 22 22 22
      22 22 22 22 22 22 22 22 22 22
      22 22 22 22 22 22 22 22 22 22
      22 22 22 22 22 22 22 22 22 22
c Cells - Fuel Assembly Array Inserted Into Assembly - cellAssy
50 3 -0.9982 -50    fill=21 u=20 $ Array
51 3 -0.9982 -51 +50 -50.6 -50.5  u=20 $ Gap to Fuel Envelope
52 6 -2.0929 -51  +50.6    u=20 $ Lower Nozzle
53 7 -1.7632 -51   +50.5  u=20 $ Upper Nozzle
54 3 -0.9982 +51     u=20 $ Remaining Space
c Cell Cards - Standard Tube, Absorber and Retainer (PX,PY)
```

```
330 3 -0.9982 -311       u=18 $ Space in Tube
331 8 -7.940 -312 +311      u=18 $ FuelTube
332 15 -1.965 -313       u=18 $ Absorber +Y
333 9 -2.702 -314 +313      u=18 $ Absorber Clad  +Y
334 3 -0.9982 -315 +314      u=18 $ Absorber Cover Opening+Y
335 8 -7.940 -316 +315      u=18 $ Absorber Cover  +Y
336 15 -1.965 -317       u=18 $ Absorber +X
337 9 -2.702 -318 +317      u=18 $ Absorber Clad  +X
338 3 -0.9982 -319 +318      u=18 $ Absorber Cover Opening+X
339 8 -7.940 -320 +319      u=18 $ Absorber Cover  +X
340 3 -0.9982 +311 +312 +316 +320      u=18 $ Exterior Space
c Cell Cards - Standard Tube, Absorber and Retainer (MX,PY)
341 3 -0.9982 -311       u=17 $ Space in Tube
342 8 -7.940 -312 +311      u=17 $ FuelTube
343 15 -1.965 -313       u=17 $ Absorber +Y
344 9 -2.702 -314 +313      u=17 $ Absorber Clad  +Y
345 3 -0.9982 -315 +314      u=17 $ Absorber Cover Opening+Y
346 8 -7.940 -316 +315      u=17 $ Absorber Cover  +Y
347 15 -1.965 -325       u=17 $ Absorber -X
348 9 -2.702 -326 +325      u=17 $ Absorber Clad  -X
349 3 -0.9982 -327 +326      u=17 $ Absorber Cover Opening-X
350 8 -7.940 -328 +327      u=17 $ Absorber Cover  -X
351 3 -0.9982 +311 +312 +316 +328      u=17 $ Exterior Space
c Cell Cards - Standard Tube, Absorber and Retainer (MX,MY)
352 3 -0.9982 -311       u=16 $ Space in Tube
353 8 -7.940 -312 +311      u=16 $ FuelTube
354 15 -1.965 -321       u=16 $ Absorber -Y
355 9 -2.702 -322 +321      u=16 $ Absorber Clad  -Y
356 3 -0.9982 -323 +322      u=16 $ Absorber Cover Opening-Y
357 8 -7.940 -324 +323      u=16 $ Absorber Cover  -Y
358 15 -1.965 -325       u=16 $ Absorber -X
359 9 -2.702 -326 +325      u=16 $ Absorber Clad  -X
360 3 -0.9982 -327 +326      u=16 $ Absorber Cover Opening-X
361 8 -7.940 -328 +327      u=16 $ Absorber Cover  -X
362 3 -0.9982 +311 +312 +324 +328      u=16 $ Exterior Space
c Cell Cards - Standard Tube, Absorber and Retainer (PX,MY)
363 3 -0.9982 -311       u=15 $ Space in Tube
364 8 -7.940 -312 +311      u=15 $ FuelTube
365 15 -1.965 -321       u=15 $ Absorber -Y
366 9 -2.702 -322 +321      u=15 $ Absorber Clad  -Y
367 3 -0.9982 -323 +322      u=15 $ Absorber Cover Opening-Y
368 8 -7.940 -324 +323      u=15 $ Absorber Cover  -Y
369 15 -1.965 -317       u=15 $ Absorber +X
370 9 -2.702 -318 +317      u=15 $ Absorber Clad  +X
371 3 -0.9982 -319 +318      u=15 $ Absorber Cover Opening+X
372 8 -7.940 -320 +319      u=15 $ Absorber Cover  +X
373 3 -0.9982 +311 +312 +320 +324      u=15 $ Exterior Space
c Cell Cards - Standard Tube, Absorber and Retainer (PX)
374 3 -0.9982 -311       u=14 $ Space in Tube
375 8 -7.940 -312 +311      u=14 $ FuelTube
376 15 -1.965 -317       u=14 $ Absorber +X
377 9 -2.702 -318 +317      u=14 $ Absorber Clad  +X
378 3 -0.9982 -319 +318      u=14 $ Absorber Cover Opening+X
379 8 -7.940 -320 +319      u=14 $ Absorber Cover  +X
380 3 -0.9982 +311 +312 +320      u=14 $ Exterior Space
c Cell Cards - Standard Tube, Absorber and Retainer (MX)
381 3 -0.9982 -311       u=13 $ Space in Tube
382 8 -7.940 -312 +311      u=13 $ FuelTube
383 15 -1.965 -325       u=13 $ Absorber -X
384 9 -2.702 -326 +325      u=13 $ Absorber Clad  -X
385 3 -0.9982 -327 +326      u=13 $ Absorber Cover Opening-X
386 8 -7.940 -328 +327      u=13 $ Absorber Cover  -X
387 3 -0.9982 +311 +312 +328      u=13 $ Exterior Space
c Cell Cards - Standard Tube, Absorber and Retainer (PY)
388 3 -0.9982 -311       u=12 $ Space in Tube
389 8 -7.940 -312 +311      u=12 $ FuelTube
390 15 -1.965 -313       u=12 $ Absorber +Y
391 9 -2.702 -314 +313      u=12 $ Absorber Clad  +Y
392 3 -0.9982 -315 +314      u=12 $ Absorber Cover Opening+Y
393 8 -7.940 -316 +315      u=12 $ Absorber Cover  +Y
```

```
394 3 -0.9982 +311 +312 +316      u=12 $ Exterior Space
c Cell Cards - Standard Tube, Absorber and Retainer (MY)
395 3 -0.9982 -311      u=11 $ Space in Tube
396 8 -7.940 -312 +311     u=11 $ FuelTube
397 15 -1.965 -321      u=11 $ Absorber -Y
398 9 -2.702 -322 +321     u=11 $ Absorber Clad  -Y
399 3 -0.9982 -323 +322     u=11 $ Absorber Cover Opening-Y
400 8 -7.940 -324 +323     u=11 $ Absorber Cover  -Y
401 3 -0.9982 +311 +312 +324      u=11 $ Exterior Space
c Cell Cards - Standard Tube
402 3 -0.9982 -311      u=10 $ Space in Tube
403 8 -7.940 -312 +311     u=10 $ FuelTube
404 3 -0.9982 +311 +312      u=10 $ Exterior Space
c Cell Cards - DFC Tube, Absorber and Retainer- 4 BORAL
411 3 -0.9982 -411      u=8 $ Space in Tube
412 8 -7.940 -412 +411     u=8 $ FuelTube
413 15 -1.965 -413      u=8 $ Absorber +Y
414 9 -2.702 -414 +413     u=8 $ Absorber Clad  +Y
415 3 -0.9982 -415 +414     u=8 $ Absorber Cover Opening+Y
416 8 -7.940 -416 +415     u=8 $ Absorber Cover  +Y
417 15 -1.965 -417      u=8 $ Absorber +X
418 8 -7.940 -418 +417     u=8 $ Absorber Clad  +X
419 3 -0.9982 -419 +418     u=8 $ Absorber Cover Opening+X
420 8 -7.940 -420 +419     u=8 $ Absorber Cover  +X
421 15 -1.965 -421      u=8 $ Absorber -Y
422 9 -2.702 -422 +421     u=8 $ Absorber Clad  -Y
423 3 -0.9982 -423 +422     u=8 $ Absorber Cover Opening-Y
424 8 -7.940 -424 +423     u=8 $ Absorber Cover  -Y
425 15 -1.965 -425      u=8 $ Absorber -X
426 8 -7.940 -426 +425     u=8 $ Absorber Clad  -X
427 3 -0.9982 -427 +426     u=8 $ Absorber Cover Opening-X
428 8 -7.940 -428 +427     u=8 $ Absorber Cover  -X
429 3 -0.9982 +411 +412 +416 +420 +424 +428      u=8 $ Exterior Space
c Cell Cards - DFC Tube, Absorber and Retainer- 2X. PY
430 3 -0.9982 -411      u=7 $ Space in Tube
431 8 -7.940 -412 +411     u=7 $ FuelTube
432 15 -1.965 -413      u=7 $ Absorber +Y
433 9 -2.702 -414 +413     u=7 $ Absorber Clad  +Y
434 3 -0.9982 -415 +414     u=7 $ Absorber Cover Opening+Y
435 8 -7.940 -416 +415     u=7 $ Absorber Cover  +Y
436 15 -1.965 -417      u=7 $ Absorber +X
437 8 -7.940 -418 +417     u=7 $ Absorber Clad  +X
438 3 -0.9982 -419 +418     u=7 $ Absorber Cover Opening+X
439 8 -7.940 -420 +419     u=7 $ Absorber Cover  +X
440 15 -1.965 -425      u=7 $ Absorber -X
441 8 -7.940 -426 +425     u=7 $ Absorber Clad  -X
442 3 -0.9982 -427 +426     u=7 $ Absorber Cover Opening-X
443 8 -7.940 -428 +427     u=7 $ Absorber Cover  -X
444 3 -0.9982 +411 +412 +416 +420 +428      u=7 $ Exterior Space
c Cell Cards - DFC Tube, Absorber and Retainer- 2X, MY
445 3 -0.9982 -411      u=6 $ Space in Tube
446 8 -7.940 -412 +411     u=6 $ FuelTube
447 15 -1.965 -417      u=6 $ Absorber +X
448 8 -7.940 -418 +417     u=6 $ Absorber Clad  +X
449 3 -0.9982 -419 +418     u=6 $ Absorber Cover Opening+X
450 8 -7.940 -420 +419     u=6 $ Absorber Cover  +X
451 15 -1.965 -421      u=6 $ Absorber -Y
452 9 -2.702 -422 +421     u=6 $ Absorber Clad  -Y
453 3 -0.9982 -423 +422     u=6 $ Absorber Cover Opening-Y
454 8 -7.940 -424 +423     u=6 $ Absorber Cover  -Y
455 15 -1.965 -425      u=6 $ Absorber -X
456 8 -7.940 -426 +425     u=6 $ Absorber Clad  -X
457 3 -0.9982 -427 +426     u=6 $ Absorber Cover Opening-X
458 8 -7.940 -428 +427     u=6 $ Absorber Cover  -X
459 3 -0.9982 +411 +412 +420 +424 +428      u=6 $ Exterior Space
c Cell Cards - DFC Tube, Absorber and Retainer-PX, 2Y
460 3 -0.9982 -411      u=5 $ Space in Tube
461 8 -7.940 -412 +411     u=5 $ FuelTube
462 15 -1.965 -413      u=5 $ Absorber +Y
463 9 -2.702 -414 +413     u=5 $ Absorber Clad  +Y
```

```
464 3 -0.9982 -415 +414     u=5 $ Absorber Cover Opening+Y
465 8 -7.940 -416 +415     u=5 $ Absorber Cover  +Y
466 15 -1.965 -417      u=5 $ Absorber +X
467 8 -7.940 -418 +417     u=5 $ Absorber Clad  +X
468 3 -0.9982 -419 +418     u=5 $ Absorber Cover Opening+X
469 8 -7.940 -420 +419     u=5 $ Absorber Cover  +X
470 15 -1.965 -421      u=5 $ Absorber -Y
471 9 -2.702 -422 +421     u=5 $ Absorber Clad  -Y
472 3 -0.9982 -423 +422     u=5 $ Absorber Cover Opening-Y
473 8 -7.940 -424 +423     u=5 $ Absorber Cover  -Y
474 3 -0.9982 +411 +412 +416 +420 +424      u=5 $ Exterior Space
c Cell Cards - DFC Tube, Absorber and Retainer- MX, 2Y
475 3 -0.9982 -411      u=4 $ Space in Tube
476 8 -7.940 -412 +411     u=4 $ FuelTube
477 15 -1.965 -413      u=4 $ Absorber +Y
478 9 -2.702 -414 +413     u=4 $ Absorber Clad  +Y
479 3 -0.9982 -415 +414     u=4 $ Absorber Cover Opening+Y
480 8 -7.940 -416 +415     u=4 $ Absorber Cover  +Y
481 15 -1.965 -421      u=4 $ Absorber -Y
482 9 -2.702 -422 +421     u=4 $ Absorber Clad  -Y
483 3 -0.9982 -423 +422     u=4 $ Absorber Cover Opening-Y
484 8 -7.940 -424 +423     u=4 $ Absorber Cover  -Y
485 15 -1.965 -425      u=4 $ Absorber -X
486 8 -7.940 -426 +425     u=4 $ Absorber Clad  -X
487 3 -0.9982 -427 +426     u=4 $ Absorber Cover Opening-X
488 8 -7.940 -428 +427     u=4 $ Absorber Cover  -X
489 3 -0.9982 +411 +412 +416 +424 +428      u=4 $ Exterior Space
c Cell Cards - Disk Stack
601 8 -7.94 -606 *trcl=( 0.0000 0.0000 2.5400 )    u=3 $ Bottom weldment disk
602 8 -7.94 -603 *trcl=( 0.0000 0.0000 9.8044 )    u=3 $ Support disk 1 (Thick Disk)
603 8 -7.94 -601 *trcl=( 0.0000 0.0000 15.1257 )    u=3 $ Support disk 2
604 like 603 but   *trcl=( 0.0000 0.0000 24.9555 )    u=3 $ Support disk 3
605 like 603 but   *trcl=( 0.0000 0.0000 34.7853 )    u=3 $ Support disk 4
606 like 603 but   *trcl=( 0.0000 0.0000 44.6151 )    u=3 $ Support disk 5
607 like 603 but   *trcl=( 0.0000 0.0000 54.4449 )    u=3 $ Support disk 6
608 9 -2.70 -604 *trcl=( 0.0000 0.0000 59.5160 )    u=3 $ Heat transfer disk 1
609 like 603 but   *trcl=( 0.0000 0.0000 64.1985 )    u=3 $ Support disk 7
610 like 608 but   *trcl=( 0.0000 0.0000 69.2696 )    u=3 $ Heat transfer disk 2
611 like 603 but   *trcl=( 0.0000 0.0000 73.9521 )    u=3 $ Support disk 8
612 like 608 but   *trcl=( 0.0000 0.0000 79.0232 )    u=3 $ Heat transfer disk 3
613 like 603 but   *trcl=( 0.0000 0.0000 83.7057 )    u=3 $ Support disk 9
614 like 608 but   *trcl=( 0.0000 0.0000 88.7768 )    u=3 $ Heat transfer disk 4
615 like 603 but   *trcl=( 0.0000 0.0000 93.4593 )    u=3 $ Support disk 10
616 like 608 but   *trcl=( 0.0000 0.0000 98.5304 )    u=3 $ Heat transfer disk 5
617 like 603 but   *trcl=( 0.0000 0.0000 103.2129 )    u=3 $ Support disk 11
618 like 608 but   *trcl=( 0.0000 0.0000 108.2840 )    u=3 $ Heat transfer disk 6
619 like 603 but   *trcl=( 0.0000 0.0000 112.9665 )    u=3 $ Support disk 12
620 like 608 but   *trcl=( 0.0000 0.0000 118.0376 )    u=3 $ Heat transfer disk 7
621 like 603 but   *trcl=( 0.0000 0.0000 122.7201 )    u=3 $ Support disk 13
622 like 608 but   *trcl=( 0.0000 0.0000 127.7912 )    u=3 $ Heat transfer disk 8
623 like 603 but   *trcl=( 0.0000 0.0000 132.4737 )    u=3 $ Support disk 14
624 like 608 but   *trcl=( 0.0000 0.0000 137.5448 )    u=3 $ Heat transfer disk 9
625 like 603 but   *trcl=( 0.0000 0.0000 142.2273 )    u=3 $ Support disk 15
626 like 608 but   *trcl=( 0.0000 0.0000 147.2984 )    u=3 $ Heat transfer disk 10
627 like 603 but   *trcl=( 0.0000 0.0000 151.9809 )    u=3 $ Support disk 16
628 like 608 but   *trcl=( 0.0000 0.0000 157.0520 )    u=3 $ Heat transfer disk 11
629 like 603 but   *trcl=( 0.0000 0.0000 161.7345 )    u=3 $ Support disk 17
630 like 608 but   *trcl=( 0.0000 0.0000 166.8056 )    u=3 $ Heat transfer disk 12
631 like 603 but   *trcl=( 0.0000 0.0000 171.4881 )    u=3 $ Support disk 18
632 like 608 but   *trcl=( 0.0000 0.0000 176.5592 )    u=3 $ Heat transfer disk 13
633 like 603 but   *trcl=( 0.0000 0.0000 181.2417 )    u=3 $ Support disk 19
634 like 608 but   *trcl=( 0.0000 0.0000 186.3128 )    u=3 $ Heat transfer disk 14
635 like 603 but   *trcl=( 0.0000 0.0000 190.9953 )    u=3 $ Support disk 20
636 like 603 but   *trcl=( 0.0000 0.0000 200.8251 )    u=3 $ Support disk 21
637 like 603 but   *trcl=( 0.0000 0.0000 210.6549 )    u=3 $ Support disk 22
638 like 603 but   *trcl=( 0.0000 0.0000 220.4847 )    u=3 $ Support disk 23
639 like 603 but   *trcl=( 0.0000 0.0000 230.3145 )    u=3 $ Support disk 24
640 like 603 but   *trcl=( 0.0000 0.0000 240.1443 )    u=3 $ Support disk 25
641 8 -7.94 -602 *trcl=( 0.0000 0.0000 248.3231 )    u=3 $ Support disk 26 (Thick Disk)
642 8 -7.94 -605 *trcl=( 0.0000 0.0000 255.8288 )    u=3 $ Top weldment disk
```

```
643 3 -0.9982       $ Outside Disks
      #601 #602 #603 #604 #605 #606 #607 #608 #609 #610
      #611 #612 #613 #614 #615 #616 #617 #618 #619 #620
      #621 #622 #623 #624 #625 #626 #627 #628 #629 #630
      #631 #632 #633 #634 #635 #636 #637 #638 #639 #640
      #641 #642        u=3
c Cell Cards - Basket
701 3 -0.9982 -702  #702  fill=6 ( -8.6463 77.3430 0.0000 )     $ Tube/Disk 1
            *trcl=( -8.7884 77.4852 0.0000 )   u=2
702 3 -0.9982 -51   fill=20 *trcl=( -8.0826 76.7793 0.0000 )    u=2 $ Assembly 1
703 3 -0.9982 -702  #704  fill=6 ( 8.6463 77.3430 0.0000 )     $ Tube/Disk 2
            *trcl=( 8.7884 77.4852 0.0000 )    u=2
704 3 -0.9982 -51   fill=20 *trcl=( 8.0826 76.7793 0.0000 )    u=2 $ Assembly 2
705 3 -0.9982 -702  #706  fill=6 ( -43.9472 61.0896 0.0000 )     $ Tube/Disk 3
            *trcl=( -44.0893 61.2318 0.0000 )    u=2
706 3 -0.9982 -51   fill=20 *trcl=( -43.3835 60.5259 0.0000 )    u=2 $ Assembly 3
707 3 -0.9982 -702  #708  fill=8 ( -26.2968 59.6927 0.0000 )     $ Tube/Disk 4
            *trcl=( -26.4389 59.8348 0.0000 )   u=2
708 3 -0.9982 -51   fill=20 *trcl=( -25.7331 59.1290 0.0000 )    u=2 $ Assembly 4
709 3 -0.9982 -702  #710  fill=8 ( -8.6463 59.6927 0.0000 )     $ Tube/Disk 5
            *trcl=( -8.7884 59.8348 0.0000 )    u=2
710 3 -0.9982 -51   fill=20 *trcl=( -8.0826 59.1290 0.0000 )    u=2 $ Assembly 5
711 3 -0.9982 -702  #712  fill=8 ( 8.6463 59.6927 0.0000 )     $ Tube/Disk 6
            *trcl=( 8.7884 59.8348 0.0000 )    u=2
712 3 -0.9982 -51   fill=20 *trcl=( 8.0826 59.1290 0.0000 )    u=2 $ Assembly 6
713 3 -0.9982 -702  #714  fill=8 ( 26.2968 59.6927 0.0000 )     $ Tube/Disk 7
            *trcl=( 26.4389 59.8348 0.0000 )    u=2
714 3 -0.9982 -51   fill=20 *trcl=( 25.7331 59.1290 0.0000 )    u=2 $ Assembly 7
715 3 -0.9982 -702  #716  fill=6 ( 43.9472 61.0896 0.0000 )     $ Tube/Disk 8
            *trcl=( 44.0893 61.2318 0.0000 )    u=2
716 3 -0.9982 -51   fill=20 *trcl=( 43.3835 60.5259 0.0000 )    u=2 $ Assembly 8
717 3 -0.9982 -702  #718  fill=5 ( -61.0896 43.9472 0.0000 )     $ Tube/Disk 9
            *trcl=( -61.2318 44.0893 0.0000 )    u=2
718 3 -0.9982 -51   fill=20 *trcl=( -60.5259 43.3835 0.0000 )    u=2 $ Assembly 9
719 3 -0.9982 -701  #720  fill=15 ( -42.4663 42.4663 0.0000 )     $ Tube/Disk 10
            *trcl=( -42.5018 42.5018 0.0000 )    u=2
720 3 -0.9982 -51   fill=20 *trcl=( -42.2328 42.2328 0.0000 )    u=2 $ Assembly 10
721 3 -0.9982 -701  #722  fill=15 ( -25.4509 42.4663 0.0000 )     $ Tube/Disk 11
            *trcl=( -25.4864 42.5018 0.0000 )    u=2
722 3 -0.9982 -51   fill=20 *trcl=( -25.2174 42.2328 0.0000 )    u=2 $ Assembly 11
723 3 -0.9982 -701  #724  fill=15 ( -8.4354 42.4663 0.0000 )     $ Tube/Disk 12
            *trcl=( -8.4709 42.5018 0.0000 )    u=2
724 3 -0.9982 -51   fill=20 *trcl=( -8.2019 42.2328 0.0000 )    u=2 $ Assembly 12
725 3 -0.9982 -701  #726  fill=11 ( 8.1739 42.4663 0.0000 )     $ Tube/Disk 13
            *trcl=( 8.4709 42.5018 0.0000 )    u=2
726 3 -0.9982 -51   fill=20 *trcl=( 7.9404 42.2328 0.0000 )    u=2 $ Assembly 13
727 3 -0.9982 -701  #728  fill=16 ( 25.4509 42.4663 0.0000 )     $ Tube/Disk 14
            *trcl=( 25.4864 42.5018 0.0000 )    u=2
728 3 -0.9982 -51   fill=20 *trcl=( 25.2174 42.2328 0.0000 )    u=2 $ Assembly 14
729 3 -0.9982 -701  #730  fill=16 ( 42.4663 42.4663 0.0000 )     $ Tube/Disk 15
            *trcl=( 42.5018 42.5018 0.0000 )    u=2
730 3 -0.9982 -51   fill=20 *trcl=( 42.2328 42.2328 0.0000 )    u=2 $ Assembly 15
731 3 -0.9982 -702  #732  fill=4 ( 61.0896 43.9472 0.0000 )     $ Tube/Disk 16
            *trcl=( 61.2318 44.0893 0.0000 )    u=2
732 3 -0.9982 -51   fill=20 *trcl=( 60.5259 43.3835 0.0000 )    u=2 $ Assembly 16
733 3 -0.9982 -702  #734  fill=8 ( -59.6927 26.2968 0.0000 )     $ Tube/Disk 17
            *trcl=( -59.8348 26.4389 0.0000 )    u=2
734 3 -0.9982 -51   fill=20 *trcl=( -59.1290 25.7331 0.0000 )    u=2 $ Assembly 17
735 3 -0.9982 -701  #736  fill=15 ( -42.4663 25.4509 0.0000 )     $ Tube/Disk 18
            *trcl=( -42.5018 25.4864 0.0000 )    u=2
736 3 -0.9982 -51   fill=20 *trcl=( -42.2328 25.2174 0.0000 )    u=2 $ Assembly 18
737 3 -0.9982 -701  #738  fill=15 ( -25.4509 25.4509 0.0000 )     $ Tube/Disk 19
            *trcl=( -25.4864 25.4864 0.0000 )    u=2
738 3 -0.9982 -51   fill=20 *trcl=( -25.2174 25.2174 0.0000 )    u=2 $ Assembly 19
739 3 -0.9982 -701  #740  fill=15 ( -8.4354 25.4509 0.0000 )     $ Tube/Disk 20
            *trcl=( -8.4709 25.4864 0.0000 )    u=2
740 3 -0.9982 -51   fill=20 *trcl=( -8.2019 25.2174 0.0000 )    u=2 $ Assembly 20
741 3 -0.9982 -701  #742  fill=11 ( 8.1739 25.4509 0.0000 )     $ Tube/Disk 21
            *trcl=( 8.4709 25.4864 0.0000 )    u=2
742 3 -0.9982 -51   fill=20 *trcl=( 7.9404 25.2174 0.0000 )    u=2 $ Assembly 21
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743 3 -0.9982 -701  #744  fill=16 ( 25.4509 25.4509 0.0000 )     $ Tube/Disk 22
            *trcl=( 25.4864 25.4864 0.0000 )    u=2
744 3 -0.9982 -51   fill=20 *trcl=( 25.2174 25.2174 0.0000 )    u=2 $ Assembly 22
745 3 -0.9982 -701  #746  fill=16 ( 42.4663 25.4509 0.0000 )     $ Tube/Disk 23
            *trcl=( 42.5018 25.4864 0.0000 )    u=2
746 3 -0.9982 -51   fill=20 *trcl=( 42.2328 25.2174 0.0000 )    u=2 $ Assembly 23
747 3 -0.9982 -702  #748  fill=8 ( 59.6927 26.2968 0.0000 )     $ Tube/Disk 24
            *trcl=( 59.8348 26.4389 0.0000 )    u=2
748 3 -0.9982 -51   fill=20 *trcl=( 59.1290 25.7331 0.0000 )    u=2 $ Assembly 24
749 3 -0.9982 -702  #750  fill=5 ( -77.3430 8.6463 0.0000 )     $ Tube/Disk 25
            *trcl=( -77.4852 8.7884 0.0000 )    u=2
750 3 -0.9982 -51   fill=20 *trcl=( -76.7793 8.0826 0.0000 )    u=2 $ Assembly 25
751 3 -0.9982 -702  #752  fill=8 ( -59.6927 8.6463 0.0000 )     $ Tube/Disk 26
            *trcl=( -59.8348 8.7884 0.0000 )    u=2
752 3 -0.9982 -51   fill=20 *trcl=( -59.1290 8.0826 0.0000 )    u=2 $ Assembly 26
753 3 -0.9982 -701  #754  fill=15 ( -42.4663 8.4354 0.0000 )     $ Tube/Disk 27
            *trcl=( -42.5018 8.4709 0.0000 )    u=2
754 3 -0.9982 -51   fill=20 *trcl=( -42.2328 8.2019 0.0000 )    u=2 $ Assembly 27
755 3 -0.9982 -701  #756  fill=15 ( -25.4509 8.4354 0.0000 )     $ Tube/Disk 28
            *trcl=( -25.4864 8.4709 0.0000 )    u=2
756 3 -0.9982 -51   fill=20 *trcl=( -25.2174 8.2019 0.0000 )    u=2 $ Assembly 28
757 3 -0.9982 -701  #758  fill=15 ( -8.4354 8.4354 0.0000 )     $ Tube/Disk 29
            *trcl=( -8.4709 8.4709 0.0000 )    u=2
758 3 -0.9982 -51   fill=20 *trcl=( -8.2019 8.2019 0.0000 )    u=2 $ Assembly 29
759 3 -0.9982 -701  #760  fill=10 ( 8.1739 8.1739 0.0000 )     $ Tube/Disk 30
            *trcl=( 8.4709 8.4709 0.0000 )    u=2
760 3 -0.9982 -51   fill=20 *trcl=( 7.9404 7.9404 0.0000 )    u=2 $ Assembly 30
761 3 -0.9982 -701  #762  fill=13 ( 25.4509 8.1739 0.0000 )     $ Tube/Disk 31
            *trcl=( 25.4864 8.4709 0.0000 )    u=2
762 3 -0.9982 -51   fill=20 *trcl=( 25.2174 7.9404 0.0000 )    u=2 $ Assembly 31
763 3 -0.9982 -701  #764  fill=13 ( 42.4663 8.1739 0.0000 )     $ Tube/Disk 32
            *trcl=( 42.5018 8.4709 0.0000 )    u=2
764 3 -0.9982 -51   fill=20 *trcl=( 42.2328 7.9404 0.0000 )    u=2 $ Assembly 32
765 3 -0.9982 -702  #766  fill=8 ( 59.6927 8.6463 0.0000 )     $ Tube/Disk 33
            *trcl=( 59.8348 8.7884 0.0000 )    u=2
766 3 -0.9982 -51   fill=20 *trcl=( 59.1290 8.0826 0.0000 )    u=2 $ Assembly 33
767 3 -0.9982 -702  #768  fill=4 ( 77.3430 8.6463 0.0000 )     $ Tube/Disk 34
            *trcl=( 77.4852 8.7884 0.0000 )    u=2
768 3 -0.9982 -51   fill=20 *trcl=( 76.7793 8.0826 0.0000 )    u=2 $ Assembly 34
769 3 -0.9982 -702  #770  fill=5 ( -77.3430 -8.6463 0.0000 )     $ Tube/Disk 35
            *trcl=( -77.4852 -8.7884 0.0000 )    u=2
770 3 -0.9982 -51   fill=20 *trcl=( -76.7793 -8.0826 0.0000 )    u=2 $ Assembly 35
771 3 -0.9982 -702  #772  fill=8 ( -59.6927 -8.6463 0.0000 )     $ Tube/Disk 36
            *trcl=( -59.8348 -8.7884 0.0000 )    u=2
772 3 -0.9982 -51   fill=20 *trcl=( -59.1290 -8.0826 0.0000 )    u=2 $ Assembly 36
773 3 -0.9982 -701  #774  fill=14 ( -42.4663 -8.1739 0.0000 )     $ Tube/Disk 37
            *trcl=( -42.5018 -8.4709 0.0000 )    u=2
774 3 -0.9982 -51   fill=20 *trcl=( -42.2328 -7.9404 0.0000 )    u=2 $ Assembly 37
775 3 -0.9982 -701  #776  fill=14 ( -25.4509 -8.1739 0.0000 )     $ Tube/Disk 38
            *trcl=( -25.4864 -8.4709 0.0000 )    u=2
776 3 -0.9982 -51   fill=20 *trcl=( -25.2174 -7.9404 0.0000 )    u=2 $ Assembly 38
777 3 -0.9982 -701  #778  fill=10 ( -8.1739 -8.1739 0.0000 )     $ Tube/Disk 39
            *trcl=( -8.4709 -8.4709 0.0000 )    u=2
778 3 -0.9982 -51   fill=20 *trcl=( -7.9404 -7.9404 0.0000 )    u=2 $ Assembly 39
779 3 -0.9982 -701  #780  fill=17 ( 8.4354 -8.4354 0.0000 )     $ Tube/Disk 40
            *trcl=( 8.4709 -8.4709 0.0000 )    u=2
780 3 -0.9982 -51   fill=20 *trcl=( 8.2019 -8.2019 0.0000 )    u=2 $ Assembly 40
781 3 -0.9982 -701  #782  fill=17 ( 25.4509 -8.4354 0.0000 )     $ Tube/Disk 41
            *trcl=( 25.4864 -8.4709 0.0000 )    u=2
782 3 -0.9982 -51   fill=20 *trcl=( 25.2174 -8.2019 0.0000 )    u=2 $ Assembly 41
783 3 -0.9982 -701  #784  fill=17 ( 42.4663 -8.4354 0.0000 )     $ Tube/Disk 42
            *trcl=( 42.5018 -8.4709 0.0000 )    u=2
784 3 -0.9982 -51   fill=20 *trcl=( 42.2328 -8.2019 0.0000 )    u=2 $ Assembly 42
785 3 -0.9982 -702  #786  fill=8 ( 59.6927 -8.6463 0.0000 )     $ Tube/Disk 43
            *trcl=( 59.8348 -8.7884 0.0000 )    u=2
786 3 -0.9982 -51   fill=20 *trcl=( 59.1290 -8.0826 0.0000 )    u=2 $ Assembly 43
787 3 -0.9982 -702  #788  fill=4 ( 77.3430 -8.6463 0.0000 )     $ Tube/Disk 44
            *trcl=( 77.4852 -8.7884 0.0000 )    u=2
788 3 -0.9982 -51   fill=20 *trcl=( 76.7793 -8.0826 0.0000 )    u=2 $ Assembly 44
789 3 -0.9982 -702  #790  fill=8 ( -59.6927 -26.2968 0.0000 )     $ Tube/Disk 45
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           *trcl=( -59.8348 -26.4389 0.0000 )    u=2
790 3 -0.9982 -51    fill=20 *trcl=( -59.1290 -25.7331 0.0000 )    u=2 $ Assembly 45
791 3 -0.9982 -701   #792  fill=18 ( -42.4663 -25.4509 0.0000 )     $ Tube/Disk 46
           *trcl=( -42.5018 -25.4864 0.0000 )    u=2
792 3 -0.9982 -51    fill=20 *trcl=( -42.2328 -25.2174 0.0000 )    u=2 $ Assembly 46
793 3 -0.9982 -701   #794  fill=18 ( -25.4509 -25.4509 0.0000 )     $ Tube/Disk 47
           *trcl=( -25.4864 -25.4864 0.0000 )    u=2
794 3 -0.9982 -51    fill=20 *trcl=( -25.2174 -25.2174 0.0000 )    u=2 $ Assembly 47
795 3 -0.9982 -701   #796  fill=12 ( -8.1739 -25.4509 0.0000 )     $ Tube/Disk 48
           *trcl=( -8.4709 -25.4864 0.0000 )    u=2
796 3 -0.9982 -51    fill=20 *trcl=( -7.9404 -25.2174 0.0000 )    u=2 $ Assembly 48
797 3 -0.9982 -701   #798  fill=17 ( 8.4354 -25.4509 0.0000 )     $ Tube/Disk 49
           *trcl=( 8.4709 -25.4864 0.0000 )    u=2
798 3 -0.9982 -51    fill=20 *trcl=( 8.2019 -25.2174 0.0000 )    u=2 $ Assembly 49
799 3 -0.9982 -701   #800  fill=17 ( 25.4509 -25.4509 0.0000 )     $ Tube/Disk 50
           *trcl=( 25.4864 -25.4864 0.0000 )    u=2
800 3 -0.9982 -51    fill=20 *trcl=( 25.2174 -25.2174 0.0000 )    u=2 $ Assembly 50
801 3 -0.9982 -701   #802  fill=17 ( 42.4663 -25.4509 0.0000 )     $ Tube/Disk 51
           *trcl=( 42.5018 -25.4864 0.0000 )    u=2
802 3 -0.9982 -51    fill=20 *trcl=( 42.2328 -25.2174 0.0000 )    u=2 $ Assembly 51
803 3 -0.9982 -702   #804  fill=8 ( 59.6927 -26.2968 0.0000 )     $ Tube/Disk 52
           *trcl=( 59.8348 -26.4389 0.0000 )    u=2
804 3 -0.9982 -51    fill=20 *trcl=( 59.1290 -25.7331 0.0000 )    u=2 $ Assembly 52
805 3 -0.9982 -702   #806  fill=5 ( -61.0896 -43.9472 0.0000 )     $ Tube/Disk 53
           *trcl=( -61.2318 -44.0893 0.0000 )    u=2
806 3 -0.9982 -51    fill=20 *trcl=( -60.5259 -43.3835 0.0000 )    u=2 $ Assembly 53
807 3 -0.9982 -701   #808  fill=18 ( -42.4663 -42.4663 0.0000 )     $ Tube/Disk 54
           *trcl=( -42.5018 -42.5018 0.0000 )    u=2
808 3 -0.9982 -51    fill=20 *trcl=( -42.2328 -42.2328 0.0000 )    u=2 $ Assembly 54
809 3 -0.9982 -701   #810  fill=18 ( -25.4509 -42.4663 0.0000 )     $ Tube/Disk 55
           *trcl=( -25.4864 -42.5018 0.0000 )    u=2
810 3 -0.9982 -51    fill=20 *trcl=( -25.2174 -42.2328 0.0000 )    u=2 $ Assembly 55
811 3 -0.9982 -701   #812  fill=12 ( -8.1739 -42.4663 0.0000 )     $ Tube/Disk 56
           *trcl=( -8.4709 -42.5018 0.0000 )    u=2
812 3 -0.9982 -51    fill=20 *trcl=( -7.9404 -42.2328 0.0000 )    u=2 $ Assembly 56
813 3 -0.9982 -701   #814  fill=17 ( 8.4354 -42.4663 0.0000 )     $ Tube/Disk 57
           *trcl=( 8.4709 -42.5018 0.0000 )    u=2
814 3 -0.9982 -51    fill=20 *trcl=( 8.2019 -42.2328 0.0000 )    u=2 $ Assembly 57
815 3 -0.9982 -701   #816  fill=17 ( 25.4509 -42.4663 0.0000 )     $ Tube/Disk 58
           *trcl=( 25.4864 -42.5018 0.0000 )    u=2
816 3 -0.9982 -51    fill=20 *trcl=( 25.2174 -42.2328 0.0000 )    u=2 $ Assembly 58
817 3 -0.9982 -701   #818  fill=17 ( 42.4663 -42.4663 0.0000 )     $ Tube/Disk 59
           *trcl=( 42.5018 -42.5018 0.0000 )    u=2
818 3 -0.9982 -51    fill=20 *trcl=( 42.2328 -42.2328 0.0000 )    u=2 $ Assembly 59
819 3 -0.9982 -702   #820  fill=4 ( 61.0896 -43.9472 0.0000 )     $ Tube/Disk 60
           *trcl=( 61.2318 -44.0893 0.0000 )    u=2
820 3 -0.9982 -51    fill=20 *trcl=( 60.5259 -43.3835 0.0000 )    u=2 $ Assembly 60
821 3 -0.9982 -702   #822  fill=7 ( -43.9472 -61.0896 0.0000 )     $ Tube/Disk 61
           *trcl=( -44.0893 -61.2318 0.0000 )    u=2
822 3 -0.9982 -51    fill=20 *trcl=( -43.3835 -60.5259 0.0000 )    u=2 $ Assembly 61
823 3 -0.9982 -702   #824  fill=8 ( -26.2968 -59.6927 0.0000 )     $ Tube/Disk 62
           *trcl=( -26.4389 -59.8348 0.0000 )    u=2
824 3 -0.9982 -51    fill=20 *trcl=( -25.7331 -59.1290 0.0000 )    u=2 $ Assembly 62
825 3 -0.9982 -702   #826  fill=8 ( -8.6463 -59.6927 0.0000 )     $ Tube/Disk 63
           *trcl=( -8.7884 -59.8348 0.0000 )    u=2
826 3 -0.9982 -51    fill=20 *trcl=( -8.0826 -59.1290 0.0000 )    u=2 $ Assembly 63
827 3 -0.9982 -702   #828  fill=8 ( 8.6463 -59.6927 0.0000 )     $ Tube/Disk 64
           *trcl=( 8.7884 -59.8348 0.0000 )    u=2
828 3 -0.9982 -51    fill=20 *trcl=( 8.0826 -59.1290 0.0000 )    u=2 $ Assembly 64
829 3 -0.9982 -702   #830  fill=8 ( 26.2968 -59.6927 0.0000 )     $ Tube/Disk 65
           *trcl=( 26.4389 -59.8348 0.0000 )    u=2
830 3 -0.9982 -51    fill=20 *trcl=( 25.7331 -59.1290 0.0000 )    u=2 $ Assembly 65
831 3 -0.9982 -702   #832  fill=7 ( 43.9472 -61.0896 0.0000 )     $ Tube/Disk 66
           *trcl=( 44.0893 -61.2318 0.0000 )    u=2
832 3 -0.9982 -51    fill=20 *trcl=( 43.3835 -60.5259 0.0000 )    u=2 $ Assembly 66
833 3 -0.9982 -702   #834  fill=7 ( -8.6463 -77.3430 0.0000 )     $ Tube/Disk 67
           *trcl=( -8.7884 -77.4852 0.0000 )    u=2
834 3 -0.9982 -51    fill=20 *trcl=( -8.0826 -76.7793 0.0000 )    u=2 $ Assembly 67
835 3 -0.9982 -702   #836  fill=7 ( 8.6463 -77.3430 0.0000 )     $ Tube/Disk 68
           *trcl=( 8.7884 -77.4852 0.0000 )    u=2
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836 3 -0.9982 -51   fill=20 *trcl=( 8.0826 -76.7793 0.0000 )    u=2 $ Assembly 68
837 3 -0.9982 +703 +704        $ Canister Cavity Q1
      #703 #711 #713 #715 #725 #727 #729 #731 #741
      #704 #712 #714 #716 #726 #728 #730 #732 #742
      #743 #745 #747 #759 #761 #763 #765 #767
      #744 #746 #748 #760 #762 #764 #766 #768
          fill=3      u=2
838 3 -0.9982 +703 -704        $ Canister Cavity Q2
      #701 #705 #707 #709 #717 #719 #721 #723 #733
      #702 #706 #708 #710 #718 #720 #722 #724 #734
      #735 #737 #739 #749 #751 #753 #755 #757
      #736 #738 #740 #750 #752 #754 #756 #758
          fill=3      u=2
839 3 -0.9982 -703 -704        $ Canister Cavity Q3
      #769 #771 #773 #775 #777 #789 #791 #793 #795
      #770 #772 #774 #776 #778 #790 #792 #794 #796
      #805 #807 #809 #811 #821 #823 #825 #833
      #806 #808 #810 #812 #822 #824 #826 #834
          fill=3      u=2
840 3 -0.9982 -703 704        $ Canister Cavity Q4
      #779 #781 #783 #785 #787 #797 #799 #801 #803
      #780 #782 #784 #786 #788 #798 #800 #802 #804
      #813 #815 #817 #819 #827 #829 #831 #835
      #814 #816 #818 #820 #828 #830 #832 #836
          fill=3      u=2
c Cell Cards - Canister
901 3 -0.9982 -901 #902     fill=2 u=1 $ Cavity
902 9 -2.702 -902      u=1 $ Spacer
903 8 -7.940 -903 +901     u=1 $ Canister Shell / Lid / Bottom
904 14 -0.0001 +903      u=1 $ Remaining Space
c Cell Cards - Transfer Cask Geometry
911 14 -0.0001 -911 -912  fill=1 ( 0.0000 0.0000 2.5400 )   $ Cask cavity
912 10 -7.821 -911 +912 -916      $ Bottom plate
913 10 -7.821 -913 +912 +916 -918    $ Inner shell
914 11 -11.344 -914 +913 +916 -917    $ Lead shell
915 12 -1.632 -914 +913 +917 -918     $ NS-4-FR (above lead)
916 12 -1.632 -915 +914 +916 -918     $ NS-4-FR
917 10 -7.821 -911 +915 +916 -918     $ Outer shell
918 10 -7.821 -911 +912 +918      $ Top plate
919 10 -7.821 -919 +920  -925     $ Door rail
920 10 -7.821 -919 -921  -925     $ Door rail
921 10 -7.821 -924 -922 +923 -925     $ Door steel
922 14 -0.0001 -925 +911 #919 #920 #921      $ Exterior space to Reflector
923 0         +925       $ Exterior space

c Surfaces - Fuel Rod - AC - BWR_10x10_0 WR
10 RCC 0.0000 0.0000 1.6764 0.0000 0.0000 210.8200 0.4445 $ Fuel pellet stack
11 RCC 0.0000 0.0000 1.6764 0.0000 0.0000 218.1352 0.4521 $ Annulus + Plenum
12 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 223.0628 0.5029 $ Clad + End-Caps
c Surfaces - Pitch - AC - BWR_10x10_0 WR
40 PX 0.7176       $ Lattice Cell Boundaries
41 PX -0.7176
42 PY 0.7176
43 PY -0.7176
c Surfaces - Fuel Assembly Array Inserted Into Assembly - AC - BWR_10x10_0 WR
50 RPP -6.9608 6.9608 -6.9608 6.9608 25.4000 249.1232  $ Array
51 RPP -7.1755 7.1755 -7.1755 7.1755 0.0000 259.9436  $ Assembly Outer Dims
c Surface Cards - Standard Tube, Absorber and Retainer
311 RPP -7.4092 7.4092 -7.4092 7.4092 0.0000 274.4470 $  Space inside tube - cavity extent
312 RPP -7.4549 7.4549 -7.4549 7.4549 5.0800 254.5588 $  Fuel tube body
313 RPP -6.4897 6.4897 7.4930 7.6200 7.1120 250.6472 $ Absorber +Y
314 RPP -6.4897 6.4897 7.4549 7.6581 7.1120 250.6472 $ Absorber Clad  +Y
315 RPP -6.7374 6.7374 7.4549 7.6581 7.1120 250.6472 $ Absorber Cover Opening +Y
316 RPP -6.7958 6.7958 7.4549 7.7164 7.0536 250.6472 $ Absorber Cover  +Y
317 RPP 7.4930 7.6200 -6.4897 6.4897 7.1120 250.6472 $ Absorber +X
318 RPP 7.4549 7.6581 -6.4897 6.4897 7.1120 250.6472 $ Absorber Clad  +X
319 RPP 7.4549 7.6581 -6.7374 6.7374 7.1120 250.6472 $ Absorber Cover Opening +X
320 RPP 7.4549 7.7164 -6.7958 6.7958 7.0536 250.6472 $ Absorber Cover  +X
321 RPP -6.4897 6.4897 -7.6200 -7.4930 7.1120 250.6472 $ Absorber -Y
322 RPP -6.4897 6.4897 -7.6581 -7.4549 7.1120 250.6472 $ Absorber Clad  -Y
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323 RPP -6.7374 6.7374 -7.6581 -7.4549 7.1120 250.6472 $ Absorber Cover Opening -Y
324 RPP -6.7958 6.7958 -7.7164 -7.4549 7.0536 250.6472 $ Absorber Cover  -Y
325 RPP -7.6200 -7.4930 -6.4897 6.4897 7.1120 250.6472 $ Absorber -X
326 RPP -7.6581 -7.4549 -6.4897 6.4897 7.1120 250.6472 $ Absorber Clad  -X
327 RPP -7.6581 -7.4549 -6.7374 6.7374 7.1120 250.6472 $ Absorber Cover Opening -X
328 RPP -7.7164 -7.4549 -6.7958 6.7958 7.0536 250.6472 $ Absorber Cover  -X
c Surface Cards - DFC Tube, Absorber and Retainer
411 RPP -7.7394 7.7394 -7.7394 7.7394 0.0000 274.4470 $  Space inside tube - cavity extent
412 RPP -7.7851 7.7851 -7.7851 7.7851 5.0800 254.5588 $  Fuel tube body
413 RPP -6.4897 6.4897 7.8232 7.9502 7.1120 250.6472 $ Absorber +Y
414 RPP -6.4897 6.4897 7.7851 7.9883 7.1120 250.6472 $ Absorber Clad  +Y
415 RPP -6.7374 6.7374 7.7851 7.9883 7.1120 250.6472 $ Absorber Cover Opening +Y
416 RPP -6.7958 6.7958 7.7851 8.0466 7.0536 250.6472 $ Absorber Cover  +Y
417 RPP 7.8232 7.9502 -6.4897 6.4897 7.1120 250.6472 $ Absorber +X
418 RPP 7.7851 7.9883 -6.4897 6.4897 7.1120 250.6472 $ Absorber Clad  +X
419 RPP 7.7851 7.9883 -6.7374 6.7374 7.1120 250.6472 $ Absorber Cover Opening +X
420 RPP 7.7851 8.0466 -6.7958 6.7958 7.0536 250.6472 $ Absorber Cover  +X
421 RPP -6.4897 6.4897 -7.9502 -7.8232 7.1120 250.6472 $ Absorber -Y
422 RPP -6.4897 6.4897 -7.9883 -7.7851 7.1120 250.6472 $ Absorber Clad  -Y
423 RPP -6.7374 6.7374 -7.9883 -7.7851 7.1120 250.6472 $ Absorber Cover Opening -Y
424 RPP -6.7958 6.7958 -8.0466 -7.7851 7.0536 250.6472 $ Absorber Cover  -Y
425 RPP -7.9502 -7.8232 -6.4897 6.4897 7.1120 250.6472 $ Absorber -X
426 RPP -7.9883 -7.7851 -6.4897 6.4897 7.1120 250.6472 $ Absorber Clad  -X
427 RPP -7.9883 -7.7851 -6.7374 6.7374 7.1120 250.6472 $ Absorber Cover Opening -X
428 RPP -8.0466 -7.7851 -6.7958 6.7958 7.0536 250.6472 $ Absorber Cover  -X
c Surface Cards - Disk Stack
601 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 1.7272 88.1380 $ Structural disk
602 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 3.3147 88.1380 $ Structural top disk
603 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 2.0447 88.1380 $ Structural bottom disk
604 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 1.3386 87.7951 $ Heat transfer disk
605 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 1.5875 88.0491 $ Top weldment disk
606 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 2.5400 88.0491 $ Bottom weldment disk
c Surface Cards - Basket
701 RPP -7.7521 7.7521 -7.7521 7.7521 0.0000 274.4470  $ Std opening
702 RPP -8.1890 8.1890 -8.1890 8.1890 0.0000 274.4470  $ DFC opening
703 PY 0.0000        $ Cut plane
704 PX 0.0000        $ Cut plane
c Surface Cards - Canister
901 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 274.4470  88.4428 $ Canister cavity
902 RPP -48.6410 48.6410 -48.6410 48.6410 264.2870 274.4469   $ Canister spacer
903 RCC 0.0000 0.0000 -2.5400 0.0000 0.0000 294.7670  89.7128 $ Canister
c Surface Cards - Transfer Cask Geometry
911 RCC 0.000 0.000 0.000 0.000 0.000 313.6900 109.8550  $ Cask Cylindrical Section
912 CZ 90.8050        $ Cask cavity radius
913 CZ 92.7100        $ Inner shell OR
914 CZ 101.6000        $ Lead shell OR
915 CZ 106.6800        $ Outer shell IR
916 PZ 2.5400        $ Top of bottom plate
917 PZ 298.4500        $ Top of lead shield
918 PZ 308.6100        $ Bottom of top plate
919 RPP -110.1852 110.1852 -107.3150 107.3150 -24.1300 0.0000   $ Door Enclosing Shape
920 PY 95.8850        $ Inside rail surface
921 PY -95.8850        $ Inside rail surface
922 PY 95.4024        $ Door surface
923 PY -95.4024        $ Door surface
924 RHP 0.0000 0.0000 -24.1300 0.0000 0.0000 24.1300
          89.9681 0.0000 0.0000 54.42077 -66.1670 0.0000
          -54.4208 -66.1670 0.0000      $ Door prism
925 RCC 0.000 0.000 -44.130 0.000 0.000 370.2000 129.8550  $ Cylinder to Reflect

c
c Materials List
c
c Fuel Pellet Material   3.94%  Weight UO2 [amu]  269.93
m1    92235.66c -3.473E-02 92238.66c -8.467E-01  8016.62c -1.185E-01
c SS348 Clad
m2
      24050.62c -7.939E-03 26054.62c -3.927E-02 28058.62c -6.384E-02
      24052.62c -1.590E-01 26056.62c -6.387E-01 28060.62c -2.543E-02
      24053.62c -1.838E-02 26057.62c -1.502E-02 28061.62c -1.124E-03
```

```
      24054.62c -4.652E-03 26058.62c -2.019E-03 28062.62c -3.639E-03
                                                28064.62c -9.623E-04
      25055.62c -2.000E-02
c Water
m3     1001.62c -1.119E-01  8016.62c -8.881E-01
mt3  lwtr.01t
c Lower Nozzle Material
m6
       1001.62c -4.496E-02  8016.62c -3.568E-01
      24050.62c -4.750E-03 26054.62c -2.349E-02 28058.62c -3.819E-02
      24052.62c -9.514E-02 26056.62c -3.821E-01 28060.62c -1.522E-02
      24053.62c -1.099E-02 26057.62c -8.987E-03 28061.62c -6.726E-04
      24054.62c -2.783E-03 26058.62c -1.208E-03 28062.62c -2.177E-03
                                                28064.62c -5.757E-04
      25055.62c -1.197E-02
mt6  lwtr.01t
c Upper Nozzle Material
m7
       1001.62c -5.637E-02  8016.62c -4.474E-01
      24050.62c -3.940E-03 26054.62c -1.949E-02 28058.62c -3.168E-02
      24052.62c -7.892E-02 26056.62c -3.170E-01 28060.62c -1.262E-02
      24053.62c -9.120E-03 26057.62c -7.455E-03 28061.62c -5.580E-04
      24054.62c -2.308E-03 26058.62c -1.002E-03 28062.62c -1.806E-03
                                                28064.62c -4.776E-04
      25055.62c -9.925E-03
mt7  lwtr.01t
c SS304
m8    24050.62c -7.939E-03 26054.62c -3.927E-02 28058.62c -6.384E-02
      24052.62c -1.590E-01 26056.62c -6.387E-01 28060.62c -2.543E-02
      24053.62c -1.838E-02 26057.62c -1.502E-02 28061.62c -1.124E-03
      24054.62c -4.652E-03 26058.62c -2.019E-03 28062.62c -3.639E-03
                                                28064.62c -9.623E-04
      25055.62c -2.000E-02
c Aluminum
m9    13027.62c -1.000E+00
c Carbon Steel
m10   26054.62c -5.594E-02  6000.66c -1.000E-02
      26056.62c -9.098E-01
      26057.62c -2.140E-02
      26058.62c -2.876E-03
c Lead
m11   82206.66c -2.534E-01
      82207.66c -2.207E-01
      82208.66c -5.259E-01
c NS-F-FR
m12    5010.66c -9.313E-04  7014.62c -1.974E-02  8016.62c -4.250E-01
       5011.66c -3.772E-03  7015.66c -7.852E-05
      13027.62c -2.142E-01  1001.62c -6.001E-02  6000.66c -2.763E-01
c Concrete
m13   26054.62c -7.911E-04 14000.60c -3.370E-01
      26056.62c -1.287E-02
      26057.62c -3.026E-04
      26058.62c -4.067E-05
       1001.62c -1.000E-02 13027.62c -3.400E-02 20000.62c -4.400E-02
       8016.62c -5.320E-01 11023.62c -2.900E-02
c Water Exterior
m14    1001.62c 2.0
       8016.62c 1.0
mt14  lwtr.01t
c Borated Aluminum (Absorber Core / Sheet)
m15    5010.66c -6.011E-02 13027.62c -5.656E-01  6000.66c -9.430E-02
       5011.66c -2.799E-01
c Zirc Alloy
m17   26054.62c -7.063E-05 24050.62c -4.179E-05  7014.62c -4.980E-04
      26056.62c -1.149E-03 24052.62c -8.370E-04  7015.66c -1.981E-06
      26057.62c -2.702E-05 24053.62c -9.673E-05
      26058.62c -3.631E-06 24054.62c -2.448E-05
      40000.66c -9.823E-01 50000.42c -1.500E-02
c SS304/Cu Heat Fin
m18   24050.62c -4.537E-03 26054.62c -2.244E-02 28058.62c -3.648E-02
```

```
      24052.62c -9.088E-02 26056.62c -3.650E-01 28060.62c -1.453E-02
      24053.62c -1.050E-02 26057.62c -8.584E-03 28061.62c -6.425E-04
      24054.62c -2.658E-03 26058.62c -1.154E-03 28062.62c -2.079E-03
                                                28064.62c -5.499E-04
      25055.62c -1.143E-02
      29000 -0.4286
c DFC fuel mixture material (if applicable)   Mix Height=264.5in
m19   92235.66c -2.683E-02 92238.66c -6.540E-01  8016.62c -9.156E-02
       1001.62c -2.547E-02  8016.62c -2.021E-01
c DFC fuel mixture material (if applicable)   Mix Height=264.5in
m20   92235.66c -2.683E-02 92238.66c -6.540E-01  8016.62c -9.156E-02
       1001.62c -2.547E-02  8016.62c -2.021E-01
c
c Rotation Matrix
*TR1 0.0 0.0 0.0 45 135 90 -45 45 90 90 90 0  $ z-rotation 45 degrees
*TR2 0.0 0.0 0.0 135 225 90 45 135 90 90 90 0  $ z-rotation 135 degrees
*TR3 0.0 0.0 0.0 15 105 90 -75 15 90 90 90 0  $ z-rotation 15 degrees
*TR4 0.0 0.0 0.0 30 120 90 -60 30 90 90 90 0  $ z-rotation 30 degrees
*TR5 0.0 0.0 0.0 60 150 90 -30 60 90 90 90 0  $ z-rotation 60 degrees
*TR6 0.0 0.0 0.0 75 165 90 -15 75 90 90 90 0  $ z-rotation 75 degrees
*TR7 0.0 0.0 0.0 8 98 90 -82 8 90 90 90 0  $ z-rotation 8 degrees
*TR8 0.0 0.0 0.0 102 192 90 12 102 90 90 90 0  $ z-rotation 102 degrees
*TR9 0.0 0.0 0.0 156 246 90 66 156 90 90 90 0  $ z-rotation 156 degrees
*TR10 0.0 0.0 0.0 78 168 90 -12 78 90 90 90 0  $ z-rotation 78 degrees
*TR11 0.0 0.0 0.0 24 114 90 -66 24 90 90 90 0  $ z-rotation 24 degrees
c
c Cell Importances
c
mode n
imp:n 1 362r 0
c
c
c Criticality Controls
c
kcode 2000 1.00 30 430
c Ones source point in each of the fuel assemblies
ksrc
      -5.2124 79.6495 100.00
      10.9528 79.6495 100.00
      -40.5133 63.3961 100.00
      -22.8629 61.9992 100.00
      -5.2124 61.9992 100.00
      10.9528 61.9992 100.00
      28.6033 61.9992 100.00
      46.2537 63.3961 100.00
      -57.6557 46.2537 100.00
      -39.3626 45.1030 100.00
      -22.3472 45.1030 100.00
      -5.3317 45.1030 100.00
      10.8106 45.1030 100.00
      28.0876 45.1030 100.00
      45.1030 45.1030 100.00
      63.3961 46.2537 100.00
      -56.2588 28.6033 100.00
      -39.3626 28.0876 100.00
      -22.3472 28.0876 100.00
      -5.3317 28.0876 100.00
      10.8106 28.0876 100.00
      28.0876 28.0876 100.00
      45.1030 28.0876 100.00
      61.9992 28.6033 100.00
      -73.9091 10.9528 100.00
      -56.2588 10.9528 100.00
      -39.3626 11.0721 100.00
      -22.3472 11.0721 100.00
      -5.3317 11.0721 100.00
      10.8106 10.8106 100.00
      28.0876 10.8106 100.00
      45.1030 10.8106 100.00
      61.9992 10.9528 100.00
```

```
      79.6495 10.9528 100.00
      -73.9091 -5.2124 100.00
      -56.2588 -5.2124 100.00
      -39.3626 -5.0702 100.00
      -22.3472 -5.0702 100.00
      -5.0702 -5.0702 100.00
      11.0721 -5.3317 100.00
      28.0876 -5.3317 100.00
      45.1030 -5.3317 100.00
      61.9992 -5.2124 100.00
      79.6495 -5.2124 100.00
      -56.2588 -22.8629 100.00
      -39.3626 -22.3472 100.00
      -22.3472 -22.3472 100.00
      -5.0702 -22.3472 100.00
      11.0721 -22.3472 100.00
      28.0876 -22.3472 100.00
      45.1030 -22.3472 100.00
      61.9992 -22.8629 100.00
      -57.6557 -40.5133 100.00
      -39.3626 -39.3626 100.00
      -22.3472 -39.3626 100.00
      -5.0702 -39.3626 100.00
      11.0721 -39.3626 100.00
      28.0876 -39.3626 100.00
      45.1030 -39.3626 100.00
      63.3961 -40.5133 100.00
      -40.5133 -57.6557 100.00
      -22.8629 -56.2588 100.00
      -5.2124 -56.2588 100.00
      10.9528 -56.2588 100.00
      28.6033 -56.2588 100.00
      46.2537 -57.6557 100.00
      -5.2124 -73.9091 100.00
      10.9528 -73.9091 100.00
c
c
c Random Number Generator Controls
c
RAND GEN=2 SEED=19073486328127
c
c
c Print Control
c
PRINT
c
```

Figure 6.A.7.1-2 Damaged Fuel Transfer Cask Sample Input

```
LACBWR Transfer Cask Model -  Fuel Assembly Type: EX - BWR_10x10_4 WR
c
c Model Revision 3.4
c
c Single Cask Model
c
c Partial Flood: No
c
c Damaged Fuel Can Option:  Yes
c DFC Content: Unclad Rod Array
c
c DFC Content Active Fuel Location: Bottom
c
c Primary Fuel Tye Enrichment:  3.71 wt%
c
c Secondary Fuel Type:  AC - BWR_10x10_0 WR
c Seondary Fuel Enrichment:  3.94 wt%
c
c Thrid Fuel Type:  AC - BWR_10x10_0 WR
c Seondary Fuel Enrichment:  3.64 wt%
c
c Density (H2O) (g/cc)
c              Lattice DFC Exterior
c              0.0001  0.9982 0.0001
c
c Tube
c      Outer_Width Thickness
c      Max         Min
c
c Absorber
c          Width Thickness
c          Min   Max
c
c Disk
c      Op_Width Location Thickness Spacing
c      Max      Min      Max       Min
c
c Shift Patterns
c  Rad Fuel Rad Tube Axial Fuel Axial Basket
c  In       In       Bottom     Bottom
c Cells - Fuel Rod - EX - BWR_10x10_4 WR
10 1 -10.522 -10     u=30 $ Fuel
11 3 -0.0001 -11 +10    u=30 $ Plenum + Fuel to Clad Gap
12 2 -7.94 -12 +11    u=30 $ Clad + End Plugs
13 3 -0.0001 +12     u=30 $ Outside Fuel Rod
c Cells - Inert Rods - EX - BWR_10x10_4 WR
30 17 -6.56 -30     u=29 $ Inside Inert Rod
31 2 -7.94 -31 +30    u=29 $ Inert Rod Clad and Plugs
32 3 -0.0001 +31     u=29 $ Outside Inert Rod
c Array_10x10_4
40 3 -0.0001 -40 +41 -42 +43
      trcl=(0.7074 0.7074 25.4)   lat=1 u=28 fill=-5:4 -5:4 0:0
      30 30 30 30 30 30 30 30 30 30
      30 30 30 30 30 30 30 30 30 30
      30 30 30 30 30 30 30 30 30 30
      30 30 30 30 30 30 30 30 30 30
      30 30 30 30 29 29 30 30 30 30
      30 30 30 30 29 29 30 30 30 30
      30 30 30 30 30 30 30 30 30 30
      30 30 30 30 30 30 30 30 30 30
      30 30 30 30 30 30 30 30 30 30
      30 30 30 30 30 30 30 30 30 30
c Cells - Fuel Assembly Array Inserted Into Assembly - cellAssy
50 3 -0.0001 -50    fill=28 u=27 $ Array
51 3 -0.0001 -51 +50 -50.6 -50.5  u=27 $ Gap to Fuel Envelope
```

```
52 6 -2.0254 -51  +50.6   u=27 $ Lower Nozzle
53 7 -0.6953 -51   +50.5  u=27 $ Upper Nozzle
54 3 -0.0001 +51     u=27 $ Remaining Space
c Cells - DFC Content
261 4 -10.522 -261     u=26  $ Pellet Stack
262 3 -0.9982 +261     u=26  $ Exterior
c Cells - DFC Content
265 3 -0.9982 -265 +266 -267 +268
      trcl=(0.76185 0.76185 0)   lat=1 u=25 fill=-5:4 -5:4 0:0
      26 26 26 26 26 26 26 26 26 26
      26 26 26 26 26 26 26 26 26 26
      26 26 26 26 26 26 26 26 26 26
      26 26 26 26 26 26 26 26 26 26
      26 26 26 26 26 26 26 26 26 26
      26 26 26 26 26 26 26 26 26 26
      26 26 26 26 26 26 26 26 26 26
      26 26 26 26 26 26 26 26 26 26
      26 26 26 26 26 26 26 26 26 26
      26 26 26 26 26 26 26 26 26 26
c Cells - Fuel Assembly Array Inserted Into Assembly - cellDFCAssy
270 3 -0.0001 -270  fill=25   ( 0.0000 0.0000 0.0000 ) u=24 $ Array
271 3 -0.0001 +270      u=24 $ Remaining Space
c Cells - DFC Content
281 5 -10.522 -281     u=23  $ Pellet Stack
282 3 -0.9982 +281     u=23  $ Exterior
c Cells - DFC Content
285 3 -0.9982 -285 +286 -287 +288
      trcl=(0.76185 0.76185 0)   lat=1 u=22 fill=-5:4 -5:4 0:0
      23 23 23 23 23 23 23 23 23 23
      23 23 23 23 23 23 23 23 23 23
      23 23 23 23 23 23 23 23 23 23
      23 23 23 23 23 23 23 23 23 23
      23 23 23 23 23 23 23 23 23 23
      23 23 23 23 23 23 23 23 23 23
      23 23 23 23 23 23 23 23 23 23
      23 23 23 23 23 23 23 23 23 23
      23 23 23 23 23 23 23 23 23 23
      23 23 23 23 23 23 23 23 23 23
c Cells - Fuel Assembly Array Inserted Into Assembly - cellDFCAssyAxis
290 3 -0.0001 -290  fill=22   ( 0.0000 0.0000 0.0000 ) u=21 $ Array
291 3 -0.0001 +290      u=21 $ Remaining Space
c Cell Cards -DFC
301 3 -0.0001 -301 -305 +303    u=20 $ DFC Cavity
302 8 -7.940 -302  -303    u=20 $ DFC Bottom Plate
303 8 -7.940 -302 +301 +303    u=20 $ DFC Body
304 8 -7.940 -301 +305 -304    u=20 $ DFC Lid Plates
305 3 -0.0001 -301 +304     u=20 $ Area above lid
306 3 -0.0001 +302      u=20 $ Exterior Space
c Cell Cards - Standard Tube, Absorber and Retainer (PX,PY)
330 3 -0.0001 -311      u=18 $ Space in Tube
331 8 -7.940 -312 +311     u=18 $ FuelTube
332 15 -1.965 -313      u=18 $ Absorber +Y
333 9 -2.702 -314 +313     u=18 $ Absorber Clad  +Y
334 3 -0.0001 -315 +314     u=18 $ Absorber Cover Opening+Y
335 8 -7.940 -316 +315     u=18 $ Absorber Cover  +Y
336 15 -1.965 -317      u=18 $ Absorber +X
337 9 -2.702 -318 +317     u=18 $ Absorber Clad  +X
338 3 -0.0001 -319 +318     u=18 $ Absorber Cover Opening+X
339 8 -7.940 -320 +319     u=18 $ Absorber Cover  +X
340 3 -0.0001 +311 +312 +316 +320      u=18 $ Exterior Space
c Cell Cards - Standard Tube, Absorber and Retainer (MX,PY)
341 3 -0.0001 -311      u=17 $ Space in Tube
342 8 -7.940 -312 +311     u=17 $ FuelTube
343 15 -1.965 -313      u=17 $ Absorber +Y
344 9 -2.702 -314 +313     u=17 $ Absorber Clad  +Y
345 3 -0.0001 -315 +314     u=17 $ Absorber Cover Opening+Y
346 8 -7.940 -316 +315     u=17 $ Absorber Cover  +Y
347 15 -1.965 -325      u=17 $ Absorber -X
348 9 -2.702 -326 +325     u=17 $ Absorber Clad  -X
349 3 -0.0001 -327 +326     u=17 $ Absorber Cover Opening-X
```

```
350 8 -7.940 -328 +327      u=17 $ Absorber Cover  -X
351 3 -0.0001 +311 +312 +316 +328      u=17 $ Exterior Space
c Cell Cards - Standard Tube, Absorber and Retainer (MX,MY)
352 3 -0.0001 -311      u=16 $ Space in Tube
353 8 -7.940 -312 +311      u=16 $ FuelTube
354 15 -1.965 -321      u=16 $ Absorber -Y
355 9 -2.702 -322 +321      u=16 $ Absorber Clad  -Y
356 3 -0.0001 -323 +322      u=16 $ Absorber Cover Opening-Y
357 8 -7.940 -324 +323      u=16 $ Absorber Cover  -Y
358 15 -1.965 -325      u=16 $ Absorber -X
359 9 -2.702 -326 +325      u=16 $ Absorber Clad  -X
360 3 -0.0001 -327 +326      u=16 $ Absorber Cover Opening-X
361 8 -7.940 -328 +327      u=16 $ Absorber Cover  -X
362 3 -0.0001 +311 +312 +324 +328      u=16 $ Exterior Space
c Cell Cards - Standard Tube, Absorber and Retainer (PX,MY)
363 3 -0.0001 -311      u=15 $ Space in Tube
364 8 -7.940 -312 +311      u=15 $ FuelTube
365 15 -1.965 -321      u=15 $ Absorber -Y
366 9 -2.702 -322 +321      u=15 $ Absorber Clad  -Y
367 3 -0.0001 -323 +322      u=15 $ Absorber Cover Opening-Y
368 8 -7.940 -324 +323      u=15 $ Absorber Cover  -Y
369 15 -1.965 -317      u=15 $ Absorber +X
370 9 -2.702 -318 +317      u=15 $ Absorber Clad  +X
371 3 -0.0001 -319 +318      u=15 $ Absorber Cover Opening+X
372 8 -7.940 -320 +319      u=15 $ Absorber Cover  +X
373 3 -0.0001 +311 +312 +320 +324      u=15 $ Exterior Space
c Cell Cards - Standard Tube, Absorber and Retainer (PX)
374 3 -0.0001 -311      u=14 $ Space in Tube
375 8 -7.940 -312 +311      u=14 $ FuelTube
376 15 -1.965 -317      u=14 $ Absorber +X
377 9 -2.702 -318 +317      u=14 $ Absorber Clad  +X
378 3 -0.0001 -319 +318      u=14 $ Absorber Cover Opening+X
379 8 -7.940 -320 +319      u=14 $ Absorber Cover  +X
380 3 -0.0001 +311 +312 +320      u=14 $ Exterior Space
c Cell Cards - Standard Tube, Absorber and Retainer (MX)
381 3 -0.0001 -311      u=13 $ Space in Tube
382 8 -7.940 -312 +311      u=13 $ FuelTube
383 15 -1.965 -325      u=13 $ Absorber -X
384 9 -2.702 -326 +325      u=13 $ Absorber Clad  -X
385 3 -0.0001 -327 +326      u=13 $ Absorber Cover Opening-X
386 8 -7.940 -328 +327      u=13 $ Absorber Cover  -X
387 3 -0.0001 +311 +312 +328      u=13 $ Exterior Space
c Cell Cards - Standard Tube, Absorber and Retainer (PY)
388 3 -0.0001 -311      u=12 $ Space in Tube
389 8 -7.940 -312 +311      u=12 $ FuelTube
390 15 -1.965 -313      u=12 $ Absorber +Y
391 9 -2.702 -314 +313      u=12 $ Absorber Clad  +Y
392 3 -0.0001 -315 +314      u=12 $ Absorber Cover Opening+Y
393 8 -7.940 -316 +315      u=12 $ Absorber Cover  +Y
394 3 -0.0001 +311 +312 +316      u=12 $ Exterior Space
c Cell Cards - Standard Tube, Absorber and Retainer (MY)
395 3 -0.0001 -311      u=11 $ Space in Tube
396 8 -7.940 -312 +311      u=11 $ FuelTube
397 15 -1.965 -321      u=11 $ Absorber -Y
398 9 -2.702 -322 +321      u=11 $ Absorber Clad  -Y
399 3 -0.0001 -323 +322      u=11 $ Absorber Cover Opening-Y
400 8 -7.940 -324 +323      u=11 $ Absorber Cover  -Y
401 3 -0.0001 +311 +312 +324      u=11 $ Exterior Space
c Cell Cards - Standard Tube
402 3 -0.0001 -311      u=10 $ Space in Tube
403 8 -7.940 -312 +311      u=10 $ FuelTube
404 3 -0.0001 +311 +312      u=10 $ Exterior Space
c Cell Cards - DFC Tube, Absorber and Retainer- 4 BORAL
411 3 -0.0001 -411      u=8 $ Space in Tube
412 8 -7.940 -412 +411      u=8 $ FuelTube
413 15 -1.965 -413      u=8 $ Absorber +Y
414 9 -2.702 -414 +413      u=8 $ Absorber Clad  +Y
415 3 -0.0001 -415 +414      u=8 $ Absorber Cover Opening+Y
416 8 -7.940 -416 +415      u=8 $ Absorber Cover  +Y
417 15 -1.965 -417      u=8 $ Absorber +X
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418 8 -7.940 -418 +417      u=8 $ Absorber Clad  +X
419 3 -0.0001 -419 +418      u=8 $ Absorber Cover Opening+X
420 8 -7.940 -420 +419      u=8 $ Absorber Cover  +X
421 15 -1.965 -421      u=8 $ Absorber -Y
422 9 -2.702 -422 +421      u=8 $ Absorber Clad  -Y
423 3 -0.0001 -423 +422      u=8 $ Absorber Cover Opening-Y
424 8 -7.940 -424 +423      u=8 $ Absorber Cover  -Y
425 15 -1.965 -425      u=8 $ Absorber -X
426 8 -7.940 -426 +425      u=8 $ Absorber Clad  -X
427 3 -0.0001 -427 +426      u=8 $ Absorber Cover Opening-X
428 8 -7.940 -428 +427      u=8 $ Absorber Cover  -X
429 3 -0.0001 +411 +412 +416 +420 +424 +428      u=8 $ Exterior Space
c Cell Cards - DFC Tube, Absorber and Retainer- 2X. PY
430 3 -0.0001 -411      u=7 $ Space in Tube
431 8 -7.940 -412 +411      u=7 $ FuelTube
432 15 -1.965 -413      u=7 $ Absorber +Y
433 9 -2.702 -414 +413      u=7 $ Absorber Clad  +Y
434 3 -0.0001 -415 +414      u=7 $ Absorber Cover Opening+Y
435 8 -7.940 -416 +415      u=7 $ Absorber Cover  +Y
436 15 -1.965 -417      u=7 $ Absorber +X
437 8 -7.940 -418 +417      u=7 $ Absorber Clad  +X
438 3 -0.0001 -419 +418      u=7 $ Absorber Cover Opening+X
439 8 -7.940 -420 +419      u=7 $ Absorber Cover  +X
440 15 -1.965 -425      u=7 $ Absorber -X
441 8 -7.940 -426 +425      u=7 $ Absorber Clad  -X
442 3 -0.0001 -427 +426      u=7 $ Absorber Cover Opening-X
443 8 -7.940 -428 +427      u=7 $ Absorber Cover  -X
444 3 -0.0001 +411 +412 +416 +420 +428      u=7 $ Exterior Space
c Cell Cards - DFC Tube, Absorber and Retainer- 2X, MY
445 3 -0.0001 -411      u=6 $ Space in Tube
446 8 -7.940 -412 +411      u=6 $ FuelTube
447 15 -1.965 -417      u=6 $ Absorber +X
448 8 -7.940 -418 +417      u=6 $ Absorber Clad  +X
449 3 -0.0001 -419 +418      u=6 $ Absorber Cover Opening+X
450 8 -7.940 -420 +419      u=6 $ Absorber Cover  +X
451 15 -1.965 -421      u=6 $ Absorber -Y
452 9 -2.702 -422 +421      u=6 $ Absorber Clad  -Y
453 3 -0.0001 -423 +422      u=6 $ Absorber Cover Opening-Y
454 8 -7.940 -424 +423      u=6 $ Absorber Cover  -Y
455 15 -1.965 -425      u=6 $ Absorber -X
456 8 -7.940 -426 +425      u=6 $ Absorber Clad  -X
457 3 -0.0001 -427 +426      u=6 $ Absorber Cover Opening-X
458 8 -7.940 -428 +427      u=6 $ Absorber Cover  -X
459 3 -0.0001 +411 +412 +420 +424 +428      u=6 $ Exterior Space
c Cell Cards - DFC Tube, Absorber and Retainer-PX, 2Y
460 3 -0.0001 -411      u=5 $ Space in Tube
461 8 -7.940 -412 +411      u=5 $ FuelTube
462 15 -1.965 -413      u=5 $ Absorber +Y
463 9 -2.702 -414 +413      u=5 $ Absorber Clad  +Y
464 3 -0.0001 -415 +414      u=5 $ Absorber Cover Opening+Y
465 8 -7.940 -416 +415      u=5 $ Absorber Cover  +Y
466 15 -1.965 -417      u=5 $ Absorber +X
467 8 -7.940 -418 +417      u=5 $ Absorber Clad  +X
468 3 -0.0001 -419 +418      u=5 $ Absorber Cover Opening+X
469 8 -7.940 -420 +419      u=5 $ Absorber Cover  +X
470 15 -1.965 -421      u=5 $ Absorber -Y
471 9 -2.702 -422 +421      u=5 $ Absorber Clad  -Y
472 3 -0.0001 -423 +422      u=5 $ Absorber Cover Opening-Y
473 8 -7.940 -424 +423      u=5 $ Absorber Cover  -Y
474 3 -0.0001 +411 +412 +416 +420 +424      u=5 $ Exterior Space
c Cell Cards - DFC Tube, Absorber and Retainer- MX, 2Y
475 3 -0.0001 -411      u=4 $ Space in Tube
476 8 -7.940 -412 +411      u=4 $ FuelTube
477 15 -1.965 -413      u=4 $ Absorber +Y
478 9 -2.702 -414 +413      u=4 $ Absorber Clad  +Y
479 3 -0.0001 -415 +414      u=4 $ Absorber Cover Opening+Y
480 8 -7.940 -416 +415      u=4 $ Absorber Cover  +Y
481 15 -1.965 -421      u=4 $ Absorber -Y
482 9 -2.702 -422 +421      u=4 $ Absorber Clad  -Y
483 3 -0.0001 -423 +422      u=4 $ Absorber Cover Opening-Y
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484 8 -7.940 -424 +423      u=4 $ Absorber Cover  -Y
485 15 -1.965 -425      u=4 $ Absorber -X
486 8 -7.940 -426 +425      u=4 $ Absorber Clad  -X
487 3 -0.0001 -427 +426      u=4 $ Absorber Cover Opening-X
488 8 -7.940 -428 +427      u=4 $ Absorber Cover  -X
489 3 -0.0001 +411 +412 +416 +424 +428      u=4 $ Exterior Space
c Cell Cards - Disk Stack
601 8 -7.94 -606 *trcl=( 0.0000 0.0000 2.5400 )     u=3 $ Bottom weldment disk
602 8 -7.94 -603 *trcl=( 0.0000 0.0000 9.8044 )     u=3 $ Support disk 1 (Thick Disk)
603 8 -7.94 -601 *trcl=( 0.0000 0.0000 15.1257 )     u=3 $ Support disk 2
604 like 603 but   *trcl=( 0.0000 0.0000 24.9555 )    u=3 $ Support disk 3
605 like 603 but   *trcl=( 0.0000 0.0000 34.7853 )    u=3 $ Support disk 4
606 like 603 but   *trcl=( 0.0000 0.0000 44.6151 )    u=3 $ Support disk 5
607 like 603 but   *trcl=( 0.0000 0.0000 54.4449 )    u=3 $ Support disk 6
608 9 -2.70 -604 *trcl=( 0.0000 0.0000 59.5160 )     u=3 $ Heat transfer disk 1
609 like 603 but   *trcl=( 0.0000 0.0000 64.1985 )    u=3 $ Support disk 7
610 like 608 but   *trcl=( 0.0000 0.0000 69.2696 )    u=3 $ Heat transfer disk 2
611 like 603 but   *trcl=( 0.0000 0.0000 73.9521 )    u=3 $ Support disk 8
612 like 608 but   *trcl=( 0.0000 0.0000 79.0232 )    u=3 $ Heat transfer disk 3
613 like 603 but   *trcl=( 0.0000 0.0000 83.7057 )    u=3 $ Support disk 9
614 like 608 but   *trcl=( 0.0000 0.0000 88.7768 )    u=3 $ Heat transfer disk 4
615 like 603 but   *trcl=( 0.0000 0.0000 93.4593 )    u=3 $ Support disk 10
616 like 608 but   *trcl=( 0.0000 0.0000 98.5304 )    u=3 $ Heat transfer disk 5
617 like 603 but   *trcl=( 0.0000 0.0000 103.2129 )    u=3 $ Support disk 11
618 like 608 but   *trcl=( 0.0000 0.0000 108.2840 )    u=3 $ Heat transfer disk 6
619 like 603 but   *trcl=( 0.0000 0.0000 112.9665 )    u=3 $ Support disk 12
620 like 608 but   *trcl=( 0.0000 0.0000 118.0376 )    u=3 $ Heat transfer disk 7
621 like 603 but   *trcl=( 0.0000 0.0000 122.7201 )    u=3 $ Support disk 13
622 like 608 but   *trcl=( 0.0000 0.0000 127.7912 )    u=3 $ Heat transfer disk 8
623 like 603 but   *trcl=( 0.0000 0.0000 132.4737 )    u=3 $ Support disk 14
624 like 608 but   *trcl=( 0.0000 0.0000 137.5448 )    u=3 $ Heat transfer disk 9
625 like 603 but   *trcl=( 0.0000 0.0000 142.2273 )    u=3 $ Support disk 15
626 like 608 but   *trcl=( 0.0000 0.0000 147.2984 )    u=3 $ Heat transfer disk 10
627 like 603 but   *trcl=( 0.0000 0.0000 151.9809 )    u=3 $ Support disk 16
628 like 608 but   *trcl=( 0.0000 0.0000 157.0520 )    u=3 $ Heat transfer disk 11
629 like 603 but   *trcl=( 0.0000 0.0000 161.7345 )    u=3 $ Support disk 17
630 like 608 but   *trcl=( 0.0000 0.0000 166.8056 )    u=3 $ Heat transfer disk 12
631 like 603 but   *trcl=( 0.0000 0.0000 171.4881 )    u=3 $ Support disk 18
632 like 608 but   *trcl=( 0.0000 0.0000 176.5592 )    u=3 $ Heat transfer disk 13
633 like 603 but   *trcl=( 0.0000 0.0000 181.2417 )    u=3 $ Support disk 19
634 like 608 but   *trcl=( 0.0000 0.0000 186.3128 )    u=3 $ Heat transfer disk 14
635 like 603 but   *trcl=( 0.0000 0.0000 190.9953 )    u=3 $ Support disk 20
636 like 603 but   *trcl=( 0.0000 0.0000 200.8251 )    u=3 $ Support disk 21
637 like 603 but   *trcl=( 0.0000 0.0000 210.6549 )    u=3 $ Support disk 22
638 like 603 but   *trcl=( 0.0000 0.0000 220.4847 )    u=3 $ Support disk 23
639 like 603 but   *trcl=( 0.0000 0.0000 230.3145 )    u=3 $ Support disk 24
640 like 603 but   *trcl=( 0.0000 0.0000 240.1443 )    u=3 $ Support disk 25
641 8 -7.94 -602 *trcl=( 0.0000 0.0000 248.3231 )     u=3 $ Support disk 26 (Thick Disk)
642 8 -7.94 -605 *trcl=( 0.0000 0.0000 255.8288 )     u=3 $ Top weldment disk
643 3 -0.0001       $ Outside Disks
      #601 #602 #603 #604 #605 #606 #607 #608 #609 #610
      #611 #612 #613 #614 #615 #616 #617 #618 #619 #620
      #621 #622 #623 #624 #625 #626 #627 #628 #629 #630
      #631 #632 #633 #634 #635 #636 #637 #638 #639 #640
      #641 #642        u=3
c Cell Cards - Basket
701 3 -0.0001 -702 #702  #703  fill=6 ( -8.6463 77.3430 0.0000 )      $ Tube/Disk 1
            *trcl=( -8.7884 77.4852 0.0000 )    u=2
702 3 -0.0001 -302 #703   fill=20 *trcl=( -8.3315 77.0282 0.0000 )    u=2 $DFC
703 3 -0.0001 -290   fill=21 *trcl=( -8.3303 77.0270 1.2700 )    u=2 $ Assembly 1
704 3 -0.0001 -702 #705  #706  fill=6 ( 8.6463 77.3430 0.0000 )      $ Tube/Disk 2
            *trcl=( 8.7884 77.4852 0.0000 )    u=2
705 3 -0.0001 -302 #706   fill=20 *trcl=( 8.3315 77.0282 0.0000 )    u=2 $DFC
706 3 -0.0001 -290   fill=21 *trcl=( 8.3303 77.0270 1.2700 )    u=2 $ Assembly 2
707 3 -0.0001 -702 #708  #709  fill=6 ( -43.9472 61.0896 0.0000 )      $ Tube/Disk 3
            *trcl=( -44.0893 61.2318 0.0000 )    u=2
708 3 -0.0001 -302 #709   fill=20 *trcl=( -43.6324 60.7748 0.0000 )    u=2 $DFC
709 3 -0.0001 -270   fill=24 *trcl=( -43.6312 60.7736 1.2700 )    u=2 $ Assembly 3
710 3 -0.0001 -702 #711  #712  fill=8 ( -26.2968 59.6927 0.0000 )      $ Tube/Disk 4
            *trcl=( -26.4389 59.8348 0.0000 )    u=2
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711 3 -0.0001 -302 #712   fill=20 *trcl=( -25.9820 59.3779 0.0000 )    u=2 $DFC
712 3 -0.0001 -270   fill=24 *trcl=( -25.9808 59.3767 1.2700 )    u=2 $ Assembly 4
713 3 -0.0001 -702 #714  #715  fill=8 ( -8.6463 59.6927 0.0000 )     $ Tube/Disk 5
            *trcl=( -8.7884 59.8348 0.0000 )    u=2
714 3 -0.0001 -302 #715   fill=20 *trcl=( -8.3315 59.3779 0.0000 )    u=2 $DFC
715 3 -0.0001 -290   fill=21 *trcl=( -8.3303 59.3767 1.2700 )    u=2 $ Assembly 5
716 3 -0.0001 -702 #717  #718  fill=8 ( 8.6463 59.6927 0.0000 )     $ Tube/Disk 6
            *trcl=( 8.7884 59.8348 0.0000 )    u=2
717 3 -0.0001 -302 #718   fill=20 *trcl=( 8.3315 59.3779 0.0000 )    u=2 $DFC
718 3 -0.0001 -290   fill=21 *trcl=( 8.3303 59.3767 1.2700 )    u=2 $ Assembly 6
719 3 -0.0001 -702 #720  #721  fill=8 ( 26.2968 59.6927 0.0000 )     $ Tube/Disk 7
            *trcl=( 26.4389 59.8348 0.0000 )    u=2
720 3 -0.0001 -302 #721   fill=20 *trcl=( 25.9820 59.3779 0.0000 )    u=2 $DFC
721 3 -0.0001 -270   fill=24 *trcl=( 25.9808 59.3767 1.2700 )    u=2 $ Assembly 7
722 3 -0.0001 -702 #723  #724  fill=6 ( 43.9472 61.0896 0.0000 )     $ Tube/Disk 8
            *trcl=( 44.0893 61.2318 0.0000 )    u=2
723 3 -0.0001 -302 #724   fill=20 *trcl=( 43.6324 60.7748 0.0000 )    u=2 $DFC
724 3 -0.0001 -270   fill=24 *trcl=( 43.6312 60.7736 1.2700 )    u=2 $ Assembly 8
725 3 -0.0001 -702 #726  #727  fill=5 ( -61.0896 43.9472 0.0000 )     $ Tube/Disk 9
            *trcl=( -61.2318 44.0893 0.0000 )    u=2
726 3 -0.0001 -302 #727   fill=20 *trcl=( -60.7748 43.6324 0.0000 )    u=2 $DFC
727 3 -0.0001 -270   fill=24 *trcl=( -60.7736 43.6312 1.2700 )    u=2 $ Assembly 9
728 3 -0.0001 -701  #729  fill=15 ( -42.4663 42.4663 0.0000 )     $ Tube/Disk 10
            *trcl=( -42.5018 42.5018 0.0000 )    u=2
729 3 -0.0001 -51    fill=27 *trcl=( -42.1871 42.1871 1.2700 )    u=2 $ Assembly 10
730 3 -0.0001 -701  #731  fill=15 ( -25.4509 42.4663 0.0000 )     $ Tube/Disk 11
            *trcl=( -25.4864 42.5018 0.0000 )    u=2
731 3 -0.0001 -51    fill=27 *trcl=( -25.1717 42.1871 1.2700 )    u=2 $ Assembly 11
732 3 -0.0001 -701  #733  fill=15 ( -8.4354 42.4663 0.0000 )     $ Tube/Disk 12
            *trcl=( -8.4709 42.5018 0.0000 )    u=2
733 3 -0.0001 -51    fill=27 *trcl=( -8.1562 42.1871 1.2700 )    u=2 $ Assembly 12
734 3 -0.0001 -701  #735  fill=11 ( 8.1739 42.4663 0.0000 )     $ Tube/Disk 13
            *trcl=( 8.4709 42.5018 0.0000 )    u=2
735 3 -0.0001 -51    fill=27 *trcl=( 7.8947 42.1871 1.2700 )    u=2 $ Assembly 13
736 3 -0.0001 -701  #737  fill=16 ( 25.4509 42.4663 0.0000 )     $ Tube/Disk 14
            *trcl=( 25.4864 42.5018 0.0000 )    u=2
737 3 -0.0001 -51    fill=27 *trcl=( 25.1717 42.1871 1.2700 )    u=2 $ Assembly 14
738 3 -0.0001 -701  #739  fill=16 ( 42.4663 42.4663 0.0000 )     $ Tube/Disk 15
            *trcl=( 42.5018 42.5018 0.0000 )    u=2
739 3 -0.0001 -51    fill=27 *trcl=( 42.1871 42.1871 1.2700 )    u=2 $ Assembly 15
740 3 -0.0001 -702 #741  #742  fill=4 ( 61.0896 43.9472 0.0000 )     $ Tube/Disk 16
            *trcl=( 61.2318 44.0893 0.0000 )    u=2
741 3 -0.0001 -302 #742   fill=20 *trcl=( 60.7748 43.6324 0.0000 )    u=2 $DFC
742 3 -0.0001 -270   fill=24 *trcl=( 60.7736 43.6312 1.2700 )    u=2 $ Assembly 16
743 3 -0.0001 -702 #744  #745  fill=8 ( -59.6927 26.2968 0.0000 )     $ Tube/Disk 17
            *trcl=( -59.8348 26.4389 0.0000 )    u=2
744 3 -0.0001 -302 #745   fill=20 *trcl=( -59.3779 25.9820 0.0000 )    u=2 $DFC
745 3 -0.0001 -270   fill=24 *trcl=( -59.3767 25.9808 1.2700 )    u=2 $ Assembly 17
746 3 -0.0001 -701  #747  fill=15 ( -42.4663 25.4509 0.0000 )     $ Tube/Disk 18
            *trcl=( -42.5018 25.4864 0.0000 )    u=2
747 3 -0.0001 -51    fill=27 *trcl=( -42.1871 25.1717 1.2700 )    u=2 $ Assembly 18
748 3 -0.0001 -701  #749  fill=15 ( -25.4509 25.4509 0.0000 )     $ Tube/Disk 19
            *trcl=( -25.4864 25.4864 0.0000 )    u=2
749 3 -0.0001 -51    fill=27 *trcl=( -25.1717 25.1717 1.2700 )    u=2 $ Assembly 19
750 3 -0.0001 -701  #751  fill=15 ( -8.4354 25.4509 0.0000 )     $ Tube/Disk 20
            *trcl=( -8.4709 25.4864 0.0000 )    u=2
751 3 -0.0001 -51    fill=27 *trcl=( -8.1562 25.1717 1.2700 )    u=2 $ Assembly 20
752 3 -0.0001 -701  #753  fill=11 ( 8.1739 25.4509 0.0000 )     $ Tube/Disk 21
            *trcl=( 8.4709 25.4864 0.0000 )    u=2
753 3 -0.0001 -51    fill=27 *trcl=( 7.8947 25.1717 1.2700 )    u=2 $ Assembly 21
754 3 -0.0001 -701  #755  fill=16 ( 25.4509 25.4509 0.0000 )     $ Tube/Disk 22
            *trcl=( 25.4864 25.4864 0.0000 )    u=2
755 3 -0.0001 -51    fill=27 *trcl=( 25.1717 25.1717 1.2700 )    u=2 $ Assembly 22
756 3 -0.0001 -701  #757  fill=16 ( 42.4663 25.4509 0.0000 )     $ Tube/Disk 23
            *trcl=( 42.5018 25.4864 0.0000 )    u=2
757 3 -0.0001 -51    fill=27 *trcl=( 42.1871 25.1717 1.2700 )    u=2 $ Assembly 23
758 3 -0.0001 -702 #759  #760  fill=8 ( 59.6927 26.2968 0.0000 )     $ Tube/Disk 24
            *trcl=( 59.8348 26.4389 0.0000 )    u=2
759 3 -0.0001 -302 #760   fill=20 *trcl=( 59.3779 25.9820 0.0000 )    u=2 $DFC
760 3 -0.0001 -270   fill=24 *trcl=( 59.3767 25.9808 1.2700 )    u=2 $ Assembly 24
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761 3 -0.0001 -702 #762  #763  fill=5 ( -77.3430 8.6463 0.0000 )     $ Tube/Disk 25
             *trcl=( -77.4852 8.7884 0.0000 )    u=2
762 3 -0.0001 -302 #763   fill=20 *trcl=( -77.0282 8.3315 0.0000 )    u=2 $DFC
763 3 -0.0001 -290   fill=21 *trcl=( -77.0270 8.3303 1.2700 )    u=2 $ Assembly 25
764 3 -0.0001 -702 #765  #766  fill=8 ( -59.6927 8.6463 0.0000 )     $ Tube/Disk 26
             *trcl=( -59.8348 8.7884 0.0000 )    u=2
765 3 -0.0001 -302 #766   fill=20 *trcl=( -59.3779 8.3315 0.0000 )    u=2 $DFC
766 3 -0.0001 -290   fill=21 *trcl=( -59.3767 8.3303 1.2700 )    u=2 $ Assembly 26
767 3 -0.0001 -701  #768  fill=15 ( -42.4663 8.4354 0.0000 )     $ Tube/Disk 27
             *trcl=( -42.5018 8.4709 0.0000 )    u=2
768 3 -0.0001 -51   fill=27 *trcl=( -42.1871 8.1562 1.2700 )    u=2 $ Assembly 27
769 3 -0.0001 -701  #770  fill=15 ( -25.4509 8.4354 0.0000 )     $ Tube/Disk 28
             *trcl=( -25.4864 8.4709 0.0000 )    u=2
770 3 -0.0001 -51   fill=27 *trcl=( -25.1717 8.1562 1.2700 )    u=2 $ Assembly 28
771 3 -0.0001 -701  #772  fill=15 ( -8.4354 8.4354 0.0000 )     $ Tube/Disk 29
             *trcl=( -8.4709 8.4709 0.0000 )    u=2
772 3 -0.0001 -51   fill=27 *trcl=( -8.1562 8.1562 1.2700 )    u=2 $ Assembly 29
773 3 -0.0001 -701  #774  fill=10 ( 8.1739 8.1739 0.0000 )     $ Tube/Disk 30
             *trcl=( 8.4709 8.4709 0.0000 )    u=2
774 3 -0.0001 -51   fill=27 *trcl=( 7.8947 7.8947 1.2700 )    u=2 $ Assembly 30
775 3 -0.0001 -701  #776  fill=13 ( 25.4509 8.1739 0.0000 )     $ Tube/Disk 31
             *trcl=( 25.4864 8.4709 0.0000 )    u=2
776 3 -0.0001 -51   fill=27 *trcl=( 25.1717 7.8947 1.2700 )    u=2 $ Assembly 31
777 3 -0.0001 -701  #778  fill=13 ( 42.4663 8.1739 0.0000 )     $ Tube/Disk 32
             *trcl=( 42.5018 8.4709 0.0000 )    u=2
778 3 -0.0001 -51   fill=27 *trcl=( 42.1871 7.8947 1.2700 )    u=2 $ Assembly 32
779 3 -0.0001 -702 #780  #781  fill=8 ( 59.6927 8.6463 0.0000 )     $ Tube/Disk 33
             *trcl=( 59.8348 8.7884 0.0000 )    u=2
780 3 -0.0001 -302 #781   fill=20 *trcl=( 59.3779 8.3315 0.0000 )    u=2 $DFC
781 3 -0.0001 -290   fill=21 *trcl=( 59.3767 8.3303 1.2700 )    u=2 $ Assembly 33
782 3 -0.0001 -702 #783  #784  fill=4 ( 77.3430 8.6463 0.0000 )     $ Tube/Disk 34
             *trcl=( 77.4852 8.7884 0.0000 )    u=2
783 3 -0.0001 -302 #784   fill=20 *trcl=( 77.0282 8.3315 0.0000 )    u=2 $DFC
784 3 -0.0001 -290   fill=21 *trcl=( 77.0270 8.3303 1.2700 )    u=2 $ Assembly 34
785 3 -0.0001 -702 #786  #787  fill=5 ( -77.3430 -8.6463 0.0000 )     $ Tube/Disk 35
             *trcl=( -77.4852 -8.7884 0.0000 )    u=2
786 3 -0.0001 -302 #787   fill=20 *trcl=( -77.0282 -8.3315 0.0000 )    u=2 $DFC
787 3 -0.0001 -290   fill=21 *trcl=( -77.0270 -8.3303 1.2700 )    u=2 $ Assembly 35
788 3 -0.0001 -702 #789  #790  fill=8 ( -59.6927 -8.6463 0.0000 )     $ Tube/Disk 36
             *trcl=( -59.8348 -8.7884 0.0000 )    u=2
789 3 -0.0001 -302 #790   fill=20 *trcl=( -59.3779 -8.3315 0.0000 )    u=2 $DFC
790 3 -0.0001 -290   fill=21 *trcl=( -59.3767 -8.3303 1.2700 )    u=2 $ Assembly 36
791 3 -0.0001 -701  #792  fill=14 ( -42.4663 -8.1739 0.0000 )     $ Tube/Disk 37
             *trcl=( -42.5018 -8.4709 0.0000 )    u=2
792 3 -0.0001 -51   fill=27 *trcl=( -42.1871 -7.8947 1.2700 )    u=2 $ Assembly 37
793 3 -0.0001 -701  #794  fill=14 ( -25.4509 -8.1739 0.0000 )     $ Tube/Disk 38
             *trcl=( -25.4864 -8.4709 0.0000 )    u=2
794 3 -0.0001 -51   fill=27 *trcl=( -25.1717 -7.8947 1.2700 )    u=2 $ Assembly 38
795 3 -0.0001 -701  #796  fill=10 ( -8.1739 -8.1739 0.0000 )     $ Tube/Disk 39
             *trcl=( -8.4709 -8.4709 0.0000 )    u=2
796 3 -0.0001 -51   fill=27 *trcl=( -7.8947 -7.8947 1.2700 )    u=2 $ Assembly 39
797 3 -0.0001 -701  #798  fill=17 ( 8.4354 -8.4354 0.0000 )     $ Tube/Disk 40
             *trcl=( 8.4709 -8.4709 0.0000 )    u=2
798 3 -0.0001 -51   fill=27 *trcl=( 8.1562 -8.1562 1.2700 )    u=2 $ Assembly 40
799 3 -0.0001 -701  #800  fill=17 ( 25.4509 -8.4354 0.0000 )     $ Tube/Disk 41
             *trcl=( 25.4864 -8.4709 0.0000 )    u=2
800 3 -0.0001 -51   fill=27 *trcl=( 25.1717 -8.1562 1.2700 )    u=2 $ Assembly 41
801 3 -0.0001 -701  #802  fill=17 ( 42.4663 -8.4354 0.0000 )     $ Tube/Disk 42
             *trcl=( 42.5018 -8.4709 0.0000 )    u=2
802 3 -0.0001 -51   fill=27 *trcl=( 42.1871 -8.1562 1.2700 )    u=2 $ Assembly 42
803 3 -0.0001 -702 #804  #805  fill=8 ( 59.6927 -8.6463 0.0000 )     $ Tube/Disk 43
             *trcl=( 59.8348 -8.7884 0.0000 )    u=2
804 3 -0.0001 -302 #805   fill=20 *trcl=( 59.3779 -8.3315 0.0000 )    u=2 $DFC
805 3 -0.0001 -290   fill=21 *trcl=( 59.3767 -8.3303 1.2700 )    u=2 $ Assembly 43
806 3 -0.0001 -702 #807  #808  fill=4 ( 77.3430 -8.6463 0.0000 )     $ Tube/Disk 44
             *trcl=( 77.4852 -8.7884 0.0000 )    u=2
807 3 -0.0001 -302 #808   fill=20 *trcl=( 77.0282 -8.3315 0.0000 )    u=2 $DFC
808 3 -0.0001 -290   fill=21 *trcl=( 77.0270 -8.3303 1.2700 )    u=2 $ Assembly 44
809 3 -0.0001 -702 #810  #811  fill=8 ( -59.6927 -26.2968 0.0000 )     $ Tube/Disk 45
             *trcl=( -59.8348 -26.4389 0.0000 )    u=2
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810 3 -0.0001 -302 #811   fill=20 *trcl=( -59.3779 -25.9820 0.0000 )    u=2 $DFC
811 3 -0.0001 -270   fill=24 *trcl=( -59.3767 -25.9808 1.2700 )    u=2 $ Assembly 45
812 3 -0.0001 -701  #813  fill=18 ( -42.4663 -25.4509 0.0000 )     $ Tube/Disk 46
          *trcl=( -42.5018 -25.4864 0.0000 )    u=2
813 3 -0.0001 -51   fill=27 *trcl=( -42.1871 -25.1717 1.2700 )    u=2 $ Assembly 46
814 3 -0.0001 -701  #815  fill=18 ( -25.4509 -25.4509 0.0000 )     $ Tube/Disk 47
          *trcl=( -25.4864 -25.4864 0.0000 )    u=2
815 3 -0.0001 -51   fill=27 *trcl=( -25.1717 -25.1717 1.2700 )    u=2 $ Assembly 47
816 3 -0.0001 -701  #817  fill=12 ( -8.1739 -25.4509 0.0000 )     $ Tube/Disk 48
          *trcl=( -8.4709 -25.4864 0.0000 )    u=2
817 3 -0.0001 -51   fill=27 *trcl=( -7.8947 -25.1717 1.2700 )    u=2 $ Assembly 48
818 3 -0.0001 -701  #819  fill=17 ( 8.4354 -25.4509 0.0000 )     $ Tube/Disk 49
          *trcl=( 8.4709 -25.4864 0.0000 )    u=2
819 3 -0.0001 -51   fill=27 *trcl=( 8.1562 -25.1717 1.2700 )    u=2 $ Assembly 49
820 3 -0.0001 -701  #821  fill=17 ( 25.4509 -25.4509 0.0000 )     $ Tube/Disk 50
          *trcl=( 25.4864 -25.4864 0.0000 )    u=2
821 3 -0.0001 -51   fill=27 *trcl=( 25.1717 -25.1717 1.2700 )    u=2 $ Assembly 50
822 3 -0.0001 -701  #823  fill=17 ( 42.4663 -25.4509 0.0000 )     $ Tube/Disk 51
          *trcl=( 42.5018 -25.4864 0.0000 )    u=2
823 3 -0.0001 -51   fill=27 *trcl=( 42.1871 -25.1717 1.2700 )    u=2 $ Assembly 51
824 3 -0.0001 -702 #825  #826  fill=8 ( 59.6927 -26.2968 0.0000 )     $ Tube/Disk 52
          *trcl=( 59.8348 -26.4389 0.0000 )    u=2
825 3 -0.0001 -302 #826   fill=20 *trcl=( 59.3779 -25.9820 0.0000 )    u=2 $DFC
826 3 -0.0001 -270   fill=24 *trcl=( 59.3767 -25.9808 1.2700 )    u=2 $ Assembly 52
827 3 -0.0001 -702 #828  #829  fill=5 ( -61.0896 -43.9472 0.0000 )     $ Tube/Disk 53
          *trcl=( -61.2318 -44.0893 0.0000 )    u=2
828 3 -0.0001 -302 #829   fill=20 *trcl=( -60.7748 -43.6324 0.0000 )    u=2 $DFC
829 3 -0.0001 -270   fill=24 *trcl=( -60.7736 -43.6312 1.2700 )    u=2 $ Assembly 53
830 3 -0.0001 -701  #831  fill=18 ( -42.4663 -42.4663 0.0000 )     $ Tube/Disk 54
          *trcl=( -42.5018 -42.5018 0.0000 )    u=2
831 3 -0.0001 -51   fill=27 *trcl=( -42.1871 -42.1871 1.2700 )    u=2 $ Assembly 54
832 3 -0.0001 -701  #833  fill=18 ( -25.4509 -42.4663 0.0000 )     $ Tube/Disk 55
          *trcl=( -25.4864 -42.5018 0.0000 )    u=2
833 3 -0.0001 -51   fill=27 *trcl=( -25.1717 -42.1871 1.2700 )    u=2 $ Assembly 55
834 3 -0.0001 -701  #835  fill=12 ( -8.1739 -42.4663 0.0000 )     $ Tube/Disk 56
          *trcl=( -8.4709 -42.5018 0.0000 )    u=2
835 3 -0.0001 -51   fill=27 *trcl=( -7.8947 -42.1871 1.2700 )    u=2 $ Assembly 56
836 3 -0.0001 -701  #837  fill=17 ( 8.4354 -42.4663 0.0000 )     $ Tube/Disk 57
          *trcl=( 8.4709 -42.5018 0.0000 )    u=2
837 3 -0.0001 -51   fill=27 *trcl=( 8.1562 -42.1871 1.2700 )    u=2 $ Assembly 57
838 3 -0.0001 -701  #839  fill=17 ( 25.4509 -42.4663 0.0000 )     $ Tube/Disk 58
          *trcl=( 25.4864 -42.5018 0.0000 )    u=2
839 3 -0.0001 -51   fill=27 *trcl=( 25.1717 -42.1871 1.2700 )    u=2 $ Assembly 58
840 3 -0.0001 -701  #841  fill=17 ( 42.4663 -42.4663 0.0000 )     $ Tube/Disk 59
          *trcl=( 42.5018 -42.5018 0.0000 )    u=2
841 3 -0.0001 -51   fill=27 *trcl=( 42.1871 -42.1871 1.2700 )    u=2 $ Assembly 59
842 3 -0.0001 -702 #843  #844  fill=4 ( 61.0896 -43.9472 0.0000 )     $ Tube/Disk 60
          *trcl=( 61.2318 -44.0893 0.0000 )    u=2
843 3 -0.0001 -302 #844   fill=20 *trcl=( 60.7748 -43.6324 0.0000 )    u=2 $DFC
844 3 -0.0001 -270   fill=24 *trcl=( 60.7736 -43.6312 1.2700 )    u=2 $ Assembly 60
845 3 -0.0001 -702 #846  #847  fill=7 ( -43.9472 -61.0896 0.0000 )     $ Tube/Disk 61
          *trcl=( -44.0893 -61.2318 0.0000 )    u=2
846 3 -0.0001 -302 #847   fill=20 *trcl=( -43.6324 -60.7748 0.0000 )    u=2 $DFC
847 3 -0.0001 -270   fill=24 *trcl=( -43.6312 -60.7736 1.2700 )    u=2 $ Assembly 61
848 3 -0.0001 -702 #849  #850  fill=8 ( -26.2968 -59.6927 0.0000 )     $ Tube/Disk 62
          *trcl=( -26.4389 -59.8348 0.0000 )    u=2
849 3 -0.0001 -302 #850   fill=20 *trcl=( -25.9820 -59.3779 0.0000 )    u=2 $DFC
850 3 -0.0001 -270   fill=24 *trcl=( -25.9808 -59.3767 1.2700 )    u=2 $ Assembly 62
851 3 -0.0001 -702 #852  #853  fill=8 ( -8.6463 -59.6927 0.0000 )     $ Tube/Disk 63
          *trcl=( -8.7884 -59.8348 0.0000 )    u=2
852 3 -0.0001 -302 #853   fill=20 *trcl=( -8.3315 -59.3779 0.0000 )    u=2 $DFC
853 3 -0.0001 -290   fill=21 *trcl=( -8.3303 -59.3767 1.2700 )    u=2 $ Assembly 63
854 3 -0.0001 -702 #855  #856  fill=8 ( 8.6463 -59.6927 0.0000 )     $ Tube/Disk 64
          *trcl=( 8.7884 -59.8348 0.0000 )    u=2
855 3 -0.0001 -302 #856   fill=20 *trcl=( 8.3315 -59.3779 0.0000 )    u=2 $DFC
856 3 -0.0001 -290   fill=21 *trcl=( 8.3303 -59.3767 1.2700 )    u=2 $ Assembly 64
857 3 -0.0001 -702 #858  #859  fill=8 ( 26.2968 -59.6927 0.0000 )     $ Tube/Disk 65
          *trcl=( 26.4389 -59.8348 0.0000 )    u=2
858 3 -0.0001 -302 #859   fill=20 *trcl=( 25.9820 -59.3779 0.0000 )    u=2 $DFC
859 3 -0.0001 -270   fill=24 *trcl=( 25.9808 -59.3767 1.2700 )    u=2 $ Assembly 65
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860 3 -0.0001 -702 #861  #862  fill=7 ( 43.9472 -61.0896 0.0000 )     $ Tube/Disk 66
            *trcl=( 44.0893 -61.2318 0.0000 )    u=2
861 3 -0.0001 -302 #862   fill=20 *trcl=( 43.6324 -60.7748 0.0000 )    u=2 $DFC
862 3 -0.0001 -270   fill=24 *trcl=( 43.6312 -60.7736 1.2700 )    u=2 $ Assembly 66
863 3 -0.0001 -702 #864  #865  fill=7 ( -8.6463 -77.3430 0.0000 )     $ Tube/Disk 67
            *trcl=( -8.7884 -77.4852 0.0000 )    u=2
864 3 -0.0001 -302 #865   fill=20 *trcl=( -8.3315 -77.0282 0.0000 )    u=2 $DFC
865 3 -0.0001 -290   fill=21 *trcl=( -8.3303 -77.0270 1.2700 )    u=2 $ Assembly 67
866 3 -0.0001 -702 #867  #868  fill=7 ( 8.6463 -77.3430 0.0000 )     $ Tube/Disk 68
            *trcl=( 8.7884 -77.4852 0.0000 )    u=2
867 3 -0.0001 -302 #868   fill=20 *trcl=( 8.3315 -77.0282 0.0000 )    u=2 $DFC
868 3 -0.0001 -290   fill=21 *trcl=( 8.3303 -77.0270 1.2700 )    u=2 $ Assembly 68
869 3 -0.0001 +703 +704        $ Canister Cavity Q1
      #704 #716 #719 #722 #734 #736 #738 #740 #752
      #706 #718 #721 #724 #735 #737 #739 #742 #753
      #754 #756 #758 #773 #775 #777 #779 #782
      #755 #757 #760 #774 #776 #778 #781 #784
      #705 #717 #720 #723 #741 #759 #780 #783
          fill=3      u=2
870 3 -0.0001 +703 -704        $ Canister Cavity Q2
      #701 #707 #710 #713 #725 #728 #730 #732 #743
      #703 #709 #712 #715 #727 #729 #731 #733 #745
      #746 #748 #750 #761 #764 #767 #769 #771
      #747 #749 #751 #763 #766 #768 #770 #772
      #702 #708 #711 #714 #726 #744 #762 #765
          fill=3      u=2
871 3 -0.0001 -703 -704        $ Canister Cavity Q3
      #785 #788 #791 #793 #795 #809 #812 #814 #816
      #787 #790 #792 #794 #796 #811 #813 #815 #817
      #827 #830 #832 #834 #845 #848 #851 #863
      #829 #831 #833 #835 #847 #850 #853 #865
      #786 #789 #810 #828 #846 #849 #852 #864
          fill=3      u=2
872 3 -0.0001 -703 704        $ Canister Cavity Q4
      #797 #799 #801 #803 #806 #818 #820 #822 #824
      #798 #800 #802 #805 #808 #819 #821 #823 #826
      #836 #838 #840 #842 #854 #857 #860 #866
      #837 #839 #841 #844 #856 #859 #862 #868
      #804 #807 #825 #843 #855 #858 #861 #867
          fill=3      u=2
c Cell Cards - Canister
901 3 -0.0001 -901 #902     fill=2 u=1 $ Cavity
902 9 -2.702 -902       u=1 $ Spacer
903 8 -7.940 -903 +901      u=1 $ Canister Shell / Lid / Bottom
904 14 -0.0001 +903      u=1 $ Remaining Space
c Cell Cards - Transfer Cask Geometry
911 14 -0.0001 -911 -912  fill=1 ( 0.0000 0.0000 2.5400 )   $ Cask cavity
912 10 -7.821 -911 +912 -916      $ Bottom plate
913 10 -7.821 -913 +912 +916 -918     $ Inner shell
914 11 -11.344 -914 +913 +916 -917     $ Lead shell
915 12 -1.632 -914 +913 +917 -918     $ NS-4-FR (above lead)
916 12 -1.632 -915 +914 +916 -918     $ NS-4-FR
917 10 -7.821 -911 +915 +916 -918     $ Outer shell
918 10 -7.821 -911 +912 +918      $ Top plate
919 10 -7.821 -919 +920  -925      $ Door rail
920 10 -7.821 -919 -921  -925      $ Door rail
921 10 -7.821 -924 -922 +923 -925     $ Door steel
922 14 -0.0001 -925 +911 #919 #920 #921      $ Exterior space to Reflector
923 0          +925       $ Exterior space

c Surfaces - Fuel Rod - EX - BWR_10x10_4 WR
10 RCC 0.0000 0.0000 1.4605 0.0000 0.0000 210.8200 0.4356 $ Fuel pellet stack
11 RCC 0.0000 0.0000 1.4605 0.0000 0.0000 221.1553 0.4445 $ Annulus + Plenum
12 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 223.5962 0.5004 $ Clad + End-Caps
c Surfaces - Inert Rods - EX - BWR_10x10_4 WR
30 RCC 0.0000 0.0000 1.4605 0.0000 0.0000 210.8200 0.4356 $ Zirc filler stack
31 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 223.5962 0.5004 $ Clad + End-Caps
c Surfaces - Pitch - EX - BWR_10x10_4 WR
40 PX 0.7074       $ Lattice Cell Boundaries
41 PX -0.7074
```

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42 PY 0.7074
43 PY -0.7074
c Surfaces - Fuel Assembly Array Inserted Into Assembly - EX - BWR_10x10_4 WR
50 RPP -6.8669 6.8669 -6.8669 6.8669 25.4000 250.6726  $ Array
51 RPP -7.1298 7.1298 -7.1298 7.1298 0.0000 260.2230  $ Assembly Outer Dims
c Surfaces - DFC Content - Fuel Pellet Stack
261 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 221.3610 0.4445 $ Fuel pellet stack
c Surfaces - DFC Content - Array
265 PX 0.7619       $ Lattice Cell Boundaries
266 PX -0.7619
267 PY 0.7619
268 PY -0.7619
c Surfaces - DFC Content - Envelope of Array
270 RPP -7.3011 7.3011 -7.3011 7.3011 0.0000 221.361  $ Array
c Surfaces - Axis DFC Content - Fuel Pellet Stack
281 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 221.3610 0.4445 $ Fuel pellet stack
c Surfaces - Axis DFC Content - Array
285 PX 0.7619       $ Lattice Cell Boundaries
286 PX -0.7619
287 PY 0.7619
288 PY -0.7619
c Surfaces - Axis DFC Content - Envelope of Array
290 RPP -7.3011 7.3011 -7.3011 7.3011 0.0000 221.361  $ Array
c Surface Cards - DFC
301 RPP -7.3025 7.3025 -7.3025 7.3025 0.0000 265.7475 $  Space inside DFC Shell
302 RPP -7.4244 7.4244 -7.4244 7.4244 0.0000 271.1450 $  DFC body
303 PZ 1.2700      $ Bottom plate top
304 PZ 267.3350      $ Top of lid
305 PZ 265.748      $ Bottom of lid
c Surface Cards - Standard Tube, Absorber and Retainer
311 RPP -7.4092 7.4092 -7.4092 7.4092 0.0000 274.4470 $  Space inside tube - cavity extent
312 RPP -7.4549 7.4549 -7.4549 7.4549 5.0800 254.5588 $  Fuel tube body
313 RPP -6.4897 6.4897 7.4930 7.6200 7.1120 250.6472 $ Absorber +Y
314 RPP -6.4897 6.4897 7.4549 7.6581 7.1120 250.6472 $ Absorber Clad  +Y
315 RPP -6.7374 6.7374 7.4549 7.6581 7.1120 250.6472 $ Absorber Cover Opening +Y
316 RPP -6.7958 6.7958 7.4549 7.7164 7.0536 250.6472 $ Absorber Cover  +Y
317 RPP 7.4930 7.6200 -6.4897 6.4897 7.1120 250.6472 $ Absorber +X
318 RPP 7.4549 7.6581 -6.4897 6.4897 7.1120 250.6472 $ Absorber Clad  +X
319 RPP 7.4549 7.6581 -6.7374 6.7374 7.1120 250.6472 $ Absorber Cover Opening +X
320 RPP 7.4549 7.7164 -6.7958 6.7958 7.0536 250.6472 $ Absorber Cover  +X
321 RPP -6.4897 6.4897 -7.6200 -7.4930 7.1120 250.6472 $ Absorber -Y
322 RPP -6.4897 6.4897 -7.6581 -7.4549 7.1120 250.6472 $ Absorber Clad  -Y
323 RPP -6.7374 6.7374 -7.6581 -7.4549 7.1120 250.6472 $ Absorber Cover Opening -Y
324 RPP -6.7958 6.7958 -7.7164 -7.4549 7.0536 250.6472 $ Absorber Cover  -Y
325 RPP -7.6200 -7.4930 -6.4897 6.4897 7.1120 250.6472 $ Absorber -X
326 RPP -7.6581 -7.4549 -6.4897 6.4897 7.1120 250.6472 $ Absorber Clad  -X
327 RPP -7.6581 -7.4549 -6.7374 6.7374 7.1120 250.6472 $ Absorber Cover Opening -X
328 RPP -7.7164 -7.4549 -6.7958 6.7958 7.0536 250.6472 $ Absorber Cover  -X
c Surface Cards - DFC Tube, Absorber and Retainer
411 RPP -7.7394 7.7394 -7.7394 7.7394 0.0000 274.4470 $  Space inside tube - cavity extent
412 RPP -7.7851 7.7851 -7.7851 7.7851 5.0800 254.5588 $  Fuel tube body
413 RPP -6.4897 6.4897 7.8232 7.9502 7.1120 250.6472 $ Absorber +Y
414 RPP -6.4897 6.4897 7.7851 7.9883 7.1120 250.6472 $ Absorber Clad  +Y
415 RPP -6.7374 6.7374 7.7851 7.9883 7.1120 250.6472 $ Absorber Cover Opening +Y
416 RPP -6.7958 6.7958 7.7851 8.0466 7.0536 250.6472 $ Absorber Cover  +Y
417 RPP 7.8232 7.9502 -6.4897 6.4897 7.1120 250.6472 $ Absorber +X
418 RPP 7.7851 7.9883 -6.4897 6.4897 7.1120 250.6472 $ Absorber Clad  +X
419 RPP 7.7851 7.9883 -6.7374 6.7374 7.1120 250.6472 $ Absorber Cover Opening +X
420 RPP 7.7851 8.0466 -6.7958 6.7958 7.0536 250.6472 $ Absorber Cover  +X
421 RPP -6.4897 6.4897 -7.9502 -7.8232 7.1120 250.6472 $ Absorber -Y
422 RPP -6.4897 6.4897 -7.9883 -7.7851 7.1120 250.6472 $ Absorber Clad  -Y
423 RPP -6.7374 6.7374 -7.9883 -7.7851 7.1120 250.6472 $ Absorber Cover Opening -Y
424 RPP -6.7958 6.7958 -8.0466 -7.7851 7.0536 250.6472 $ Absorber Cover  -Y
425 RPP -7.9502 -7.8232 -6.4897 6.4897 7.1120 250.6472 $ Absorber -X
426 RPP -7.9883 -7.7851 -6.4897 6.4897 7.1120 250.6472 $ Absorber Clad  -X
427 RPP -7.9883 -7.7851 -6.7374 6.7374 7.1120 250.6472 $ Absorber Cover Opening -X
428 RPP -8.0466 -7.7851 -6.7958 6.7958 7.0536 250.6472 $ Absorber Cover  -X
c Surface Cards - Disk Stack
601 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 1.7272 88.1380 $ Structural disk
602 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 3.3147 88.1380 $ Structural top disk
```

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603 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 2.0447 88.1380 $ Structural bottom disk
604 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 1.3386 87.7951 $ Heat transfer disk
605 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 1.5875 88.0491 $ Top weldment disk
606 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 2.5400 88.0491 $ Bottom weldment disk
c Surface Cards - Basket
701 RPP -7.7521 7.7521 -7.7521 7.7521 0.0000 274.4470  $ Std opening
702 RPP -8.1890 8.1890 -8.1890 8.1890 0.0000 274.4470  $ DFC opening
703 PY 0.0000       $ Cut plane
704 PX 0.0000       $ Cut plane
c Surface Cards - Canister
901 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 274.4470  88.4428 $ Canister cavity
902 RPP -48.6410 48.6410 -48.6410 48.6410 264.2870 274.4469   $ Canister spacer
903 RCC 0.0000 0.0000 -2.5400 0.0000 0.0000 294.7670  89.7128 $ Canister
c Surface Cards - Transfer Cask Geometry
911 RCC 0.000 0.000 0.000 0.000 0.000 313.6900 109.8550  $ Cask Cylindrical Section
912 CZ 90.8050        $ Cask cavity radius
913 CZ 92.7100        $ Inner shell OR
914 CZ 101.6000        $ Lead shell OR
915 CZ 106.6800        $ Outer shell IR
916 PZ 2.5400        $ Top of bottom plate
917 PZ 298.4500        $ Top of lead shield
918 PZ 308.6100        $ Bottom of top plate
919 RPP -110.1852 110.1852 -107.3150 107.3150 -24.1300 0.0000   $ Door Enclosing Shape
920 PY 95.8850        $ Inside rail surface
921 PY -95.8850        $ Inside rail surface
922 PY 95.4024        $ Door surface
923 PY -95.4024        $ Door surface
924 RHP 0.0000 0.0000 -24.1300 0.0000 0.0000 24.1300
          89.9681 0.0000 0.0000 54.42077 -66.1670 0.0000
          -54.4208 -66.1670 0.0000       $ Door prism
925 RCC 0.000 0.000 -44.130 0.000 0.000 370.2000 129.8550  $ Cylinder to Reflect

c
c Materials List
c
c Fuel Pellet Material   3.71%  Weight UO2 [amu]  269.94
m1    92235.66c -3.270E-02 92238.66c -8.488E-01  8016.62c -1.185E-01
c SS348 Clad
m2
      24050.62c -7.939E-03 26054.62c -3.927E-02 28058.62c -6.384E-02
      24052.62c -1.590E-01 26056.62c -6.387E-01 28060.62c -2.543E-02
      24053.62c -1.838E-02 26057.62c -1.502E-02 28061.62c -1.124E-03
      24054.62c -4.652E-03 26058.62c -2.019E-03 28062.62c -3.639E-03
                                                28064.62c -9.623E-04
      25055.62c -2.000E-02
c Water
m3     1001.62c -1.119E-01  8016.62c -8.881E-01
mt3  lwtr.01t
c Sec. Fuel - 45 Degree Axis - Exterior   3.94%  Weight UO2 [amu]  269.93
m4    92235.66c -3.473E-02 92238.66c -8.467E-01  8016.62c -1.185E-01
c Third Fuel -Coord. Axis - Exterior   3.64%  Weight UO2 [amu]  269.94
m5    92235.66c -3.209E-02 92238.66c -8.494E-01  8016.62c -1.185E-01
c Lower Nozzle Material
m6
       1001.62c -4.116E-06  8016.62c -3.266E-05
      24050.62c -7.939E-03 26054.62c -3.927E-02 28058.62c -6.384E-02
      24052.62c -1.590E-01 26056.62c -6.387E-01 28060.62c -2.543E-02
      24053.62c -1.838E-02 26057.62c -1.502E-02 28061.62c -1.124E-03
      24054.62c -4.651E-03 26058.62c -2.019E-03 28062.62c -3.638E-03
                                                28064.62c -9.623E-04
      25055.62c -2.000E-02
mt6  lwtr.01t
c Upper Nozzle Material
m7
       1001.62c -1.469E-05  8016.62c -1.165E-04
      24050.62c -7.938E-03 26054.62c -3.927E-02 28058.62c -6.383E-02
      24052.62c -1.590E-01 26056.62c -6.386E-01 28060.62c -2.543E-02
      24053.62c -1.838E-02 26057.62c -1.502E-02 28061.62c -1.124E-03
      24054.62c -4.651E-03 26058.62c -2.019E-03 28062.62c -3.638E-03
                                                28064.62c -9.622E-04
```

```
      25055.62c -2.000E-02
mt7  lwtr.01t
c SS304
m8    24050.62c -7.939E-03 26054.62c -3.927E-02 28058.62c -6.384E-02
      24052.62c -1.590E-01 26056.62c -6.387E-01 28060.62c -2.543E-02
      24053.62c -1.838E-02 26057.62c -1.502E-02 28061.62c -1.124E-03
      24054.62c -4.652E-03 26058.62c -2.019E-03 28062.62c -3.639E-03
                                                28064.62c -9.623E-04
      25055.62c -2.000E-02
c Aluminum
m9    13027.62c -1.000E+00
c Carbon Steel
m10   26054.62c -5.594E-02  6000.66c -1.000E-02
      26056.62c -9.098E-01
      26057.62c -2.140E-02
      26058.62c -2.876E-03
c Lead
m11   82206.66c -2.534E-01
      82207.66c -2.207E-01
      82208.66c -5.259E-01
c NS-F-FR
m12    5010.66c -9.313E-04  7014.62c -1.974E-02  8016.62c -4.250E-01
       5011.66c -3.772E-03  7015.66c -7.852E-05
      13027.62c -2.142E-01  1001.62c -6.001E-02  6000.66c -2.763E-01
c Concrete
m13   26054.62c -7.911E-04 14000.60c -3.370E-01
      26056.62c -1.287E-02
      26057.62c -3.026E-04
      26058.62c -4.067E-05
       1001.62c -1.000E-02 13027.62c -3.400E-02 20000.62c -4.400E-02
       8016.62c -5.320E-01 11023.62c -2.900E-02
c Water Exterior
m14    1001.62c 2.0
       8016.62c 1.0
mt14  lwtr.01t
c Borated Aluminum (Absorber Core / Sheet)
m15    5010.66c -6.011E-02 13027.62c -5.656E-01  6000.66c -9.430E-02
       5011.66c -2.799E-01
c Zirc Alloy
m17   26054.62c -7.063E-05 24050.62c -4.179E-05  7014.62c -4.980E-04
      26056.62c -1.149E-03 24052.62c -8.370E-04  7015.66c -1.981E-06
      26057.62c -2.702E-05 24053.62c -9.673E-05
      26058.62c -3.631E-06 24054.62c -2.448E-05
      40000.66c -9.823E-01 50000.42c -1.500E-02
c SS304/Cu Heat Fin
m18   24050.62c -4.537E-03 26054.62c -2.244E-02 28058.62c -3.648E-02
      24052.62c -9.088E-02 26056.62c -3.650E-01 28060.62c -1.453E-02
      24053.62c -1.050E-02 26057.62c -8.584E-03 28061.62c -6.425E-04
      24054.62c -2.658E-03 26058.62c -1.154E-03 28062.62c -2.079E-03
                                                28064.62c -5.499E-04
      25055.62c -1.143E-02
      29000 -0.4286
c DFC fuel mixture material (if applicable)   Mix Height=264.5in
m19   92235.66c -2.683E-02 92238.66c -6.540E-01  8016.62c -9.156E-02
       1001.62c -2.547E-02  8016.62c -2.021E-01
c DFC fuel mixture material (if applicable)   Mix Height=264.5in
m20   92235.66c -2.478E-02 92238.66c -6.561E-01  8016.62c -9.156E-02
       1001.62c -2.547E-02  8016.62c -2.021E-01
c
c Rotation Matrix
*TR1 0.0 0.0 0.0 45 135 90 -45 45 90 90 90 0  $ z-rotation 45 degrees
*TR2 0.0 0.0 0.0 135 225 90 45 135 90 90 90 0  $ z-rotation 135 degrees
*TR3 0.0 0.0 0.0 15 105 90 -75 15 90 90 90 0  $ z-rotation 15 degrees
*TR4 0.0 0.0 0.0 30 120 90 -60 30 90 90 90 0  $ z-rotation 30 degrees
*TR5 0.0 0.0 0.0 60 150 90 -30 60 90 90 90 0  $ z-rotation 60 degrees
*TR6 0.0 0.0 0.0 75 165 90 -15 75 90 90 90 0  $ z-rotation 75 degrees
*TR7 0.0 0.0 0.0 8 98 90 -82 8 90 90 90 0  $ z-rotation 8 degrees
*TR8 0.0 0.0 0.0 102 192 90 12 102 90 90 90 0  $ z-rotation 102 degrees
*TR9 0.0 0.0 0.0 156 246 90 66 156 90 90 90 0  $ z-rotation 156 degrees
*TR10 0.0 0.0 0.0 78 168 90 -12 78 90 90 90 0  $ z-rotation 78 degrees
```

```
*TR11 0.0 0.0 0.0 24 114 90 -66 24 90 90 90 0  $ z-rotation 24 degrees
c
c Cell Importances
c
mode n
imp:n 1 413r 0
c
c
c Criticality Controls
c
kcode 500 1.00 30 430
c Ones source point in each of the fuel assemblies
ksrc
      -5.5007 79.8566 100.00
      11.1599 79.8566 100.00
      -40.8016 63.6032 100.00
      -23.1512 62.2063 100.00
      -5.5007 62.2063 100.00
      11.1599 62.2063 100.00
      28.8104 62.2063 100.00
      46.4608 63.6032 100.00
      -57.9440 46.4608 100.00
      -39.3575 45.0167 100.00
      -22.3421 45.0167 100.00
      -5.3266 45.0167 100.00
      10.7243 45.0167 100.00
      28.0013 45.0167 100.00
      45.0167 45.0167 100.00
      63.6032 46.4608 100.00
      -56.5471 28.8104 100.00
      -39.3575 28.0013 100.00
      -22.3421 28.0013 100.00
      -5.3266 28.0013 100.00
      10.7243 28.0013 100.00
      28.0013 28.0013 100.00
      45.0167 28.0013 100.00
      62.2063 28.8104 100.00
      -74.1974 11.1599 100.00
      -56.5471 11.1599 100.00
      -39.3575 10.9858 100.00
      -22.3421 10.9858 100.00
      -5.3266 10.9858 100.00
      10.7243 10.7243 100.00
      28.0013 10.7243 100.00
      45.0167 10.7243 100.00
      62.2063 11.1599 100.00
      79.8566 11.1599 100.00
      -74.1974 -5.5007 100.00
      -56.5471 -5.5007 100.00
      -39.3575 -5.0651 100.00
      -22.3421 -5.0651 100.00
      -5.0651 -5.0651 100.00
      10.9858 -5.3266 100.00
      28.0013 -5.3266 100.00
      45.0167 -5.3266 100.00
      62.2063 -5.5007 100.00
      79.8566 -5.5007 100.00
      -56.5471 -23.1512 100.00
      -39.3575 -22.3421 100.00
      -22.3421 -22.3421 100.00
      -5.0651 -22.3421 100.00
      10.9858 -22.3421 100.00
      28.0013 -22.3421 100.00
      45.0167 -22.3421 100.00
      62.2063 -23.1512 100.00
      -57.9440 -40.8016 100.00
      -39.3575 -39.3575 100.00
      -22.3421 -39.3575 100.00
      -5.0651 -39.3575 100.00
      10.9858 -39.3575 100.00
```

```
      28.0013 -39.3575 100.00
      45.0167 -39.3575 100.00
      63.6032 -40.8016 100.00
      -40.8016 -57.9440 100.00
      -23.1512 -56.5471 100.00
      -5.5007 -56.5471 100.00
      11.1599 -56.5471 100.00
      28.8104 -56.5471 100.00
      46.4608 -57.9440 100.00
      -5.5007 -74.1974 100.00
      11.1599 -74.1974 100.00
c
c
c Random Number Generator Controls
c
RAND GEN=2 SEED=19073486328127
c
c
c Print Control
c
PRINT
c
```

6.A.7.2 Concrete Cask

The only difference between the transfer and concrete cask inputs is the cask body geometry. Storage casks are evaluated as single casks and infinite cask arrays. A sample infinite cask array is provided for this case.

Figure 6.A.7.2-1 Storage Cask Sample Input

```
LACBWR Storage Cask Model -  Fuel Assembly Type: EX - BWR_10x10_4 WR
c
c Model Revision 3.4
c
c Infinite Cask Array Model
c
c Partial Flood: No
c
c Damaged Fuel Can Option:  Yes
c DFC Content: Unclad Rod Array
c
c DFC Content Active Fuel Location: Bottom
c
c Primary Fuel Tye Enrichment:  3.71 wt%
c
c Secondary Fuel Type:  AC - BWR_10x10_0 WR
c Seondary Fuel Enrichment:  3.94 wt%
c
c Thrid Fuel Type:  AC - BWR_10x10_0 WR
c Seondary Fuel Enrichment:  3.64 wt%
c
c Density (H2O) (g/cc)
c              Lattice DFC Exterior
c              0.0001  N/A 0.9982
c
c Tube
c     Outer_Width Thickness
c     Max         Min
c
c Absorber
c         Width Thickness
c         Min   Max
c
c Disk
c     Op_Width Location Thickness Spacing
c     Max      Min      Max       Min
c
c Shift Patterns
c  Rad Fuel Rad Tube Axial Fuel Axial Basket
c  In       In       Bottom     Bottom
c Cells - Fuel Rod - EX - BWR_10x10_4 WR
10 1 -10.522 -10     u=30 $ Fuel
11 3 -0.0001 -11 +10    u=30 $ Plenum + Fuel to Clad Gap
12 2 -7.94 -12 +11    u=30 $ Clad + End Plugs
13 3 -0.0001 +12     u=30 $ Outside Fuel Rod
c Cells - Inert Rods - EX - BWR_10x10_4 WR
30 17 -6.56 -30     u=29 $ Inside Inert Rod
31 2 -7.94 -31 +30    u=29 $ Inert Rod Clad and Plugs
32 3 -0.0001 +31     u=29 $ Outside Inert Rod
c Array_10x10_4
40 3 -0.0001 -40 +41 -42 +43
      trcl=(0.7074 0.7074 25.4)   lat=1 u=28 fill=-5:4 -5:4 0:0
      30 30 30 30 30 30 30 30 30 30
      30 30 30 30 30 30 30 30 30 30
      30 30 30 30 30 30 30 30 30 30
      30 30 30 30 30 30 30 30 30 30
      30 30 30 30 29 29 30 30 30 30
      30 30 30 30 29 29 30 30 30 30
      30 30 30 30 30 30 30 30 30 30
      30 30 30 30 30 30 30 30 30 30
      30 30 30 30 30 30 30 30 30 30
      30 30 30 30 30 30 30 30 30 30
c Cells - Fuel Assembly Array Inserted Into Assembly - cellAssy
50 3 -0.0001 -50    fill=28 u=27 $ Array
51 3 -0.0001 -51 +50 -50.6 -50.5  u=27 $ Gap to Fuel Envelope
```

```
52 6 -2.0254 -51  +50.6   u=27 $ Lower Nozzle
53 7 -0.6953 -51   +50.5  u=27 $ Upper Nozzle
54 3 -0.0001 +51     u=27 $ Remaining Space
c Cells - DFC Content
261 4 -10.522 -261     u=26  $ Pellet Stack
262 3 -0.0001 +261     u=26  $ Exterior
c Cells - DFC Content
265 3 -0.0001 -265 +266 -267 +268
      trcl=(0.76185 0.76185 0)   lat=1 u=25 fill=-5:4 -5:4 0:0
      26 26 26 26 26 26 26 26 26 26
      26 26 26 26 26 26 26 26 26 26
      26 26 26 26 26 26 26 26 26 26
      26 26 26 26 26 26 26 26 26 26
      26 26 26 26 26 26 26 26 26 26
      26 26 26 26 26 26 26 26 26 26
      26 26 26 26 26 26 26 26 26 26
      26 26 26 26 26 26 26 26 26 26
      26 26 26 26 26 26 26 26 26 26
      26 26 26 26 26 26 26 26 26 26
c Cells - Fuel Assembly Array Inserted Into Assembly - cellDFCAssy
270 3 -0.0001 -270  fill=25   ( 0.0000 0.0000 0.0000 ) u=24 $ Array
271 3 -0.0001 +270       u=24 $ Remaining Space
c Cells - DFC Content
281 5 -10.522 -281     u=23  $ Pellet Stack
282 3 -0.0001 +281     u=23  $ Exterior
c Cells - DFC Content
285 3 -0.0001 -285 +286 -287 +288
      trcl=(0.76185 0.76185 0)   lat=1 u=22 fill=-5:4 -5:4 0:0
      23 23 23 23 23 23 23 23 23 23
      23 23 23 23 23 23 23 23 23 23
      23 23 23 23 23 23 23 23 23 23
      23 23 23 23 23 23 23 23 23 23
      23 23 23 23 23 23 23 23 23 23
      23 23 23 23 23 23 23 23 23 23
      23 23 23 23 23 23 23 23 23 23
      23 23 23 23 23 23 23 23 23 23
      23 23 23 23 23 23 23 23 23 23
      23 23 23 23 23 23 23 23 23 23
c Cells - Fuel Assembly Array Inserted Into Assembly - cellDFCAssyAxis
290 3 -0.0001 -290  fill=22   ( 0.0000 0.0000 0.0000 ) u=21 $ Array
291 3 -0.0001 +290       u=21 $ Remaining Space
c Cell Cards -DFC
301 3 -0.0001 -301 -305 +303    u=20 $ DFC Cavity
302 8 -7.940 -302  -303    u=20 $ DFC Bottom Plate
303 8 -7.940 -302 +301 +303    u=20 $ DFC Body
304 8 -7.940 -301 +305 -304    u=20 $ DFC Lid Plates
305 3 -0.0001 -301 +304     u=20 $ Area above lid
306 3 -0.0001 +302       u=20 $ Exterior Space
c Cell Cards - Standard Tube, Absorber and Retainer (PX,PY)
330 3 -0.0001 -311       u=18 $ Space in Tube
331 8 -7.940 -312 +311      u=18 $ FuelTube
332 15 -1.965 -313       u=18 $ Absorber +Y
333 9 -2.702 -314 +313      u=18 $ Absorber Clad  +Y
334 3 -0.0001 -315 +314      u=18 $ Absorber Cover Opening+Y
335 8 -7.940 -316 +315      u=18 $ Absorber Cover  +Y
336 15 -1.965 -317       u=18 $ Absorber +X
337 9 -2.702 -318 +317      u=18 $ Absorber Clad  +X
338 3 -0.0001 -319 +318      u=18 $ Absorber Cover Opening+X
339 8 -7.940 -320 +319      u=18 $ Absorber Cover  +X
340 3 -0.0001 +311 +312 +316 +320       u=18 $ Exterior Space
c Cell Cards - Standard Tube, Absorber and Retainer (MX,PY)
341 3 -0.0001 -311       u=17 $ Space in Tube
342 8 -7.940 -312 +311      u=17 $ FuelTube
343 15 -1.965 -313       u=17 $ Absorber +Y
344 9 -2.702 -314 +313      u=17 $ Absorber Clad  +Y
345 3 -0.0001 -315 +314      u=17 $ Absorber Cover Opening+Y
346 8 -7.940 -316 +315      u=17 $ Absorber Cover  +Y
347 15 -1.965 -325       u=17 $ Absorber -X
348 9 -2.702 -326 +325      u=17 $ Absorber Clad  -X
349 3 -0.0001 -327 +326      u=17 $ Absorber Cover Opening-X
```

```
350 8 -7.940 -328 +327     u=17 $ Absorber Cover  -X
351 3 -0.0001 +311 +312 +316 +328      u=17 $ Exterior Space
c Cell Cards - Standard Tube, Absorber and Retainer (MX,MY)
352 3 -0.0001 -311      u=16 $ Space in Tube
353 8 -7.940 -312 +311     u=16 $ FuelTube
354 15 -1.965 -321      u=16 $ Absorber -Y
355 9 -2.702 -322 +321     u=16 $ Absorber Clad  -Y
356 3 -0.0001 -323 +322     u=16 $ Absorber Cover Opening-Y
357 8 -7.940 -324 +323     u=16 $ Absorber Cover  -Y
358 15 -1.965 -325      u=16 $ Absorber -X
359 9 -2.702 -326 +325     u=16 $ Absorber Clad  -X
360 3 -0.0001 -327 +326     u=16 $ Absorber Cover Opening-X
361 8 -7.940 -328 +327     u=16 $ Absorber Cover  -X
362 3 -0.0001 +311 +312 +324 +328      u=16 $ Exterior Space
c Cell Cards - Standard Tube, Absorber and Retainer (PX,MY)
363 3 -0.0001 -311      u=15 $ Space in Tube
364 8 -7.940 -312 +311     u=15 $ FuelTube
365 15 -1.965 -321      u=15 $ Absorber -Y
366 9 -2.702 -322 +321     u=15 $ Absorber Clad  -Y
367 3 -0.0001 -323 +322     u=15 $ Absorber Cover Opening-Y
368 8 -7.940 -324 +323     u=15 $ Absorber Cover  -Y
369 15 -1.965 -317      u=15 $ Absorber +X
370 9 -2.702 -318 +317     u=15 $ Absorber Clad  +X
371 3 -0.0001 -319 +318     u=15 $ Absorber Cover Opening+X
372 8 -7.940 -320 +319     u=15 $ Absorber Cover  +X
373 3 -0.0001 +311 +312 +320 +324      u=15 $ Exterior Space
c Cell Cards - Standard Tube, Absorber and Retainer (PX)
374 3 -0.0001 -311      u=14 $ Space in Tube
375 8 -7.940 -312 +311     u=14 $ FuelTube
376 15 -1.965 -317      u=14 $ Absorber +X
377 9 -2.702 -318 +317     u=14 $ Absorber Clad  +X
378 3 -0.0001 -319 +318     u=14 $ Absorber Cover Opening+X
379 8 -7.940 -320 +319     u=14 $ Absorber Cover  +X
380 3 -0.0001 +311 +312 +320     u=14 $ Exterior Space
c Cell Cards - Standard Tube, Absorber and Retainer (MX)
381 3 -0.0001 -311      u=13 $ Space in Tube
382 8 -7.940 -312 +311     u=13 $ FuelTube
383 15 -1.965 -325      u=13 $ Absorber -X
384 9 -2.702 -326 +325     u=13 $ Absorber Clad  -X
385 3 -0.0001 -327 +326     u=13 $ Absorber Cover Opening-X
386 8 -7.940 -328 +327     u=13 $ Absorber Cover  -X
387 3 -0.0001 +311 +312 +328     u=13 $ Exterior Space
c Cell Cards - Standard Tube, Absorber and Retainer (PY)
388 3 -0.0001 -311      u=12 $ Space in Tube
389 8 -7.940 -312 +311     u=12 $ FuelTube
390 15 -1.965 -313      u=12 $ Absorber +Y
391 9 -2.702 -314 +313     u=12 $ Absorber Clad  +Y
392 3 -0.0001 -315 +314     u=12 $ Absorber Cover Opening+Y
393 8 -7.940 -316 +315     u=12 $ Absorber Cover  +Y
394 3 -0.0001 +311 +312 +316     u=12 $ Exterior Space
c Cell Cards - Standard Tube, Absorber and Retainer (MY)
395 3 -0.0001 -311      u=11 $ Space in Tube
396 8 -7.940 -312 +311     u=11 $ FuelTube
397 15 -1.965 -321      u=11 $ Absorber -Y
398 9 -2.702 -322 +321     u=11 $ Absorber Clad  -Y
399 3 -0.0001 -323 +322     u=11 $ Absorber Cover Opening-Y
400 8 -7.940 -324 +323     u=11 $ Absorber Cover  -Y
401 3 -0.0001 +311 +312 +324     u=11 $ Exterior Space
c Cell Cards - Standard Tube
402 3 -0.0001 -311      u=10 $ Space in Tube
403 8 -7.940 -312 +311     u=10 $ FuelTube
404 3 -0.0001 +311 +312      u=10 $ Exterior Space
c Cell Cards - DFC Tube, Absorber and Retainer- 4 BORAL
411 3 -0.0001 -411      u=8 $ Space in Tube
412 8 -7.940 -412 +411     u=8 $ FuelTube
413 15 -1.965 -413      u=8 $ Absorber +Y
414 9 -2.702 -414 +413     u=8 $ Absorber Clad  +Y
415 3 -0.0001 -415 +414     u=8 $ Absorber Cover Opening+Y
416 8 -7.940 -416 +415     u=8 $ Absorber Cover  +Y
417 15 -1.965 -417      u=8 $ Absorber +X
```

```
418 8 -7.940 -418 +417     u=8 $ Absorber Clad  +X
419 3 -0.0001 -419 +418     u=8 $ Absorber Cover Opening+X
420 8 -7.940 -420 +419     u=8 $ Absorber Cover  +X
421 15 -1.965 -421      u=8 $ Absorber -Y
422 9 -2.702 -422 +421     u=8 $ Absorber Clad  -Y
423 3 -0.0001 -423 +422     u=8 $ Absorber Cover Opening-Y
424 8 -7.940 -424 +423     u=8 $ Absorber Cover  -Y
425 15 -1.965 -425      u=8 $ Absorber -X
426 8 -7.940 -426 +425     u=8 $ Absorber Clad  -X
427 3 -0.0001 -427 +426     u=8 $ Absorber Cover Opening-X
428 8 -7.940 -428 +427     u=8 $ Absorber Cover  -X
429 3 -0.0001 +411 +412 +416 +420 +424 +428      u=8 $ Exterior Space
c Cell Cards - DFC Tube, Absorber and Retainer- 2X. PY
430 3 -0.0001 -411      u=7 $ Space in Tube
431 8 -7.940 -412 +411     u=7 $ FuelTube
432 15 -1.965 -413      u=7 $ Absorber +Y
433 9 -2.702 -414 +413     u=7 $ Absorber Clad  +Y
434 3 -0.0001 -415 +414     u=7 $ Absorber Cover Opening+Y
435 8 -7.940 -416 +415     u=7 $ Absorber Cover  +Y
436 15 -1.965 -417      u=7 $ Absorber +X
437 8 -7.940 -418 +417     u=7 $ Absorber Clad  +X
438 3 -0.0001 -419 +418     u=7 $ Absorber Cover Opening+X
439 8 -7.940 -420 +419     u=7 $ Absorber Cover  +X
440 15 -1.965 -425      u=7 $ Absorber -X
441 8 -7.940 -426 +425     u=7 $ Absorber Clad  -X
442 3 -0.0001 -427 +426     u=7 $ Absorber Cover Opening-X
443 8 -7.940 -428 +427     u=7 $ Absorber Cover  -X
444 3 -0.0001 +411 +412 +416 +420 +428      u=7 $ Exterior Space
c Cell Cards - DFC Tube, Absorber and Retainer- 2X, MY
445 3 -0.0001 -411      u=6 $ Space in Tube
446 8 -7.940 -412 +411     u=6 $ FuelTube
447 15 -1.965 -417      u=6 $ Absorber +X
448 8 -7.940 -418 +417     u=6 $ Absorber Clad  +X
449 3 -0.0001 -419 +418     u=6 $ Absorber Cover Opening+X
450 8 -7.940 -420 +419     u=6 $ Absorber Cover  +X
451 15 -1.965 -421      u=6 $ Absorber -Y
452 9 -2.702 -422 +421     u=6 $ Absorber Clad  -Y
453 3 -0.0001 -423 +422     u=6 $ Absorber Cover Opening-Y
454 8 -7.940 -424 +423     u=6 $ Absorber Cover  -Y
455 15 -1.965 -425      u=6 $ Absorber -X
456 8 -7.940 -426 +425     u=6 $ Absorber Clad  -X
457 3 -0.0001 -427 +426     u=6 $ Absorber Cover Opening-X
458 8 -7.940 -428 +427     u=6 $ Absorber Cover  -X
459 3 -0.0001 +411 +412 +420 +424 +428      u=6 $ Exterior Space
c Cell Cards - DFC Tube, Absorber and Retainer-PX, 2Y
460 3 -0.0001 -411      u=5 $ Space in Tube
461 8 -7.940 -412 +411     u=5 $ FuelTube
462 15 -1.965 -413      u=5 $ Absorber +Y
463 9 -2.702 -414 +413     u=5 $ Absorber Clad  +Y
464 3 -0.0001 -415 +414     u=5 $ Absorber Cover Opening+Y
465 8 -7.940 -416 +415     u=5 $ Absorber Cover  +Y
466 15 -1.965 -417      u=5 $ Absorber +X
467 8 -7.940 -418 +417     u=5 $ Absorber Clad  +X
468 3 -0.0001 -419 +418     u=5 $ Absorber Cover Opening+X
469 8 -7.940 -420 +419     u=5 $ Absorber Cover  +X
470 15 -1.965 -421      u=5 $ Absorber -Y
471 9 -2.702 -422 +421     u=5 $ Absorber Clad  -Y
472 3 -0.0001 -423 +422     u=5 $ Absorber Cover Opening-Y
473 8 -7.940 -424 +423     u=5 $ Absorber Cover  -Y
474 3 -0.0001 +411 +412 +416 +420 +424      u=5 $ Exterior Space
c Cell Cards - DFC Tube, Absorber and Retainer- MX, 2Y
475 3 -0.0001 -411      u=4 $ Space in Tube
476 8 -7.940 -412 +411     u=4 $ FuelTube
477 15 -1.965 -413      u=4 $ Absorber +Y
478 9 -2.702 -414 +413     u=4 $ Absorber Clad  +Y
479 3 -0.0001 -415 +414     u=4 $ Absorber Cover Opening+Y
480 8 -7.940 -416 +415     u=4 $ Absorber Cover  +Y
481 15 -1.965 -421      u=4 $ Absorber -Y
482 9 -2.702 -422 +421     u=4 $ Absorber Clad  -Y
483 3 -0.0001 -423 +422     u=4 $ Absorber Cover Opening-Y
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484 8 -7.940 -424 +423     u=4 $ Absorber Cover  -Y
485 15 -1.965 -425      u=4 $ Absorber -X
486 8 -7.940 -426 +425     u=4 $ Absorber Clad  -X
487 3 -0.0001 -427 +426     u=4 $ Absorber Cover Opening-X
488 8 -7.940 -428 +427     u=4 $ Absorber Cover  -X
489 3 -0.0001 +411 +412 +416 +424 +428      u=4 $ Exterior Space
c Cell Cards - Disk Stack
601 8 -7.94 -606 *trcl=( 0.0000 0.0000 2.5400 )    u=3 $ Bottom weldment disk
602 8 -7.94 -603 *trcl=( 0.0000 0.0000 9.8044 )    u=3 $ Support disk 1 (Thick Disk)
603 8 -7.94 -601 *trcl=( 0.0000 0.0000 15.1257 )    u=3 $ Support disk 2
604 like 603 but   *trcl=( 0.0000 0.0000 24.9555 )    u=3 $ Support disk 3
605 like 603 but   *trcl=( 0.0000 0.0000 34.7853 )    u=3 $ Support disk 4
606 like 603 but   *trcl=( 0.0000 0.0000 44.6151 )    u=3 $ Support disk 5
607 like 603 but   *trcl=( 0.0000 0.0000 54.4449 )    u=3 $ Support disk 6
608 9 -2.70 -604 *trcl=( 0.0000 0.0000 59.5160 )    u=3 $ Heat transfer disk 1
609 like 603 but   *trcl=( 0.0000 0.0000 64.1985 )    u=3 $ Support disk 7
610 like 608 but   *trcl=( 0.0000 0.0000 69.2696 )    u=3 $ Heat transfer disk 2
611 like 603 but   *trcl=( 0.0000 0.0000 73.9521 )    u=3 $ Support disk 8
612 like 608 but   *trcl=( 0.0000 0.0000 79.0232 )    u=3 $ Heat transfer disk 3
613 like 603 but   *trcl=( 0.0000 0.0000 83.7057 )    u=3 $ Support disk 9
614 like 608 but   *trcl=( 0.0000 0.0000 88.7768 )    u=3 $ Heat transfer disk 4
615 like 603 but   *trcl=( 0.0000 0.0000 93.4593 )    u=3 $ Support disk 10
616 like 608 but   *trcl=( 0.0000 0.0000 98.5304 )    u=3 $ Heat transfer disk 5
617 like 603 but   *trcl=( 0.0000 0.0000 103.2129 )    u=3 $ Support disk 11
618 like 608 but   *trcl=( 0.0000 0.0000 108.2840 )    u=3 $ Heat transfer disk 6
619 like 603 but   *trcl=( 0.0000 0.0000 112.9665 )    u=3 $ Support disk 12
620 like 608 but   *trcl=( 0.0000 0.0000 118.0376 )    u=3 $ Heat transfer disk 7
621 like 603 but   *trcl=( 0.0000 0.0000 122.7201 )    u=3 $ Support disk 13
622 like 608 but   *trcl=( 0.0000 0.0000 127.7912 )    u=3 $ Heat transfer disk 8
623 like 603 but   *trcl=( 0.0000 0.0000 132.4737 )    u=3 $ Support disk 14
624 like 608 but   *trcl=( 0.0000 0.0000 137.5448 )    u=3 $ Heat transfer disk 9
625 like 603 but   *trcl=( 0.0000 0.0000 142.2273 )    u=3 $ Support disk 15
626 like 608 but   *trcl=( 0.0000 0.0000 147.2984 )    u=3 $ Heat transfer disk 10
627 like 603 but   *trcl=( 0.0000 0.0000 151.9809 )    u=3 $ Support disk 16
628 like 608 but   *trcl=( 0.0000 0.0000 157.0520 )    u=3 $ Heat transfer disk 11
629 like 603 but   *trcl=( 0.0000 0.0000 161.7345 )    u=3 $ Support disk 17
630 like 608 but   *trcl=( 0.0000 0.0000 166.8056 )    u=3 $ Heat transfer disk 12
631 like 603 but   *trcl=( 0.0000 0.0000 171.4881 )    u=3 $ Support disk 18
632 like 608 but   *trcl=( 0.0000 0.0000 176.5592 )    u=3 $ Heat transfer disk 13
633 like 603 but   *trcl=( 0.0000 0.0000 181.2417 )    u=3 $ Support disk 19
634 like 608 but   *trcl=( 0.0000 0.0000 186.3128 )    u=3 $ Heat transfer disk 14
635 like 603 but   *trcl=( 0.0000 0.0000 190.9953 )    u=3 $ Support disk 20
636 like 603 but   *trcl=( 0.0000 0.0000 200.8251 )    u=3 $ Support disk 21
637 like 603 but   *trcl=( 0.0000 0.0000 210.6549 )    u=3 $ Support disk 22
638 like 603 but   *trcl=( 0.0000 0.0000 220.4847 )    u=3 $ Support disk 23
639 like 603 but   *trcl=( 0.0000 0.0000 230.3145 )    u=3 $ Support disk 24
640 like 603 but   *trcl=( 0.0000 0.0000 240.1443 )    u=3 $ Support disk 25
641 8 -7.94 -602 *trcl=( 0.0000 0.0000 248.3231 )    u=3 $ Support disk 26 (Thick Disk)
642 8 -7.94 -605 *trcl=( 0.0000 0.0000 255.8288 )    u=3 $ Top weldment disk
643 3 -0.0001       $ Outside Disks
      #601 #602 #603 #604 #605 #606 #607 #608 #609 #610
      #611 #612 #613 #614 #615 #616 #617 #618 #619 #620
      #621 #622 #623 #624 #625 #626 #627 #628 #629 #630
      #631 #632 #633 #634 #635 #636 #637 #638 #639 #640
      #641 #642        u=3
c Cell Cards - Basket
701 3 -0.0001 -702 #702  #703  fill=6 ( -8.6463 77.3430 0.0000 )     $ Tube/Disk 1
            *trcl=( -8.7884 77.4852 0.0000 )    u=2
702 3 -0.0001 -302 #703   fill=20 *trcl=( -8.3315 77.0282 0.0000 )    u=2 $DFC
703 3 -0.0001 -290   fill=21 *trcl=( -8.3303 77.0270 1.2700 )    u=2 $ Assembly 1
704 3 -0.0001 -702 #705  #706  fill=6 ( 8.6463 77.3430 0.0000 )     $ Tube/Disk 2
            *trcl=( 8.7884 77.4852 0.0000 )    u=2
705 3 -0.0001 -302 #706   fill=20 *trcl=( 8.3315 77.0282 0.0000 )    u=2 $DFC
706 3 -0.0001 -290   fill=21 *trcl=( 8.3303 77.0270 1.2700 )    u=2 $ Assembly 2
707 3 -0.0001 -702 #708  #709  fill=6 ( -43.9472 61.0896 0.0000 )     $ Tube/Disk 3
            *trcl=( -44.0893 61.2318 0.0000 )    u=2
708 3 -0.0001 -302 #709   fill=20 *trcl=( -43.6324 60.7748 0.0000 )    u=2 $DFC
709 3 -0.0001 -270   fill=24 *trcl=( -43.6312 60.7736 1.2700 )    u=2 $ Assembly 3
710 3 -0.0001 -702 #711  #712  fill=8 ( -26.2968 59.6927 0.0000 )     $ Tube/Disk 4
            *trcl=( -26.4389 59.8348 0.0000 )    u=2
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711 3 -0.0001 -302 #712   fill=20 *trcl=( -25.9820 59.3779 0.0000 )    u=2 $DFC
712 3 -0.0001 -270   fill=24 *trcl=( -25.9808 59.3767 1.2700 )    u=2 $ Assembly 4
713 3 -0.0001 -702 #714  #715  fill=8 ( -8.6463 59.6927 0.0000 )     $ Tube/Disk 5
           *trcl=( -8.7884 59.8348 0.0000 )    u=2
714 3 -0.0001 -302 #715   fill=20 *trcl=( -8.3315 59.3779 0.0000 )    u=2 $DFC
715 3 -0.0001 -290   fill=21 *trcl=( -8.3303 59.3767 1.2700 )    u=2 $ Assembly 5
716 3 -0.0001 -702 #717  #718  fill=8 ( 8.6463 59.6927 0.0000 )     $ Tube/Disk 6
           *trcl=( 8.7884 59.8348 0.0000 )    u=2
717 3 -0.0001 -302 #718   fill=20 *trcl=( 8.3315 59.3779 0.0000 )    u=2 $DFC
718 3 -0.0001 -290   fill=21 *trcl=( 8.3303 59.3767 1.2700 )    u=2 $ Assembly 6
719 3 -0.0001 -702 #720  #721  fill=8 ( 26.2968 59.6927 0.0000 )     $ Tube/Disk 7
           *trcl=( 26.4389 59.8348 0.0000 )    u=2
720 3 -0.0001 -302 #721   fill=20 *trcl=( 25.9820 59.3779 0.0000 )    u=2 $DFC
721 3 -0.0001 -270   fill=24 *trcl=( 25.9808 59.3767 1.2700 )    u=2 $ Assembly 7
722 3 -0.0001 -702 #723  #724  fill=6 ( 43.9472 61.0896 0.0000 )     $ Tube/Disk 8
           *trcl=( 44.0893 61.2318 0.0000 )    u=2
723 3 -0.0001 -302 #724   fill=20 *trcl=( 43.6324 60.7748 0.0000 )    u=2 $DFC
724 3 -0.0001 -270   fill=24 *trcl=( 43.6312 60.7736 1.2700 )    u=2 $ Assembly 8
725 3 -0.0001 -702 #726  #727  fill=5 ( -61.0896 43.9472 0.0000 )     $ Tube/Disk 9
           *trcl=( -61.2318 44.0893 0.0000 )    u=2
726 3 -0.0001 -302 #727   fill=20 *trcl=( -60.7748 43.6324 0.0000 )    u=2 $DFC
727 3 -0.0001 -270   fill=24 *trcl=( -60.7736 43.6312 1.2700 )    u=2 $ Assembly 9
728 3 -0.0001 -701  #729  fill=15 ( -42.4663 42.4663 0.0000 )     $ Tube/Disk 10
           *trcl=( -42.5018 42.5018 0.0000 )    u=2
729 3 -0.0001 -51   fill=27 *trcl=( -42.1871 42.1871 1.2700 )    u=2 $ Assembly 10
730 3 -0.0001 -701  #731  fill=15 ( -25.4509 42.4663 0.0000 )     $ Tube/Disk 11
           *trcl=( -25.4864 42.5018 0.0000 )    u=2
731 3 -0.0001 -51   fill=27 *trcl=( -25.1717 42.1871 1.2700 )    u=2 $ Assembly 11
732 3 -0.0001 -701  #733  fill=15 ( -8.4354 42.4663 0.0000 )     $ Tube/Disk 12
           *trcl=( -8.4709 42.5018 0.0000 )    u=2
733 3 -0.0001 -51   fill=27 *trcl=( -8.1562 42.1871 1.2700 )    u=2 $ Assembly 12
734 3 -0.0001 -701  #735  fill=11 ( 8.1739 42.4663 0.0000 )     $ Tube/Disk 13
           *trcl=( 8.4709 42.5018 0.0000 )    u=2
735 3 -0.0001 -51   fill=27 *trcl=( 7.8947 42.1871 1.2700 )    u=2 $ Assembly 13
736 3 -0.0001 -701  #737  fill=16 ( 25.4509 42.4663 0.0000 )     $ Tube/Disk 14
           *trcl=( 25.4864 42.5018 0.0000 )    u=2
737 3 -0.0001 -51   fill=27 *trcl=( 25.1717 42.1871 1.2700 )    u=2 $ Assembly 14
738 3 -0.0001 -701  #739  fill=16 ( 42.4663 42.4663 0.0000 )     $ Tube/Disk 15
           *trcl=( 42.5018 42.5018 0.0000 )    u=2
739 3 -0.0001 -51   fill=27 *trcl=( 42.1871 42.1871 1.2700 )    u=2 $ Assembly 15
740 3 -0.0001 -702 #741  #742  fill=4 ( 61.0896 43.9472 0.0000 )     $ Tube/Disk 16
           *trcl=( 61.2318 44.0893 0.0000 )    u=2
741 3 -0.0001 -302 #742   fill=20 *trcl=( 60.7748 43.6324 0.0000 )    u=2 $DFC
742 3 -0.0001 -270   fill=24 *trcl=( 60.7736 43.6312 1.2700 )    u=2 $ Assembly 16
743 3 -0.0001 -702 #744  #745  fill=8 ( -59.6927 26.2968 0.0000 )     $ Tube/Disk 17
           *trcl=( -59.8348 26.4389 0.0000 )    u=2
744 3 -0.0001 -302 #745   fill=20 *trcl=( -59.3779 25.9820 0.0000 )    u=2 $DFC
745 3 -0.0001 -270   fill=24 *trcl=( -59.3767 25.9808 1.2700 )    u=2 $ Assembly 17
746 3 -0.0001 -701  #747  fill=15 ( -42.4663 25.4509 0.0000 )     $ Tube/Disk 18
           *trcl=( -42.5018 25.4864 0.0000 )    u=2
747 3 -0.0001 -51   fill=27 *trcl=( -42.1871 25.1717 1.2700 )    u=2 $ Assembly 18
748 3 -0.0001 -701  #749  fill=15 ( -25.4509 25.4509 0.0000 )     $ Tube/Disk 19
           *trcl=( -25.4864 25.4864 0.0000 )    u=2
749 3 -0.0001 -51   fill=27 *trcl=( -25.1717 25.1717 1.2700 )    u=2 $ Assembly 19
750 3 -0.0001 -701  #751  fill=15 ( -8.4354 25.4509 0.0000 )     $ Tube/Disk 20
           *trcl=( -8.4709 25.4864 0.0000 )    u=2
751 3 -0.0001 -51   fill=27 *trcl=( -8.1562 25.1717 1.2700 )    u=2 $ Assembly 20
752 3 -0.0001 -701  #753  fill=11 ( 8.1739 25.4509 0.0000 )     $ Tube/Disk 21
           *trcl=( 8.4709 25.4864 0.0000 )    u=2
753 3 -0.0001 -51   fill=27 *trcl=( 7.8947 25.1717 1.2700 )    u=2 $ Assembly 21
754 3 -0.0001 -701  #755  fill=16 ( 25.4509 25.4509 0.0000 )     $ Tube/Disk 22
           *trcl=( 25.4864 25.4864 0.0000 )    u=2
755 3 -0.0001 -51   fill=27 *trcl=( 25.1717 25.1717 1.2700 )    u=2 $ Assembly 22
756 3 -0.0001 -701  #757  fill=16 ( 42.4663 25.4509 0.0000 )     $ Tube/Disk 23
           *trcl=( 42.5018 25.4864 0.0000 )    u=2
757 3 -0.0001 -51   fill=27 *trcl=( 42.1871 25.1717 1.2700 )    u=2 $ Assembly 23
758 3 -0.0001 -702 #759  #760  fill=8 ( 59.6927 26.2968 0.0000 )     $ Tube/Disk 24
           *trcl=( 59.8348 26.4389 0.0000 )    u=2
759 3 -0.0001 -302 #760   fill=20 *trcl=( 59.3779 25.9820 0.0000 )    u=2 $DFC
760 3 -0.0001 -270   fill=24 *trcl=( 59.3767 25.9808 1.2700 )    u=2 $ Assembly 24
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761 3 -0.0001 -702 #762  #763  fill=5 ( -77.3430 8.6463 0.0000 )     $ Tube/Disk 25
            *trcl=( -77.4852 8.7884 0.0000 )    u=2
762 3 -0.0001 -302 #763   fill=20 *trcl=( -77.0282 8.3315 0.0000 )    u=2 $DFC
763 3 -0.0001 -290   fill=21 *trcl=( -77.0270 8.3303 1.2700 )    u=2 $ Assembly 25
764 3 -0.0001 -702 #765  #766  fill=8 ( -59.6927 8.6463 0.0000 )     $ Tube/Disk 26
            *trcl=( -59.8348 8.7884 0.0000 )    u=2
765 3 -0.0001 -302 #766   fill=20 *trcl=( -59.3779 8.3315 0.0000 )    u=2 $DFC
766 3 -0.0001 -290   fill=21 *trcl=( -59.3767 8.3303 1.2700 )    u=2 $ Assembly 26
767 3 -0.0001 -701  #768  fill=15 ( -42.4663 8.4354 0.0000 )     $ Tube/Disk 27
            *trcl=( -42.5018 8.4709 0.0000 )    u=2
768 3 -0.0001 -51    fill=27 *trcl=( -42.1871 8.1562 1.2700 )    u=2 $ Assembly 27
769 3 -0.0001 -701  #770  fill=15 ( -25.4509 8.4354 0.0000 )     $ Tube/Disk 28
            *trcl=( -25.4864 8.4709 0.0000 )    u=2
770 3 -0.0001 -51    fill=27 *trcl=( -25.1717 8.1562 1.2700 )    u=2 $ Assembly 28
771 3 -0.0001 -701  #772  fill=15 ( -8.4354 8.4354 0.0000 )     $ Tube/Disk 29
            *trcl=( -8.4709 8.4709 0.0000 )    u=2
772 3 -0.0001 -51    fill=27 *trcl=( -8.1562 8.1562 1.2700 )    u=2 $ Assembly 29
773 3 -0.0001 -701  #774  fill=10 ( 8.1739 8.1739 0.0000 )     $ Tube/Disk 30
            *trcl=( 8.4709 8.4709 0.0000 )    u=2
774 3 -0.0001 -51    fill=27 *trcl=( 7.8947 7.8947 1.2700 )    u=2 $ Assembly 30
775 3 -0.0001 -701  #776  fill=13 ( 25.4509 8.1739 0.0000 )     $ Tube/Disk 31
            *trcl=( 25.4864 8.4709 0.0000 )    u=2
776 3 -0.0001 -51    fill=27 *trcl=( 25.1717 7.8947 1.2700 )    u=2 $ Assembly 31
777 3 -0.0001 -701  #778  fill=13 ( 42.4663 8.1739 0.0000 )     $ Tube/Disk 32
            *trcl=( 42.5018 8.4709 0.0000 )    u=2
778 3 -0.0001 -51    fill=27 *trcl=( 42.1871 7.8947 1.2700 )    u=2 $ Assembly 32
779 3 -0.0001 -702 #780  #781  fill=8 ( 59.6927 8.6463 0.0000 )     $ Tube/Disk 33
            *trcl=( 59.8348 8.7884 0.0000 )    u=2
780 3 -0.0001 -302 #781   fill=20 *trcl=( 59.3779 8.3315 0.0000 )    u=2 $DFC
781 3 -0.0001 -290   fill=21 *trcl=( 59.3767 8.3303 1.2700 )    u=2 $ Assembly 33
782 3 -0.0001 -702 #783  #784  fill=4 ( 77.3430 8.6463 0.0000 )     $ Tube/Disk 34
            *trcl=( 77.4852 8.7884 0.0000 )    u=2
783 3 -0.0001 -302 #784   fill=20 *trcl=( 77.0282 8.3315 0.0000 )    u=2 $DFC
784 3 -0.0001 -290   fill=21 *trcl=( 77.0270 8.3303 1.2700 )    u=2 $ Assembly 34
785 3 -0.0001 -702 #786  #787  fill=5 ( -77.3430 -8.6463 0.0000 )     $ Tube/Disk 35
            *trcl=( -77.4852 -8.7884 0.0000 )    u=2
786 3 -0.0001 -302 #787   fill=20 *trcl=( -77.0282 -8.3315 0.0000 )    u=2 $DFC
787 3 -0.0001 -290   fill=21 *trcl=( -77.0270 -8.3303 1.2700 )    u=2 $ Assembly 35
788 3 -0.0001 -702 #789  #790  fill=8 ( -59.6927 -8.6463 0.0000 )     $ Tube/Disk 36
            *trcl=( -59.8348 -8.7884 0.0000 )    u=2
789 3 -0.0001 -302 #790   fill=20 *trcl=( -59.3779 -8.3315 0.0000 )    u=2 $DFC
790 3 -0.0001 -290   fill=21 *trcl=( -59.3767 -8.3303 1.2700 )    u=2 $ Assembly 36
791 3 -0.0001 -701  #792  fill=14 ( -42.4663 -8.1739 0.0000 )     $ Tube/Disk 37
            *trcl=( -42.5018 -8.4709 0.0000 )    u=2
792 3 -0.0001 -51    fill=27 *trcl=( -42.1871 -7.8947 1.2700 )    u=2 $ Assembly 37
793 3 -0.0001 -701  #794  fill=14 ( -25.4509 -8.1739 0.0000 )     $ Tube/Disk 38
            *trcl=( -25.4864 -8.4709 0.0000 )    u=2
794 3 -0.0001 -51    fill=27 *trcl=( -25.1717 -7.8947 1.2700 )    u=2 $ Assembly 38
795 3 -0.0001 -701  #796  fill=10 ( -8.1739 -8.1739 0.0000 )     $ Tube/Disk 39
            *trcl=( -8.4709 -8.4709 0.0000 )    u=2
796 3 -0.0001 -51    fill=27 *trcl=( -7.8947 -7.8947 1.2700 )    u=2 $ Assembly 39
797 3 -0.0001 -701  #798  fill=17 ( 8.4354 -8.4354 0.0000 )     $ Tube/Disk 40
            *trcl=( 8.4709 -8.4709 0.0000 )    u=2
798 3 -0.0001 -51    fill=27 *trcl=( 8.1562 -8.1562 1.2700 )    u=2 $ Assembly 40
799 3 -0.0001 -701  #800  fill=17 ( 25.4509 -8.4354 0.0000 )     $ Tube/Disk 41
            *trcl=( 25.4864 -8.4709 0.0000 )    u=2
800 3 -0.0001 -51    fill=27 *trcl=( 25.1717 -8.1562 1.2700 )    u=2 $ Assembly 41
801 3 -0.0001 -701  #802  fill=17 ( 42.4663 -8.4354 0.0000 )     $ Tube/Disk 42
            *trcl=( 42.5018 -8.4709 0.0000 )    u=2
802 3 -0.0001 -51    fill=27 *trcl=( 42.1871 -8.1562 1.2700 )    u=2 $ Assembly 42
803 3 -0.0001 -702 #804  #805  fill=8 ( 59.6927 -8.6463 0.0000 )     $ Tube/Disk 43
            *trcl=( 59.8348 -8.7884 0.0000 )    u=2
804 3 -0.0001 -302 #805   fill=20 *trcl=( 59.3779 -8.3315 0.0000 )    u=2 $DFC
805 3 -0.0001 -290   fill=21 *trcl=( 59.3767 -8.3303 1.2700 )    u=2 $ Assembly 43
806 3 -0.0001 -702 #807  #808  fill=4 ( 77.3430 -8.6463 0.0000 )     $ Tube/Disk 44
            *trcl=( 77.4852 -8.7884 0.0000 )    u=2
807 3 -0.0001 -302 #808   fill=20 *trcl=( 77.0282 -8.3315 0.0000 )    u=2 $DFC
808 3 -0.0001 -290   fill=21 *trcl=( 77.0270 -8.3303 1.2700 )    u=2 $ Assembly 44
809 3 -0.0001 -702 #810  #811  fill=8 ( -59.6927 -26.2968 0.0000 )     $ Tube/Disk 45
            *trcl=( -59.8348 -26.4389 0.0000 )    u=2
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810 3 -0.0001 -302 #811   fill=20 *trcl=( -59.3779 -25.9820 0.0000 )    u=2 $DFC
811 3 -0.0001 -270    fill=24 *trcl=( -59.3767 -25.9808 1.2700 )    u=2 $ Assembly 45
812 3 -0.0001 -701  #813  fill=18 ( -42.4663 -25.4509 0.0000 )     $ Tube/Disk 46
            *trcl=( -42.5018 -25.4864 0.0000 )     u=2
813 3 -0.0001 -51   fill=27 *trcl=( -42.1871 -25.1717 1.2700 )    u=2 $ Assembly 46
814 3 -0.0001 -701  #815  fill=18 ( -25.4509 -25.4509 0.0000 )     $ Tube/Disk 47
            *trcl=( -25.4864 -25.4864 0.0000 )     u=2
815 3 -0.0001 -51   fill=27 *trcl=( -25.1717 -25.1717 1.2700 )    u=2 $ Assembly 47
816 3 -0.0001 -701  #817  fill=12 ( -8.1739 -25.4509 0.0000 )     $ Tube/Disk 48
            *trcl=( -8.4709 -25.4864 0.0000 )    u=2
817 3 -0.0001 -51   fill=27 *trcl=( -7.8947 -25.1717 1.2700 )    u=2 $ Assembly 48
818 3 -0.0001 -701  #819  fill=17 ( 8.4354 -25.4509 0.0000 )     $ Tube/Disk 49
            *trcl=( 8.4709 -25.4864 0.0000 )    u=2
819 3 -0.0001 -51   fill=27 *trcl=( 8.1562 -25.1717 1.2700 )    u=2 $ Assembly 49
820 3 -0.0001 -701  #821  fill=17 ( 25.4509 -25.4509 0.0000 )     $ Tube/Disk 50
            *trcl=( 25.4864 -25.4864 0.0000 )    u=2
821 3 -0.0001 -51   fill=27 *trcl=( 25.1717 -25.1717 1.2700 )    u=2 $ Assembly 50
822 3 -0.0001 -701  #823  fill=17 ( 42.4663 -25.4509 0.0000 )     $ Tube/Disk 51
            *trcl=( 42.5018 -25.4864 0.0000 )    u=2
823 3 -0.0001 -51   fill=27 *trcl=( 42.1871 -25.1717 1.2700 )    u=2 $ Assembly 51
824 3 -0.0001 -702 #825  #826  fill=8 ( 59.6927 -26.2968 0.0000 )     $ Tube/Disk 52
            *trcl=( 59.8348 -26.4389 0.0000 )    u=2
825 3 -0.0001 -302 #826   fill=20 *trcl=( 59.3779 -25.9820 0.0000 )    u=2 $DFC
826 3 -0.0001 -270    fill=24 *trcl=( 59.3767 -25.9808 1.2700 )    u=2 $ Assembly 52
827 3 -0.0001 -702 #828  #829  fill=5 ( -61.0896 -43.9472 0.0000 )     $ Tube/Disk 53
            *trcl=( -61.2318 -44.0893 0.0000 )     u=2
828 3 -0.0001 -302 #829   fill=20 *trcl=( -60.7748 -43.6324 0.0000 )    u=2 $DFC
829 3 -0.0001 -270    fill=24 *trcl=( -60.7736 -43.6312 1.2700 )    u=2 $ Assembly 53
830 3 -0.0001 -701  #831  fill=18 ( -42.4663 -42.4663 0.0000 )     $ Tube/Disk 54
            *trcl=( -42.5018 -42.5018 0.0000 )     u=2
831 3 -0.0001 -51   fill=27 *trcl=( -42.1871 -42.1871 1.2700 )    u=2 $ Assembly 54
832 3 -0.0001 -701  #833  fill=18 ( -25.4509 -42.4663 0.0000 )     $ Tube/Disk 55
            *trcl=( -25.4864 -42.5018 0.0000 )     u=2
833 3 -0.0001 -51   fill=27 *trcl=( -25.1717 -42.1871 1.2700 )    u=2 $ Assembly 55
834 3 -0.0001 -701  #835  fill=12 ( -8.1739 -42.4663 0.0000 )     $ Tube/Disk 56
            *trcl=( -8.4709 -42.5018 0.0000 )    u=2
835 3 -0.0001 -51   fill=27 *trcl=( -7.8947 -42.1871 1.2700 )    u=2 $ Assembly 56
836 3 -0.0001 -701  #837  fill=17 ( 8.4354 -42.4663 0.0000 )     $ Tube/Disk 57
            *trcl=( 8.4709 -42.5018 0.0000 )    u=2
837 3 -0.0001 -51   fill=27 *trcl=( 8.1562 -42.1871 1.2700 )    u=2 $ Assembly 57
838 3 -0.0001 -701  #839  fill=17 ( 25.4509 -42.4663 0.0000 )     $ Tube/Disk 58
            *trcl=( 25.4864 -42.5018 0.0000 )    u=2
839 3 -0.0001 -51   fill=27 *trcl=( 25.1717 -42.1871 1.2700 )    u=2 $ Assembly 58
840 3 -0.0001 -701  #841  fill=17 ( 42.4663 -42.4663 0.0000 )     $ Tube/Disk 59
            *trcl=( 42.5018 -42.5018 0.0000 )    u=2
841 3 -0.0001 -51   fill=27 *trcl=( 42.1871 -42.1871 1.2700 )    u=2 $ Assembly 59
842 3 -0.0001 -702 #843  #844  fill=4 ( 61.0896 -43.9472 0.0000 )     $ Tube/Disk 60
            *trcl=( 61.2318 -44.0893 0.0000 )    u=2
843 3 -0.0001 -302 #844   fill=20 *trcl=( 60.7748 -43.6324 0.0000 )    u=2 $DFC
844 3 -0.0001 -270    fill=24 *trcl=( 60.7736 -43.6312 1.2700 )    u=2 $ Assembly 60
845 3 -0.0001 -702 #846  #847  fill=7 ( -43.9472 -61.0896 0.0000 )     $ Tube/Disk 61
            *trcl=( -44.0893 -61.2318 0.0000 )     u=2
846 3 -0.0001 -302 #847   fill=20 *trcl=( -43.6324 -60.7748 0.0000 )    u=2 $DFC
847 3 -0.0001 -270    fill=24 *trcl=( -43.6312 -60.7736 1.2700 )    u=2 $ Assembly 61
848 3 -0.0001 -702 #849  #850  fill=8 ( -26.2968 -59.6927 0.0000 )     $ Tube/Disk 62
            *trcl=( -26.4389 -59.8348 0.0000 )     u=2
849 3 -0.0001 -302 #850   fill=20 *trcl=( -25.9820 -59.3779 0.0000 )    u=2 $DFC
850 3 -0.0001 -270    fill=24 *trcl=( -25.9808 -59.3767 1.2700 )    u=2 $ Assembly 62
851 3 -0.0001 -702 #852  #853  fill=8 ( -8.6463 -59.6927 0.0000 )     $ Tube/Disk 63
            *trcl=( -8.7884 -59.8348 0.0000 )    u=2
852 3 -0.0001 -302 #853   fill=20 *trcl=( -8.3315 -59.3779 0.0000 )    u=2 $DFC
853 3 -0.0001 -290    fill=21 *trcl=( -8.3303 -59.3767 1.2700 )    u=2 $ Assembly 63
854 3 -0.0001 -702 #855  #856  fill=8 ( 8.6463 -59.6927 0.0000 )     $ Tube/Disk 64
            *trcl=( 8.7884 -59.8348 0.0000 )    u=2
855 3 -0.0001 -302 #856   fill=20 *trcl=( 8.3315 -59.3779 0.0000 )    u=2 $DFC
856 3 -0.0001 -290    fill=21 *trcl=( 8.3303 -59.3767 1.2700 )    u=2 $ Assembly 64
857 3 -0.0001 -702 #858  #859  fill=8 ( 26.2968 -59.6927 0.0000 )     $ Tube/Disk 65
            *trcl=( 26.4389 -59.8348 0.0000 )    u=2
858 3 -0.0001 -302 #859   fill=20 *trcl=( 25.9820 -59.3779 0.0000 )    u=2 $DFC
859 3 -0.0001 -270    fill=24 *trcl=( 25.9808 -59.3767 1.2700 )    u=2 $ Assembly 65
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860 3 -0.0001 -702 #861  #862  fill=7 ( 43.9472 -61.0896 0.0000 )      $ Tube/Disk 66
            *trcl=( 44.0893 -61.2318 0.0000 )    u=2
861 3 -0.0001 -302 #862   fill=20 *trcl=( 43.6324 -60.7748 0.0000 )    u=2 $DFC
862 3 -0.0001 -270.  fill=24 *trcl=( 43.6312 -60.7736 1.2700 )    u=2 $ Assembly 66
863 3 -0.0001 -702 #864  #865  fill=7 ( -8.6463 -77.3430 0.0000 )      $ Tube/Disk 67
            *trcl=( -8.7884 -77.4852 0.0000 )    u=2
864 3 -0.0001 -302 #865   fill=20 *trcl=( -8.3315 -77.0282 0.0000 )    u=2 $DFC
865 3 -0.0001 -290   fill=21 *trcl=( -8.3303 -77.0270 1.2700 )    u=2 $ Assembly 67
866 3 -0.0001 -702 #867  #868  fill=7 ( 8.6463 -77.3430 0.0000 )     $ Tube/Disk 68
            *trcl=( 8.7884 -77.4852 0.0000 )    u=2
867 3 -0.0001 -302 #868   fill=20 *trcl=( 8.3315 -77.0282 0.0000 )    u=2 $DFC
868 3 -0.0001 -290   fill=21 *trcl=( 8.3303 -77.0270 1.2700 )    u=2 $ Assembly 68
869 3 -0.0001 +703 +704         $ Canister Cavity Q1
      #704 #716 #719 #722 #734 #736 #738 #740 #752
      #706 #718 #721 #724 #735 #737 #739 #742 #753
      #754 #756 #758 #773 #775 #777 #779 #782
      #755 #757 #760 #774 #776 #778 #781 #784
      #705 #717 #720 #723 #741 #759 #780 #783
          fill=3      u=2
870 3 -0.0001 +703 -704         $ Canister Cavity Q2
      #701 #707 #710 #713 #725 #728 #730 #732 #743
      #703 #709 #712 #715 #727 #729 #731 #733 #745
      #746 #748 #750 #761 #764 #767 #769 #771
      #747 #749 #751 #763 #766 #768 #770 #772
      #702 #708 #711 #714 #726 #744 #762 #765
          fill=3      u=2
871 3 -0.0001 -703 -704         $ Canister Cavity Q3
      #785 #788 #791 #793 #795 #809 #812 #814 #816
      #787 #790 #792 #794 #796 #811 #813 #815 #817
      #827 #830 #832 #834 #845 #848 #851 #863
      #829 #831 #833 #835 #847 #850 #853 #865
      #786 #789 #810 #828 #846 #849 #852 #864
          fill=3      u=2
872 3 -0.0001 -703 704         $ Canister Cavity Q4
      #797 #799 #801 #803 #806 #818 #820 #822 #824
      #798 #800 #802 #805 #808 #819 #821 #823 #826
      #836 #838 #840 #842 #854 #857 #860 #866
      #837 #839 #841 #844 #856 #859 #862 #868
      #804 #807 #825 #843 #855 #858 #861 #867
          fill=3      u=2
c Cell Cards - Canister
901 3 -0.0001 -901 #902     fill=2 u=1 $ Cavity
902 9 -2.702 -902      u=1 $ Spacer
903 8 -7.940 -903 +901     u=1 $ Canister Shell / Lid / Bottom
904 14 -0.9982 +903      u=1 $ Remaining Space
c Cell Cards - Storage Cask Geometry
911 10 -7.8212 -915         $ Base Plate
912 14 -0.9982 (-924 +922 -911):          $ Air Inlet Channel Void
                                  (-924 +923 -922 +928)
913 10 -7.8212 -925 +924 +922 -911       $ Air Inlet Channel Mat
914 14 -0.9982 (-926 +922 -911):          $ Air Inlet Channel Void
                                  (-926 +923 -922 +928)
915 10 -7.8212 -927 +926 +922 -911       $ Air Inlet Channel Mat
916 14 -0.9982 -929 -922 +923        $ Stand Cut-Out Top
917 like 916 but *trcl = (0.0 0.0 0.0 90 180 90 0 90 90 90 90 0)       $ Stand Cut-Out Top
918 10 -7.8212 -911 -922 +923 +928 +915 +924 +926 #916 #917    $ Stand Material
919 10 -7.8212 (-911 -922 -928) : (-911 +922 -928 +925 +927)         $ Bottom Plate
920 10 -7.8212 (-916 +917 +928 -920) : (-918 +919 +920 -921)         $ Baffle Cone Mat
921 14 -0.9982 (-917 +928 -920) : (-919 +920 -921)          $ Baffle Cone Int. Void
922 14 -0.9982 -923 +928 -921 +916 +918      $ Void inside stand - A
923 14 -0.9982 -911 -923 +921 +915       $ Void inside stand - B
924 14 -0.9982 -911 -913 +922 +928 +915 +925 +927    $ Void stand to liner
925 10 -7.8212 -911 -914 +913 +928 +925 +927     $ Liner
926 13 -2.3220 -911 +914 +928 +925 +927      $ Concrete
927 10 -7.8212 -930         $ VCC Lid
928 10 -7.8212 -931 +932         $ TopFlange
929 14 -0.9982 -931 -932 +913 +933       $ Void Cavity to Flange
930 13 -2.3220 -934         $ Lid Concrete
931 10 -7.8212 -933 +934         $ Lid Cover
932 13 -2.3220 (-936 +914) : (-937 -912 +938)         $ Concrete - Outlet Box
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933 14 -0.9982 (-939 +940 +914) : (-941 +939 -912)        $ Air Outlet Void
934 10 -7.8212 -935 -912 +914 #932 #933       $ Air Outlet Steel
935 13 -2.3220 (-943 +914) : (-944 -912 +945)        $ Concrete - Outlet Box
936 14 -0.9982 (-946 +947 +914) : (-948 +946 -912)        $ Air Outlet Void
937 10 -7.8212 -942 -912 +914 #935 #936       $ Air Outlet Steel
938 13 -2.3220 -912 +914 +931 #932 #933 #934 #935 #936 #937       $ Concrete
939 14 -0.9982 (-949 -951 +913) : (-950 -914 +951)        $ Air Outlet Liner Void
940 like 939 but *trcl = (0.0 0.0 0.0 90 180 90 0 90 90 90 90 0)       $ Air Outlet Liner Void
941 10 -7.8212 -912 -914 +913 +931 #939 #940      $ Liner Minus Voids
942 14 -0.9982 -912 -913 +933  fill=1 ( 0.0000 0.0000 2.5400 )     $ Cavity
943 14 -0.9982 -952 +911 +912 +930  #912 #913 #914 #915     $ Exterior space to Reflector
944 0        +952         $ Exterior space

c Surfaces - Fuel Rod - EX - BWR_10x10_4 WR
10 RCC 0.0000 0.0000 1.4605 0.0000 0.0000 210.8200 0.4356 $ Fuel pellet stack
11 RCC 0.0000 0.0000 1.4605 0.0000 0.0000 221.1553 0.4445 $ Annulus + Plenum
12 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 223.5962 0.5004 $ Clad + End-Caps
c Surfaces - Inert Rods - EX - BWR_10x10_4 WR
30 RCC 0.0000 0.0000 1.4605 0.0000 0.0000 210.8200 0.4356 $ Zirc filler stack
31 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 223.5962 0.5004 $ Clad + End-Caps
c Surfaces - Pitch - EX - BWR_10x10_4 WR
40 PX 0.7074       $ Lattice Cell Boundaries
41 PX -0.7074
42 PY 0.7074
43 PY -0.7074
c Surfaces - Fuel Assembly Array Inserted Into Assembly - EX - BWR_10x10_4 WR
50 RPP -6.8669 6.8669 -6.8669 6.8669 25.4000 250.6726  $ Array
51 RPP -7.1298 7.1298 -7.1298 7.1298 0.0000 260.2230  $ Assembly Outer Dims
c Surfaces - DFC Content - Fuel Pellet Stack
261 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 221.3610 0.4445 $ Fuel pellet stack
c Surfaces - DFC Content - Array
265 PX 0.7619       $ Lattice Cell Boundaries
266 PX -0.7619
267 PY 0.7619
268 PY -0.7619
c Surfaces - DFC Content - Envelope of Array
270 RPP -7.3011 7.3011 -7.3011 7.3011 0.0000 221.361  $ Array
c Surfaces - Axis DFC Content - Fuel Pellet Stack
281 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 221.3610 0.4445 $ Fuel pellet stack
c Surfaces - Axis DFC Content - Array
285 PX 0.7619       $ Lattice Cell Boundaries
286 PX -0.7619
287 PY 0.7619
288 PY -0.7619
c Surfaces - Axis DFC Content - Envelope of Array
290 RPP -7.3011 7.3011 -7.3011 7.3011 0.0000 221.361  $ Array
c Surface Cards - DFC
301 RPP -7.3025 7.3025 -7.3025 7.3025 0.0000 265.7475 $  Space inside DFC Shell
302 RPP -7.4244 7.4244 -7.4244 7.4244 0.0000 271.1450 $  DFC body
303 PZ 1.2700       $ Bottom plate top
304 PZ 267.3350       $ Top of lid
305 PZ 265.748       $ Bottom of lid
c Surface Cards - Standard Tube, Absorber and Retainer
311 RPP -7.4092 7.4092 -7.4092 7.4092 0.0000 274.4470 $  Space inside tube - cavity extent
312 RPP -7.4549 7.4549 -7.4549 7.4549 5.0800 254.5588 $  Fuel tube body
313 RPP -6.4897 6.4897 7.4930 7.6200 7.1120 250.6472 $ Absorber +Y
314 RPP -6.4897 6.4897 7.4549 7.6581 7.1120 250.6472 $ Absorber Clad  +Y
315 RPP -6.7374 6.7374 7.4549 7.6581 7.1120 250.6472 $ Absorber Cover Opening +Y
316 RPP -6.7958 6.7958 7.4549 7.7164 7.0536 250.6472 $ Absorber Cover  +Y
317 RPP 7.4930 7.6200 -6.4897 6.4897 7.1120 250.6472 $ Absorber +X
318 RPP 7.4549 7.6581 -6.4897 6.4897 7.1120 250.6472 $ Absorber Clad  +X
319 RPP 7.4549 7.6581 -6.7374 6.7374 7.1120 250.6472 $ Absorber Cover Opening +X
320 RPP 7.4549 7.7164 -6.7958 6.7958 7.0536 250.6472 $ Absorber Cover  +X
321 RPP -6.4897 6.4897 -7.6200 -7.4930 7.1120 250.6472 $ Absorber -Y
322 RPP -6.4897 6.4897 -7.6581 -7.4549 7.1120 250.6472 $ Absorber Clad  -Y
323 RPP -6.7374 6.7374 -7.6581 -7.4549 7.1120 250.6472 $ Absorber Cover Opening -Y
324 RPP -6.7958 6.7958 -7.7164 -7.4549 7.0536 250.6472 $ Absorber Cover  -Y
325 RPP -7.6200 -7.4930 -6.4897 6.4897 7.1120 250.6472 $ Absorber -X
326 RPP -7.6581 -7.4549 -6.4897 6.4897 7.1120 250.6472 $ Absorber Clad  -X
327 RPP -7.6581 -7.4549 -6.7374 6.7374 7.1120 250.6472 $ Absorber Cover Opening -X
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328 RPP -7.7164 -7.4549 -6.7958 6.7958 7.0536 250.6472 $ Absorber Cover  -X
c Surface Cards - DFC Tube, Absorber and Retainer
411 RPP -7.7394 7.7394 -7.7394 7.7394 0.0000 274.4470 $  Space inside tube - cavity extent
412 RPP -7.7851 7.7851 -7.7851 7.7851 5.0800 254.5588 $  Fuel tube body
413 RPP -6.4897 6.4897 7.8232 7.9502 7.1120 250.6472 $ Absorber +Y
414 RPP -6.4897 6.4897 7.7851 7.9883 7.1120 250.6472 $ Absorber Clad  +Y
415 RPP -6.7374 6.7374 7.7851 7.9883 7.1120 250.6472 $ Absorber Cover Opening +Y
416 RPP -6.7958 6.7958 7.7851 8.0466 7.0536 250.6472 $ Absorber Cover  +Y
417 RPP 7.8232 7.9502 -6.4897 6.4897 7.1120 250.6472 $ Absorber +X
418 RPP 7.7851 7.9883 -6.4897 6.4897 7.1120 250.6472 $ Absorber Clad  +X
419 RPP 7.7851 7.9883 -6.7374 6.7374 7.1120 250.6472 $ Absorber Cover Opening +X
420 RPP 7.7851 8.0466 -6.7958 6.7958 7.0536 250.6472 $ Absorber Cover  +X
421 RPP -6.4897 6.4897 -7.9502 -7.8232 7.1120 250.6472 $ Absorber -Y
422 RPP -6.4897 6.4897 -7.9883 -7.7851 7.1120 250.6472 $ Absorber Clad  -Y
423 RPP -6.7374 6.7374 -7.9883 -7.7851 7.1120 250.6472 $ Absorber Cover Opening -Y
424 RPP -6.7958 6.7958 -8.0466 -7.7851 7.0536 250.6472 $ Absorber Cover  -Y
425 RPP -7.9502 -7.8232 -6.4897 6.4897 7.1120 250.6472 $ Absorber -X
426 RPP -7.9883 -7.7851 -6.4897 6.4897 7.1120 250.6472 $ Absorber Clad  -X
427 RPP -7.9883 -7.7851 -6.7374 6.7374 7.1120 250.6472 $ Absorber Cover Opening -X
428 RPP -8.0466 -7.7851 -6.7958 6.7958 7.0536 250.6472 $ Absorber Cover  -X
c Surface Cards - Disk Stack
601 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 1.7272 88.1380 $ Structural disk
602 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 3.3147 88.1380 $ Structural top disk
603 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 2.0447 88.1380 $ Structural bottom disk
604 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 1.3386 87.7951 $ Heat transfer disk
605 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 1.5875 88.0491 $ Top weldment disk
606 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 2.5400 88.0491 $ Bottom weldment disk
c Surface Cards - Basket
701 RPP -7.7521 7.7521 -7.7521 7.7521 0.0000 274.4470  $ Std opening
702 RPP -8.1890 8.1890 -8.1890 8.1890 0.0000 274.4470  $ DFC opening
703 PY 0.0000       $ Cut plane
704 PX 0.0000       $ Cut plane
c Surface Cards - Canister
901 RCC 0.0000 0.0000 0.0000 0.0000 0.0000 274.4470  88.4428 $ Canister cavity
902 RPP -48.6410 48.6410 -48.6410 48.6410 264.2870 274.4469   $ Canister spacer
903 RCC 0.0000 0.0000 -2.5400 0.0000 0.0000 294.7670  89.7128 $ Canister
c Surface Cards - Storage Cask Geometry
911  RCC 0.0000 0.0000 0.0000 0.0000 0.0000 -58.6740 162.5600 $ Bottom Section Container
912  RCC 0.0000 0.0000 0.0000 0.0000 0.0000 352.5520 162.5600 $ Top Section Container (Not VCC
Lid)
913  CZ 100.3300       $ VCC liner inner
914  CZ 106.6800       $ VCC liner outer
915  RCC 0.0000 0.0000 -5.7150 0.0000 0.0000 5.7150 91.4400 $ Base plate/cover
916  KZ 47.2803 0.1357 -1      $ Baffle weldment bot
917  KZ 45.4435 0.1357 -1      $ Baffle weldment bot void
918  KZ -111.2883 0.1357 1      $ Baffle weldment top
919  KZ -109.4515 0.1357 1      $ Baffle weldment top void
920  PZ -32.0040       $ Baffle middle cut surface
921  PZ -7.8740       $ Baffle top cut surface
922  CZ 63.5000       $ Stand outer
923  CZ 58.4200       $ Stand inner
924 1 RPP -162.5600 162.5600 -15.2400 15.2400 -58.6740 -25.6540  $ Air inlet void
925 1 RPP -162.5600 162.5600 -16.1925 16.1925 -58.6740 -23.1140  $ Air inlet channel
926 2 RPP -162.5600 162.5600 -15.2400 15.2400 -58.6740 -25.6540  $ Air inlet void
927 2 RPP -162.5600 162.5600 -16.1925 16.1925 -58.6740 -23.1140  $ Air inlet channel
928  PZ -56.1340       $ Bottom plate height
929  RPP -25.6540 25.6540 -63.5001 63.5001 -25.6540 -5.7150  $ Stand top cut box
930  RCC 0.0000 0.0000 352.5520 0.0000 0.0000 3.8100 116.2050 $ VCC lid
931  RCC 0.0000 0.0000 347.4720 0.0000 0.0000 5.0800 124.3330 $ Top flange cylinder
932  CZ 102.8700       $ Top flange inner cut cylinder
933  RCC 0.0000 0.0000 331.7240 0.0000 0.0000 20.8280 99.0600 $ Lid concrete enclosure
934  RCC 0.0000 0.0000 332.6765 0.0000 0.0000 19.8755 98.1075 $ Lid concrete
935  RPP -54.2290 54.2290 -162.5600 162.5600 303.6570 336.8040  $ Box for outlet structure
(outside liner)
936  RPP -54.2290 54.2290 -127.0635 127.0635 315.7220 336.8040  $ Upper portion concrete
937  RPP -54.2290 54.2290 -162.5600 162.5600 303.6570 324.7390  $ Lower portion concrete
938  RPP -54.2290 54.2290 -143.2560 143.2560 303.6570 324.7390  $ Lower portion concrete cut
surface
939  RPP -53.2765 53.2765 -138.1760 138.1760 304.6095 335.8515  $ Lower/middle outlet void
940  RPP -53.2765 53.2765 -128.0160 128.0160 314.7695 335.8515  $ Cut box for lower/middle void
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941  RPP -53.2765 53.2765 -162.5600 162.5600 325.6915 335.8515  $ Upper void
942  RPP -162.5600 162.5600 -54.2290 54.2290 303.6570 336.8040  $ Box for outlet structure
(outside liner)
943  RPP -127.0635 127.0635 -54.2290 54.2290 315.7220 336.8040  $ Upper portion concrete
944  RPP -162.5600 162.5600 -54.2290 54.2290 303.6570 324.7390  $ Lower portion concrete
945  RPP -143.2560 143.2560 -54.2290 54.2290 303.6570 324.7390  $ Lower portion concrete cut
surface
946  RPP -138.1760 138.1760 -53.2765 53.2765 304.6095 335.8515  $ Lower/middle outlet void
947  RPP -128.0160 128.0160 -53.2765 53.2765 314.7695 335.8515  $ Cut box for lower/middle void
948  RPP -162.5600 162.5600 -53.2765 53.2765 325.6915 335.8515  $ Upper void
949  RPP -54.2290 54.2290 -106.6800 106.6800 303.6570 315.7220  $ Outlet cut in liner
950  RPP -53.2765 53.2765 -106.6800 106.6800 304.6095 314.7695  $ Portion of outlet in liner
951  CZ 104.1400       $ Air outlet inner radius
*952  RCC 0.0000 0.0000 -78.6740 0.0000 0.0000 455.0360 182.5600 $ Cylinde to reflect

c
c Materials List
c
c Fuel Pellet Material   3.71%  Weight UO2 [amu]  269.94
m1    92235.66c -3.270E-02 92238.66c -8.488E-01  8016.62c -1.185E-01
c SS348 Clad
m2
      24050.62c -7.939E-03 26054.62c -3.927E-02 28058.62c -6.384E-02
      24052.62c -1.590E-01 26056.62c -6.387E-01 28060.62c -2.543E-02
      24053.62c -1.838E-02 26057.62c -1.502E-02 28061.62c -1.124E-03
      24054.62c -4.652E-03 26058.62c -2.019E-03 28062.62c -3.639E-03
                                                28064.62c -9.623E-04
      25055.62c -2.000E-02
c Water
m3     1001.62c -1.119E-01  8016.62c -8.881E-01
mt3  lwtr.01t
c Sec. Fuel - 45 Degree Axis - Exterior   3.94%  Weight UO2 [amu]  269.93
m4     92235.66c -3.473E-02 92238.66c -8.467E-01  8016.62c -1.185E-01
c Third Fuel -Coord. Axis - Exterior   3.64%  Weight UO2 [amu]  269.94
m5     92235.66c -3.209E-02 92238.66c -8.494E-01  8016.62c -1.185E-01
c Lower Nozzle Material
m6
       1001.62c -4.116E-06  8016.62c -3.266E-05
      24050.62c -7.939E-03 26054.62c -3.927E-02 28058.62c -6.384E-02
      24052.62c -1.590E-01 26056.62c -6.387E-01 28060.62c -2.543E-02
      24053.62c -1.838E-02 26057.62c -1.502E-02 28061.62c -1.124E-03
      24054.62c -4.651E-03 26058.62c -2.019E-03 28062.62c -3.638E-03
                                                28064.62c -9.623E-04
      25055.62c -2.000E-02
mt6  lwtr.01t
c Upper Nozzle Material
m7
       1001.62c -1.469E-05  8016.62c -1.165E-04
      24050.62c -7.938E-03 26054.62c -3.927E-02 28058.62c -6.383E-02
      24052.62c -1.590E-01 26056.62c -6.386E-01 28060.62c -2.543E-02
      24053.62c -1.838E-02 26057.62c -1.502E-02 28061.62c -1.124E-03
      24054.62c -4.651E-03 26058.62c -2.019E-03 28062.62c -3.638E-03
                                                28064.62c -9.622E-04
      25055.62c -2.000E-02
mt7  lwtr.01t
c SS304
m8    24050.62c -7.939E-03 26054.62c -3.927E-02 28058.62c -6.384E-02
      24052.62c -1.590E-01 26056.62c -6.387E-01 28060.62c -2.543E-02
      24053.62c -1.838E-02 26057.62c -1.502E-02 28061.62c -1.124E-03
      24054.62c -4.652E-03 26058.62c -2.019E-03 28062.62c -3.639E-03
                                                28064.62c -9.623E-04
      25055.62c -2.000E-02
c Aluminum
m9    13027.62c -1.000E+00
c Carbon Steel
m10   26054.62c -5.594E-02  6000.66c -1.000E-02
      26056.62c -9.098E-01
      26057.62c -2.140E-02
      26058.62c -2.876E-03
c Lead
```

```
m11    82206.66c -2.534E-01
       82207.66c -2.207E-01
       82208.66c -5.259E-01
c NS-F-FR
m12     5010.66c -9.313E-04  7014.62c -1.974E-02  8016.62c -4.250E-01
        5011.66c -3.772E-03  7015.66c -7.852E-05
       13027.62c -2.142E-01  1001.62c -6.001E-02  6000.66c -2.763E-01
c Concrete
m13    26054.62c -7.911E-04 14000.60c -3.370E-01
       26056.62c -1.287E-02
       26057.62c -3.026E-04
       26058.62c -4.067E-05
        1001.62c -1.000E-02 13027.62c -3.400E-02 20000.62c -4.400E-02
        8016.62c -5.320E-01 11023.62c -2.900E-02
c Water Exterior
m14     1001.62c 2.0
        8016.62c 1.0
mt14   lwtr.01t
c Borated Aluminum (Absorber Core / Sheet)
m15     5010.66c -6.011E-02 13027.62c -5.656E-01  6000.66c -9.430E-02
        5011.66c -2.799E-01
c Zirc Alloy
m17    26054.62c -7.063E-05 24050.62c -4.179E-05  7014.62c -4.980E-04
       26056.62c -1.149E-03 24052.62c -8.370E-04  7015.66c -1.981E-06
       26057.62c -2.702E-05 24053.62c -9.673E-05
       26058.62c -3.631E-06 24054.62c -2.448E-05
       40000.66c -9.823E-01 50000.42c -1.500E-02
c SS304/Cu Heat Fin
m18    24050.62c -4.537E-03 26054.62c -2.244E-02 28058.62c -3.648E-02
       24052.62c -9.088E-02 26056.62c -3.650E-01 28060.62c -1.453E-02
       24053.62c -1.050E-02 26057.62c -8.584E-03 28061.62c -6.425E-04
       24054.62c -2.658E-03 26058.62c -1.154E-03 28062.62c -2.079E-03
                                                28064.62c -5.499E-04
       25055.62c -1.143E-02
       29000 -0.4286
c DFC fuel mixture material (if applicable)   Mix Height=264.5in
m19    92235.66c -3.473E-02 92238.66c -8.467E-01  8016.62c -1.185E-01
        1001.62c -3.303E-06  8016.62c -2.621E-05
c DFC fuel mixture material (if applicable)   Mix Height=264.5in
m20    92235.66c -3.208E-02 92238.66c -8.493E-01  8016.62c -1.185E-01
        1001.62c -3.303E-06  8016.62c -2.621E-05
c
c Rotation Matrix
*TR1 0.0 0.0 0.0 45 135 90 -45 45 90 90 90 0  $ z-rotation 45 degrees
*TR2 0.0 0.0 0.0 135 225 90 45 135 90 90 90 0  $ z-rotation 135 degrees
*TR3 0.0 0.0 0.0 15 105 90 -75 15 90 90 90 0  $ z-rotation 15 degrees
*TR4 0.0 0.0 0.0 30 120 90 -60 30 90 90 90 0  $ z-rotation 30 degrees
*TR5 0.0 0.0 0.0 60 150 90 -30 60 90 90 90 0  $ z-rotation 60 degrees
*TR6 0.0 0.0 0.0 75 165 90 -15 75 90 90 90 0  $ z-rotation 75 degrees
*TR7 0.0 0.0 0.0 8 98 90 -82 8 90 90 90 0  $ z-rotation 8 degrees
*TR8 0.0 0.0 0.0 102 192 90 12 102 90 90 90 0  $ z-rotation 102 degrees
*TR9 0.0 0.0 0.0 156 246 90 66 156 90 90 90 0  $ z-rotation 156 degrees
*TR10 0.0 0.0 0.0 78 168 90 -12 78 90 90 90 0  $ z-rotation 78 degrees
*TR11 0.0 0.0 0.0 24 114 90 -66 24 90 90 90 0  $ z-rotation 24 degrees
c
c Cell Importances
c
mode n
imp:n 1 434r 0
c
c
c Criticality Controls
c
kcode 500 1.00 30 430
c Ones source point in each of the fuel assemblies
ksrc
      -5.5007 79.8566 100.00
      11.1599 79.8566 100.00
      -40.8016 63.6032 100.00
      -23.1512 62.2063 100.00
```

```
        -5.5007 62.2063 100.00
        11.1599 62.2063 100.00
        28.8104 62.2063 100.00
        46.4608 63.6032 100.00
        -57.9440 46.4608 100.00
        -39.3575 45.0167 100.00
        -22.3421 45.0167 100.00
        -5.3266 45.0167 100.00
        10.7243 45.0167 100.00
        28.0013 45.0167 100.00
        45.0167 45.0167 100.00
        63.6032 46.4608 100.00
        -56.5471 28.8104 100.00
        -39.3575 28.0013 100.00
        -22.3421 28.0013 100.00
        -5.3266 28.0013 100.00
        10.7243 28.0013 100.00
        28.0013 28.0013 100.00
        45.0167 28.0013 100.00
        62.2063 28.8104 100.00
        -74.1974 11.1599 100.00
        -56.5471 11.1599 100.00
        -39.3575 10.9858 100.00
        -22.3421 10.9858 100.00
        -5.3266 10.9858 100.00
        10.7243 10.7243 100.00
        28.0013 10.7243 100.00
        45.0167 10.7243 100.00
        62.2063 11.1599 100.00
        79.8566 11.1599 100.00
        -74.1974 -5.5007 100.00
        -56.5471 -5.5007 100.00
        -39.3575 -5.0651 100.00
        -22.3421 -5.0651 100.00
        -5.0651 -5.0651 100.00
        10.9858 -5.3266 100.00
        28.0013 -5.3266 100.00
        45.0167 -5.3266 100.00
        62.2063 -5.5007 100.00
        79.8566 -5.5007 100.00
        -56.5471 -23.1512 100.00
        -39.3575 -22.3421 100.00
        -22.3421 -22.3421 100.00
        -5.0651 -22.3421 100.00
        10.9858 -22.3421 100.00
        28.0013 -22.3421 100.00
        45.0167 -22.3421 100.00
        62.2063 -23.1512 100.00
        -57.9440 -40.8016 100.00
        -39.3575 -39.3575 100.00
        -22.3421 -39.3575 100.00
        -5.0651 -39.3575 100.00
        10.9858 -39.3575 100.00
        28.0013 -39.3575 100.00
        45.0167 -39.3575 100.00
        63.6032 -40.8016 100.00
        -40.8016 -57.9440 100.00
        -23.1512 -56.5471 100.00
        -5.5007 -56.5471 100.00
        11.1599 -56.5471 100.00
        28.8104 -56.5471 100.00
        46.4608 -57.9440 100.00
        -5.5007 -74.1974 100.00
        11.1599 -74.1974 100.00
c
c
c Random Number Generator Controls
c
RAND GEN=2 SEED=19073486328127
c
```

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c
c Print Control
c
PRINT
c
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7.0 CONFINEMENT

The NAC-MPC storage system is provided in three configurations. The Yankee-MPC provides storage for up to 36 intact Yankee Class spent fuel assemblies and reconfigured fuel assemblies (RFA). The CY-MPC holds up to 26 Connecticut Yankee spent fuel assemblies, reconfigured fuel assemblies or damaged fuel cans. The MPC-LACBWR provides storage for up to 68 Dairyland Power Cooperative La Crosse Boiling Water Reactor spent fuel assemblies with 32 damaged fuel cans. These three configurations of the NAC-MPC have similar components and operating features, but have different physical dimensions, weights and storage capacities. Confinement features for the Yankee-MPC and CY-MPC systems are addressed in the main body of this chapter. Appendix 7.A has been added to address the MPC-LACBWR system.

The Transportable Storage Canister (canister) provides long-term storage confinement of the Yankee Class and Connecticut Yankee spent fuel. The canister confinement boundary is closed by welding, which presents a leaktight barrier to the release of contents in all of the evaluated normal, off-normal and accident conditions. The method of closing the confinement boundary is the same for both NAC-MPC configurations.

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

The NAC-MPC canister confinement system meets the requirements of 10 CFR 72.24 for protection of the public from release of radioactive material, and 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.

The helium purity level of at least 99.9% maintains the quantity of oxidizing contaminant to less than one mole per canister for all loading conditions. Based on the calculations presented in Sections 4.4.5 and 4.5.5, respectively, the free gas volume of the empty Yankee-MPC or CY-MPC 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 NAC-MPC 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 Impurities and Their Effects on the Dry Storage of LWR Spent Fuel," PNL-6365 are satisfied.

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Appendix 7.A CONFINEMENT – MPC-LACBWR MPC STORAGE SYSTEM FOR DAIRYLAND POWER COOPERATIVE LA CROSSE BOILING WATER REACTOR

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7.A CONFINEMENT IN THE MPC-LACBWR STORAGE SYSTEM

The MPC-LACBWR Transportable Storage Canister (TSC) provides confinement for its radioactive contents in long-term storage. The confinement boundary provided by the TSC is closed by welding, creating a solid barrier to the release of contents in the design basis normal conditions and off-normal or accident events. The welds are visually inspected and nondestructively examined to verify integrity.

The sealed TSC contains helium, an inert gas, at atmospheric pressure. The confinement boundary retains the helium and also prevents entry of outside air into the TSC in long-term storage. The exclusion of air from the confinement boundary precludes fuel rod cladding oxidation failures during storage.

The TSC confinement system meets the requirements of 10 CFR 72.24 for protection of the public from release of radioactive material. The design of the TSC allows the recovery of stored spent fuel should it become necessary per the requirements of 10 CFR 72.122. The TSC meets the requirements of 10 CFR 72.122 (h) 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.

The MPC-LACBWR TSC provides an austenitic stainless steel closure design sealed by welding, precluding the need for continuous monitoring. The analysis for normal conditions and off-normal or accident events demonstrates that the integrity of the confinement boundary is maintained in all the evaluated conditions. Consequently, there is no release of radionuclides from the TSC resulting in site boundary doses in excess of regulatory requirements. Therefore, the confinement design of the MPC-LACBWR system meets the regulatory requirements of 10 CFR 72 [A1] and the acceptance criteria defined in NUREG-1536 [A2].

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7.A.1 MPC-LACBWR Confinement Boundary

The MPC-LACBWR TSC provides the confinement vessel for the radioactive contents.

7.A.1.1 Confinement Vessel

The TSC confinement vessel consists of three principal components: the TSC shell, the bottom plate and the closure lid. The TSC shell is a right-circular cylinder constructed of rolled Type 304/304L (dual certified) stainless steel plate with the edges of the plate joined by full-penetration welds. It is closed at the bottom end by a circular plate joined to the shell by a full-penetration weld. The TSC shell is helium leak tested following fabrication.

After loading, the TSC is closed at the top by a closure lid fabricated from Type 304 stainless steel. It is joined to the TSC shell using a field-installed groove weld. The closure lid-to-TSC shell weld is analyzed, installed and examined in accordance with Interim Staff Guidance (ISG)-15 [A5] and ISG-18 [A4] guidance. This closure lid-to-TSC shell weld is a partial penetration weld progressively examined at the root, midplane and final surface by dye penetrant (PT) examination. Following NDE of the closure lid-to-TSC shell weld, the TSC cavity is reflooded and the TSC vessel is hydrostatically pressure tested as described in the Operating Procedures of Appendix 8A and the Acceptance Test Program of Appendix 9A. The acceptance criteria for the test are no leakage and no loss of pressure during the minimum 10-minute test duration.

After successful completion of the hydrostatic pressure test, the Type 304 stainless steel closure ring is installed in the TSC-to-closure lid weld groove and welded to both the closure lid and the TSC shell. The closure ring welds are inspected by PT examination of the final weld surfaces. The closure ring provides the double-weld redundant sealing of the confinement boundary, as required by 10 CFR 72.236(e). The TSC confinement boundary welds are listed in Table 7.A.1-1.

The closure lid incorporates drain and vent penetrations, which provide access to the TSC cavity for canister draining, drying and helium backfilling operations during TSC closure and placement into storage. The design of the penetrations incorporates features to provide adequate shielding for the operators during these operations and closure welding.

Following final helium backfill, the vent and drain port penetrations are closed with Type 304 stainless steel inner port covers that are partial-penetration welded in place. Each inner port cover weld is helium leak tested. Each inner port cover weld final surface is then PT examined.

A second (outer) port cover is then installed and welded to the closure lid at each of the ports to provide the double-weld redundant sealing of the confinement boundary. The outer port cover weld final surfaces are inspected by PT examination.

Prior to sealing, the TSC cavity is backfilled with helium. The minimum helium purity level of 99.995% (minimum) specified in the Operating Procedures (Appendix 8.A) maintains the quantity of oxidizing contaminants to less than one mole per canister for all loading conditions. Based on the maximum empty canister free volume of 4,000 liters and the design basis helium density, an empty canister would contain approximately 100 moles of gases. Conservatively, assuming that all of the impurities in the helium are oxidants, a maximum of less than 0.1 mole of oxidants could exist in the canister during storage. By limiting the amount of oxidants to less than one mole, the recommended limits for preventing cladding degradation found in the PNL-6365 [A3] are satisfied. The maintenance of a positive helium pressure (e.g., atmospheric or greater) eliminates any potential for in-leakage of air into the TSC cavity during storage operations.

The closure lid weld completed in the field is not helium leakage tested. ISG-18 [A4] provides that an adequate confinement boundary is established for stainless steel spent fuel storage canisters that are closed using a closure weld that meets the guidance of ISG-15 [A5]. The TSC closure weld meets the ISG-15 guidance in that the analysis of the weld considers a stress reduction factor of 0.8. The weld is qualified and performed in accordance with the ASME Code, Section IX [A6] requirements; and the weld is PT examined after the root, midplane and final surface passes. The final surfaces of the welds joining the closure ring to the closure lid and shell, and joining the redundant port covers to the closure lid, are PT examined. The inner port cover welds are helium leakage tested as defined in Appendix 9.A.

During fabrication, the TSC shell and bottom plate welds are volumetrically inspected and the shell assembly is shop helium leakage tested to the leaktight criteria of 1 × 10^{-7} ref cm^3/sec, or 2 × 10^{-7} cm^3/sec (helium), in accordance with ANSI N14.5 [A7] using the evacuated envelope test method. A minimum test sensitivity of 1 × 10^{-7} cm^3/sec (helium) is required.

The loaded TSC is considered and analyzed as having no credible leakage based on: the shop helium leakage testing of the TSC shell, bottom plate and the joining welds; the design analyses and qualifications of the closure lid and port cover welds; the performance of a TSC field hydrostatic pressure test of the closure lid-to-TSC shell weld; the helium leakage test performed on the inner vent and drain port covers; and the multiple NDE performed on all of the confinement boundary welds.

The confinement boundary details at the top of the TSC are shown in Figure 7.A.1-1. The closure is welded by qualified welders using weld procedures certified in accordance with ASME Code, Section IX. Over its 50-year design life, the TSC precludes the release of radioactive contents to the environment and the entry of air or water that could potentially damage the cladding of the stored spent fuel.

7.A.1.2 Confinement Penetrations

Two penetrations fitted with quick-disconnect fittings are provided in the TSC closure lid for operational functions during system loading and sealing operations. The drain port accesses a drain tube that extends into a sump located in the bottom plate. The vent port extends to the underside of the closure lid and accesses the top of the TSC cavity.

After the completion of the closure lid-to-TSC shell weld, TSC pressure test, closure ring welding and cavity draining, the vent and drain penetrations are utilized for drying the TSC internals and contents and for helium backfilling and pressurizing the TSC. After backfilling with helium, both penetrations are closed with redundant port covers welded to the closure lid. As presented for storage, the TSC has no exposed or accessible penetrations and uses no mechanical closures or seals to maintain confinement.

7.A.1.3 Seals and Welds

The confinement boundary welds consist of the field-installed welds that close and seal the TSC and the shop welds that join the bottom plate to the TSC and that join the rolled plates that form the TSC shell. The TSC shell may incorporate both longitudinal and circumferential weld seams in joining the rolled plates. No elastomer or metallic seals are used in the confinement boundary of the TSC.

All cutting, machining, welding, and forming of the TSC vessel are performed in accordance with Section III, Article NB-4000 of the ASME Code, unless otherwise specified in the approved fabrication drawings and specifications. Code alternatives are listed in Table B.3-1 of Appendix 12.B of the Technical Specifications.

Weld procedures, welders, and welding machine operators shall be qualified in accordance with ASME Code, Section IX. Refer to Appendix 9.A for the acceptance criteria for the TSC weld visual inspections and nondestructive examinations (NDE).

The loaded TSC is closed using field-installed welds. The closure lid to TSC shell weld is dye penetrant (PT) examined at the root, at the midplane level and the final surface. After the completion of TSC hydrostatic pressure testing, the closure ring is installed and welded to the TSC shell and closure lid. The final surface of each of the closure ring welds is PT examined. Following draining, drying, and helium backfilling operations, the vent and drain ports are closed with redundant port covers that are welded in place. The inner port cover welds are helium leakage tested. The final surface of each port cover to closure lid weld is PT examined.

Shop and field examinations of TSC confinement boundary welds are performed by personnel qualified in accordance with American Society of Nondestructive Testing Recommended Practice No. SNT-TC-1A [A8]. Weld examinations are documented in written reports.

7.A.1.4 Closure

The closure of the TSC consists of the welded closure lid, the welded closure ring, and the welded redundant vent and drain port covers. There are no bolted closures or mechanical seals in the confinement boundary.

Figure 7.A.1-1 TSC Confinement Boundary

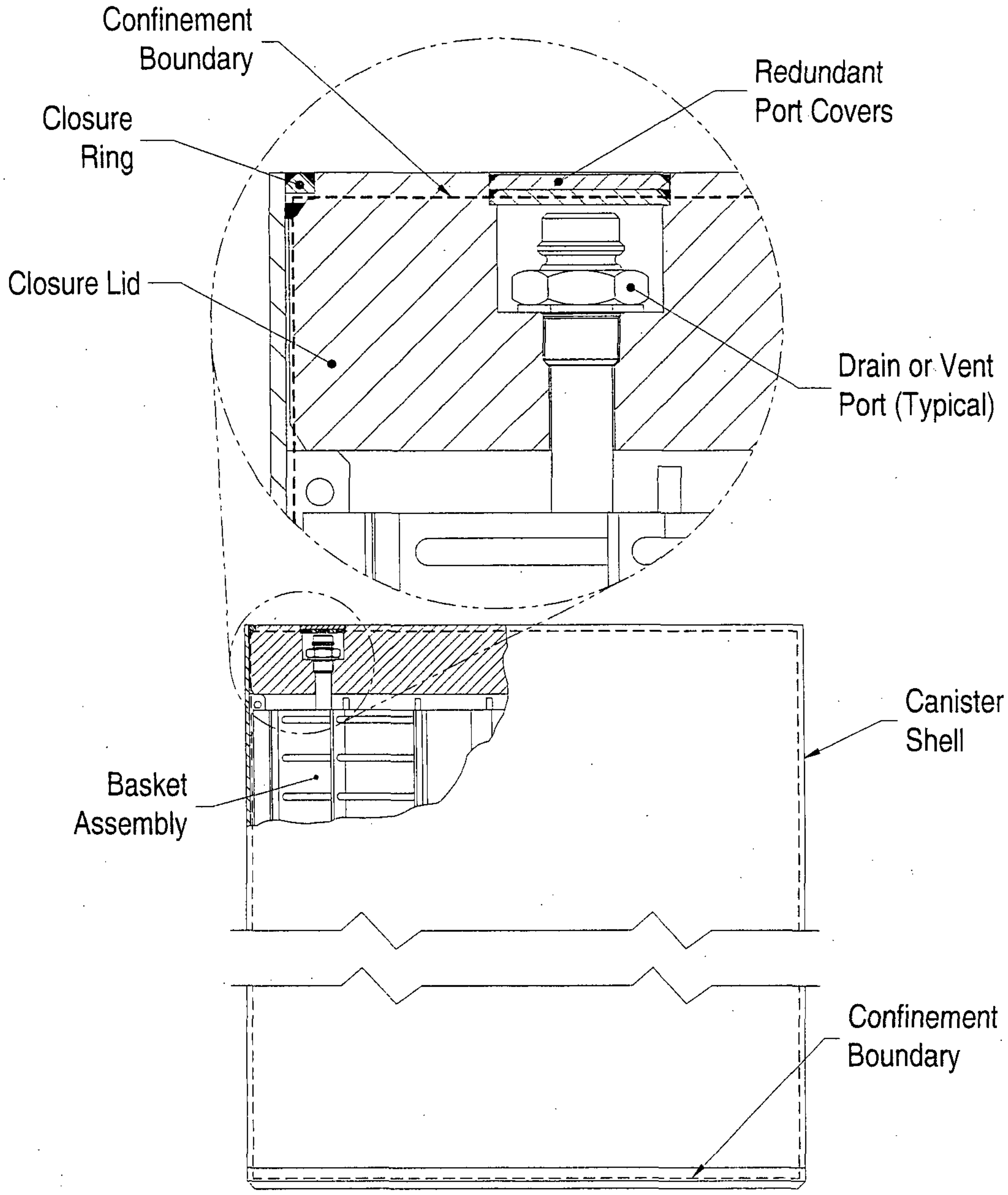

Table 7.A.1-1 TSC Confinement Boundary Welds

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
TSC closure lid to shell	Groove (field weld)	C
Redundant vent and drain port covers to closure lid	Bevel (field weld)	C
Closure ring to TSC shell and to closure lid	Bevel (field weld)	C

7.A.2 Confinement Requirements for Normal Conditions of Storage

The TSC is transferred to a concrete cask using a transfer cask. Once the TSC is placed inside the concrete cask, it is effectively protected from direct structural loading due to natural phenomena, such as wind, snow and ice loading. The principal direct loading for normal operating conditions results from increased internal pressure caused by decay heat, solar insolation and ambient temperature. Loading due to transient handling may occur during the transfer of the loaded TSC to the concrete cask.

7.A.2.1 Release of Radioactive Material

The structural analysis of the TSC for normal conditions of storage presented in Appendix 3.A demonstrates that the confinement boundary is not breached in any of the normal operating events. Therefore, there is no release of radioactive material during normal storage conditions.

7.A.2.2 Pressurization of the Confinement Vessel

The TSC cavity is dried and backfilled with helium prior to installing and welding the vent and drain port covers. Under normal conditions, the internal pressure increases due to an increase in temperature of the helium and the postulated normal storage cladding failure of 1% of the stored fuel rods, which is assumed to release 30% of the available fission gases in the rods.

The TSC, closure lid, fittings and the basket assembly are fabricated from materials that do not react with spent fuel pool water to generate gases. The BORAL® neutron absorber and aluminum sheets in the fuel baskets, as described in Appendix 6.A, are held in place by stainless steel sheathing welded to the fuel tubes. The BORAL® neutron absorber plates are aluminum clad encasing a layer of B_4C, and the BORAL® is protected from excessive oxidation by an oxide film that forms shortly after fabrication of the plates. This oxide layer effectively precludes further oxidation that could result in the generation of gases in the TSC.

The TSC is dried and helium backfilled during closure and, therefore, no significant moisture or other gases, such as air, remain in the TSC. Consequently, there is no potential that radiolytic decomposition could cause an increase in TSC internal pressure or result in a buildup of explosive gases in the TSC. Foreign materials will be excluded from the cavity to ensure that explosive levels of gases due to radiological decomposition will not be generated.

The calculated TSC pressure for normal conditions of storage is presented in Appendix 4.A and is less than the pressure evaluated in Appendix 3.A for the maximum normal operating pressure. Consequently, there is no adverse consequence due to the internal pressure resulting from normal storage conditions.

As the confinement boundary is closed by welding and does not contain seals or O-rings, and the boundary is not ruptured or otherwise compromised under any normal handling event, the release of contents during normal conditions of storage is precluded.

7.A.3 Confinement Requirements for Hypothetical Accident Conditions

The results of the structural analyses of the TSC for off-normal and accident events of storage, presented in Appendix 11.A, show that the TSC is not breached in any of the evaluated events. Consequently, based on the welded closure TSC confinement boundary and the leakage tests described in Section 9.A.2 of Appendix 9.A, the TSC has no credible leakage and, therefore, there is no release of radioactive material during off-normal or accident events of storage.

A hypothetical accident condition assumes the cladding failure of all the fuel rods stored in the TSC. This postulated event results in an increase in TSC internal pressure due to the release of the fission product and fuel rod charge gases. The accident condition internal pressures for the LACBWR fuel configuration is calculated in Appendix 4.A of Chapter 4 and is shown to be less than the design pressure. Consequently, the integrity of the TSC confinement boundary is maintained and there is no release of radioactive material under off-normal or accident events of storage.

Since no release occurs as the result of accident events, the resulting site boundary dose due to a hypothetical accident is less than the 5 rem whole body or organ (including skin) dose at the 100-meter minimum boundary specified by 10 CFR 72.106 (b) for accident exposures.

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7.A.4 References

[A1] 10 CFR 72, Code of Federal Regulations, "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor-Related Greater Than Class C Waste," US Nuclear Regulatory Commission, Washington, DC.

[A2] NUREG-1536, "Standard Review Plan for Dry Cask Storage Systems," Nuclear Regulatory Commission, Washington, DC, January 1997.

[A3] PNL-6365, "Evaluation of Cover Gas Impurities and Their Effects on the Dry Storage of LWR Spent Fuel," Pacific Northwest Laboratory, Richland, Washington, November, 1987.

[A4] ISG-18, "The Design/Qualification of Final Closure Welds on Austenitic Stainless Steel Canisters as Confinement Boundary for Spent Fuel Storage and Containment Boundary for Spent Fuel Transportation," US Nuclear Regulatory Commission, Washington, DC, May 2003.

[A5] ISG-15, "Materials Evaluation," US Nuclear Regulatory Commission, Washington, DC, Revision 0, January 10, 2001.

[A6] ASME Boiler and Pressure Vessel Code, Section IX, "Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators," American Society of Mechanical Engineers, New York, NY, 1995 Edition with 1997Addenda.

[A7] ANSI N14.5-1997. "American National Standard for Radioactive Materials – Leakage Tests on Packages for Shipment," American National Standards Institute, Washington, DC, 1997.

[A8] Recommended Practice No. SNT-TC-1A, "Personnel Qualification and Certification in Nondestructive Testing," The American Society for Nondestructive Testing, Inc., Columbus, OH, edition as invoked by the applicable ASME Code.

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8.0 OPERATING PROCEDURES

This chapter provides general guidance for using the NAC-MPC spent fuel storage system configured for the Yankee-MPC and the CY-MPC for storage operations. MPC-LACBWR operations are addressed in Appendix 8.A. Three operating conditions are addressed. The first is loading the transportable storage canister (canister), installing it in the vertical concrete cask (concrete cask), and transferring it to the storage (ISFSI) pad. The second is the removal of the loaded canister from the concrete cask. The third is opening the canister to remove spent fuel in the unlikely event that this should be necessary. The procedures provided describe acceptable methods of performing the NAC-MPC system loading, unloading and recovery operations. Users may alter these procedures to allow alternate methods and operations to be performed in parallel or out of the given sequence as long as the general intent of the procedure is met. The procedures provided in Sections 8.1, 8.2 and 8.3 can also be appropriately revised to allow dry loading and unloading of the NAC-MPC system.

The operating procedure for transferring a loaded canister from a concrete cask to the NAC Storage Transport Cask (NAC-STC) is described in Section 7.2.2 of the NAC-STC Safety Analysis Report, Docket 71-9235.

In accordance with the Standard Review Plan (NUREG-1536), the operating sequences described in this chapter are intended to provide an effective basis for the development of the more detailed operating and test procedures required by the NAC-MPC system user. The user will use procedures provided by NAC as guidance when preparing and implementing detailed site procedures. The procedures in this chapter show the sequence in which limiting conditions established by the LCOs and Certificate of Compliance should be met, but mechanical operations may be performed in an appropriate sequence. Further, site procedures are expected to include the additional detailed activities that are required to perform the operation sequences.

Operation of the NAC-MPC system requires the use of ancillary equipment items. The ancillary equipment supplied with the system is shown in Table 8.1-1. 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 the canister, have threaded fittings. Table 8.1-2 provides the torque values for installed bolts and hoist rings. In addition, supplemental shielding may be employed to reduce radiation exposure for certain tasks specified by these procedures. The use of supplemental shielding is at the discretion of the User.

The design of the NAC-MPC is such that the potential for spread of contamination during handling and future transport of the canister is minimized. The concrete cask is constructed of new materials. The canister is loaded in the spent fuel pool, but is protected from gross contact with pool water by a jacket of clean water while it is in the transfer cask. Clean water is processed or filtered pool water, or any water external to the spent fuel pool that that has water chemistry that is compatible with use in the pool. Only the top of the open canister is exposed to contaminated pool water. 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 clean.

When the NAC-MPC system is 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 Appendix A of the Certificate of Compliance that is intended to assist the User in complying with the training and dry run requirements of 10 CFR 72. This program addresses the NAC-MPC storage system operational features and requirements.

Appendix 8.A OPERATING PROCEDURES – MPC-LACBWR MPC STORAGE SYSTEM FOR DAIRYLAND POWER COOPERATIVE LA CROSSE BOILING WATER REACTOR

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8.A OPERATING PROCEDURES FOR THE MPC-LACBWR STORAGE SYSTEM

This chapter provides general procedural guidance for the loading, unloading and recovery of the MPC-LACBWR system. This information shall be used to prepare the detailed, site-specific procedures for loading, handling, storing and unloading the MPC-LACBWR system. Users may add, delete or change the sequence of specific steps of the procedures to accommodate site-specific requirements provided that the intent of the tasks associated with Transportable Storage Canister (TSC) closure and storage is preserved and that the specific numerical acceptance criteria, such as: fastener torque values, temperature limits for operations and other defined values in these procedure are also met.

All facility-specific procedures prepared by users must fully comply with the applicable requirements of the NAC-MPC Certificate of Compliance (CoC) and Technical Specifications, including the approved contents and design features.

Equipment and operating requirements will be established by the user prior to implementation. Refer to Table 8.A.1-1 for a listing of the major ancillary equipment generally required by the user to load and close or to open and unload the system. The MPC-LACBWR system provides effective shielding for operations personnel; however, the licensee/user may utilize supplemental shielding to further reduce operator radiation exposure. The planned location, type and possible interactions of the temporary supplemental shielding with MPC-LACBWR components shall be appropriately evaluated by the licensee/user. The MPC-LACBWR system, when operated by properly trained personnel in accordance with the generic procedures provided herein, will meet As Low As Reasonably Achievable (ALARA) guidance for personnel exposure control.

The design features of the MPC-LACBWR system minimize the potential for contamination of the TSC during fuel loading, canister preparation and transfer. The TSC is loaded in the fuel pool, but the external surfaces of the canister are protected from contact with the contaminated pool water by clean water maintained in the annulus between the transfer cask and the TSC. For purposes of the operating procedures, clean water is defined as demineralized, processed or filtered pool water, or any water external to the fuel pool that has water chemistry compatible for use in spent fuel pools. During loading operations, only the TSC closure lid is exposed to the spent fuel pool water. The smooth top surface of the closure lid can be readily decontaminated. Therefore, the TSC external surfaces are expected to be essentially free of removable contamination during long-term storage operations.

Tables in Chapter 3, Appendix 3.A provide the handling weights for the major components of the MPC-LACBWR system and the loads to be lifted during various phases of the loading and unloading operations. Licensees/users must perform appropriate reviews and evaluations to ensure that the lifted loads do not exceed rated load limits of user-supplied lifting equipment and comply with the facility's heavy-load control program.

8.A.1 Loading of the MPC-LACBWR Storage System

The MPC-LACBWR system is used to load, transfer and store used intact, damaged fuel and fuel debris from the La Crosse BWR at the onsite Independent Spent Fuel Storage Installation (ISFSI). Damaged fuel and fuel debris are required to be stored in damaged fuel cans (DFCs). The three principal components of the system are the transportable storage canister (TSC), the transfer cask and the concrete cask. The transfer cask contains and supports the TSC during fuel loading, lid welding and closure operations. The transfer cask, with the transfer adapter, is also used to move the TSC into position for placement in the concrete cask.

These loading procedures are based on three initial conditions:

- the transfer cask is located in a facility's designated workstation for cask preparation
- an empty TSC (properly receipt inspected and accepted) is located in the transfer cask cavity
- an accepted concrete cask is available to receive the TSC when loading and preparation activities are complete

The TSC is filled with clean or filtered pool water, and the transfer cask containing the TSC is lowered into the fuel pool for fuel assembly loading and verification. The user must identify and select the fuel assemblies to be loaded and ensure that all loaded fuel assemblies comply with the Approved Content provisions of the CoC.

Following fuel loading, the closure lid is installed and the transfer cask containing the loaded TSC is lifted from the bottom of the fuel pool and placed in the cask preparation area. The TSC water level is lowered to allow for thermal expansion of the cavity water and the closure lid is welded to the TSC shell. The closure lid-to-shell weld is visual and progressive liquid penetrant (PT) examined. The cavity is refilled, and the TSC is subjected to a hydrostatic pressure test. Following hydrostatic pressure test acceptance, the closure ring, which provides the redundant confinement closure barrier, is installed, welded and inspected.

The TSC cavity water is drained, the residual moisture in the TSC is removed by vacuum drying techniques and the TSC dryness is verified. The TSC is evacuated to ≤ 3 torr (e.g., torr = mm of Hg) and backfilled with high-purity helium to provide an inert atmosphere for the safe long-term storage of the spent fuel contents. System connections to the vent and drain openings are removed and the inner port covers are installed, welded, PT examined and helium leak tested. The outer port covers, which provide the redundant sealing of the confinement boundary, are installed, welded and PT examined. Installation, welding examination and testing of the closure lid, closure ring and port covers complete the assembly of the confinement boundary.

The concrete cask is positioned for the transfer of the TSC and the transfer adapter is installed. The transfer cask containing the loaded TSC is positioned on the transfer adapter on the top of the concrete cask. The TSC is lowered into the concrete cask, and the transfer cask and transfer adapter are removed. The concrete lid assembly is installed and secured to complete the loading process.

The loaded concrete cask is moved onto the ISFSI storage pad using the heavy-haul trailer and air pads, and placed in its long-term storage location.

8.A.1.1 Loading and Closing the TSC

This section describes the sequence of operations to load and close the TSC in preparation for transferring the TSC to the concrete cask. The empty TSC is assumed to be positioned inside the transfer cask located at the designated workstation.

1. Perform gross visual inspection of the TSC and basket internals for foreign materials or debris.
2. Visually inspect the top of the TSC shell and closure lid weld preps.
3. Verify that at least one lock pin or door stop is installed on each transfer cask shield door.
4. Fill the TSC with clean or pool water to approximately 6” from the top.
5. Attach the lift yoke to a crane suitable for handling the loaded TSC, transfer cask and yoke. Position the lift yoke over the transfer cask and engage the lift yoke to the two transfer cask trunnions.

   Note: The temperature of the transfer cask (surrounding ambient air temperature) must be verified to be at or above the minimum operating temperature of 0°F, per Appendix 12.B, Section B 3.4.8 of the Technical Specifications.
6. Lift the transfer cask containing the empty TSC and move it into position above the fuel pool following the prescribed load path.

Note: A protective cover, attached to the bottom of the transfer cask, may be used to prevent imbedding contaminated particles in the shield doors and door rails.

7. Connect the clean water lines to the lower annulus fill ports of the transfer cask. Ensure that the unused ports are closed or capped to prevent pool water in-leakage.
8. Lower the transfer cask to the pool surface and turn on the clean water supply lines to the lower annulus fill ports to fill the transfer cask/TSC annulus.
9. If desired, spray the transfer cask and lift yoke with clean water to wet the exposed surfaces.

   Note: Wetting the components that enter the fuel pool and spraying the components leaving the pool will reduce the effort required to decontaminate the components.
10. Lower the transfer cask as the annulus fills with clean water until the upper annulus fill ports are accessible. Hold this position and connect the clean water annulus fill lines to the upper fill ports. Ensure the unused ports are closed or capped to prevent pool water in-leakage.
11. Lower the transfer cask to the bottom of the pool in the cask loading area.
12. Disengage the lift yoke, visually verify that the lift yoke is fully disengaged and remove it from the pool.
13. Load the previously selected fuel assemblies or DFCs containing damaged fuel assemblies, damaged fuel rods or fuel debris into the TSC basket.

    Note: The fuel assemblies shall be selected in compliance with the requirements of the approved contents specified in Appendix 12.B of the Technical Specifications including limitations on fuel assembly and DFC positions within the basket. Assembly selection and placement within the basket shall be independently verified.
14. Visually verify the fuel assembly identification prior to loading into the TSC to confirm the serial numbers match the approved fuel-loading pattern.

    Note: For DFC contents, the verification shall be performed prior to installing the DFC lid.
15. Install three swivel hoist rings hand tight in three of the six TSC closure lid lift holes. Connect a three-legged sling set to the hoist rings and the crane hook.
16. Raise the closure lid and adjust closure lid rigging to level the closure lid.
17. Move the closure lid over the fuel pool and align the lift yoke (if used) to the transfer cask trunnions and align the closure lid to the match marks of the TSC.

18. Lower the closure lid until it enters the TSC and seats in the top of the TSC. Visually verify closure lid alignment using the match marks.
19. Allow lid sling cables to go slack and disengage lift slings from the crane hook.
20. Install lift yoke to the crane hook, lower the lift yoke into the fuel pool and move the lift yoke into position to engage the transfer cask trunnions. Actuate the lift yoke arms and engage the lift yoke to the trunnions. Apply a slight tension to the yoke and visually verify engagement of the arm to the trunnions.
21. Raise the transfer cask and visually verify that the closure lid is properly seated. Rinse and flush the lift yoke, transfer cask and top of TSC with clean water as the equipment is removed from the pool. Survey the top of the TSC closure lid and the top of the transfer cask to check for radioactive particles.
22. As the transfer cask is removed from the fuel pool, terminate the annulus fill water supply, remove the annulus fill system hoses and allow annulus water to drain into the fuel pool.
23. Following the prescribed load path, move the transfer cask to the designated workstation for TSC closure operations.
24. Disengage the three-legged sling set from the closure lid and the lift yoke from the transfer cask trunnions. Place lift yoke and sling set in storage/lay-down area.
25. Detorque and remove the lifting hoist rings from the closure lid.
26. Using a portable suction pump, remove any standing water from the closure lid weld groove, and the vent and drain ports.
27. Decontaminate the top of the transfer cask and TSC closure lid to allow installation of the welding equipment. Decontaminate external surfaces of the transfer cask.
28. Insert the drain line with a female quick-connector attached to the drain line male quick disconnect nipple through the drain port opening and into the basket drain port sleeve. After insertion, disconnect the female quick-disconnect from the drain port quick disconnect, and remove any contaminated water displaced from the cavity.
29. Torque the drain tube connector to the drain opening to the value specified in Table 8.A.1-2. Confirm the vent port male quick disconnect nipple is properly installed and torqued in the vent port opening.
30. Install a venting device (e.g., hose line) to the vent port quick-disconnect to prevent combustible gas or pressure buildup below the closure lid.

31. Verify that the top of the closure lid is level (flush) with, or slightly above (< 0.25 inch), the top of the TSC shell.

32. At the discretion of the user, establish foreign material exclusion controls to prevent objects from being dropped into the annulus or TSC.

33. Install the welding system, including supplemental shielding if used, to the top of the closure lid.

    Note: At the discretion of the user, supplemental shielding may be installed around the transfer cask to reduce operator dose. Use of supplemental shielding shall be evaluated to ensure its use does not adversely affect the safety performance of the MPC-LACBWR system.

34. Connect a suction pump to the drain port quick-disconnect and verify venting through the vent port quick-disconnect.

35. Operate the suction pump to remove approximately 50 gallons of water from the TSC. Disconnect the suction pump.

    Note: The radiation level may increase as water is removed from the TSC cavity.

    Note: Fuel rods shall not be exposed to air during the 50-gallon pump-down.

36. Attach a hydrogen detector to the vent line. Ensure that the vent line does not interfere with the operation of the weld machine.

37. Sample the gas volume below the closure lid and observe hydrogen detector for H_2 concentration prior to commencing closure lid welding operations. Monitor H_2 concentration in the TSC until the closure lid-to-shell weld root pass is completed.

    Note: If H_2 concentration exceeds 2.4% prior to or during root pass welding operations, immediately stop welding operations. Evacuate the TSC gas volume or purge the gas volume with helium or argon. Verify H_2 levels are <2.4% prior to restarting welding operations.

38. Install shims into the closure lid-to-TSC shell gap, as necessary, to establish a uniform gap for welding. Tack weld the closure lid and shims, as required.

39. Operate the welding equipment to complete the closure lid-to-TSC shell root pass weld in accordance with the approved weld procedure.

40. At the completion of the root pass, discontinue use of the hydrogen detector. Leave the connector and vent tube installed to vent the canister.

Caution: It is necessary to continue to vent the cavity volume below the closure lid to ensure that there is no buildup of hydrogen gas until the completion of closure lid welding.

41. Perform visual and liquid penetrant (PT) examinations of the root pass and record the results.
42. Operate the welding equipment to perform the closure lid-to-shell weld to the midplane between the root and final weld surfaces. Perform visual and PT examinations for the midplane weld pass and record the results.
43. Complete welding through the completion of the final pass of the closure lid weld, perform final visual and PT examinations, and record the results.
44. Perform the hydrostatic test of the TSC as follows:
    a. Connect a drain line to the vent port and a pressure test system to the drain port.
    b. Refill the TSC with clean water until water is observed flowing from the vent port drain line. Close the vent line isolation valve.
    c. Pressurize the TSC to 15 (+2, -0) psig and isolate the TSC.
    d. Monitor the TSC pressure for a minimum of 10 minutes and visually examine the closure lid-to-TSC shell weld for water leakage.
    e. The hydrostatic test is acceptable if there is no observed pressure drop on the test gauge or visible water leakage from the closure lid weld during the test.
    f. Vent the TSC cavity and remove the pressure test system from the drain port and the drain line from the vent line. Reinstall a vent line to the vent port to prevent pressurization of the TSC.
45. Install and tack the closure ring in position in the closure lid-to-TSC shell weld groove.
46. Weld the closure ring to the TSC shell and to the closure lid. Perform visual and PT examinations of the final surfaces of the welds and record the results.
47. Remove the water from the TSC using one of the following methods: a) drain down using a suction pump supplemented with pressurized helium cover gas; or b) blow down using pressurized helium gas.

    Note: Fuel rods shall not be exposed to air during canister draining operations.
48. Connect a drain line with or without suction pump to the drain port connector.
49. Connect a regulated helium gas supply to the vent port connector.

50. Open gas supply valve and start suction pump, if used, and drain water from the TSC until water ceases to flow out of the drain line. Close gas supply valve and stop suction pump.

51. At the option of the user, disconnect suction pump, close discharge line isolation valve, and open helium gas supply line. Pressurize TSC to approximately 10 psig and open discharge line isolation valve to blow down the TSC. Repeat blow down operations until no significant water flows out of the drain line.

52. Disconnect the drain line and gas supply line from the drain and vent port quick-disconnects.

53. Dry the TSC cavity using vacuum drying methods as follows.

    Note: The low maximum decay heat load of the MPC-LACBWR system precludes the need to monitor total vacuum drying times (LCO 3.1.1 provides for unlimited vacuum drying time) in order to maintain the fuel clad temperatures below 806°F.

    Note: At the option of the user, the drain and/or vent port quick-disconnects can be removed and replaced temporarily with suitable straight-through fittings to increase flow area cross-section and to reduce resistance to gas flow. The quick-disconnect fittings must be reinstalled and torqued prior to final helium backfill.

    a. Connect the vacuum drying system to the vent and drain port openings.

    b. Operate the vacuum pump until a vapor pressure of < 10 torr is achieved in the TSC. The time duration for vacuum drying per LCO 3.1.1 is unlimited.

    c. Isolate the vacuum pump from the TSC and turn off the vacuum pump. Observe the vacuum gauge connected to the TSC for an increase in pressure for a minimum period of 10 minutes. If the TSC pressure is ≤ 10 torr at the end of 10 minutes, the TSC is considered dry in accordance with LCO 3.1.2.

54. Upon satisfactory completion of the dryness verification, continue to evacuate the TSC cavity to a pressure of ≤ 3 torr. Isolate the vacuum pump and backfill the TSC cavity with 99.995% (minimum) pure helium to 15 (+2,-0) psia per LCO 3.1.3.

    Note: This Step 55 through Step 18 (of the concrete cask loading procedure, Section 8.A.1.2) must be completed within 25 days in accordance with LCO 3.1.4.

55. Disconnect the vacuum drying helium backfill system from the vent and drain openings. Note the time the helium backfill is completed.

56. Install and weld the inner port cover on the drain port opening.

57. Install and weld the inner port cover on the vent port opening.
58. Perform visual and PT examinations of the final surface of the port cover welds and record the results.
59. Perform helium leak test on each of the inner port cover welds to verify the absence of helium leakage past the inner port cover welds.
60. Install and weld the outer port cover on the drain port opening. Perform visual and PT examinations of the final weld surface and record the results.
61. Install and weld the outer port cover on the vent port opening. Perform visual and PT examinations of the final weld surface and record the results.
62. Remove the weld machine and supplemental shielding if used.
63. Install the transfer cask retaining ring.
64. Install the six swivel hoist rings into the six threaded holes in the closure lid and torque the hoist rings to the value specified in Table 8.A.1-2.
65. Complete final decontamination of the transfer cask exterior surfaces. Perform final TSC canister exterior surface contamination surveys in accordance with LCO 3.2.1.
66. Proceed to Section 8.A.1.2.

8.A.1.2 Transferring the TSC to the Concrete Cask

This loading procedure section assumes that the concrete cask is located on the bed of a heavy-haul trailer sitting on a deflated air pad set under the site-approved crane, the concrete cask lid is not in place and the bottom pedestal plate cover is installed. The hydraulic jacks of the trailer are extended, as appropriate.

1. Using a site-approved crane, place the transfer adapter on the top of the concrete cask.
2. Align the transfer adapter to the concrete cask, and at the option of the user, bolt the adapter to the concrete cask using four (4) socket head cap screws.
3. Connect the hydraulic actuation system to the transfer adapter and verify that the shield door connectors on the adapter plate are in the fully extended position.
4. If not already completed, attach the transfer cask lifting yoke to the site-approved crane. Verify that the transfer cask retaining ring is installed.

5. Install six (6) swivel hoist rings in the TSC closure lid. Verify that the hoist ring threads are fully engaged, and attach two (2) three-legged slings. Stack the slings on the top of the TSC so they are available for use in lowering the TSC into the concrete cask.
6. 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 surrounding air must be verified to be higher than 0°F prior to lifting in accordance with Appendix 12.B, Section B 3.4.8 of the Technical Specifications.
7. Raise the transfer cask and move it to a position above the concrete cask and transfer adapter. Lower the transfer cask, ensuring that the shield door rails and connector tees align with the transfer adapter plate rails and door connectors. Prior to final set-down, remove transfer cask shield door lock bolts/lock pins.
8. Ensure that the shield door connector tees are engaged with the adapter plate door connectors.
9. Disengage the transfer cask lift yoke from the transfer cask.
10. Return the cask site-approved crane hook to the top of the transfer cask and engage the two (2) three-legged slings attached to the TSC. Lift the TSC slightly (approximately 1/2 inch) to take the canister weight off of the transfer cask shield doors.
11. Using the hydraulic system, open the shield doors to access the concrete cask cavity.
12. Lower the TSC into the concrete cask, using a slow crane speed as the TSC nears the bottom of the concrete cask.
13. Disconnect the slings from the crane hook and lower them to the top of the TSC. Close the transfer cask bottom doors.
14. Retrieve the transfer cask lifting yoke and attach the yoke to the transfer cask.
15. Lift the transfer cask off the concrete cask and return it to the decontamination area or designated workstation.
16. Using the site-approved crane, remove the adapter plate from the top of the concrete cask.
17. Remove the swivel hoist rings, slings, and other lifting equipment from the TSC closure lid and install lid hole plugs hand-tight.

18. Using the site-approved crane, retrieve the concrete cask lid and install the lid in the top of the concrete cask and secure using the concrete cask lid bolts. Record the time the concrete cask lid is secured. The total time from 8.A.1.1, Step 56 through 8.A.1.2, Step 18 shall be less than 25 days in accordance with LCO 3.1.4.
19. Ensure that there is no foreign material left at the top of the concrete cask.
20. Retract the trailer hydraulic jacks and tow the heavy-haul trailer containing the loaded concrete cask to the ISFSI.

8.A.1.3 Transporting and Placing the Loaded Concrete Cask

This section of the procedure assumes that the loaded concrete cask is positioned on a heavy-haul trailer.

1. Using a suitable towing vehicle, tow the heavy-haul trailer to the ISFSI storage pad. Position the trailer bed adjacent to the storage pad and verify that the bed of the trailer is approximately at the same height as the pad surface.
2. Lower trailer hydraulic jacks to provide trailer stability.
3. Install bridging plates to cover the gap between the trailer bed and pad surface.
4. Connect air compressor lines to the air pad set control box and start air compressor.
5. Connect appropriate towing/pushing vehicle to the concrete cask to move and restrain the concrete cask.
6. Inflate the air pad set.
7. Move the concrete cask from the bed of the transporter to the designated location on the storage pad.
8. Deflate air pads by turning off the air supply.
9. Install a hydraulic jack in each inlet vent and raise the concrete cask approximately 4 inches.

   Caution: Do not exceed a maximum lift height of 6 inches.
10. Remove the air pads. Ensure that the surface of the storage pad under the cask is free of foreign objects.
11. Lower the concrete cask to the surface.

    Note: Ensure that the centerline spacing between concrete casks is 15 feet minimum.

12. Remove the four (4) hydraulic jacks.
13. Install screens on the inlets and outlets.
14. Install/connect the temperature monitoring equipment, if required, and verify operation.
15. Scribe/stamp the concrete cask name plate to indicate loading date.
16. Perform radiological survey of the concrete cask within the ISFSI array to confirm the concrete dose rates comply with LCO 3.2.2 dose rate limits.
17. Verify operability of the concrete cask heat removal system in accordance with LCO 3.1.6.

Table 8.A.1-1 Major MPC-LACBWR Ancillary Equipment

Item	Description
Air Pad Rig Set	A device consisting of four air pads, a controller, and an air supply source that lifts the concrete cask using air supplied at a high volume.
Annulus Fill System	System that supplies clean/filtered fuel pool water through the transfer cask/TSC annulus using the lower and upper transfer cask fill lines. The system maintains a positive clean water flow to minimize the exposure of the TSC external surfaces to contaminated fuel pool water.
Bottom Protective Cover	Optional plate temporarily attached to the base of the transfer cask to prevent particulate contamination of the transfer cask shield doors and rails.
Canister Upender	Lifting device used to upright a TSC from the horizontal position to a vertical orientation to allow vertical handling for placing the TSC in the transfer cask.
Cask Transporter	A heavy-haul trailer used onsite to move the concrete cask. The loaded concrete cask is transported vertically resting on its base.
Closure Lid Lifting Sling System	Sling system used to install the closure lid into the TSC in the fuel pool. At the user's option, the sling system can be suspended from the lift yoke and used to install the lid and engage the yoke with one crane sequence.
Cooldown System (CDS)	Gas and water system used to cool down the TSC internals and stored fuel to allow the return of the TSC to the fuel pool for the unloading of the fuel assemblies. This system would only be required in the highly unlikely event that a loaded TSC had to be unloaded.
Drain and Blow Down System (DBS)	System used to pump out and/or blow down the water from the TSC cavity prior to the start of drying operations, and to refill the cavity and hydrostatic test the closure lid weld. The system includes the appropriate suction pump, piping/hoses, helium cover gas supply, pressure gauges, and valves to connect to the TSC vent and drain port connections to complete the draining and hydrostatic testing of the cavity.

8.A.1-1 Major MPC-LACBWR Ancillary Equipment (continued)

Item	Description
Hydrogen Detection System	System that detects increased concentration of H_2 in the cavity resulting from material reactions during closure lid welding operations and for closure lid weld removal operations.
Helium Mass Spectrometer Leak Detector (MSLD)	A system utilized to perform the helium leakage testing of the inner vent and drain port cover welds.
Lift Yoke	Device for lifting and moving the transfer cask by engaging the lifting trunnions.
Loaded TSC Sling System	Redundant sling system (two 3-legged slings) used to transfer a TSC into a concrete cask or a transfer cask and meeting the requirements of ANSI N14.6.
Remote/Robotic Welding System	System that completes the closure lid and port cover welds with minimal operator assistance. The system may include video cameras and a recording device to remotely observe the welding activities and to videotape the results of the closure lid PT examinations.
Supplemental Weld Shield	Optional steel plate installed on the closure lid to provide additional shielding to the cask operators during TSC welding, preparation, and test activities. The supplemental weld shield may be installed separately or as the base plate for the welding system.
Vacuum Drying and Helium Backfill System	The system used to vaporize and remove residual water, water vapor, and oxidizing gases from the TSC cavity prior to backfilling with helium. The system includes the appropriate vacuum pump(s), vacuum and pressure gauges, helium supply connections and valves, and hoses to connect the system to the vent and drain connections.
Weld Removal System	Semiautomatic mechanical weld and/or TSC shell cutting system used to remove the closure lid and port cover welds in the unlikely event that a TSC needs to be unloaded.

Table 8.A.1-2 Threaded Component Torque Values

Threaded Component	**Torque Value (ft-lb)**
Concrete Cask Lid Bolts	Snug + 1 wrench flat
Closure Lid Lifting Hoist Rings	
• Lid Handling Only	Hand Tight
• Loaded TSC Handling	Per hoist ring manufacturer's recommendation
Drain Tube Connector	
• Viton, EDPM, or Elastomer Seal	Per seal manufacturer's specs
• Metallic Seal	Per seal manufacturer's specs
Vent Port Connector	
• Viton, EDPM, or Elastomer Seal	Per seal manufacturer's specs
• Metallic Seal	Per seal manufacturer's specs
Concrete Cask Lid Lifting Hoist Rings	Hand Tight

8.A.2 Removal of the Loaded MPC-LACBWR Transportable Storage Canister from the Vertical Concrete Cask

This procedure assumes the loaded concrete cask is returned to the reactor loading facility for unloading. However, transfer of the TSC to another concrete cask can be performed at the ISFSI without the need to return to the loading facility, provided a canister handling cask transfer facility that meets the requirements specified in the Technical Specifications is available.

As the steps to move a loaded concrete cask are essentially the reverse of the procedures in Section 8.A.1.3 and Section 8.A.1.2, the procedural steps are only summarized here.

1. Remove inlet and outlet screens and temperature measuring equipment (if installed).
2. Move the loaded concrete cask to the handling facility.
3. Remove the concrete cask lid.
4. Install the six hoist rings into the canister closure lid threaded holes.
5. Install transfer adapter on top of the concrete cask.
6. Note: The minimum ambient air temperature (either in the facility or external air temperature, as applicable for the handling sequence) must be ≥0°F for the use of the transfer cask, per Appendix 12.B, Section B 3.4.8 of the Technical Specifications.
7. Place transfer cask onto the transfer adapter and engage the shield door connectors.
8. Open the shield doors, retrieve the lifting slings, and install the slings on the lifting system.
9. Slowly withdraw the TSC from the concrete cask. The chamfer on the underside of the transfer adapter assists in the alignment into the transfer cask.
10. Bring the TSC up to just below the retaining ring. Close the transfer cask shield doors and install the shield door lock pins.
11. Lift transfer cask off the concrete cask and move to the designated workstation.

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8.A.3 Wet Unloading the MPC-LACBWR Transportable Storage Canister

This section provides the basic operational sequence to prepare, open and unload a TSC in a spent fuel pool. Due to the rugged design and fabrication of the TSC, users are not expected to perform this operational sequence. However, in accordance with the LCO 3.1.7 of the Technical Specifications, each user shall have the procedures and required equipment available, and perform a dry run of the unloading process.

The procedure that follows assumes that the TSC is in a transfer cask in the appropriate workstation.

1. Remove the retaining ring from the transfer cask.
2. Survey the TSC and transfer cask to establish radiation areas.
3. Install the weld removal system on the closure lid and bolt the system to the closure lid threaded holes.
4. Establish appropriate airborne radiation controls.
5. Using the weld removal system, remove the outer and inner port covers from the vent and drain ports.
6. Remove the weld removal system.
7. Using a vacuum sample bottle, take a gas sample of cavity gas.
8. Determine total gaseous inventory and connect a venting system to the vent connector and route to HEPA filters or to the off-gas system.
9. Determine TSC internal pressure and vent the cavity gas.
10. Once pressure has been reduced to atmospheric, and using appropriate radiological controls, remove the vent and drain quick-disconnects and seals.
11. Replace the quick-connects and seals with approved spares, and torque them to the value specified in Table 8.A.1-2.
12. Attach the cooldown system to the vent and drain connections.
13. Initiate nitrogen gas flow through the TSC to flush out residual radioactive gases. Continue nitrogen flow for a minimum of 10 minutes.
14. Initiate the controlled filling (5 +3/-0 gpm) of the TSC with clean or pool water through the drain connector under controlled temperature (minimum 70°F) and pressure conditions (25 +10/-0 psig). Limit maximum outlet to < 50 psig.
15. Monitor gassteam/water temperature of the discharge from the vent connection.
16. Continue cooldown operations until the discharge water temperature is below 200°F.

17. Terminate cooling water flow and disconnect the cooldown system from the drain and vent ports. Install a vent line to the vent port.
18. Connect a suction pump to the drain connector. Operate the pump and remove approximately 50 gallons of water from the cavity. Disconnect and remove the pump.
19. Remove the drain line from the closure lid.
20. Install the hydrogen detector to the vent line and verify hydrogen gas concentration in the gas volume in the cavity. If the concentration reaches 2.4%, stop all cutting activities and remove cavity gas using a vacuum pump.
21. Install the weld removal system on the closure lid. Operate the weld removal system to remove the closure ring-to-TSC shell and closure ring-to-closure lid welds. Remove the closure ring from the lid area.
22. Operate the weld removal system to remove the closure lid-to-shell weld.
23. Remove shims, if installed, to provide a suitable gap to be able to extract the closure lid under water.
24. Remove the weld removal system.
25. Install three swivel hoist rings into the closure lid threaded holes. Attach three-legged sling set to the hoist rings and the lifting system (or, alternately, the transfer cask lifting yoke).
26. Engage the lift yoke to the transfer cask trunnions and bring the transfer cask over the spent fuel pool.
27. Install lower annulus fill lines and fill the annulus with clean water while lowering the transfer cask.
28. When the trunnions are near the pool surface, install upper annulus fill lines and start clean water flow.
29. Lower the transfer cask to the bottom of the pool. Disengage the lift yoke.
30. Slowly remove the closure lid and move the lid to an appropriate storage area.
    Note: The closure lid may be contaminated and slightly activated.
31. Unload the fuel assemblies and DFCs from the MPC-LACBWR basket.
32. Following fuel unloading, reengage the lift yoke to the transfer cask trunnions and remove the transfer cask from the pool.
33. While the transfer cask is over the pool, stop the flow of water to the annulus, disconnect the upper and lower fill lines, and allow the water in the annulus to drain back into the pool.
34. Place transfer cask and empty TSC in the cask decontamination area or other workstation.
35. Using a suction pump, remove the water from the TSC and pump to radioactive waste drains or return the water to the spent fuel pool designated plant location.

36. Remove and store the contaminated TSC until a determination is made regarding reuse or disposition of the closure lid and TSC.
37. As appropriate, the user may proceed with the loading of the removed fuel assemblies in a new TSC in accordance with the procedures in Section 8.A.1.

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9.0 ACCEPTANCE TESTS AND MAINTENANCE PROGRAM

The NAC-MPC storage system is provided in three configurations. The Yankee-MPC designed for the safe storage of Yankee Class spent fuel, the CY-MPC designed for the safe storage of Connecticut Yankee spent fuel, and the MPC-LACBWR designed for the safe storage of Dairyland Power Cooperative La Crosse Boiling Water Reactor (LACBWR) spent fuel. These three configurations of the NAC-MPC differ in principal dimensions and basket design to accommodate the respective fuel designs and characteristics.

The acceptance tests and maintenance program for the Yankee-MPC and the CY-MPC are addressed in the main body of Chapter 9. The acceptance tests and maintenance program for MPC-LACBWR are presented in Appendix 9.A.

The acceptance criteria and the maintenance program for the NAC-MPC Storage System primary components – the vertical concrete cask (storage cask), transfer cask and the transportable storage canister (canister) – described in this chapter are applicable to both configurations. The design of the NAC-MPC system requires shop fabrication of the canister shell with the bottom plate, the shield and structural lids for the canister, and the basket that holds the spent fuel. The storage cask consists of reinforced concrete placed around steel components that are integral to the performance of the storage cask. These steel components include: a liner that forms the central cavity of the storage cask, a set of air outlet passage-ways that allow cooling to the stored canister, a shield plug, a steel closure lid, and a steel base. The base includes the air inlets and associated pathways, it provides a pedestal upon which the canister rests, and it provides a structural support for raising the storage cask. The steel components are shop fabricated. The reinforcing steel will be fabricated in accordance with ACI 318-95. The storage cask construction will include the erection of the cask liner onto the steel base. The concrete is placed around the liner after the reinforcing steel has been properly erected.

As described in Chapter 8, the storage cask is designed to be lifted using hydraulic jacks and moved using air pads under the base. It does not have lifting trunnions.

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9.1.4.2 Gaskets

The NAC-MPC canister and concrete cask have no mechanical seals or gaskets that form an integral part of the package, and there are no mechanical seals or gaskets in the confinement boundary.

9.1.5 Shielding Tests

Based on the conservative design of the NAC-MPC storage cask for shielding criteria and the detailed construction requirements, no shielding tests of the concrete storage cask are required. However, shielding dose rates of loaded concrete casks are measured in accordance with LCO 3.2.2 of the Certificate of Compliance, to ensure that the average concrete cask surface dose rates do not exceed the design limits.

9.1.6 Neutron-Absorber Tests

Neutron absorber material (commercially available as BORAL®), in the form of sheets consisting of boron-carbide evenly dispersed within a matrix of aluminum and clad with aluminum, is used in the NAC-MPC transportable storage canister fuel baskets. BORAL® used in the Yankee-MPC and CY-MPC systems was 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 to control the weight and to blend the powders were patented and proprietary processes of AAR and, subsequently, of Ceradyne Corporation of Chicoutimi (Quebec), Canada.

After manufacturing, test samples from each batch of BORAL® neutron absorber (poison) sheets shall be tested using wet chemistry or neutron absorption 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.

9.1.6.1 Neutron Absorber Material Sampling Plan

The neutron absorber sampling plan is selected to demonstrate a 95/95 (95% probability and 95% confidence level) statistical confidence level in the neutron absorber sheet material compliance with the specification. In addition to the specified sampling plan, each sheet of material is visually and dimensionally inspected using at least 6 measurements (along the edges near each corner and the longitudinal centerline) on each sheet. No rejected neutron absorber sheet is used. The sampling plan is supported by written and approved procedures.

The sampling plan requires that a coupon sample be taken from each sheet of the first set of 100 sheets of absorber material. Thereafter, coupon samples are taken from 20 randomly selected sheets from each set of 100 sheets. This 1 in 5 sampling plan continues until there is a change in lot or batch of constituent materials of the sheet (i.e., boron carbide powder, aluminum powder, or aluminum extrusion), or a process change, at which time the sampling process is reinitiated as previously described. The sheet samples are indelibly marked and recorded for identification. This identification is used to document neutron absorber test results, which become part of the quality record documentation package.

9.1.6.2 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.

9.1.6.3 Neutron Absorption Test Performance

An approved facility with a neutron source and neutron detection capability shall be selected to perform the described tests, if the neutron absorption test method is used. The tests will assure that the neutron absorption capacity of the material tested is equal to, or higher than, the given reference value and will verify the uniformity of boron distribution. The principle of measurement of neutron absorption is that the presence of boron results in a reduction of neutron flux between the thermalized neutron source and the neutron detector—depending on the material thickness and boron content.

Appendix 9.A ACCEPTANCE TESTS AND MAINTENANCE PROGRAM – MPC –LACBWR MPC STORAGE SYSTEM FOR DAIRYLAND POWER COOPERATIVE LA CROSSE BOILING WATER REACTOR

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9.A ACCEPTANCE CRITERIA FOR THE MPC-LACBWR STORAGE SYSTEM

This Appendix provides the workmanship and acceptance tests to be performed on the MPC-LACBWR System components prior to and during loading operations and the continuing maintenance program requirements. These tests and inspections described herein provide assurance that the MPC-LACBWR components and systems have been procured, fabricated, assembled, inspected, tested and accepted for use under the conditions and controls specified in this document and the Certificate of Compliance.

The acceptance criteria and the maintenance program for the NAC-MPC storage system primary components – the vertical concrete cask (storage cask), transfer cask and the transportable storage canister (canister) – described in this Appendix to Chapter 9 are applicable to the MPC-LACBWR system. The design of the MPC-LACBWR system requires shop fabrication of the canister shell with the bottom plate, the closure lid and ring for the canister, and the basket that holds the spent fuel. The storage cask consists of reinforced concrete placed around steel components that are integral to the performance of the storage cask. These steel components include: a liner that forms the central cavity of the storage cask, a set of air outlet passage-ways that allows cooling to the stored canister, a steel and concrete lid, and a steel base weldment. The base weldment includes the air inlets and associated pathways and provides a pedestal upon which the canister rests. The weldment also provides structural support for the lifting of the storage cask using jacks or air pads. The steel components are shop fabricated. The reinforcing steel will be fabricated in accordance with ACI 318-95 [A7]. The storage cask construction will include the erection of the cask liner onto the steel base weldment. The concrete is placed around the liner after the reinforcing steel has been properly erected.

As described in Chapter 8, the storage cask is designed to be lifted using hydraulic jacks and moved using air pads under the base. It does not have lifting lugs.

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9.A.1 Visual Inspection and Nondestructive Examination

NAC-MPC fabrication, inspection and testing are performed in accordance with the applicable design criteria, codes and standards specified in Chapter 2, on the license drawings and in the Certificate of Compliance (CoC).

The following fabrication controls and inspections shall be performed on the MPC-LACBWR system components to ensure compliance with this document and the license drawings:

a) Materials of construction for the MPC-LACBWR system are identified on the license drawings and shall be procured with certification and supporting documentation as required by the ASME Code, Section II, when applicable, and the requirements of ASME Code, Section III, Subsection NB [A1] and Subsection NG [A6], when applicable.

b) Materials and components shall be receipt inspected for visual and dimensional acceptability, material conformance to the applicable Code specification and traceability markings, as applicable. Materials for the TSC confinement boundary (e.g., TSC shell plates, base plate, closure lid and port covers) shall also be inspected per the requirements of ASME Code, Section III, Subsection NB-2500.

c) The confinement boundary shall be fabricated and inspected in accordance with ASME Code, Section III, Subsection NB, with the code alternatives as listed in Table B3-1 of the Technical Specifications. The TSC fuel basket and basket supports shall be fabricated and inspected in accordance with the ASME Code, Section III, Subsection NG, with the alternatives listed in Table B.3-1 of the Technical Specifications in Appendix 12.B.

d) The steel components of the concrete cask shall be in accordance with ASTM specifications and fabricated in accordance with ASME Code, Section VIII (or fabrication may be in accordance with ANSI/AWS D1.1 [A4]). Inspections of the welded steel components of the concrete cask shall be in accordance with ASME Code, Section VIII or ANSI/AWS D1.1.

e) ASME Code welding shall be performed using welders and weld procedures qualified in accordance with ASME Code, Section IX [A5], and the ASME Code, Section III subsection applicable to the component (e.g., NB, NG or NF). ANSI/AWS code welding may be performed using welders and procedures qualified in accordance with the applicable AWS requirements or in accordance with ASME Code, Section IX.

f) Construction and inspections of the concrete component of the concrete cask shall be performed in accordance with the applicable sections and requirements of ACI-318 [A7].

g) Visual examinations of the welds of the confinement boundary shall be performed in accordance with ASME Code, Section V [A2], Articles 1 and 9, with acceptance per Section III, Subsection NF, Article NF-5360. The final surface of TSC shell welds shall be dye penetrant (PT) examined in accordance with ASME Code, Section V, Articles 1 and 6, with acceptance per Section III, Subsection NB, Article NB-5350. The TSC shell longitudinal and circumferential welds shall be radiographic (RT) examined in accordance with ASME Code, Section V, Articles 1 and 2, with acceptance per Section III, Subsection NB, Article NB-5320. The weld of the TSC baseplate to the TSC shell shall be ultrasonic (UT) examined in accordance with ASME Code, Section V, Articles 1 and 5, with acceptance per Section III, Subsection NB, Article NB-5330. In accordance with ISG-15 [A10], the TSC closure lid to shell weld, performed following fuel loading, shall be PT examined at the root, midplane and final surface in accordance with ASME Code, Section V, Articles 1 and 6, with acceptance per Section III, Subsection NB, Article NB-5350. The closure ring to TSC shell weld and the closure ring to closure lid weld shall be PT examined in accordance with the same code and acceptance criteria as the closure lid to TSC shell weld, except that only the weld final surface will be examined. The inner and outer (redundant) port covers to closure lid welds shall be PT examined at the final surface in accordance with the same code and acceptance criteria as for the closure lid to shell weld. Repairs to TSC vessel welds shall be performed in accordance with ASME Code, Section III, Subsection NB, Article NB-4450, and the welds reinspected per the original acceptance criteria applicable to the examination method.

h) Visual examinations of the welds of the fuel basket and basket supports shall be performed in accordance with ASME Code, Section V, Articles 1 and 9, with acceptance per Section III, Subsection NG, Article NG-5360. Repairs to fuel basket welds shall be performed in accordance with ASME Code, Section III, Subsection NG, Article NG-4450, and the welds reinspected per the original acceptance criteria applicable to the examination method.

i) Visual examinations of the concrete cask structural steel weldments shall be performed in accordance with the ASME Code, Section V, Articles 1 and 9, or ANS/AWS D1.1, Section 6.9, with acceptance per Section VIII, Division 1, Part UW [A3], Articles UW-35 and UW-36, or Table 6.1 of ANSI/AWS D1.1. Repairs to concrete cask structural weldment welds shall be performed in accordance with ANSI/AWS D1.1, and the welds reinspected per the original acceptance criteria.

j) Dimensional inspections of components shall be performed in accordance with written and approved procedures to verify compliance to the license drawings and fit-up of individual components. All dimensional inspections and functional fit-up tests shall be documented.

k) All components shall be inspected for cleanliness and proper packaging for shipping in accordance with written and approved procedures. All components will be free of any foreign material, oil, grease and solvents.

l) Inspection and nondestructive examination personnel shall be qualified in accordance with the requirements of SNT-TC-1A [A11].

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9.A.2 Structural and Pressure Tests

9.A.2.1 Pressure Testing of the TSC

Following completion of the closure lid-to-TSC shell weld during the TSC preparation operations after fuel loading, the TSC shall be hydrostatically pressure tested in accordance with ASME Code, Section III, Subsection NB, NB-6000 requirements as described in operating procedures in Appendix 8A. The minimum test pressure of 15 psig shall be applied to the drain port connection for a minimum of 10 minutes. The minimum test pressure is 125% of the normal design pressure of 12 psig. There shall be no loss in pressure or visible water leakage from the closure lid weld during the 10-minute test period.

9.A.2.2 Transfer Cask Structural Load Testing

The Yankee-MPC Transfer Cask will be utilized for the loading operations of the MPC-LACBWR system. Prior to delivery to the La Crosse BWR site, the Yankee Transfer Cask lifting trunnions and bottom shield doors will be load tested in accordance with the requirements of ANSI N14.6 "Special Lifting Devices for Shipping Containers Weighing 10,000 Pounds (4500 kg) or More" [A8] for nuclear materials.

The load tests shall consist of applying 300 percent of the maximum vertical loads for a minimum of 10 minutes to the lifting trunnions and bottom shield door components. The load tests will be performed in accordance with approved written procedures. The test conditions are:

	Transfer Cask Shield Doors		**Transfer Cask Trunnions**	
NAC-MPC System	**Canister Weight (lbs)**	**Test Load (lbs)**	**Loaded Cask Weight (lbs)**	**Test Load (lbs)**
MPC-LACBWR	65,875	197,625 (+5%, -0%)	146,625	439,875 (+5%, -0%)

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. Similarly, following completion of the bottom shield door load test, all door rail welds and all load bearing surfaces shall be visually inspected for permanent deformation, galling and cracking. Magnetic particle or liquid penetrant examinations, using the method appropriate to the material, shall be performed on accessible trunnion and shield door rail load bearing welds in accordance with

ASME Code Section V, Articles 1, 6 and/or 7, with acceptance in accordance with ASME Code Section III, NF-5340 or NF-5350, as applicable.

Any evidence of permanent deformation, cracking, galling of the load bearing surfaces or unacceptable liquid penetrant or magnetic particle examination results shall be cause for rejection of the affected component.

9.A.2.3 Damaged Fuel Can (DFC) Load Testing

The first MPC-LACBWR damaged fuel can (DFC) shall be load tested at the fabricator to 685 +50, -0 pounds to qualify the DFC design. The test load is calculated as 150% of the weight of the heaviest LACBWR fuel assembly (400 pounds) plus the weight of the damaged fuel can (55 pounds). The test load is applied and held for a minimum of 10 minutes. Following completion of the load test, all load bearing welds and surfaces shall be visually inspected for permanent deformation, galling or cracking. Load bearing welds shall be inspected using liquid penetrant examination in accordance with the ASME Code Section V, Article 6. Acceptance criteria shall be in accordance with ASME Code Section III, NG-5350.

9.A.2.4 Leakage Tests

The MPC-LACBWR confinement boundary is defined as the TSC shell weldment, closure lid, and inner vent and drain port covers. As described in Appendix 7.A.1, the confinement boundary is designed, fabricated, examined and tested in accordance with the requirements of the ASME Code, Section III, Subsection NB, except for the code alternatives listed in Table B.3-1 of the Technical Specifications.

Following welding, the TSC shell weldment shall be leakage tested using the evacuated envelope method as described in ASME Code, Section V, Article 10, and ANSI N14.5-1997 [A9] to confirm the total leakage rate is less than or equal to 1×10^{-7} ref. cm^3/s at an upstream pressure of 1 atmosphere absolute and a downstream pressure of 5 torr or less. Under these test conditions, this corresponds to a test leakage rate of 2×10^{-7} cm^3/s, helium at standard conditions.

The TSC shell weldment will be closed using a test lid installed over the top of the shell and the cavity evacuated with a vacuum pump to a vacuum of 5 torr or less. A test envelope will be installed around the TSC enclosing all of the TSC shell confinement welds, evacuated and backfilled to approximately 1 atmosphere absolute with 99.995% (minimum) pure helium. The percentage of helium gas in the test envelope will be accounted for in the determination of the test sensitivity. A mass spectrometer leak detector (MSLD) will be attached to the test lid and sample the evacuated volume for helium. The minimum sensitivity of the helium MSLD and test system shall be less than or equal to 1×10^{-7} cm^3/s, helium, which is one-half of the allowable leakage criteria for leaktight.

If helium leakage is detected, the area of leakage shall be identified and repaired in accordance with the ASME Code, Section III, Subsection NB, NB-4450. Following repair, the complete helium leakage test shall be performed again to the original test acceptance criteria.

Leakage testing of the TSC shell weldment shall be performed in accordance with written and approved procedures, and the test results documented.

Based on the confinement system materials, welding requirements and inspection methods, leakage testing of the closure lid is not required. To ensure the integrity of the vent and drain inner port cover welds, a helium leakage test of each weld is performed using the evacuated envelope method, as described in ASME Code, Section V, Article 10, and ANSI N14.5. The leakage test is to confirm that the leakage rate for each port cover is $\leq 1\times10^{-7}$ ref. cm^3/s, which corresponds to a helium test leakage rate of $\leq 2\times10^{-7}$ ref. cm^3/s. Following inner port cover welding, a test bell is installed over the top of the port cover and the test bell volume is evacuated to a low pressure by a helium MSLD system. The minimum sensitivity of the helium MSLD shall be $\leq 1\times10^{-7}$ ref. cm^3/s, helium, which is one-half of the allowable leakage criteria for leaktight.

If leakage is detected, the area of leakage shall be identified and repaired in accordance with ASME Code, Section III, Subsection NB, NB-4450. Following repair, the helium leak test shall be reperformed to the original test acceptance criteria.

9.A.2.5 Component Tests

The components of the MPC-LACBWR system do not require any special tests in addition to the material receipt, dimensional, and form and fit tests described above, or as described below.

9.A.2.5.1 Valves, Rupture Disks and Fluid Transport Devices

The MPC-LACBWR canister, concrete cask, and transfer 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 canister vent and drain ports of the closure lid. These valves are intended to be convenience items for the operator, as they provide a means of quickly connecting (or disconnecting) ancillary drain and vent lines to the canister. The quick-disconnect fittings consist of male and female halves. The male fitting is installed in the canister and the female fitting is used as the connecting piece. The male fitting automatically closes when the mating fitting is removed; however, no credit is taken for this sealing feature. During storage and transport, these fittings are not accessible, as port cover plates are welded in place. As presented for storage, the canister has no accessible valves or fittings.

9.A.2.5.2 Gaskets

The MPC-LACBWR canister and concrete cask have no mechanical seals or gaskets that form an integral part of the package, and there are no mechanical seals or gaskets in the confinement boundary.

9.A.2.6 Shielding Tests

Based on the conservative design of the MPC-LACBWR storage cask for shielding criteria and the detailed construction requirements, no shielding tests of the concrete storage cask are required. However, shielding dose rates of loaded concrete casks are measured in accordance with LCO 3.2.2 of the Technical Specifications to ensure that the average concrete cask surface dose rates do not exceed the design limits.

9.A.2.7 Neutron Absorber Tests

Neutron absorber material (commercially available as BORAL®), in the form of sheets consisting of boron-carbide evenly dispersed within a matrix of aluminum and clad with aluminum, is used in the MPC-LACBWR TSC fuel baskets.

After manufacturing, test samples from each batch of BORAL® neutron absorber (poison) sheets shall be tested using wet chemistry or neutron absorption 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.

9.A.2.7.1 Neutron Absorber Material Sampling Plan

The neutron absorber sampling plan is selected to demonstrate a 95/95 (95% probability and 95% confidence level) statistical confidence level in the neutron absorber sheet material compliance with the specification. In addition to the specified sampling plan, each sheet of material is visually and dimensionally inspected using at least 6 measurements (along the edges near each corner and the longitudinal centerline) on each sheet. No rejected neutron absorber sheet is used. The sampling plan is supported by written and approved procedures.

The sampling plan requires that a coupon sample be taken from each sheet of the first set of 50 sheets of absorber material. Thereafter, coupon samples are taken from 10 randomly selected sheets from each set of 50 sheets. This 1 in 5 sampling plan continues until there is a change in lot or batch of constituent materials of the sheet (i.e., boron carbide powder, aluminum powder, or aluminum extrusion), or a process change, at which time the sampling process is reinitiated as previously described. The sheet samples are indelibly marked and recorded for identification. This identification is used to document neutron absorber test results, which become part of the quality record documentation package.

9.A.2.7.2 Wet Chemistry Test Performance

An approved facility with chemical analysis capability shall be selected to perform the wet chemistry tests. The tests will verify the presence of boron and provide input to 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.

9.A.2.7.3 Neutron Absorption Test Performance

An approved facility with a neutron source and neutron detection capability shall be selected to perform the described tests, if the neutron absorption test method is used. The tests will assure that the neutron absorption capacity of the material tested is equal to, or higher than, the given reference value and will verify the uniformity of boron distribution. The principle of measurement of neutron absorption is that the presence of boron results in a reduction of neutron flux between the thermalized neutron source and the neutron detector—depending on the material thickness and boron content.

Determination of neutron absorber material acceptance shall be performed by neutron attenuation testing. Neutron attenuation testing of the final product or the coupons shall compare the results with those for calibrated standards composed of a homogeneous ^{10}B compound. Other calibrated standards may be used, but those standards must be shown to be equivalent to a homogeneous standard. These tests shall include a statistical sample of finished product or test couponstaken from each lot of material to verify the presence, uniform distribution and the minimum areal density of ^{10}B.

9.A.2.7.4 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 BORAL standard, which is based on the ^{10}B areal density specified on the fuel tube drawings. Any specimen not meeting the acceptance criteria for either test method shall be rejected. Nonconforming material shall be evaluated within the NAC International QA Program and shall be assigned one of the following dispositions: "use-as-is," "rework" or "reject." Only material that is determined to meet all applicable conditions of the license will be accepted.

9.A.2.8 Thermal Tests

No thermal acceptance testing of the MPC-LACBWR system is required during fabrication and construction. The thermal analysis of the MPC-LACBWR system in Appendix 4.A, which is limited to a maximum fuel content decay heat load of 4.5 kW, confirms that thermal monitoring of the MPC-LACBWR system in storage operations is not required to ensure system safety.

9.A.2.9 Cask Identification

Each MPC-LACBWR concrete cask will be appropriately identified by a stamped stainless steel nameplate as shown on Drawing No. 630045-864 that will be affixed to the outer surface of the cask.

9.A.3 Maintenance Program

This section presents the maintenance requirements for the MPC-LACBWR system and the transfer cask.

9.A.3.1 MPC-LACBWR System Maintenance

The MPC-LACBWR 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.

The MPC-LACBWR system has no valves, gaskets, rupture discs, seals, or accessible penetrations. Consequently, there is no maintenance associated with these types of features.

Following an off-normal, accident or natural phenomena event, the user shall perform a Response Surveillance of the MPC-LACBWR systems in use at the ISFSI and take corrective actions, as required, in accordance with the requirements of Section A 5.3 of the Technical Specifications.

Annually, or on a frequency established by the user based on the environmental conditions at the ISFSI (i.e., higher inspection frequency may be appropriate at ISFSIs exposed to marine environments, lower frequency for sites located in dry environments, etc.), a program of visual inspections and maintenance of the loaded MPC-LACBWR systems in service shall be implemented. The concrete cask(s) shall be inspected as described herein.

- Visually inspect exterior concrete surfaces for chipping, spalling or other defects. Minor surface defects (i.e., approximately one cubic inch) shall be repaired by cleaning and regrouting.
- Visually inspect accessible exterior coated carbon steel surfaces for loss of coating, corrosion or other damage. The repair of corroded surfaces or surfaces missing coating materials shall be done by cleaning the areas and reapplying corrosion-inhibiting coatings in accordance with the coating manufacturer's recommendations. Exterior surface coatings authorized for use on the exposed carbon steel surfaces of concrete cask are not limited to those defined in Chapter 3 of the MPC FSAR or specified on the original design drawings. The user shall select coating appropriate to the ability to clean and recoat the affected surface areas.

- Visually inspect the installed lid bolts for presence of external corrosion. Excessively corroded, or missing, bolting shall be replaced with approved spare parts.
- Visually inspect the attachment hardware and the integrity of the inlet and outlet screens. Damaged or missing components shall be repaired or replaced with approved spare parts.
- Significant damage or defects identified during the visual inspections that exceed routine maintenance shall be processed as nonconforming items.

The schedule, results and corrective actions taken during the performance of the MPC-LACBWR system inspection and maintenance program shall be documented and retained as part of the system maintenance program.

9.A.3.2 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 (or a period not exceeding 14 months), an inspection and testing program shall be performed on the transfer cask in accordance with the requirements of ANSI N14.6. The following actions or alternatives shall be performed:

- Visually inspect the lifting trunnions, shield doors and shield door rails for permanent deformation and cracking. Carbon steel-coated surfaces will be inspected for chipped, cracked or missing areas of coating, and repaired by reapplication of the approved coating(s) in accordance with the coating manufacturer's recommendations.
- In addition, one of the following testing/inspection methods shall be completed.
- Perform a load test equal to or greater than 300% of the maximum service load and a post-test visual inspection of major load-bearing welds and critical components for defects, weld cracking, material displacement or permanent deformation; or
- If surface cleanliness and conditions permit, perform a dimensional and visual inspection of load-bearing components, and a nondestructive examination of major load-bearing welds.

The annual examination and testing program may be deferred during periods of nonuse of the transfer cask, provided that the transfer cask examination or testing program is performed prior to the next use of the transfer cask. The inspection results and corrective actions taken as part of the maintenance program shall be documented and retained as part of the system maintenance program.

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9.A.4 References

[A1] ASME Boiler and Pressure Vessel Code, Section III, Division I, Subsection NB, "Class 1 Components," 1995 Edition with 1995 Addenda.

[A2] ASME Boiler and Pressure Vessel Code, Section V, "Nondestructive Examination," 1995 Edition with 1995 Addenda.

[A3] ASME Boiler and Pressure Vessel Code, Section VIII, Subsection B, Part UW, "Requirements for Pressure Vessels Fabricated by Welding," 1995 Edition with 1995 Addenda.

[A4] American Welding Society, Inc., "Structural Welding Code - Steel," AWS D1.1-96, 1996.

[A5] 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 1995 Addenda.

[A6] ASME Boiler and Pressure Vessel Code, Section III, Division I, Subsection NG, "Core Support Structures," 1995 Edition with 1995 Addenda.

[A7] American Concrete Institute, "Building Code Requirements for Structural Concrete," ACI-318-95, October 1995.

[A8] American National Standards Institute, "Radioactive Materials - Special Lifting Devices for Shipping Containers Weighing 10,000 Pounds (4,500 kg) or More," ANSI N14.6-1993.

[A9] American National Standards Institute, "Leakage Tests on Packages for Shipment," ANSI N14.5-1997.

[A10] ISG-15, "Materials Evaluation," US Nuclear Regulatory Commission, Washington, DC, Revision 0, January 10, 2001.

[A11] Recommended Practice No. SNT-TC-1A, "Personnel Qualification and Certification in Nondestructive Testing," The American Society for Nondestructive Testing, Inc., Columbus, OH, edition as invoked by the applicable ASME Code.

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10.0 RADIATION PROTECTION

The NAC-MPC is provided in three configurations. The Yankee Class MPC (Yankee-MPC) is designed to store up to 36 Yankee Class spent fuel assemblies. The Connecticut Yankee MPC (CY-MPC) is designed to store up to 26 Connecticut Yankee spent fuel assemblies. The Dairyland Power Cooperative La Crosse Boiling Water Reactor MPC (MPC-LACBWR) is designed to store up to 68 LACBWR spent fuel assemblies, including up to 32 LACBWR damaged fuel cans. The radiation protection features and analysis presented in this chapter apply to both Yankee-MPC configurations, except as noted in the appropriate sections.

Appendix 10.A contains the description of radiation protection features and analysis for the MPC-LACBWR system.

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

The NAC-MPC provides radiation protection for all areas and systems that may expose personnel to radiation or radioactive materials. The components of the NAC-MPC system that require operation, maintenance and inspection are designed, fabricated, located, and shielded to minimize radiation exposure to personnel.

10.1.1 Policy Considerations

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

10.1.2 Design Considerations

The design of the NAC-MPC system complies with the requirement of 10 CFR 72.3 concerning ALARA and meets the requirements of 10 CFR 72.126(a) and 10 CFR 20.1101 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 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 average side surface dose rate to 40 mrem/hr (average) for the Yankee-MPC and 108 mrem/hr for the CY-MPC.
- Nonplanar cooling air pathways to minimize radiation streaming at the inlets and outlets of the concrete cask.
- Optional use of remote, automated outlet air temperature measurement to reduce surveillance time.

10.1.3 Operational Considerations

The ALARA philosophy has been incorporated into the procedural steps necessary to operate the NAC-MPC in accordance with its design. The following features or actions, which comprise a baseline radiological controls approach, have been incorporated in the design or procedures to minimize occupational radiation exposure:

- Use of prefabricated, shaped temporary shielding during automated welding equipment set up and removal, manual welding, and weld inspection of the shielding and structural lids and for use during all of the canister closing and sealing operations.
- 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.

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

Appendix 10.A RADIATION PROTECTION – MPC-LACBWR MPC STORAGE SYSTEM FOR DAIRYLAND POWER COOPERATIVE LA CROSSE BOILING WATER REACTOR

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10.A RADIATION PROTECTION FOR THE MPC-LACBWR STORAGE SYSTEM

This Appendix describes the radiation protection provisions of the MPC-LACBWR storage system. The MPC-LACBWR is designed to store up to 68 Dairyland Power Cooperative (DPC) La Crosse Boiling Water Reactor (LACBWR) spent fuel assemblies, including up to 32 LACBWR damaged fuel cans.

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10.A.1 Ensuring that Occupational Radiation Exposures Are As Low As Reasonably Achievable (ALARA)

The MPC-LACBWR storage system provides appropriate radiation protection features in accordance with the requirements of 10 CFR 20 [A2] for system operations that may expose personnel to radiation or radioactive materials. The components of the system that require operation, maintenance, and inspection are designed to minimize radiation exposure to personnel.

10.A.1.1 Policy Considerations

The MPC-LACBWR system is designed so that operation, inspection, repair, and maintenance can be carried out while maintaining occupational exposure As Low As Reasonably Achievable (ALARA).

10.A.1.2 Design Considerations

When used in accordance with its design, the MPC-LACBWR system maintains occupational radiation exposures ALARA while meeting overall system performance objectives. The following specific design features demonstrate the ALARA philosophy:

- Material selection and surface preparation that facilitate decontamination.
- A basket configuration that allows spent fuel loading using accepted standard practices and current experience.
- Positive clean water flow in the transfer cask/TSC annulus to minimize the potential for contamination of the TSC surfaces during in-pool loading.
- Passive confinement, thermal, criticality, and shielding systems that require no maintenance.
- Thick steel and concrete shells in the storage system, and a steel/lead/neutron shield/steel configuration in the transfer system.
- Nonplanar cooling air pathways with respect to the spent fuel assembly source regions to minimize radiation streaming at the concrete cask inlets and outlets.

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

10.A.1.3 Operational Considerations

The ALARA philosophy has been incorporated into the procedural steps necessary to operate the MPC-LACBWR system in accordance with its design. The following features or actions, which comprise a baseline radiological controls approach, have been incorporated in the design or procedures to minimize occupational radiation exposure:

- Use of a prefabricated weld shield as a base for the welding system during welding equipment setup, removal, welding, and weld inspection of the closure lid, closure ring, and port covers. The weld shield is used during the TSC closing and sealing operations.

- Use of remote manual or automatic equipment for welding the closure lid and closure ring.

- Decontamination of the exterior surface of the transfer cask and welding of the closure lid while the TSC remains filled with water. (Personnel exposures reported in this chapter are based on a conservative dry TSC shielding evaluation.)

- Use of quick-disconnect fittings at vent and drain port penetrations to facilitate auxiliary system connections.

- Use of remote handling equipment, where practicable, to reduce radiation exposure. The operational procedures at a particular facility will be determined by the user's operational conditions and facilities.

10.A.2 Radiation Protection Design Features

The detailed description of the MPC-LACBWR radiation shielding design is provided in Appendix 5.A. Radiation protection features and site exposures are based on cask surface dose rates and fluxes determined in Appendix 5.A for a bounding source description. The bounding source description includes the conservative application of maximum cobalt content assembly hardware, maximum burnup, minimum cool time, and minimum enrichment fuel source to every fuel assembly location within the basket. In combination with the other analysis inputs described in Appendix 5.A, such as applying the minimum average concrete density allowed by the drawing to the bulk shield, this analysis configuration produces significantly higher dose rates and site exposures than those expected during implementation of the MPC-LACBWR system at the utility ISFSI.

The principal radiation protection design features are the shielding necessary to meet the design objectives, the placement of penetrations near the edge of the TSC lid to reduce operator exposure and improve access, and a weld shield used for work on and around the closure lid. Use of the weld shield reduces operator exposure during the welding, inspection, draining, drying and helium backfilling operations.

Radiation exposure rates at various work locations were determined with the MCNP5 code within the vicinity of a single transfer and concrete cask and the NAC-CASC code (a modified SKYSHINE-III version) for the concrete cask array. These codes generated bounding dose rate profiles at various distances from the transfer and concrete cask, which are used to estimate the operator exposures for loading and routine operations.

10.A.2.1 Design Basis for Normal Storage Conditions

The radiation protection design basis for the MPC-LACBWR storage cask is derived from 10 CFR 72 [A1] and the applicable ALARA guidelines. The design basis surface dose rates and the calculated one meter dose rates are shown in Appendix 5.A, Section 5.A.1, Table 5.A.1-1.

10.A.2.2 Design Basis for Accident Conditions

Damage to the MPC-LACBWR storage system after a design basis accident will not result in a radiation exposure at the controlled area boundary in excess of 5 rem to the whole body or any organ, including skin. The high-energy missile impact is estimated to reduce the concrete shielding thickness, locally at the point of impact, by 6 inches. Dose rates and the analysis method for this accident are listed in Appendix 5.A., Section 5.A.4.3. There are no other design basis accident conditions that result in a greater estimated loss of shielding.

Two hypothetical accident events that evaluate storage cask tip-over and the rupture of 100% of the fuel rods are considered in Appendix 11.A. There are no design basis events that result in the tip-over of the MPC-LACBWR storage cask or the release of any radioactive material from the canister.

10.A.3 Estimated On-Site Collective Dose Assessment

Operations personnel exposure estimates are based on identifying the operational cask sequence, estimating the duration and number of personnel required to perform the tasks, determining the location of the personnel in relation to the cask, and multiplying the dose rates at the particular task location by the number of personnel and the task duration. The operational tasks identified are based on the MPC-LACBWR operating procedures provided in this document and operational experiences in loading other canister-based systems.

A collective dose estimate is provided for placing a single MPC-LACBWR on the ISFSI, and for exposures related to routine storage operations of a 5-cask ISFSI. Each cask in the array is assumed to be loaded with the contents that produce the maximum dose rate.

The personnel exposure estimates associated with loading and routine operations are presented in Table 10.A.3-1 and Table 10.A.3-2. The estimated durations, task sequences, and personnel requirements are based on the MPC-LACBWR design features, operational experiences in loading systems of similar design, and operational and equipment improvements based on previous experience. These estimates are provided to allow the user to perform ALARA evaluations on MPC-LACBWR implementation and use, and to establish personnel exposure guidelines for operating personnel. The site-specific design features, location and configuration of workstations, equipment staging, standard practices, operating crew size, temporary shielding use, etc., will result in personnel exposures that may be higher or lower than those presented.

10.A.3.1 Estimated Dose Due to Loading

The estimated dose due to loading operations considers the collective dose due to the loading, closure, transfer, and placement of a single TSC containing bounding fuel assembly contents. This analysis assumes that the exposure incurred by the operators is independent of background radiation, as background will vary with site conditions. A 2 mrem/hr dose rate is assigned to tasks not performed within four meters of the equipment or component surface. An example for these tasks is the monitoring of the operation of the welding system using cameras. This task may be performed at more than four meters from the cask body, and behind significant auxiliary shielding. The number of persons allocated to task completion is generally the minimum number of actual operators required for the task and excludes supervisory, health physics, security, and other nonoperating personnel.

Area dose rates are assigned based on the orientation of the worker(s) with respect to the source for a given operational task or sequence. Exposure estimates are shown in Table 10.A.3-1. The number of individual tasks required for loading and transfer of the TSCs is collapsed to eight groups for this presentation. Dose rates shown are time-averaged values across the individual subtasks. Activities 7 and 8 of Table 10.A.3-1 include a crane operator who is considered to be outside of the radiation zone around the cask. Exposures due to loading operations are based on design basis casks.

10.A.3.2 Estimated Dose Due to Routine Operations

Once the MPC-LACBWR is in storage at the ISFSI, limited ongoing maintenance and surveillance will be required. The annual dose evaluations presented herein consider the tasks that are anticipated to be representative of an operational facility. Exposure due to certain events, such as clearing the material blocking the air vents, is taken into account.

Routine operations may include the following:

- An optional daily electronic measurement of ambient air and outlet air temperatures for each TSC in service. Outlet temperature measurements are recorded at a location away from the cask array, and operators are not expected to incur dose as a result of the temperature measurement.
- An optional inspection of the concrete cask inlet and outlet screens to verify that they are unobstructed. The time required to perform the inspection, and the expected dose, will be site-specific due to ISFSI pad dimensions and configurations, the concrete cask array, distance of the inspector, etc.
- A daily inspection of the security fence and equipment surrounding the ISFSI storage area. This surveillance is assumed to require 15 minutes and is performed by one security officer.
- 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 30 minutes, and be performed quarterly by one health physics technician.

- Annual visual inspection of the general condition of the concrete casks. This inspection is estimated to require 10 minutes per cask and require one technician. For each cask, three minutes of health physics support is also included.

- Corrective maintenance. As the MPC-LACBWR is a passively cooled and shielded system, no significant maintenance is expected over the lifetime of the IFSFI. To account for activities such as minor concrete repairs, air inlet and outlet cleaning, or temperature-monitoring equipment replacement, 20% of the array (one cask) is assumed to require maintenance each year. Maintenance exposure is evaluated based on two operators for 30 minutes each and one health physics technician for 10 minutes.

- Grounds maintenance performed twice a month by one maintenance technician. Grounds maintenance is assumed to require 60 minutes.

Storage operation exposures for a 5-cask array of MPC-LACBWR concrete casks loaded with TSCs containing bounding fuel assembly sources are presented in Table 10.A.3-2. ISFSI exposures are based on design basis casks.

Table 10.A.3-1 Estimated Person-mrem Exposure for Loading Operations of a Single MPC-LACBWR Storage Cask

Step	Description	# Sub-Tasks	# Personnel	Exposure Duration (min)	Average Dose Rate (mrem/hr)	Exposure (mrem)
1	Fuel Assembly Loading and Transfer Cask Removal from Pool	4	2	1605	2.0	108
2	HP Survey and Decon Top of TSC/Transfer Cask	3	1	30	8.0	4
3	Install Weld Shield/Weld Machine, and Perform Partial Drain of TSC	4	1	45	5.3	4
4	Perform Closure Lid and Ring Welding and PT Exams, Hydrostatically Test TSC	16	1	480	8.1	65
5	Drain TSC and Decontaminate Transfer Cask	5	1	230	4.2	16
6	Dry TSC Cavity, Backfill/Pressure TSC, Install Port Covers, Weld and Inspect Covers, Remove Weld Shield/Weld Machine, and Survey Cask/TSC Surfaces	13	1	505	6.5	55
7	Install Hoist Rings, Place Transfer Cask on Concrete Cask, Transfer TSC, Install Concrete Cask Lid, and Perform HP Survey	17	2	220	37.4	137
8	Move Concrete Cask to ISFSI, Position Concrete Cask on ISFSI Pad, and Install/Connect Screens and Temperature Measuring System	11	2	180	4.3	13
	Total					402

Table 10.A.3-2 Estimate of Annual Occupational Exposures Due to Routine Operations for a 5 MPC-LACBWR Storage Cask Array

Activity	**Location**	**# of Casks**	**Frequency (/year)**	**Time (min)**	**Dose Rate (mrem/hr)**	**# of Personnel**	**Exposure (mrem)**
Security Surveillance	Outside Fence	Array	365	15	2	1	183
Radiological Surveillance	4 m	Array	4	30	3.7	1	7
Annual Inspection	1 m	5	1	10	10.4	1	9
Radiological Support	1 m	5	1	3	10.4	1	3
Corrective Maintenance	1 ft	1	1	30	13.3	2	13
Radiological Support	1 m	1	1	10	10.4	1	2
Grounds Maintenance	Outside Fence	Array	26	60	2	1	52
Total Person-mrem for the Array							269
Total Person-mrem - Average Dose Per Cask							54

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10.A.4 Exposures to the Public

The MPC-LACBWR 5-cask array shown in Figure 10.A.4-1 is evaluated to determine the minimum distance necessary to achieve a controlled area boundary dose of 25 mrem/year as required by 10 CFR 72.104(a). NAC's Version 6.0.1 of the SKYSHINE-III code (NAC-CASC) is used to evaluate the placement of the controlled area boundary for the cask array. Given the source geometry, spectra and desired detector locations, SKYSHINE-III calculates dose rates using a combination of pre-calculated transmission and reflection data and the Monte Carlo technique to integrate over the source direction and energy variables.

Version 6.0.1 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.

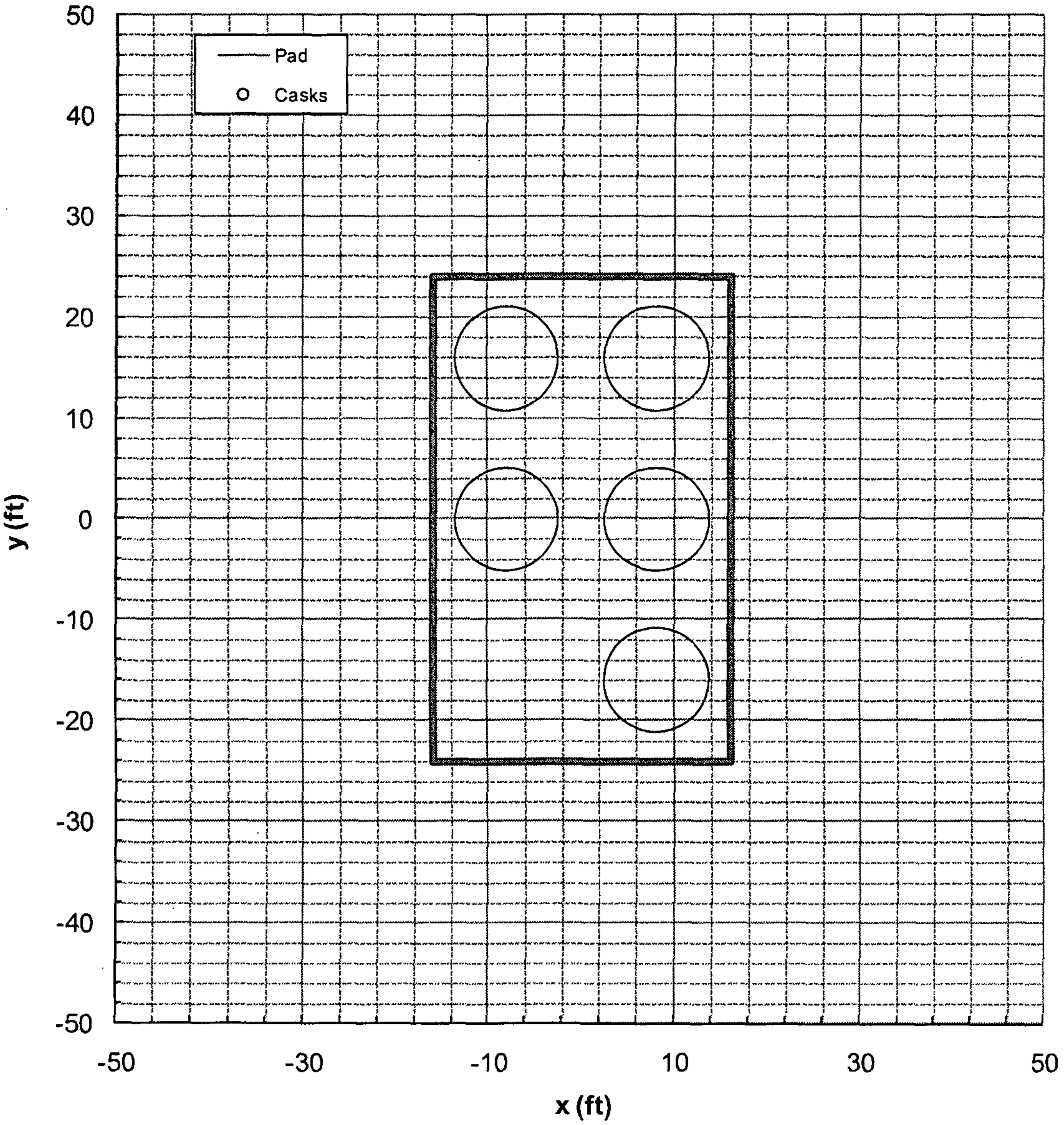
The performance of the SKYSHINE-III Code is benchmarked by modeling a set of Kansas State University ^{60}Co skyshine experiments and by modeling two Kansas State University neutron computational benchmarks. The code compared well with these benchmarks for both neutron and gamma doses versus distance.

While these analyses are performed for typical arrays of casks containing design-basis spent fuel assemblies, full compliance with the requirements of 10 CFR 72.104(a) can only be demonstrated on a site-specific basis. Consequently, each ISFSI licensee performs a site-specific dose analysis for the facility to show that the requirements of 10 CFR 72 are met. Site-specific boundary distances may vary significantly based on fuel type, fuel cooling time, exposure duration and number of casks in service.

The MPC-LACBWR 5-cask array is explicitly modeled in the code, with the source term from each cask represented as top and side surface sources. The cask surface source strength is provided from the three-dimensional MCNP shielding evaluation. The top and side source energy distributions for both neutron and gamma radiation are taken from the design basis cask results in Appendix 5.A. Table 10.A.4-1 and Table 10.A.4-2 list the total neutron and gamma source strengths based on the cylindrical area on the side of the storage cask and the circular area on the top of the storage cask.

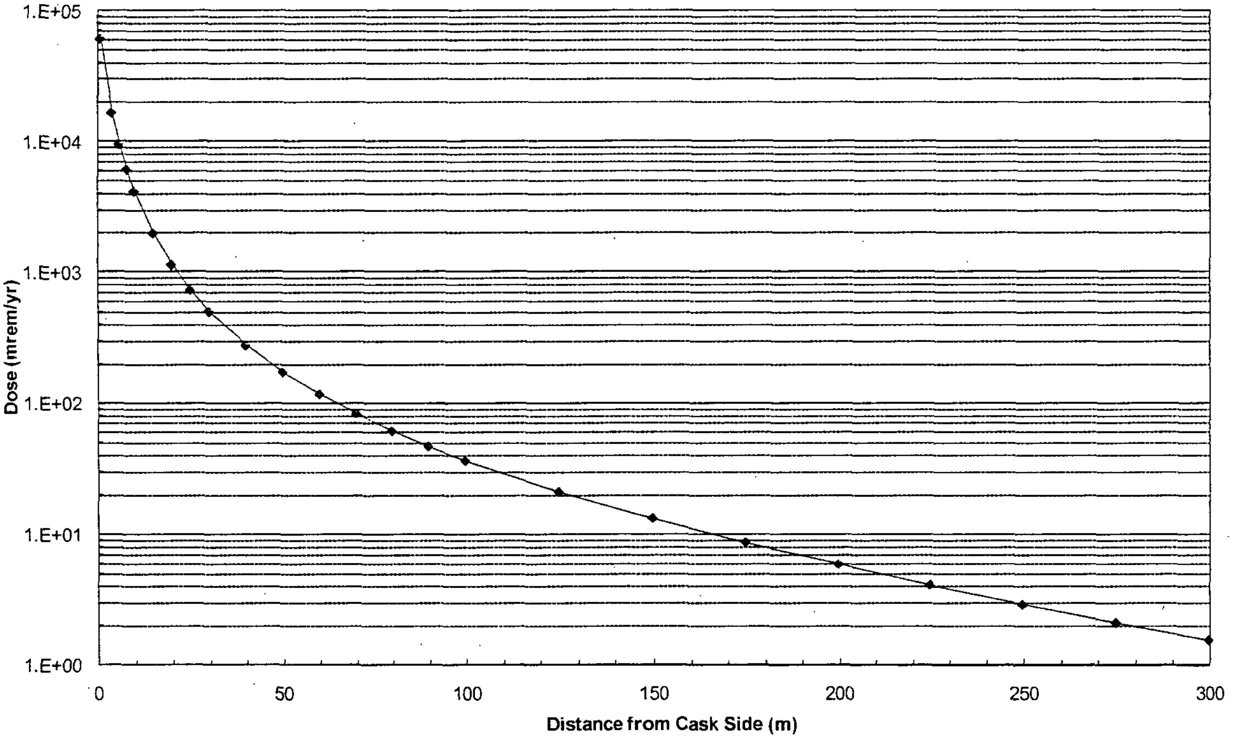
Annual exposures, based on an 8760-hour residence year, were determined from the center of a single cask and a 5-cask array and are shown in Figure 10.A.4-2 and Figure 10.A.4-3, respectively. Figure 10.A.4-4 includes a plot of the 25 mrem/year footprint and the resultant rectangular site boundary. An enveloping boundary around the ISFSI, using these dimensions, will ensure compliance with the requirements of 10 CFR 72.104(a), i.e., a dose rate not exceeding 25 mrem/year.

Figure 10.A.4-1 Layout of 5-Cask Array



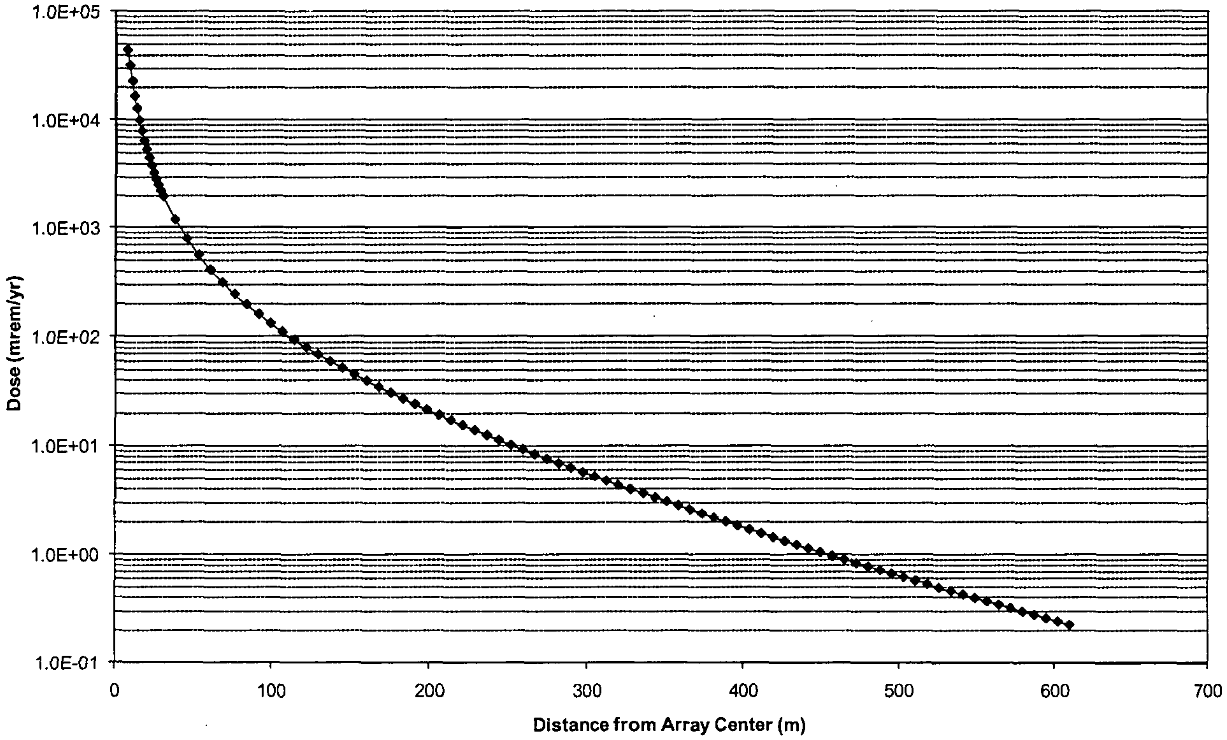
Note: Cask pitch of 16 feet is assumed for analysis.

Figure 10.A.4-2 Exposures from a Single Cask



Distance (m)	Dose Rate (mrem/year)					
	Radial Gamma	Radial Neutron	Axial Gamma	Axial Neutron	Total n-γ	Total
10	4.07E+03	1.35E+01	6.23E+00	3.64E-01	1.08E+01	4.10E+03
25	7.13E+02	2.59E+00	3.25E+00	1.97E-01	7.19E-03	7.19E+02
50	1.69E+02	7.11E-01	1.60E+00	9.89E-02	1.90E-04	1.71E+02
100	3.54E+01	1.82E-01	5.77E-01	3.59E-02	7.79E-05	3.62E+01
125	2.05E+01	1.12E-01	3.75E-01	2.33E-02	6.78E-05	2.10E+01
150	1.27E+01	7.37E-02	2.50E-01	1.56E-02	6.19E-05	1.31E+01
175	8.32E+00	5.05E-02	1.70E-01	1.07E-02	5.88E-05	8.56E+00
200	5.64E+00	3.58E-02	1.17E-01	7.47E-03	5.52E-05	5.80E+00
225	3.93E+00	2.59E-02	8.16E-02	5.30E-03	5.26E-05	4.04E+00
250	2.79E+00	1.92E-02	5.74E-02	3.81E-03	4.97E-05	2.87E+00
275	2.02E+00	1.44E-02	4.08E-02	2.78E-03	4.66E-05	2.08E+00
300	1.48E+00	1.10E-02	2.91E-02	2.05E-03	4.34E-05	1.52E+00

Figure 10.A.4-3 Exposures from a 5-Cask Array



Distance (m)	Dose Rate (mrem/year)			
	Gamma	Neutron	n-γ	Total
50	6.58E+02	3.25E+00	2.48E-03	6.61E+02
100	1.30E+02	8.49E-01	7.04E-04	1.31E+02
150	4.66E+01	3.48E-01	3.90E-04	4.70E+01
200	2.07E+01	1.68E-01	2.88E-04	2.09E+01
250	1.03E+01	8.92E-02	2.37E-04	1.04E+01
300	5.46E+00	5.02E-02	1.99E-04	5.51E+00
350	3.04E+00	2.96E-02	1.65E-04	3.07E+00
400	1.75E+00	1.82E-02	1.37E-04	1.77E+00
450	1.03E+00	1.15E-02	1.10E-04	1.05E+00
500	6.26E-01	7.41E-03	8.76E-05	6.33E-01
550	3.85E-01	4.89E-03	6.87E-05	3.90E-01
600	2.42E-01	3.28E-03	5.31E-05	2.45E-01

Figure 10.A.4-4 Controlled Area Boundary Determination for a 5-Cask Array

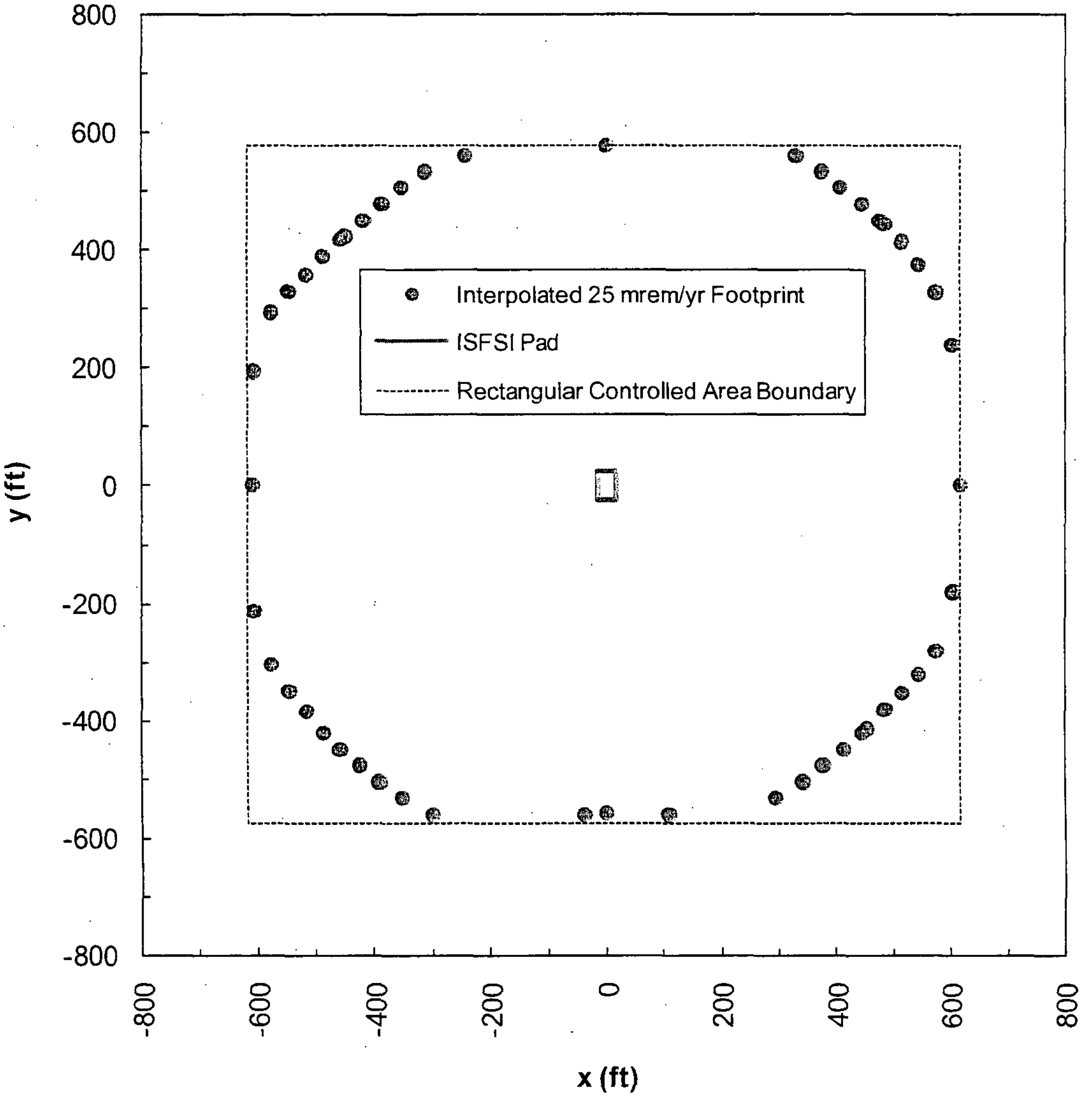


Table 10.A.4-1 MPC-LACBWR Neutron Surface Currents

Group	E Lower [MeV]	E Upper [MeV]	Surface Current [/sec]	
			Radial	Top Axial
1	1.360E+01	1.460E+01	0.000E+00	0.000E+00
2	1.250E+01	1.360E+01	0.000E+00	0.000E+00
3	1.125E+01	1.250E+01	0.000E+00	0.000E+00
4	1.000E+01	1.125E+01	2.038E+01	0.000E+00
5	8.250E+00	1.000E+01	5.653E+01	1.273E+01
6	7.000E+00	8.250E+00	2.251E+02	1.021E+01
7	6.070E+00	7.000E+00	4.991E+02	2.418E+01
8	4.720E+00	6.070E+00	1.680E+03	3.594E+01
9	3.680E+00	4.720E+00	1.843E+03	1.004E+02
10	2.870E+00	3.680E+00	2.173E+03	3.058E+02
11	1.740E+00	2.870E+00	2.119E+04	1.790E+03
12	6.400E-01	1.740E+00	2.356E+04	1.006E+04
13	3.900E-01	6.400E-01	1.753E+04	1.147E+04
14	1.100E-01	3.900E-01	5.338E+04	4.139E+04
15	6.740E-02	1.100E-01	1.595E+04	1.077E+04
16	2.480E-02	6.740E-02	2.615E+04	1.502E+04
17	9.120E-03	2.480E-02	3.456E+04	2.994E+04
18	2.950E-03	9.120E-03	2.179E+04	9.580E+03
19	9.610E-04	2.950E-03	1.964E+04	9.516E+03
20	3.540E-04	9.610E-04	1.808E+04	7.857E+03
21	1.660E-04	3.540E-04	1.312E+04	6.171E+03
22	4.810E-05	1.660E-04	2.167E+04	1.078E+04
23	1.600E-05	4.810E-05	2.105E+04	1.030E+04
24	4.000E-06	1.600E-05	2.500E+04	1.346E+04
25	1.500E-06	4.000E-06	1.512E+04	9.271E+03
26	5.500E-07	1.500E-06	1.811E+04	8.014E+03
27	7.090E-08	5.500E-07	2.968E+05	2.988E+04
28	1.000E-11	7.090E-08	7.439E+05	3.625E+04
Total	--	--	1.413E+06	2.720E+05

Table 10.A.4-2 MPC-LACBWR Gamma Surface Currents

Group	E Lower [MeV]	E Upper [MeV]	Surface Current [/sec]	
			Radial	Top Axial
1	1.20E+01	1.40E+01	0.000E+00	0.000E+00
2	1.00E+01	1.20E+01	8.420E+02	3.096E+01
3	8.00E+00	1.00E+01	4.721E+04	7.182E+03
4	6.50E+00	8.00E+00	5.221E+05	5.750E+04
5	5.00E+00	6.50E+00	4.472E+05	3.126E+04
6	4.00E+00	5.00E+00	4.955E+05	2.704E+04
7	3.00E+00	4.00E+00	5.939E+05	3.566E+04
8	2.50E+00	3.00E+00	2.750E+05	1.866E+04
9	2.00E+00	2.50E+00	8.755E+05	3.352E+04
10	1.66E+00	2.00E+00	1.539E+06	2.123E+04
11	1.44E+00	1.66E+00	5.377E+06	3.736E+04
12	1.22E+00	1.44E+00	1.602E+08	5.362E+06
13	1.00E+00	1.22E+00	2.555E+08	9.967E+06
14	8.00E-01	1.00E+00	3.137E+08	1.472E+07
15	6.00E-01	8.00E-01	4.968E+08	2.580E+07
16	4.00E-01	6.00E-01	7.374E+08	8.537E+07
17	3.00E-01	4.00E-01	4.858E+08	8.234E+07
18	2.00E-01	3.00E-01	6.096E+08	8.675E+07
19	1.00E-01	2.00E-01	1.034E+09	6.107E+07
20	5.00E-02	1.00E-01	5.650E+08	4.088E+06
21	2.00E-02	5.00E-02	1.522E+07	7.878E+04
22	1.00E-02	2.00E-02	2.349E+05	1.508E+04
Total	--	--	4.684E+09	3.758E+08

10.A.5 References

[A1] 10 CFR 72, "Licensing Requirements for the Storage of Spent Fuel in an Independent Spent Nuclear Fuel, High-Level Radioactive Waste, and Reactor-Related Greater Than Class C Waste," US Nuclear Regulatory Commission, Washington, DC.

[A2] 10 CFR 20, "Standards for Protection Against Radiation," US Nuclear Regulatory Commission, Washington, DC.

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11.0 ACCIDENT ANALYSIS

The analyses of the off-normal and accident design events, including those identified by ANSI/ANS 57.9-1992, are presented in this section. Section 11.1 describes the off-normal events that could occur during the use of the NAC-MPC storage system, possibly as often as once per calendar year. Section 11.2 addresses very low probability events that might occur once during the lifetime of the ISFSI or hypothetical events that are postulated because their consequences may result in the maximum potential impact on the surrounding environment. Section 11.3 describes the design basis load conditions for the Yankee-MPC transportable storage canister. As described in Section 11.3, the canister is analyzed for loads imposed during transportation. These transport condition loads envelope the loads for the storage condition analyzed herein.

This chapter demonstrates that the NAC-MPC satisfies the requirements of 10 CFR 72.24 and 10 CFR 72.122 for off-normal and accident conditions. These analyses are based on conservative assumptions to ensure that the consequences of off-normal conditions and accident events are bounded by the reported results. The actual response of the NAC-MPC system to the postulated events will be much better than that reported, i.e., stresses, temperatures, and radiation doses will be lower than predicted. If required for a site-specific application, a more detailed evaluation could be used to extend the limits defined by the events evaluated in this section.

The NAC-MPC is provided in three configurations. The first is designed to store up to 36 intact Yankee Class spent fuel and reconfigured fuel assemblies and is referred to as the Yankee-MPC. The second is designed to store up to 26 Connecticut Yankee fuel assemblies, reconfigured fuel assemblies or damaged fuel cans and is referred to as the CY-MPC. The third configuration is designed to store up to 68 Dairyland Power Cooperative La Crosse Boiling Water Reactor (LACBWR) spent fuel assemblies, including up to 32 LACBWR damaged fuel cans, and is referred to as MPC-LACBWR.

The off-normal and accident conditions evaluation for each configuration is presented separately when appropriate due to differences in capacity, weight and principal dimensions. The off-normal and accident conditions evaluation for the MPC-LACBWR configuration is presented in Appendix 11.A.

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11.1 Off-Normal Events

This section evaluates postulated events that might occur once during any calendar year of operations. The actual occurrence of any of these events is unlikely.

The NAC-MPC is provided in three configurations. The first is designed to store up to 36 intact Yankee Class spent fuel and reconfigured fuel assemblies and is referred to as the Yankee-MPC. The second is designed to store up to 26 Connecticut Yankee fuel assemblies, CY-MPC reconfigured fuel assemblies, and CY-MPC damaged fuel cans and is referred to as the CY-MPC. The third configuration is designed to store up to 68 Dairyland Power Cooperative La Crosse Boiling Water Reactor (LACBWR) spent fuel assemblies, including up to 32 LACBWR damaged fuel cans, and is referred to as MPC-LACBWR.

The off-normal condition evaluation for each configuration is presented separately when appropriate due to differences in capacity, weight and principal dimensions. The postulated off-normal events evaluation for the MPC-LACBWR storage system is presented in Section 11.A.1 of Appendix 11.A.

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11.2 Accidents

This section provides the results of analyses of the design basis and hypothetical accident conditions evaluated for the NAC-MPC system. The analyses presented show that the NAC-MPC system has substantial design margin of safety and provides protection to the public and to occupational personnel. In addition to these design basis accidents, this section addresses very low probability events that might occur over the lifetime of the ISFSI or hypothetical events that are postulated because their consequences may result in the maximum potential impact on the immediate environment.

The NAC-MPC is provided in three configurations. The first is designed to store up to 36 intact Yankee Class spent fuel and reconfigured fuel assemblies and is referred to as the Yankee-MPC. The second is designed to store up to 26 Connecticut Yankee fuel assemblies, CY-MPC reconfigured fuel assemblies or CY-MPC damaged fuel cans and is referred to as the CY-MPC. The third configuration is designed to store up to 68 Dairyland Power Cooperative La Crosse Boiling Water Reactor (LACBWR) spent fuel assemblies, including up to 32 LACBWR damaged fuel cans, and is referred to as MPC-LACBWR.

The accident conditions evaluation for each configuration is presented separately when appropriate due to differences in capacity, weight and principal dimensions. The accident conditions evaluation for the MPC-LACBWR configuration is presented in Section 11.A.2 of Appendix 11.A.

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11.3 Design Basis Loading of the Yankee-MPC Transportable Storage Canister

The Transportable Storage Canister (canister) is designed to be stored in the Yankee-MPC storage cask and transported in the NAC Storage Transport Canister (NAC-STC). The NAC-STC is licensed to transport spent fuel in accordance with 10 CFR 71 and has been issued Certificate of Compliance Number 71-9235. An amendment to the Safety Analysis Report (SAR) for the NAC-STC has been approved, in conjunction with this Safety Analysis Report for storage of Yankee class fuel, to include the loaded Yankee-MPC canister as authorized contents.

The load condition imposed on the canister and its basket by the transport conditions—including the 30 foot end and side impacts and the fire accident—are more rigorous than those imposed by design basis storage normal, off-normal and accident conditions.

Sections 11.1.2 and 11.2.11 use the results of analysis performed for transport end and side impact conditions to show adequate performance of the canister in the off-normal handling condition (Section 11.1.2) and of the canister and basket in the 6-inch concrete cask drop accident (Section 11.2.11). This section summarizes the transport analysis upon which the results of Sections 11.1.2 and 11.2.11 are based. The canister and basket are evaluated in accordance with ASME Code Section III, Subsection NB, and Subsection NG, respectively.

The complete evaluation of the transport normal and accident conditions loading on the canister and basket is presented in the NAC-STC SAR, Docket Number 71-9235. The design basis loading of the MPC-LACBWR transportable storage canister is evaluated in Section 11.A.3 of Appendix 11.A.

11.3.1 Yankee-MPC Canister Impact Analysis

The canister is a right-circular shell fabricated from rolled 5/8-inch thick, Type 304L stainless steel plate and closed by a 1-inch thick, Type 304L stainless steel plate that is welded to one end of the shell. The canister is closed at the top end by the installation and welding of the 5-inch thick, Type 304 stainless steel shield lid and the 3-inch thick, Type 304L stainless steel structural lid.

11.3.1.1 Yankee-MPC Canister Finite Element Model Description

A finite element model of the canister was constructed using ANSYS solid (SOLID45) elements. The model represents a one-half (180°) section of the canister and basket. The basket support discs were modeled with three-dimensional shell (SHELL63) elements. The model uses gap-spring elements to simulate contact between adjacent components. Interaction between the basket and canister were accomplished using three-dimensional gap elements (CONTACT52) along the periphery of the support disks. Contact between the canister and the cask inner shell is also modeled using CONTACT52 gap elements. Contact between the canister structural lid and shield lid is modeled using COMBIN40 combination elements in the axial degree of freedom. Simulation of the backing ring is accomplished using a ring of COMBIN40 spring gap elements connecting the shield lid and the canister in the axial direction at the lid lower outside radius. In addition, CONTACT52 elements are used to model interaction between the structural lid and canister shell and the shield lid and canister shell just below the respective lid weld joints. The size of the CONTACT52 gaps were determined from the nominal dimensions of contacting components. The COMBIN40 elements used between the structural and shield lids and for the backing ring were assigned small gap sizes of 1E-8 inches. All gap-spring elements are assigned a stiffness of 1E8 lb/in.

Boundary conditions were applied to enforce symmetry at the plane of symmetry of the model. All nodes on the cask shell side of the canister to cask spring gap elements were fixed in all degrees of freedom. In addition, the axial and inplane rotational degrees of freedom of the basket nodes were fixed.

Figure 11.3.1.1-1 is a plot of the entire canister finite element model. An isolated view of the canister shield and structural lids portion of the model is presented in Figure 11.3.1.1-2 and an enlarged view of the model in the structural lid and shield lid weld regions is shown in Figure 11.3.1.1-3. The canister bottom plate portion of the model is shown in Figure 11.3.1.1-4. Identification of the sections for evaluating the linearized stresses in the canister is shown in Figure 11.3.1.1-5.

In the bottom end impact orientation, the fuel weight as well as the basket weight are transferred to the canister bottom plate. In the finite element model, the canister content weight is represented by applying a pressure load to the surface of the canister bottom plate. The support

11.4 Evaluation of Site Specific Fuel Components

Site-specific fuel components are structures designed to hold fuel assemblies, individual fuel rods, or fuel debris configurations that are not in a standard fuel assembly. The fuel assemblies and the individual fuel rods may be classified as intact, failed or damaged. For fuel rods and fuel debris, the fuel fixture design typically incorporates fuel tubes in a lattice array. The fuel tubes hold the fuel rods or debris in a known geometry during storage normal, off-normal and accident conditions. The design of the fixture is reactor site specific in that the design accommodates the range of fuel conditions, dimensions and handling requirements that exist at the site.

This section presents the evaluation of site-specific fuel components used with the Yankee-MPC and CY-MPC configurations of the NAC-MPC storage system. The evaluation of the site-specific fuel components used with the MPC-LACBWR system is presented in Section 11.A.4 of Appendix 11.A.

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Appendix 11.A ACCIDENT ANALYSIS – MPC-LACBWR MPC STORAGE SYSTEM FOR DAIRYLAND POWER COOPERATIVE LA CROSSE BOILING WATER REACTOR

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11.A ACCIDENT ANALYSIS FOR THE MPC-LACBWR STORAGE SYSTEM

The analyses of the MPC-LACBWR storage system for off-normal and accident design events, including those identified by ANSI/ANS 57.9-1992 [A1], are presented in this appendix. The analyses of off-normal events, which could occur during the use of the MPC-LACBWR storage system as often as once per calendar year, are described in Section 11.A.1. The analyses of accident conditions, which are postulated events that have a very low probability of occurrence (e.g., may occur once during the lifetime of the ISFSI) or have consequences that may result in maximum potential impact on the surrounding environment, are described in Section 11.A.2. The analyses of the MPC-LACBWR transportable storage canister for design basis transportation accident conditions are described in Section 11.A.3.

This appendix demonstrates that the MPC-LACBWR storage system satisfies the requirements of 10 CFR 72.24 and 10 CFR 72.122 for off-normal and accident conditions. The analyses are based on conservative assumptions to ensure that the consequences of off-normal conditions and accident events are bounded by the reported results. In many cases, the accident analyses of the Yankee-MPC storage system are shown to bound those of the MPC-LACBWR storage system, and are conservatively used for the evaluation of the MPC-LACBWR storage system.

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11.A.1 Off-Normal Events for the MPC-LACBWR Storage System

This section presents the evaluation of the MPC-LACBWR storage system for off-normal events that, although unlikely to occur, are postulated to occur on the order of one time per calendar year of operation.

11.A.1.1 Blockage of Half of the Air Inlets

This section evaluates the MPC-LACBWR storage cask for the steady state effects of a blockage of one-half of the air inlets at the normal ambient temperature (75°F).

11.A.1.1.1 Cause of Event

The most likely causes of a partial blockage of the concrete cask air inlets is the accumulation of snow or debris at the base of the concrete cask or an obstruction caused by intrusion of a burrowing animal. It is expected that screens over the inlets would preclude such animals and would exclude debris from the inlet channels.

Blockage of the concrete cask air inlets would be detected by the daily visual inspection of the concrete cask inlet screens. However, it is not necessary to detect this event since it will not cause the maximum component temperatures to exceed those reported in Section 4.A (Table 4.A.3-3) for normal condition. The analysis for normal condition documented in Section 4.A is based on the conservative assumption of the no air follow in the inlets, outlets, and the concrete cask annulus region.

11.A.1.1.2 Analysis of the Blockage Event

Off-normal temperature conditions are evaluated using the thermal models described in Section 4.A.3.1.1 for the MPC-LACBWR. Since air flow is neglected in the thermal model, the analysis results for the normal storage condition bound the analysis results for the condition due to one-half of the air inlets being blocked. The analysis results are listed in Table 4.A.3-3.

The evaluations show that the component temperatures are within the allowable temperature range for the one-half of the inlets blocked condition.

11.A.1.1.3 Radiological Consequences

There are no radiological consequences for this event.

11.A.1.1.4 NAC-MPC Performance

There are no adverse consequences for this off-normal condition. The maximum component temperatures are less than the allowable temperatures. The MPC-LACBWR concrete cask continues to perform its thermal function with one-half of the air inlets blocked.

11.A.1.1.5 Recovery and/or Corrective Actions

The debris blocking the inlets does not have to be removed.

11.A.1.2 Canister Off-Normal Handling Load

The MPC-LACBWR canister is evaluated for off-normal handling loads that are postulated to occur during the canister transfer operations. For this condition, the MPC-LACBWR canister, suspended by the shield lid lift points, is subjected to simultaneous acceleration loads of 0.5*g* in the vertical direction and 0.7071g in the horizontal direction (i.e., 0.5*g* acting along two orthogonal horizontal axes.) These off-normal handling loads are evaluated in combination with dead weight and normal internal pressure loads.

11.A.1.2.1 Cause of Event

Off-normal canister handling is postulated to result from canister misalignment, faulty crane operation, or inattention of the operators during canister transfer operations. An off-normal canister handling event would most likely be detected by the crew performing the canister transfer operation due to banging and/or scraping noise.

11.A.1.2.2 Analysis of Canister Off-Normal Handling Event

The stresses in the MPC-LACBWR canister due to the combined loading of dead weight, off-normal handling, and internal pressure loads are calculated using the finite element model shown in Figure 11.A.1.2.2-1. This is the same model used for the MPC-LACBWR canister normal condition stress analysis, as described in Section 3.A.4.4.1.1, but includes the basket support disks in order to properly simulate the interaction between the basket and shell under transverse loading conditions. Gap elements are used to simulate the contact between the basket support disks and canister shell and between the canister shell and transfer cask cavity. The initial gap sizes are determined using the nominal dimensions of the contacting components.

Vertical and horizontal acceleration loads of 1.5*g* and 0.7071*g*, respectively, are applied to the model to account for the combined effects of dead weight and off-normal handling. The vertical load from the canister contents is applied as a uniform pressure load acting on the inside surface of the cansiter bottom plate. The horizontal loading from the canister contents includes an acceleration load of 0.7071*g* to account for the support disks that are included in the model and applied forces to account for the remainder of the canister contents. The horizontal load from the basket components that are not modeled (i.e., fuel assemblies, fuel tubes, and heat transfer disks) is assumed to be evenly distributed between the support disks that are included in the model.

A design off-normal internal pressure is calculated based on the condition of 10 percent fuel rod failure with 30 percent fission gas release at a conservative gas temperature of 475 °F. The calculated off-normal internal pressure is 10.1 psig. A bounding design internal pressure load of 12 psig is applied to the inside surfaces of canister shell, bottom plate, and lid elements in combination with dead weight and off-normal handling loads.

The linearized membrane and membrane plus bending stress components and stress intensities at each canister stress section identified in Figure 3.A.4.4.1-2 due to the combined dead weight, off-normal handling, and normal internal pressure loads are summarized in Tables 11.A.1.2.2-1 and 11.A.1.2.2-2, respectively. The allowable stresses and the corresponding margins of safety are also summarized in Tables 11.A.1.2.2-1 and 11.A.1.2.2-2. The results of the analysis show that the MPC-LACBWR canister satisfies the applicable allowable stress design criteria for the off-normal handing event.

As noted in Table 11.A.1.2.2-2, the bending stress at the bottom plate-to-shell junction is classified as secondary stress in accordance with Table NB-3217-1 if the edge moment is not required to maintain the bending stress at the center of the bottom plate to within acceptable limits. To demonstrate this, the bending stress at the center of the bottom plate is determined using hand calculations (Roark), treating it as a simply-supported circular plate subjected to a uniform pressure load. For a combined pressure load of 28.2 psi from the 1.5*g* dead weight plus off-normal handling load (i.e., 16.2 psi pressure load) and design internal pressure (12 psig), the membrane plus bending stress at the center of the bottom plate is calculated to be 28.28 ksi. The allowable primary membrane plus bending stress intensity, based on Type 304 stainless steel properties at a bounding design temperature of 400°F, is 33.48 ksi. Therefore, the edge moment is not required to maintain the bending stress at the center of the bottom plate to within acceptable limits, and the design margin for primary membrane plus bending stress intensity at the center of the bottom plate is 0.18 (= 33.48/28.28 – 1).

The maximum stresses in the MPC-LACBWR basket support disks due to the off-normal handling loads are calculated using the finite element model described in Section 3.A.4.4.2.1.

The off-normal handling horizontal acceleration is assumed to act along the +X direction. The support disk model nodes located at the centerline of each tie-rod are restrained in the vertical direction (i.e., UY=0).

The inertial loading due to the support disk self weight is accounted for by applying a horizontal acceleration loads of 0.7071*g* and a vertical acceleration load of 1.5*g* to the model. The horizontal load from the basket components that are not modeled (i.e., fuel assemblies, fuel tubes, heat transfer disks, and tie-rods) is applied as line loads on the supporting disk ligaments.

The linearized membrane and membrane plus bending stress intensities are evaluated at all critical sections of the support disk. All membrane and membrane plus bending stress intensities are conservatively classified as primary stresses and compared to the off-normal condition (i.e., Service Level C) allowable primary membrane (P_m) and membrane plus bending (P_m+P_b) stress intensity limits. The maximum calculated P_m and P_m+P_b stress intensities in the MPC-LACBWR basket assembly support disk due to the combined off-normal handling plus dead weight loading are summarized in Table 11.A.1.2.2-3 along with the corresponding accident condition allowable stresses and margins of safety. The result of the analysis show that MPC-LACBWR basket support disks satisfy the applicable allowable stress design criteria for the off-normal handing event.

11.A.1.2.3 Radiological Consequences

There are no radiological consequences for the canister off-normal handling event.

11.A.1.2.4 NAC-MPC Performance

This evaluation of the MPC-LACBWR canister for the off-normal handling event shows that the maximum stresses in the canister and fuel basket satisfy the applicable allowable stress design criteria. This event does not cause any damage to the MPC-LACBWR canister that would affect its ability to perform its design functions.

11.A.1.2.5 Recovery and/or Corrective Actions

Operations should be halted until the cause of the misalignment, interference or faulty operation is identified and corrected. Since the radiation level of the canister sides and bottom is high, extreme caution should be exercised if inspection of these surfaces is required.

Figure 11.A.1.2.2-1 MPC-LACBWR Canister Off-Normal Handling Finite Element Model

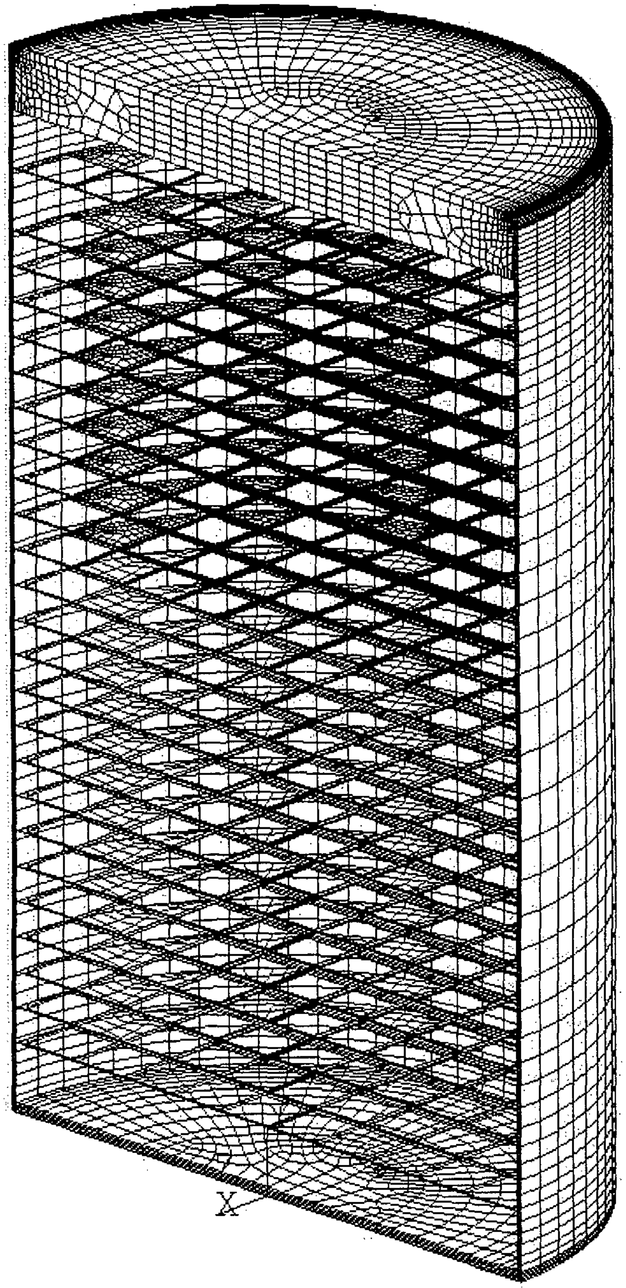

Table 11.A.1.2.2-1 Summary of MPC-LACBWR Primary Membrane (P_m) Stresses, Dead Weight + Off-Normal Handling + Internal Pressure

Section No.[1]	Component Stresses (ksi)						Stress Intensity (ksi)	Allowable Stress Intensity (ksi)	Margin of Safety
	SX	SY	SZ	SXY	SYZ	SXZ			
1	-1.8	1.2	6.0	0.0	0.0	-0.7	7.96	23.13	1.91
2	4.7	-4.4	-2.3	0.0	0.0	-1.5	9.45	23.13	1.45
3	-0.8	-8.6	1.5	0.0	0.0	1.4	10.71	23.11	1.16
4	-0.2	0.9	1.3	0.0	0.0	0.0	1.49	22.77	14.24
5	-0.2	0.8	1.2	0.0	0.1	0.0	1.40	22.46	15.05
6	0.0	0.9	1.5	0.0	0.0	0.0	1.49	22.67	14.21
7	0.0	0.9	1.6	0.0	0.0	0.0	1.66	23.26	13.05
8	0.0	0.6	2.0	0.0	0.1	0.0	2.05	23.80	10.59
9	-1.1	0.0	0.9	0.0	0.0	-0.2	2.07	23.95	10.55
10	-1.8	-0.3	0.1	0.0	0.0	-0.6	2.26	23.96	9.60
11	-1.7	-0.2	0.0	0.0	0.0	0.1	1.77	23.97	12.52
12	0.0	0.3	-0.8	0.0	0.0	-1.0	2.08	19.16[2]	8.20
13	-2.9	0.0	0.2	0.0	0.0	-0.1	3.13	23.97	6.66
14	0.6	0.5	0.0	0.0	0.0	0.0	0.63	22.32	34.41
15	0.0	0.0	0.0	0.0	0.0	0.0	0.01	24.00	>100

1. Canister section locations are shown in Figure 3.A.4.4.1-2.
2. The closure weld allowable stress intensity includes a weld strength reduction factor of 0.8.

Table 11.A.1.2.2-2 Summary of MPC-LACBWR Primary Membrane + Bending (P_m+P_b) Stresses, Dead Weight + Off-Normal Handling + Internal Pressure

Section No.[1]	Component Stresses (ksi)						Stress Intensity (ksi)	Allowable Stress Intensity (ksi)	Margin of Safety
	SX	SY	SZ	SXY	SYZ	SXZ			
1	4.9	1.7	16.3	-0.3	-0.2	0.4	14.68	34.69	1.36
2	4.7	-4.4	-2.3	0.0	0.0	-1.5	9.45[2]	34.69	2.67
3	-0.8	-8.6	1.5	0.0	0.0	1.4	10.71[2]	34.67	2.24
4	-0.4	1.5	1.5	0.0	0.0	0.0	1.90	34.15	16.95
5	-0.3	1.5	1.4	0.0	0.1	0.0	1.75	33.69	18.27
6	-0.3	1.8	1.5	0.0	0.1	0.0	2.07	34.01	15.45
7	-0.3	1.9	1.4	0.0	0.1	0.0	2.16	34.89	15.12
8	0.0	0.7	2.1	0.0	0.0	0.0	2.14	35.71	15.65
9	-0.7	0.6	1.4	0.0	0.0	-0.9	2.80	35.92	11.82
10	-1.3	0.0	1.2	0.0	0.0	-0.1	2.52	35.94	13.26
11	-2.3	0.0	0.1	0.0	0.0	0.1	2.41	35.96	13.93
12	-0.5	0.2	-0.3	0.0	0.0	-1.4	2.72	28.74[3]	9.56
13	-3.0	-0.1	0.2	0.0	0.0	-0.3	3.18	35.96	10.30
14	18.7	19.0	-0.1	0.0	0.0	0.0	19.02	33.48	0.76
15	-0.5	-0.5	0.0	0.0	0.0	0.0	0.53	36.00	66.98

1. Canister section locations are shown in Figure 3.A.4.4.1-2.
2. The bending stress at a gross structural discontinuity (flat head at junction to shell) is classified as a secondary stress per Table NB-3217-1 since the edge moment is not required to maintain the bending stress at the center of the plate to within acceptable limits. Therefore, the maximum membrane stress is reported.
3. The closure weld allowable stress intensity includes a weld strength reduction factor of 0.8.

Table 11.A.1.2.2-3 Summary of Maximum Stresses for the MPC-LACBWR Fuel Basket Support Disks, Off-Normal Handling + Dead Weight

Canister Basket Component	**Calculated Stress**		**Allowable Stress**		**Margin of Safety**
	Stress Type	**Maximum Value (ksi)**	**Criteria**	**Allowable Value (ksi)**	
Support Disks	P_m	9.57	$1.5S_m$	64.2	5.71
	P_m+P_b	12.63	$2.25S_m$	96.3	6.62

11.A.1.3 Failure of Instrumentation

The MPC-LACBWR storage system may use a temperature-sensing system to take daily measurements of the outlet air temperature at each of the four outlets of the concrete cask in lieu of performing daily visual inspection of the concrete cask air inlet and outlet screens for obstructions. This section presents the evaluation of the MPC-LACBWR storage system for a potential failure of the temperature-sensing system. The cause, radiological consequences, and recovery actions for the event are the same as those described in MPC FSAR Sections 11.1.3.1, 11.1.3.3, and 11.1.3.5, respectively.

The analysis of the MPC-LACBWR storage system temperature-sensing system failure event is essentially the same as that of the Yankee-MPC storage system. Failure of the temperature-sensing system does not have any adverse effects on the storage system. When the concrete cask air inlets are clear, no significant changes in the MPC-LACBWR storage system temperatures will occur during the time that it takes to indentify and correct the condition causing the failure of the temperature-sensing system. Furthermore, even under the worst-case fully blocked inlets and outlets accident condition evaluated in Section 11.A.2.8, the temperatures of the MPC-LACBWR storage system components do not reach or exceed their allowable temperature limits in 24 hours. Therefore, the 24-hour inspection interval provides sufficient time to identify and correct the condition causing the temperature-sensing system failure.

11.A.1.4 Severe Environmental Conditions (100°F and -40°F)

This section evaluates the MPC-LACBWR storage system for the steady-state effects of high and low ambient temperature conditions.

11.A.1.4.1 Cause of Event

To bound the expected steady state temperatures of the canister and storage cask during severe ambient conditions, analyses were performed to calculate the steady state storage cask, canister, and fuel cladding temperatures for a 105°F ambient temperature and 24-hour average solar loads. Similarly, winter weather analyses were performed for a -40°F ambient temperature with no solar load. A bounding heat load of 4.5 kW is conservatively used for the MPC-LACBWR storage system thermal analyses.

11.A.1.4.2 Analysis of the Off-Normal Ambient Temperature Event

Off-normal temperature conditions are evaluated using the thermal models described in Section 4.A.3.1.1. This evaluation shows that the component temperatures are within the allowable values for the off-normal ambient conditions. The principal component temperatures for each of these ambient temperature conditions are summarized as follows:

MPC-LACBWR Component	Maximum Temperature (°F)		Allowable Temperature (°F)
	105°F Ambient	-40°F Ambient	
Fuel Cladding	459	377	806
Support Disks	454	370	800
Heat Transfer Disks	452	368	700
Canister Shell	365	280	800
Concrete(1)	196	5	350

1. Concrete temperature is from Table 4.1-4 for NAC-MPC with a heat load of 12.5 kW.

The thermal stress evaluation for the MPC-LACBWR concrete cask for these off-normal conditions is bounded by that for the accident condition with 125°F ambient temperature (Section 11.2.10), since the heat load for MPC-LACBWR is much lower than the heat load for NAC-MPC and the accident condition has the maximum temperature gradient through the storage cask concrete wall.

The thermal stresses for the MPC-LACBWR canister, the support disks and weldments are classified as secondary stress in accordance with the ASME Code, which need not be evaluated for off-normal and accident conditions.

11.A.1.4.3 Radiological Consequences

There are no radiological consequences for this off-normal event.

11.A.1.4.4 MPC-LACBWR Performance

There are no adverse consequences for this off-normal condition. The maximum component temperatures are within the allowable temperature values. The materials used are not subject to low temperature brittle fracture.

11.A.1.4.5 Corrective Actions

No corrective actions are required for this off-normal condition.

11.A.1.5 Small Release of Radioactive Particulate from the Canister Exterior

The procedures for loading the canister provide for steps to ensure that the canister exterior surface does not come into contact with contaminated spent fuel pool water. The exterior surface of the canister is surveyed by smear to verify canister surface conditions. No particulate release from the canister exterior surface is expected to occur in normal use.

11.A.1.5.1 Cause of Event

Irrespective of precautions taken to preclude contamination to the external surface of the canister, it is possible that a portion of the canister surface may become slightly contaminated and that the contamination will go undetected. Surface contamination could become airborne and be released as a result of the air flow over the canister surface.

Detection of the release of small amounts of radioactive particles over time would be difficult to ascertain. The release would likely not be at a level that would result in detection by any of the long-term radiation dose monitoring methods (such as TLDs) normally employed. It is possible that a suspected release could be verified by a smear survey of the air outlets.

11.A.1.5.2 Analysis

The small release analysis is performed using the plume dispersion method of Regulatory Guides 1.109 and 1.145.

A calculation was made to determine dose rate as a function of distance based on residual contamination limits of 20,000 dpm/100 cm^2 β-γ activity and 200 dpm/100 cm^2 α activity, simultaneously released from the surface of 5 MPC-LACBWR canisters, using the plume dispersion method of Regulatory Guides 1.109 and 1.145.

The factor χ/Q is determined according to the formula from Regulatory Guide 1.145:

$$\frac{\chi}{Q} = \frac{1}{U_{10} \cdot \pi \cdot \Sigma_y \cdot \sigma_z}$$

where:

U_{10} = the wind speed at ten meters above plant grade [m/sec]

Σ_y = the lateral plume spread with meander and building wake effects [m]

σ_z = the vertical plume spread [m]

For distances less than 800 meters, $\sum_y$ is the product of the horizontal plume spread, σ_y, and the plume meander and building wake correction factor, M.

From Regulatory Guide 1.145, the values for these parameters are as follows, with σ values taken at 100 meters:

U_{10} = 1 m/sec

M = 4

σ_y = 4.0

σ_z = 2.4

$\sum_y$ = 16.0

χ/Q = 8.29×10^{-3} sec/m^3

The releasable activity is determined using:

$$Q[\text{Ci}] = \frac{(\text{C})(\text{A})(\text{N})}{(2.22\text{E}+12)(100)}$$

where 2.22E+12 is the conversion from curies (Ci) to disintegrations per minute [dpm], and;

C = the contamination limits [20,000 dpm/100 cm^2 β-γ and 200 dpm/100 cm^2 α]

Q = the activity released [Ci]

A = the surface area of the canister [217,000 cm^2]

N = the number of canisters placed in service [5]

Therefore, the releasable activities are:

Q(β-γ) = 9.77E-05 Ci

Q(α) = 9.77E-07 Ci

Regulatory Guide 1.109 defines the annual dose due to submersion and inhalation. These equations are solved for the annual dose, D [rem].

Submersion: $D_{\text{submersion}} = Q \cdot \frac{\chi}{Q} \cdot DCF_S$

Inhalation: $D_{\text{inhalation}} = Q \cdot \frac{\chi}{Q} \cdot BR \cdot DCF_I$

where:

Q = activity released [Ci]

DCF_S = submersion dose conversion factor [rem-m^3/Ci-yr]

DCF_I = inhalation dose conversion factor [rem/Ci]

BR = amount of air breathed annually [8,000 m^3]

The selected dose conversion factors are based on using the highest conversion factor for each group of nuclides, with ^{60}Co assumed to comprise all of the β-γ activity and ^{241}Am assumed to comprise all of the α activity. Dose conversion factors are taken from EPA Federal Guidance Report No. 11, Table 2.1 and Federal Guidance Report No. 12, Table III.1. Both Class Y (oxide) and W compound dose conversion factors were extracted. Class Y (oxide) conversion factors are bounding for the β-γ cobalt release. Only class W conversion factors are available for the ^{241}Am release. The dose conversion factors employed after conversion for unit consistency are:

Activity	Submersion Skin (Rem-m^3/Ci-yr)	Inhalation -Lung (Rem/Ci)	Inhalation-Whole Body (Rem/Ci)	Inhalation -bone (Rem/Ci)
β-γ (^{60}Co)	1.70 x 10^7	1.28 x 10^6	2.19 x 10^5	--
α (^{241}Am)	--	6.81 x 10^7	4.44 x 10^8	8.03 x 10^9

The inventory available for release is calculated assuming that 100% of the surface area of each canister is covered with the contamination levels listed above, and applies a conservative release fraction of 1% using the methodology presented in Section 1.2.1 of NUREG-1400, which references the values presented in 10 CFR 30.72. The resulting inventory available for release is conservative, as the release fractions presented in 10 CFR 30.72 are a factor of 10 lower for ^{241}Am (0.001) and ^{60}Co (0.001). This inventory is conservatively assumed to be simultaneously released from every canister for the purposes of calculating the worst-case dose contributions at the site boundary.

Employing the submersion and inhalation equations from Regulatory Guide 1.109, doses were calculated over a range of distances from 100 to 1000 meters. A dose summary for a distance of 100 meters is shown below for 1 and 5 cask arrays. Included in the listing is the skin dose, followed by the β–γ and α dose contributors to the significant organs and whole body. Also shown is the total exposure from α and β–γ for lungs, bone and whole body.

Dose	Exposures at 100 meters	Unit	1 Cask	5 Casks
β–γ	Skin Dose (β–γ)	[mrem]	8.69E-07	4.34E-06
	Lung Dose (β–γ)	[mrem]	5.24E-04	2.62E-03
	Whole Body Dose (β–γ)	[mrem]	8.97E-05	4.49E-04
α	Bone Surface Dose (α)	[mrem]	3.29E-02	1.65E-01
	Lung Dose (α)	[mrem]	4.90E-03	2.45E-02
	Whole Body Dose (α)	[mrem]	1.82E-03	9.11E-03
Total	Skin Dose (β–γ)	[mrem]	8.69E-07	4.34E-06
	Bone Surface Dose (α)	[mrem]	3.29E-02	1.65E-01
	Whole Body Dose (α + β–γ)	[mrem]	1.91E-03	9.56E-03
	Lung Dose (α + β–γ)	[mrem]	5.43E-03	2.71E-02

11.A.1.5.3 Radiological Consequences

The projected dose at a boundary located 100 meters from the MPC-LACBWR 5-cask array ISFSI is estimated to be less than one (1) mrem due to the postulated release of surface contamination. This dose is based on a postulated surface contamination of approximately 20,000 dpm/100 cm^2 β-γ and 200 dpm/100 cm^2 α, for each of 5 storage casks being simultaneously released to the environment. These analyses are highly conservative and demonstrate that the potential off-site radiological consequences from the release of canister surface contamination are negligible.

11.A.1.5.4 NAC-LACBWR Performance

Procedural steps are employed to ensure that the canister surface is generally free of surface contamination prior to its installation in the storage cask. The surface of the canister is free of traps that could hold contamination. The presence of external surface contamination on the canister is unlikely.

11.A.1.5.5 Corrective Actions

No corrective action is required, since the radiological consequence is negligible.

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11.A.2 Accident Conditions for the MPC-LACBWR Storage System

This section presents the evaluation of the MPC-LACBWR storage system for postulated accident events whose consequences could have the maximum potential impact on the immediate environment, and very low probability natural phenomena events that might occur once during the lifetime of an ISFSI. The analyses of the MPC-LACBWR storage system for accident conditions show that the owner-controlled area boundary dose limits of 10 CFR 72.106 are satisfied. In addition, the accident evaluation of the MPC-LACBWR storage system demonstrates that occupational exposure can be adequately controlled.

11.A.2.1 Accident Pressurization

This section describes the evaluation of the MPC-LACBWR storage system for an accident pressurization event in which all fuel rods in the canister are postulated to fail and release their fission and fill gases into the canister. The evaluations of the canister internal pressure load resulting from this condition and the stresses in the canister due to that internal pressure load are presented in this section. There are no radiological consequences for the accident pressurization event and no corrective actions are required for recovery from the event.

11.A.2.1.1 MPC-LACBWR Canister Maximum Internal Pressure

The analysis requires the calculation of the free volume of the canister, calculation of the quantity of fill and fission gas in the 68 fuel assemblies, and the subsequent calculation of the pressure in the canister if these gases are added to the helium pressure (initially at 1 atm) already present in the canister (Section 4.A.3.5). The quantity of fission gases was conservatively estimated assuming that 30% of the total gases present are released from the fuel. The bulk temperature of the fill gas is conservatively taken to be 680°F. This temperature bounds the calculated bulk temperature of fill gas for any of the evaluated normal, off-normal, or accident conditions. The internal pressure is a function of rod-fill, fission and canister backfill gases. All of the gases, except the fission gases, are helium. The total pressure for each volume are found by calculating the molar quantity of each gas and summing those directly. The design basis fuel assembly for the internal pressure calculation is the Allis Chalmers 10×10 fuel assembly. This assembly has the highest fuel mass (0.1201 MTU) and received the highest burnup (22,000 MWd/MTU).

The number of moles of the backfill gases is calculated using the Ideal Gas Law, $PV = NRT$. Backfill gases for the canister and cavity are assumed to be initially at 1 atmosphere. The quantity of fission gas is derived from the SAS2H source term evaluation of the Allis Chalmers fuel assembly. The number of moles of gas in the canister is:

$$N = N_{\text{TSC Back-Fill}} + N_{\text{Rod Back-Fill}} + 0.3\left(N_{\text{Fission Gas}}\right)$$

The number of moles of helium contained in the canister as backfill and the number of moles of gas in the fuel rods (as helium backfill and fission products) are calculated in Section 4.A.3.5.

Based on an assumed bounding temperature of 680°F, the maximum pressure in the canister is 2.32 atm ≈ 34.0 psia.

11.A.2.1.2 MPC-LACBWR Canister Maximum Stress Due to Internal Pressure

The stresses in the MPC-LACBWR canister due to the combined loading of dead weight, normal handling, and accident pressurization are calculated using the finite element model described in Section 3.A.4.4.1.1 and shown in Figure 3.A.4.4.1-1. A bounding uniform pressure load of 20 psig is conservatively applied to the inside surfaces of canister shell, bottom plate, and shield lid elements. In addition, the 1.1*g* vertical acceleration loading for combined effects of dead weight and normal handling are applied to the model as described in Section 3.A.4.4.1.4.

The membrane and membrane plus bending stresses in the MPC-LACBWR canister due to the combined dead weight, normal handling, and 20 psig internal pressure loads are evaluated at the stress sections shown in Figure 3.A.4.4.1-2. The results show that the maximum primary membrane (P_m) and primary membrane plus bending (P_m+P_b) stress intensities in the canister due to the 20 psig internal pressure load, which both occur at the bottom plate-to-shell junction, are 11.11 ksi and 44.99 ksi, respectively. The corresponding allowable P_m and P_m+P_b stress intensities for accident conditions are 46.23 ksi and 66.04 ksi, respectively. Therefore, the minimum margin of safety in the MPC-LACBWR canister for the accident pressurization event is 0.47.

11.A.2.1.3 Radiological Consequences

There are no radiological consequences for this accident.

11.A.2.1.4 MPC-LACBWR Performance

This analysis demonstrates that the canister performance is not significantly affected by the increase in internal pressure that results from the hypothetical rupture of all of the fuel rods contained in the canister. There is a positive margin of safety throughout the canister.

11.A.2.1.5 Recovery and/or Corrective Actions

There are no recovery or corrective actions required for this hypothetical accident event. The rupture of fuel rods within the canister is unlikely to be detected by any measurements or inspections that could be undertaken from the exterior of the canister or storage cask.

11.A.2.2 Earthquake Event

This section describes the evaluation of the MPC-LACBWR storage system for the design basis earthquake event. The design basis earthquake load for the MPC-LACBWR storage system is defined as a horizontal acceleration load of 0.45*g* at the top surface of the ISFSI pad. The design basis vertical acceleration is equal to two-thirds of the horizontal acceleration in accordance with ASCE 4-86. The earthquake evaluation of the MPC-LACBWR storage system demonstrates that the design basis earthquake loading will not cause the loaded concrete cask to overturn or slide to an extent that it could impact any adjacent casks or slide off the edge of the ISFSI pad. The evaluation also shows that the maximum stresses in the MPC-LACBWR concrete cask shell due to the design basis earthquake load satisfy the applicable allowable stress design criteria.

Overturning stability of the MPC-LACBWR concrete cask is evaluated for the 0.45*g* design basis horizontal base acceleration using the same moment-equilibrium methods used for the evaluation of the Yankee-MPC concrete cask, as described in MPC FSAR Section 11.2.2.2.1. Although the design basis earthquake loads for the MPC-LACBWR storage system are higher than those of the Yankee-MPC system, they are proportionally identical. Therefore, the general overturning stability equations developed in MPC FSAR Section 11.2.2.2.1 for the Yankee-MPC storage system are applicable to the MPC-LACBWR storage system. These equations relate the horizontal acceleration required to overturn the cask to the horizontal and vertical distances from the concrete cask bottom edge to its center of gravity (i.e., moment arms b and d, respectively). The general overturning stability equations, which are developed considering the possible combinations of horizontal and vertical acceleration using the 100-40-40 rule of ASCE 4-86, are:

<u>Case 1</u>: $$a \le \frac{(b/d)}{[0.566 + 0.667(b/d)]} = 0.68g$$

<u>Case 2</u>: $$a \le \frac{(b/d)}{[1.077 + 0.267(b/d)]} = 0.56g$$

Where the horizontal moment arm, b, of the MPC-LACBWR storage system is 58.83 inches (calculated based on the maximum possible off-center position of the canister, as described in

MPC FSAR Section 11.2.2.2.1) and the vertical moment arm, d, of the MPC-LACBWR storage system is 83.0 inches.

Therefore, the minimum horizontal acceleration load that is required to overturn the loaded MPC-LACBWR concrete cask is 0.56*g*. Since this is higher than the 0.45*g*, the MPC-LACBWR concrete cask will not overturn due to the design basis earthquake. The minimum factor of safety provided by the MPC-LACBWR concrete cask against overturning is 1.24 (= 0.56/0.45), which is greater than the factor of safety of 1.10 required by ANSI/ANS-57.9.

The maximum horizontal sliding displacement of the concrete cask due to a horizontal peak base acceleration of 0.45*g* is determined based on the following curve fit equation and parameters provided in Appendix VII of NUREG/CR-6865 [A2]:

$$y = Ax^{B} = (0.837)(0.45)^{2.52} = 0.112\text{ m }(4.4\text{ in.})$$

Where parameters A and B are conservatively taken from Table VII.2 of NUREG/CR-6865, based on a lower bound sliding coefficient of friction between the cask and ISFSI pad of 0.2. This coefficient value is conservative when compared to the results of steel-on-concrete friction tests performed under both dry and wet conditions [A3]. The test results show that the coefficient of sliding friction between clean steel (i.e., blasted to remove mill scale) and concrete is in the range of 0.51 to 0.68.

At the minimum concrete cask center-to-center spacing of 15 feet, a 52-inch clear space is provided between adjacent casks. Thus, sliding of the MPC-LACBWR concrete cask due to design basis earthquake loading will not cause adjacent concrete casks to impact one another, nor will it cause a concrete cask to slide off the edge of the ISFSI pad. The minimum factor or safety for sliding, conservatively assuming that adjacent cask slides toward one another by the calculated maximum sliding distance of 4.4 inches, is 5.91 (= 52/8.8).

The stresses in the MPC-LACBWR concrete cask shell due to the design basis earthquake load are determined using the same approach described in MPC FSAR Section 11.2.2.2.1 for the Yankee-MPC concrete cask evaluation. The design basis horizontal base acceleration of 0.45*g* is conservatively applied simultaneously in two orthogonal horizontal directions (i.e., $a_x = 0.64g$), and the vertical acceleration is taken as two-thirds of the horizontal acceleration (i.e., $a_y = 0.30g$). The maximum vertical stress due to combined axial and bending loads in the concrete shell due to the seismic acceleration loads is calculated based on simple beam theory equations, treating it as a cantilever beam (fixed at the bottom end), as follows:

σ_y = $\frac{Mr}{I} + \frac{P}{A}$
= 65.4 psi at outer diameter of concrete shell base
= 44.9 psi at inside diameter of concrete shell base

where:

M = 9.96×10^6 in-lb, Maximum bending moment at the base of the concrete shell.
= $wL^2/2$

r = Radial distance to stress location.
= 64.0 inches (to outside of concrete shell)
= 42.0 inches (to inside of concrete shell)

I = 10.7×10^6 in^4, Section modulus of the concrete shell.
= $\pi(D_O^4 - D_I^4)/64$

P = 42,360 lbs, Vertical force at base of concrete shell due to vertical acceleration.
= $(0.30g \times W_E)$

A = 7,326 in^2, Area of concrete shell.
= $\pi(D_O^2 - D_I^2)/4$

w = 779 lb/inch, Uniform line load on concrete shell beam due to horizontal acceleration.
= $\sqrt{(0.45g)^2 + (0.45g)^2} \times (W_L)/L$

L = 159.9 in., Concrete shell length.

D_O = 128.0 in., Concrete shell outside diameter.

D_I = 84.0 in., Concrete shell inside diameter.

W_E = 141,200 lbs, Weight of empty MPC-LACBWR concrete cask.

W_L = 195,800 lbs, Weight of loaded MPC-LACBWR concrete cask.

The average shear stress at the base of the MPC-LACBWR concrete cask shell is calculated as follows:

$$\sigma_v = \frac{V}{A} = \frac{wL}{A} = 17.0 \text{ psi}$$

where w, L, and A are defined previously in this section.

The maximum stresses in the LACBWR concrete cask shell due to the earthquake loading are evaluated in combination with the stresses due to dead load, live load, and normal thermal loads, and are shown to satisfy the applicable allowable stress criteria in Section 3.A.4.4.3.

The cause, radiological consequences, and corrective actions for recovery from the earthquake event are the same as those described in MPC FSAR Sections 11.2.2.1, 11.2.2.3, and 11.2.2.5, respectively.

11.A.2.3 Explosion

The evaluation of the MPC-LACBWR storage system for explosive overpressure shows that it will not be adversely affected by explosion events that are bounded by the design basis flood event. The cause, radiological consequences, and recovery actions for the explosion event are discussed in MPC FSAR Sections 11.2.3.1, 11.2.3.3, and 11.2.3.5, respectively.

The analysis of the MPC-LACBWR storage system for explosive overpressure is based on the bounding effects of the design basis flood event. As discussed in Section 11.A.2.6, the loaded MPC-LACBWR concrete cask will not overturn or slide due to the bounding lateral forces associated with the design basis flood. In addition, the stresses in the MPC-LACBWR concrete cask shell resulting from the bounding flood loads, which are evaluated in combination with stresses due to dead load, live load, and normal thermal load, are shown to satisfy the applicable allowable stress design criteria. The stresses in the MPC-LACBWR canister shell due to a flood hydrostatic pressure load of 22 psig are also evaluated and shown to meet the applicable structural design criteria.

11.A.2.4 Failure of all Fuel Rods with a Subsequent Ground Level Breach of the Canister

This section addresses the potential mechanistic failure of the MPC-LACBWR canister and subsequent release of radioactive gas, volatile and particulate material from the canister.

As described in Appendices 3.A, 4.A and 11.A, the NAC-MPC is evaluated for normal conditions and for a series of off-normal and accident events that include cask tip over, cask drop, flooding, fire and explosion, lightning, earthquake, loss of shielding, adiabatic heat up, and tornado generated missiles. The evaluations show that for these design basis events, there is no mechanistic failure of the confinement boundary of the canister, i.e., the canister maintains its structural integrity. As described in Appendix 7.A and in Section 8.A.1.1, the canister is tested to demonstrate that it is leaktight as defined by ANSI N14.5-1997.

Therefore, no further evaluation of this potential accident condition is required.

11.A.2.5 Fire Accident

The bounding hypothetical fire accident condition is assumed to be an 8-minute fire in which the conditions applied are listed in MPC FSAR Section 11.2.5.2 for the Yankee-MPC system.

The fire transient analyses performed in MPC FSAR Section 11.2.5.2 for the Yankee-MPC system utilize the heat load of 12.5 kW, which bounds the heat load of 4.5 kW for the MPC-LACBWR fuels. Convection is considered in the analysis documented in MPC FSAR Section 11.2.5.2. The maximum steady-state temperatures for the NAC-MPC components (MPC FSAR Table 4.4.3-1) for normal storage condition, which are used as the initial temperature for the fire accident analysis, are higher than the corresponding maximum component temperatures for the MPC-LACBWR system. Also, the similar design of the Yankee-MPC system and the MPC-LACBWR system results in an insignificant difference in thermal mass, therefore, the analysis results of the fire accident condition for the NAC-MPC bound the analysis results of the fire accident condition for the MPC-LACBWR.

11.A.2.6 Flood

The MPC-LACBWR storage system is evaluated for a fully-immersing design basis flood with a 50-foot water depth and a steady-state flow velocity of 15-feet/second. Under design basis flood conditions, the concrete cask is subjected to the same horizontal drag force calculated for the Yankee-MPC storage system (21.72 kips per MPC FSAR Section 11.2.6.2.) The horizontal drag force is resisted by shear and bending loads developed in the concrete cask shell, which are considered in the stress analysis. The water displaced by the MPC-LACBWR storage system produces buoyancy forces that are considered in the overturning and sliding analyses. In addition, stresses in the canister shell resulting from hydrostatic pressure due to the 50-foot flood depth are evaluated.

The overturning stability analysis of the MPC-LACBWR concrete cask is evaluated using the moment balance approach developed in MPC FSAR Section 11.2.6.2 for the Yankee-MPC concrete cask flood evaluation. The flood drag force ($F_{D,OT}$) required for overturning the MPC-LACBWR concrete cask is calculated using the following equation, assuming the concrete cask pivots about its outer edge and that the lateral drag force acts at the mid-height of the concrete cask:

$$F_{D,OT} = \frac{(W_{VCC} - F_B)(r)}{(h/2)} = 98.7 \text{ kips}$$

where:

W_{VCC} = 195.8 kips, weight of the loaded LACBWR concrete cask.

F_B = 64.3 kips, buoyancy force from water displaced by LACBWR concrete cask system.
= $(\rho)(V_D)$

r = 5.0 ft (60.0 in.), radial distance from the concrete cask bottom edge to the system center of gravity (accounting for 4-inch chamfer at bottom end.)

h = 13.33 ft (159.9 in.), height of concrete cask.

ρ = 62.4 lb/ft^3 (1.94 slugs/ft^3), density of water.

V_D = 1,030 ft^3, total volume of water displaced by MPC-LACBWR concrete cask and canister.

The drag force required to overturn the MPC-LACBWR concrete cask is greater than the drag force resulting from the design basis flood. Therefore, the MPC-LACBWR concrete cask will not overturn under design basis flood loading. The factor of safety provided by the MPC-LACBWR concrete cask against overturning due to the design basis flood is 4.54 (= 98.7/21.72), which is higher than the required factor of safety of 1.1.

The corresponding flood velocity required to overturn the MPC-LACBWR concrete cask is calculated as follows:

$$V = \sqrt{\frac{2F_{D,OT}}{C_D \rho A}} = 32 \text{ ft/second}$$

Where ρ is the density of water (1.94 slugs/ft^3), C_D is 0.7, and A is the horizontally projected area of the concrete cask (142 ft^2).

The minimum coefficient of friction between the bottom end of the MPC-LACBWR concrete cask and the ISFSI pad that is required to prevent sliding under the design basis flood condition is calculated as follows:

$$\mu_{min} = \frac{1.1(F_D)}{F_y} = \frac{1.1(F_D)}{W_{VCC} - F_B} = 0.18$$

Where F_D is the drag force resulting from the design basis flood (21.72 kips), and W_{VCC} and F_B are defined above. Since the minimum required coefficient of static friction is less than the lower bound coefficient of static friction for steel-on-concrete (0.35), the design basis flood will not cause the MPC-LACBWR concrete cask to slide. Therefore, the LACBWR concrete cask system provides a minimum factor of safety against sliding of 1.94 (= 0.35/0.18) due to the design basis flood load.

The stresses in the MPC-LACBWR concrete cask shell due to the design basis flood are lower than those calculated in MPC FSAR Section 11.2.6.2.2 for the Yankee-MPC concrete cask shell since the MPC-LACBWR cask concrete shell is thicker and has higher section properties than the Yankee-MPC cask shell. Conservatively, the bounding flood stresses calculated for the Yankee-MPC cask concrete shell are conservatively used for the structural evaluation of the MPC-LACBWR cask shell. These stresses, when evaluated in combination with the maximum stresses resulting from dead load, live load, and normal thermal loads, as discussed in Section 3.A.4.4.3, are shown to satisfy the applicable allowable stress criteria.

The stresses in the MPC-LACBWR canister due to the flood hydrostatic pressure load are determined using the finite element model shown in Figure 3.A.4.4.1-1. A uniform pressure load of 22 psig is applied to the exterior surfaces of the canister model. For this analysis, the canister internal pressure is conservatively assumed to be 0 psig. The membrane and membrane plus bending stresses in the canister due to the flood hydrostatic pressure loading are evaluated at the stress sections shown in Figure 3.A.4.4.1-2. The results show that the maximum primary membrane (P_m) and primary membrane plus bending (P_m+P_b) stress intensities, which both occur at the bottom plate-to-shell junction in the canister due to the 22 psig flood hydrostatic pressure load, are 7.28 ksi and 30.14 ksi, respectively. The corresponding allowable P_m and P_m+P_b stress intensities for accident conditions are 46.23 ksi and 66.04 ksi, respectively. Therefore, the minimum margin of safety in the MPC-LACBWR canister for the flood accident is 1.19.

The cause, radiological consequences, and corrective actions for recovery from the flood event are the same as those described in MPC FSAR Sections 11.2.6.1, 11.2.6.3, and 11.2.6.5, respectively.

11.A.2.7 Fresh Fuel Loading in Canister

This section presents the results of the evaluation of the effects of the inadvertent loading of fresh, unburned fuel assemblies in the canister. While, this event is not considered to be credible, the MPC-LACBWR criticality analysis presented in Appendix 6.A is based on fresh fuel loading.

11.A.2.7.1 Cause of Accident

The cause of this event would be operator and/or procedural error. The design basis criticality condition demonstrates that the canister is designed to accommodate fresh fuel without a resulting criticality event.

This accident is expected to be identified immediately by observation of the condition of the fuel installed in the canister or by a review of the fuel handling records.

11.A.2.7.2 Analysis of Fresh Fuel Loading in the MPC-LACBWR Canister

The criticality analysis presented in Appendix 6.A assumes the loading of up to 68 LACBWR Class fuel assemblies in the MPC-LACBWR having no burn up. The design of the NAC-MPC is adequate to preclude any effects due to this accident condition.

The analysis presented in Section 6.A.4 shows that the maximum k_{eff} for the MPC canister in the dry normal condition is < 0.4. The maximum k_{eff} in the accident condition is 0.930. The accident condition assumes the most reactive configuration of the fuel and full moderator intrusion.

11.A.2.7.3 Radiological Consequences

There are no radiological consequences for this event.

11.A.2.7.4 MPC-LACBWR Performance

The criticality control features of the MPC-LACBWR canister and basket ensure that the k_{eff} of the fuel is less than 0.95 for all loading conditions of fresh fuel. There is no adverse impact on the MPC-LACBWR due to this event.

11.A.2.7.5 Recovery and Corrective Actions

This event requires that the canister be unloaded when the incorrect loading is identified. Compliance with the controls placed on the movement of fuel assemblies will preclude this accident event from occurring.

11.A.2.8 Full Blockage of Air Inlets and Outlets

This section evaluates the MPC-LACBWR storage system for the effects of full blockage of the air inlets and outlets at the normal ambient temperature (75°F). It determines the duration of the event that would result in the concrete reaching its design basis limiting temperature of 350°F.

11.A.2.8.1 Cause of Event

The likely cause of complete air inlet and outlet blockage is the covering of the cask with earth in a catastrophic event such as a greater than design basis earthquake or a landslide. This event is a bounding condition accident that is not credible.

This event would be detected by inspection of general conditions at the site following such an event. It would be detected visually by the persons inspecting the ISFSI site.

11.A.2.8.2 Analysis of the Blockage Event

Accident temperature conditions are evaluated using the thermal models described in Section 4.A.3.1.1 for the MPC-LACBWR storage system. Since no air flow is modeled in the model, the analysis results for the normal storage condition bound the analysis results for the accident conditions due to all air inlets and outlets being blocked. The analysis results are listed in Table 4.A.3-3.

11.A.2.8.3 Radiological Consequences

There are no significant radiological consequences for this event, as the MPC-LACBWR storage system retains its shielding performance. Dose is incurred as a consequence of uncovering the storage cask. Since the dose rates at the air inlets and outlets are higher than the maximum dose rate at the cask wall, personnel will be subject to an estimated maximum dose rate of 75 mrem/hr when clearing the inlets and outlets. For the MPC-LACBWR storage system, if it is assumed that a worker kneeling with his hands on the inlets or outlets would require 15 minutes to clear each inlet or outlet, the estimated extremity dose is 150 mrem for the 8 openings. The whole body dose would be slightly less. In addition, some dose is incurred clearing debris away from the cask body. Based on an average dose rate at 1 foot from the cask of 30 mrem/hr, this dose is estimated at 60 mrem, assuming 2 hours is spent near the cask exterior surface.

11.A.2.8.4 MPC-LACBWR Performance

There are no adverse consequences for this accident condition, even if the debris is not cleared. The maximum component temperatures are less than the allowable temperatures. The MPC-LACBWR storage system continues to satisfactorily perform the cooling function with all the inlets and outlets blocked.

11.A.2.8.5 Recovery and/or Corrective Actions

The debris blocking the vents can be manually removed. In addition, a considerable effort may be involved in clearing the area around the storage casks. No actions are required with regard to the casks proper, provided that the inlets and outlets are cleared within certain days (as many as needed).

11.A.2.9 Lightning

The MPC-LACBWR storage system is evaluated for the same design basis lightning accident event as the Yankee-MPC storage system. The cause of the lightning accident event is discussed in MPC FSAR Section 11.2.9.1. The lightning accident analysis of the Yankee-MPC concrete cask presented in Section 11.2.9.2 of the MPC FSAR is applicable to the MPC-LACBWR concrete cask since the concrete cask design parameters considered in the lightning accident analysis are the same. The analysis shows that the maximum increase in the temperatures of the concrete cask steel liner and concrete shell caused by the lightning strike are small. As discussed in MPC FSAR Sections 11.2.9.3 and 11.2.9.5, there are no radiological consequences or required recovery actions for the lightning accident event.

11.A.2.10 Maximum Anticipated Heat Load (125°F Ambient Temperature)

The MPC-LACBWR storage system is evaluated for steady-state operation with an ambient air temperature of 125°F. The evaluation demonstrates that the maximum temperatures of the MPC-LACBWR storage system components for this thermal condition are all within the corresponding allowable material temperatures. Thermal stresses in the MPC-LACBWR canister are not calculated for this thermal condition since thermal stress is classified as secondary stress, which does not require evaluation for accident conditions. However, thermal stresses in the MPC-LACBWR concrete cask shell are evaluated for this condition. The evaluation demonstrates that the maximum stresses in the MPC-LACBWR concrete cask shell resulting from this thermal condition, which are evaluated in combination with the stresses due to dead load, live load, and wind load, as discussed in Section 3.A.4.4.1.5, satisfy the applicable requirements of ACI 349-85.

11.A.2.10.1 Cause of Accident

The cause of this condition is a weather event that subjects the MPC-LACBWR storage system to a 125°F ambient temperature with full solar insolance. Detection of the high ambient temperature condition would occur during the daily measurement of ambient temperature and storage cask outlet air temperature.

11.A.2.10.2 Analysis of the 125°F Ambient Temperature Event

The severe high temperature condition is evaluated using the thermal models described in Section 4.A.3.1.1. A contents heat load of 4.5 kW is assumed. The principal component temperatures for this ambient condition are:

Component	**Maximum Temperature (°F)**	**Allowable Temperature (°F)**
Fuel Cladding	470	806
Support Disks	465	800
Heat Transfer Disks	463	700
Canister Shell	377	800
Concrete[1]	228	350

1. Concrete temperature is from Table 4.1-4 for NAC-MPC with a heat load of 12.5 kW.

This evaluation shows that the component temperatures are within the allowable temperature for the severe high ambient temperature conditions.

For this thermal condition, the decay heat load from the canister inside the concrete cask is transferred to the environment primarily by passive convective air flow through the concrete cask ventilation ducts. However, some portion of the decay heat is transferred to the environment by conduction through the concrete cask. The thermal resistance of the concrete cask steel and concrete shells produces axial and radial temperature gradients that generate stress within the concrete cask shell. Given that the MPC-LACBWR concrete cask and Yankee-MPC concrete cask designs are very similar; their heat transfer characteristics are also very similar. Therefore, since the design basis canister heat load for the MPC-LACBWR canister is much lower than that of the Yankee-MPC canister (i.e., 4.5 kW vs. 12.5 kW) the temperature gradients and the thermal stresses in the MPC-LACBWR concrete cask resulting from the 125°F ambient air temperature will be much lower than those calculated for the Yankee-MPC concrete cask in MPC FSAR Section 11.2.10.2.1. However, the bounding thermal stresses calculated for the Yankee-MPC concrete cask are conservatively used for evaluation of the MPC-LACBWR concrete cask.

11.A.2.10.3 Radiological Consequences

There are no radiological consequences for this event.

11.A.2.10.4 MPC-LACBWR Performance

There are no adverse consequences for this accident condition. The maximum component temperatures are less than the allowable temperatures for accident conditions and are also less than the temperature limits for normal conditions of storage.

11.A.2.10.5 Corrective Actions

No corrective actions are required for this accident condition.

11.A.2.11 Storage Cask 6-Inch Drop

The loaded MPC-LACBWR concrete cask is evaluated for a 6-inch free drop onto a concrete storage pad. The evaluation shows that the event does not cause any significant structural damage to the MPC-LACBWR concrete cask or canister.

11.A.2.11.1 Cause of Accident

As discussed in MPC FSAR Section 11.2.11.1, the concrete storage cask, containing the loaded canister, must be raised approximately 4 inches using hydraulic jacks in order to install the inflatable air pads beneath it. A 6-inch cask drop is conservatively evaluated in this section based on the assumption of the failure of one or more of the jacks or of the air pad system.

11.A.2.11.2 Analysis of the 6-Inch Drop Event

The analyses of the MPC-LACBWR concrete cask and canister for the concrete cask 6-inch drop event are described in this section.

11.A.2.11.2.1 MPC-LACBWR Concrete Cask Analysis

The MPC-LACBWR concrete cask is analyzed for the 6-inch drop using the same approach described in MPC FSAR Section 11.2.11.2.1 for the Yankee-MPC concrete cask. The analysis considers the concrete cask dropping onto an infinitely rigid target, conservatively neglecting any deflection of the ISFSI concrete pad and underlying soil. The kinetic energy of the loaded concrete cask at impact is assumed to be absorbed entirely through crushing of the cask concrete shell and plastic deformation of the concrete cask steel pedestal stand. The analyses provide a conservative estimate of the concrete cask damage resulting from the 6-inch drop event. In addition, the analyses provide an estimate of the average canister deceleration resulting from the 6-inch drop.

The crush depth of the concrete at the bottom end of the MPC-LACBWR concrete cask shell required to absorb the kinetic energy due to the 6-inch drop is shown to be 0.044 inch, based on the energy balance approach described in MPC FSAR Section 11.2.11.2.1. The area of concrete at the bottom end of the cask concrete shell, between the air inlets, is assumed to crush when it reaches its compressive strength. The concrete crush depth is calculated based on the empty weight of the MPC-LACBWR concrete cask, considering that the canister weight is supported by the concrete cask pedestal stand and does not load the concrete shell. The average deceleration of the concrete cask due to the 6-inch drop is calculated to be 137g.

The maximum plastic deformation of the concrete cask pedestal stand, which supports the canister during the 6-inch drop event, is shown to be 0.31 inch, based on the energy balance approach described in MPC FSAR Section 11.2.11.2.1. Under bottom end drop loads, the area of the steel ligaments in the concrete cask pedestal stand between the cutouts for the air inlet (i.e., 24 in^2 total area) experiences the highest stress. These steel ligaments are assumed to deform plastically and absorb the kinetic energy due to the weight of the MPC-LACBWR canister. The plastic deformation of the steel ligaments is calculated based on a flow stress that is equal to the average of the steel yield and ultimate strengths. Using the approach described in MPC FSAR Section 11.2.11.2.1, the average deceleration of the canister due to the 6-inch drop event is shown to be 21g based on the plastic flow force developed in the concrete cask pedestal ligaments.

11.A.2.11.2.2 MPC-LACBWR Canister and Basket Analysis

Canister Stress Analysis

The MPC-LACBWR canister is evaluated for the concrete cask 6-inch end drop conditions using finite element analysis. The maximum stresses in the canister are conservatively calculated using a 60*g* bottom end drop load, which bounds the 21*g* canister load determined in the concrete cask drop analysis. The results of the concrete cask 6-inch drop analyses demonstrate that the maximum stresses in the MPC-LACBWR canister shell and basket assembly resulting from a 60*g* bottom end drop satisfy the applicable accident condition allowable stress design criteria.

The maximum stresses in the MPC-LACBWR canister due to a 60*g* bottom end drop load are calculated using the finite element model described in Section 3.A.4.4.1.2. Analyses are performed for a 60*g* bottom end drop load both with and without internal pressure loading (12.0 psig.) The inertial load from the weight of the canister contents (i.e., basket assembly and spent fuel) is applied as a uniform pressure load on the inside surface of the canister bottom plate. The linearized membrane and membrane plus bending stress components and stress intensities at each canister stress section identified in Figure 3.A.4.4.1-2 are summarized in Table 11.A.2.11-1 through Table 11.A.2.11-4. The results of the analysis show that the canister maintains positive margins of safety for the concrete cask 6-inch drop condition.

Basket Support Disk and Weldment Stress Analysis

The basket support disks and weldments are also conservatively evaluated for a 60g bottom end drop condition. The maximum stresses in the support disks and top and bottom weldments are calculated using the finite element models described in Sections 3.A.4.4.2.1 and 3.A.4.4.2.2. The 60*g* bottom end drop loads are applied in the same manner as the loading due to dead weight plus handling load for normal conditions. The linearized membrane and membrane plus bending stress intensities are evaluated at all critical sections of the support disk, top weldment, and bottom weldment. The maximum calculated primary membrane (P_m) and primary membrane plus bending (P_m+P_b) stress intensities in the MPC-LACBWR basket support disk, top weldment, and bottom weldment due to a 60*g* bottom end drop are summarized in Table 11.A.2.11-5 along with the corresponding accident condition allowable stresses and margins of safety.

Basket Tie-Rod Analysis

For the concrete cask 6-inch drop, the tie-rod spacers located at the bottom end of the basket assembly must support the entire weight of the basket assembly, not including the weight of the fuel assemblies or damaged fuel cans. The cross-section dimensions of the MPC-LACBWR basket tie-rod spacers are the same as those of the Yankee-MPC basket. Furthermore, the MPC-LACBWR basket weighs less than the Yankee-MPC basket. Therefore, the maximum axial compressive stress in the MPC-LACBWR basket tie-rod spacers due to the 21*g* bottom end drop are bounded by those calculated for the Yankee-MPC basket tie-rod spacers for a 56.1*g* bottom end drop load in MPC FSAR Section 11.3.2.2.

Basket Fuel Tube Analysis

For the concrete cask 6-inch drop, the fuel tubes in the MPC-LACBWR canister basket are supported at their bottom ends by the basket bottom weldment and are loaded only by their own weight. Thus, the fuel tube loading and support conditions for the concrete cask 6-inch drop are the same as those for normal handling, only different in the magnitude of the load.

As shown in Section 3.A.4.4.2.3, the maximum compressive stresses at the bottom end of the standard and oversized fuel tubes due to a 1.1*g* vertical acceleration load are 45 psi and 59 psi, respectively. For the 21*g* bottom end drop load, the maximum compressive stresses at the bottom end of the standard and oversized fuel tubes are 859 psi and 1,126 psi, respectively. The maximum stresses in the fuel tubes are much lower than the yield strength of Type 304 stainless steel material (e.g., S_y = 17,300 psi at 750°F) from which they are made. Therefore, it is concluded that the fuel tubes will remain in position and maintain the position of the neutron absorbers for the concrete cask 6-inch drop event.

Damaged Fuel Can Analysis

The stresses in the Damaged Fuel Can (DFC) are calculated for a 20*g* vertical acceleration load in Section 3.A.4.4.2.4. The results of that analysis show that the maximum compressive stress at the bottom end of the DFC tube is 862 psi and the maximum bending stress for the DFC lid is 1,717 psi. For the 21*g* bottom end drop load, these stresses will be only 5% higher (i.e., 905 psi and 1,803 psi). The maximum stresses in the DFC are much lower than the yield strength of Type 304 stainless steel material (e.g., S_y = 17,300 psi at 750°F) from which they are made. Therefore, it is concluded that the DFC will remain in position and retain its contents for the concrete cask 6-inch drop event.

11.A.2.11.3 Radiological Consequences

There are no radiological consequences for this accident.

11.A.2.11.4 NAC-MPC Performance

Evaluations of the Yankee-MPC concrete storage cask for a 6-inch bottom end drop accident results in a maximum deceleration of 137 g for the storage cask, which does not reduce the shielding effectiveness of the cask. The base support, which contains the air inlets, is crushed approximately 0.31 inch. The effect of the reduction of the inlet area by the 6-inch drop is to reduce cooling air flow. The consequence of the loss of one-half of the air inlets is evaluated in Section 11.A.1.1, which bounds this condition.

The maximum deceleration of 21g for the MPC-LACBWR canister and basket, as a result of the 6-inch storage cask drop, is conservatively evaluated using a bounding deceleration of 60g. The analysis results indicate that the canister and basket remain structurally adequate.

11.A.2.11.5 Recovery and/or Corrective Actions

Even though the storage cask system remains functional and no immediate recovery steps are required, the canister should be moved to a new concrete storage cask as soon as one is available. The damaged storage cask should be inspected for stability, and repaired as required prior to continued use.

Table 11.A.2.11-1 MPC-LACBWR Canister Membrane (P_m) Stresses, Concrete Cask 6-inch Drop without Internal Pressure

Section No.[1]	**Stress Components (ksi)**						**Stress Intensity (ksi)**	**Stress Allowable (ksi)**	**Margin of Safety**
	SX	**SY**	**SZ**	**SXY**	**SYZ**	**SXZ**			
1	0.0	-0.6	-2.7	0.0	0.0	-0.2	2.76	46.26	15.74
2	0.4	-1.4	-6.1	0.0	0.0	-0.1	6.54	46.25	6.07
3	-0.1	-1.5	-6.5	0.0	0.0	0.1	6.41	46.23	6.21
4	0.0	0.0	-6.1	0.0	0.0	0.0	6.10	45.53	6.46
5	0.0	0.0	-5.8	0.0	0.0	0.0	5.76	44.92	6.80
6	0.0	0.0	-5.4	0.0	0.0	0.0	5.37	45.35	7.45
7	0.0	0.0	-5.0	0.0	0.0	0.0	4.98	46.51	8.34
8	0.0	0.2	-4.6	0.0	0.0	0.0	4.79	47.61	8.95
9	0.8	-1.7	-3.2	0.0	0.0	0.5	4.15	47.90	10.54
10	0.6	-1.4	-0.8	0.0	0.0	0.7	2.29	47.92	19.94
11	-1.7	-2.2	-0.2	0.0	0.0	0.5	2.19	47.94	20.92
12	0.2	-0.4	2.3	0.0	0.0	2.0	4.50	38.32[2]	7.52
13	-0.9	-2.3	-1.0	0.0	0.0	0.2	1.54	47.94	30.05
14	0.1	0.1	-0.7	0.0	0.1	0.0	0.79	44.64	55.73
15	0.0	0.0	0.0	0.0	0.0	0.0	0.01	48.00	>100

1. Refer to Figure 3.A.4.4.1-2 for canister section locations.
2. Section 12 allowable multiplied by a weld strength reduction factor of 0.8.

Table 11.A.2.11-2 MPC-LACBWR Canister Membrane + Bending (P_m+P_b) Stresses, Concrete Cask 6-inch Drop without Internal Pressure

Section No.[1]	Stress Components (ksi)						Stress Intensity (ksi)	Stress Allowable (ksi)	Margin of Safety
	SX	SY	SZ	SXY	SYZ	SXZ			
1	0.4	-0.6	-3.1	0.0	0.0	-0.4	3.53	66.08	17.71
2	-0.1	-2.3	-8.4	0.0	0.0	0.1	8.29	66.08	6.97
3	0.0	-1.7	-7.3	0.0	0.0	0.1	7.30	66.04	8.04
4	0.0	0.0	-6.1	0.0	0.0	0.0	6.10	65.04	9.66
5	0.0	0.0	-5.8	0.0	0.0	0.0	5.76	64.17	10.15
6	0.0	0.0	-5.4	0.0	0.0	0.0	5.37	64.78	11.07
7	0.0	0.0	-5.0	0.0	0.0	0.0	4.98	66.45	12.34
8	0.0	-0.1	-5.4	0.0	0.0	0.0	5.39	68.01	11.63
9	-0.5	-2.7	-5.4	0.0	0.0	-0.8	5.07	68.43	12.49
10	0.2	-3.0	-5.8	0.0	0.0	0.1	6.06	68.45	10.29
11	-3.9	-3.0	-0.3	0.0	0.0	0.7	3.86	68.49	16.75
12	1.6	0.1	1.7	0.0	0.0	2.6	5.28	54.75[2]	9.37
13	3.1	-0.9	-0.2	0.0	0.0	-0.4	4.07	68.49	15.83
14	0.8	0.6	-0.7	0.0	0.1	0.0	1.54	63.77	40.36
15	4.1	4.1	0.0	0.0	0.0	0.0	4.07	68.57	15.84

1. Refer to Figure 3.A.4.4.1-2 for canister section locations.
2. Section 12 allowable multiplied by a weld strength reduction factor of 0.8.

Table 11.A.2.11-3 MPC-LACBWR Canister Membrane (P_m) Stresses, Concrete Cask 6-inch Drop with 12 psig Internal Pressure

Section No.[1]	Stress Components (ksi)						Stress Intensity (ksi)	Stress Allowable (ksi)	Margin of Safety
	SX	SY	SZ	SXY	SYZ	SXZ			
1	0.0	-0.5	-2.5	0.0	0.0	-0.2	2.46	46.26	17.78
2	0.5	-1.3	-5.8	0.0	0.0	-0.1	6.37	46.25	6.26
3	-0.1	-1.4	-6.1	0.0	0.0	0.1	5.97	46.23	6.74
4	0.0	0.8	-5.7	0.0	0.0	0.0	6.52	45.53	5.98
5	0.0	0.8	-5.3	0.0	0.0	0.0	6.18	44.92	6.27
6	0.0	0.8	-5.0	0.0	0.0	0.0	5.79	45.35	6.83
7	0.0	0.8	-4.6	0.0	0.0	0.0	5.40	46.51	7.61
8	0.0	0.9	-4.2	0.0	0.0	0.0	5.09	47.61	8.36
9	0.9	-1.5	-3.0	0.0	0.0	0.5	4.03	47.90	10.87
10	0.5	-1.3	-0.8	0.0	0.0	0.7	2.11	47.92	21.75
11	-1.6	-2.1	-0.2	0.0	0.0	0.5	2.02	47.94	22.75
12	0.2	-0.2	2.4	0.0	0.0	1.8	4.27	38.32[2]	7.98
13	-0.9	-2.1	-0.9	0.0	0.0	0.2	1.39	47.94	33.52
14	0.1	0.1	-0.7	0.0	0.1	0.0	0.82	44.64	53.18
15	0.0	0.0	0.0	0.0	0.0	0.0	0.01	48.00	>100

1. Refer to Figure 3.A.4.4.1-2 for canister section locations.
2. Section 12 allowable multiplied by a weld strength reduction factor of 0.8.

Table 11.A.2.11-4 MPC-LACBWR Canister Membrane + Bending (P_m+P_b) Stresses, Concrete Cask 6-inch Drop with 12 psig Internal Pressure

Section No.[1]	**Stress Components (ksi)**						**Stress Intensity (ksi)**	**Stress Allowable (ksi)**	**Margin of Safety**
	SX	**SY**	**SZ**	**SXY**	**SYZ**	**SXZ**			
1	0.4	-0.3	-2.5	0.0	0.0	-0.4	3.01	66.08	20.98
2	0.0	-2.4	-8.8	0.0	0.0	0.0	8.75	66.08	6.56
3	0.0	-1.8	-7.7	0.0	0.0	0.2	7.68	66.04	7.60
4	0.0	0.8	-5.7	0.0	0.0	0.0	6.53	65.04	8.97
5	0.0	0.8	-5.3	0.0	0.0	0.0	6.18	64.17	9.38
6	0.0	0.8	-5.0	0.0	0.0	0.0	5.80	64.78	10.18
7	0.0	0.8	-4.6	0.0	0.0	0.0	5.41	66.45	11.29
8	0.0	0.6	-5.2	0.0	0.0	0.0	5.78	68.01	10.77
9	-0.5	-2.7	-5.8	0.0	0.0	-0.7	5.47	68.43	11.51
10	0.2	-2.9	-5.7	0.0	0.0	0.1	5.93	68.45	10.55
11	-3.7	-2.8	-0.3	0.0	0.0	0.7	3.71	68.49	17.46
12	-1.4	-0.7	2.9	0.0	0.0	1.2	4.90	54.75[2]	10.17
13	2.9	-0.8	-0.2	0.0	0.0	-0.3	3.75	68.49	17.26
14	0.9	0.6	-0.7	0.0	0.1	0.0	1.59	63.77	39.03
15	3.7	3.7	0.0	0.0	0.0	0.0	3.70	68.57	17.55

1. Refer to Figure 3.A.4.4.1-2 for canister section locations.
2. Section 12 allowable multiplied by a weld strength reduction factor of 0.8.

Table 11.A.2.11-5 MPC-LACBWR Basket Maximum Stress Summary, Concrete Cask 6-inch Drop

Canister Component	**Calculated Stress**		**Allowable Stress**		**Margin of Safety**
	Stress Type	**Maximum Value (ksi)**	**Criteria**	**Allowable Value (ksi)**	
Support Disk	P_m	3.4	$2.4S_m$	90.0	25.5
	P_m+P_b	36.3	$3.6S_m$	128.5	2.53
Top Weldment	P_m	3.0	$2.4S_m$	44.9	14.0
	P_m+P_b	26.2	$1.0S_u$	64.4	1.46
Bottom Weldment	P_m	0.4	$2.4S_m$	43.4	107.5
	P_m+P_b	39.2	$1.0S_u$	64.0	0.63

11.A.2.12 Tip-Over of the Concrete Cask

This section discusses the evaluation of the MPC-LACBWR concrete cask for a non-mechanistic tip-over onto the ISFSI concrete pad. For a concrete cask tip over event to occur, the center of gravity of the loaded cask must be rotated beyond the cask bottom edge, i.e., the point of rotation. When the center of gravity passes beyond the point of rotation, the potential energy of the loaded concrete cask will be converted to kinetic energy as it rotates toward a horizontal orientation on the ISFSI pad. The subsequent motion of the concrete cask is governed by the structural characteristics of the concrete cask, ISFSI pad, and underlying soil.

11.A.2.12.1 Cause of Concrete Cask Tip-Over Event

The structural analysis of the concrete cask demonstrates that no design-basis accident events will cause the concrete cask to tip-over. An earthquake magnitude that greatly exceeds the design-basis earthquake described in Section 11.A.2.2 would be required to tip-over the concrete cask.

A tip-over of the concrete cask would be observed during a survey of the site following the earthquake or other catastrophic event. The tipped-over orientation of the concrete cask would be obvious by inspection.

11.A.2.12.2 Analysis of the MPC-LACBWR Concrete Cask Tip-Over Event

11.A.2.12.2.1 Analysis of the MPC-LACBWR Concrete Cask

The concrete cask tip-over evaluation is performed to determine the response of the concrete cask to the tip-over event and the maximum accelerations experienced by canister and basket structural. The methodology used to determine the concrete cask response is based on NUREG/CR-6608. The dynamic response of the concrete cask for the tip-over event is evaluated using the LS-DYNA program. The MPC-LACBWR concrete cask tip-over analysis is performed using the Yankee-MPC concrete cask tip-over finite element model described in MPC FSAR Section 11.2.12, with the following modifications to the density and elastic modulus of the soil underneath the concrete pad:

Soil Property	Concrete Cask Tip-Over Model Yankee - MPC	 LACBWR - MPC
Density	100 pcf	120 pcf
Elastic Modulus	70,000 psi	10,000 psi

The results of the MPC-LACBWR concrete cask tip-over analysis show that the peak accelerations at key locations of the concrete cask liner, which are used in the evaluation of the loaded canister/basket model (Section 11.A.2.12.2 and Section 11.A.2.12.3) are:

Axial Position (Distance from Cask Bottom End)	Canister/Basket Component at Location	Peak Acceleration
126.19 in.	Top Support Disk	20.5*g*
141.6 in.	Canister Top End	22.9*g*

11.A.2.12.2.2 Analysis of the MPC-LACBWR Canister and Basket

Canister Stress Analysis

The MPC-LACBWR canister is evaluated for the concrete cask tip-over condition using a plastic analysis in accordance with Appendix F of the ASME Code. The analysis is performed using the half-symmetry finite element model shown in Figure 11.A.2.12-1. This model is similar to the model used for the MPC-LACBWR canister normal condition stress analysis, as described in Section 3.A.4.4.1.1, but has a refined mesh, gap elements that are sized based on the concrete cask annulus, and plastic material properties.

A bi-linear kinematic hardening material model, defined by a yield strength and a tangent modulus, is used to perform a plastic analysis. The material model is based on the properties of the canister Type 304 stainless steel material at a temperature of 300°F, corresponding to the temperature of the lid weld region where the highest stresses are expected to occur. The yield strength is modeled as 21.4 ksi. The tangent modulus is taken as $(S_u - S_y)/\varepsilon_p = 10.95 \times 10^4$ psi, where S_u is the ultimate tensile strength (66.2 ksi) and ε_p is the ultimate strain (40%).

The canister tip-over stress analysis is conservatively performed using a transverse acceleration of 25*g* over the full length of the canister. Note that this corresponds to a DLF of 1.09 (25/22.9) at top of the canister, which is conservative since the canister lid (7 inches thick) region is stiff due to its monolithic structure. The inertial load of the basket assembly is modeled as a pressure load on the inside surface of the canister shell. The basket pressure load distribution is assumed to be uniform over the length of the canister shell that is in contact with the support disks and is assumed to vary linearly in the circumferential direction, from a maximum value at the symmetry plane to zero at an angle of 22° from the symmetry plane. In addition, a uniform internal pressure load of 12 psig is applied to the model.

The maximum primary membrane (P_m) and primary membrane plus bending (P_m+P_b) stress components and stress intensities in the MPC-LACBWR canister due to the storage cask tip-over load are summarized in Tables 11.A.2.12-1 and 11.A.2.12-2, respectively. In accordance with Appendix F of the ASME Code, the membrane stress is limited to 0.7S_u and the membrane plus bending stress is limited to 0.9S_u. An additional factor of 0.8 is applied to the allowable stresses for the lid closure weld (Section 12). The results of the analysis show that the lowest margins of safety in the cansiter shell for P_m and P_m+P_b stress intensities both occur in the lid closure weld (Section 12 in Figure 3.A.4.4.1-2) and result from the storage cask tip-over load with internal pressure loading. The lowest margins of safety for P_m and P_m+P_b stress intensity are 0.40 and 0.63, respectively.

Support Disk and Weldment Stress Analysis

The MPC-LACBWR canister fuel basket is evaluated for the concrete cask tip-over conditions using the finite element model shown in Figure 11.A.2.12-2. This finite element model is similar to the model used for the MPC-LACBWR canister normal condition stress analysis, as described in Section 3.A.4.4.1.1, but uses a coarse mesh for the canister and includes the basket support disks in order to properly model the interaction between the basket and shell under transverse loading conditions.

Each of the basket support disks and the top weldment are modeled using elastic shell elements (SHELL63) with thickness input as real constants. The 15 support disks that are located in the bottom-end region of the canister, where tip-over loads are lowest, are modeled using the coarse mesh shown in Figure 11.A.2.12-3. The 11 support disks located in the canister top-end region, where the tip-over loads are highest, are modeled using the fine mesh shown in Figure 11.A.2.12-4. The top weldment disk is also modeled using a fine mesh, similar to that shown in Figure 11.A.2.12-4 for the support disk. Rather than modeling the basket tie-rods, each support disk is restrained in the axial direction (i.e., UY=0) at the nodes located at the centerline of each tie-rod. The interface between the basket and canister is modeled by CONTAC52 elements. Contact between the canister shell and the concrete cask steel liner is modeled by CONTAC52 elements that are attached at one end to the canister shell and constrained in all degrees-of-freedom on the other end. The gap elements on the canister shell are positioned to model the shift in the position of the canister shell as it comes into contact with the concrete cask inner liner.

As presented in Section 11.A.2.12.2.1, the maximum acceleration of the steel liner at the location of the top support disk is determined to be 20.5g. Using the acceleration time history developed in Section 11.A.2.12.2.1 and the methodology described in Section 11.2.12.2.2 for the Yankee-MPC basket support disk DLF calculation, the maximum DLF and corresponding frequencies for the MPC-LACBWR support disks are:

Mode Number	Frequency (Hz)	DLF
1	87	1.02
2	256	1.02
3	347	1.02
4	421	1.01

Applying the maximum DLF of 1.02 to the 20.5g results in a peak acceleration of 20.9g. The applied inertial load to the finite element model described in this section corresponds to a bounding transverse load of 25*g* at the basket top support disk. The inertial load of the canister and basket support disks due to the 25*g* tip-over load is accounted from by applying a rotational acceleration load of 76.4 rad/s^2 about the global origin of the model, which corresponds to the location of the concrete cask bottom edge about which the concrete cask tips over. In addition, horizontal line loads are applied to the edges of the fuel tube holes in each support disk to account for the weight of the basket components that are not modeled (i.e., fuel, fuel tubes, damaged fuel cans, heat transfer disks, and tie-rods.) The magnitudes of horizontal line loads applied to the ligaments of the standard and damaged fuel tube openings are calculated based on the weight of the contents of each opening and the transverse acceleration corresponding to the tip-over rotational acceleration. The analysis is performed for five (5) basket impact orientations as shown in Figure 11.A.2.12-5.

The highest stresses occur in the top two support disks (disk no. 25 and 26). The maximum primary membrane (P_m) and primary membrane plus bending (P_m+P_b) stresses for the sections defined in Figure 11.A.2.12-6 for support disks 25 and 26 due to each of the concrete cask tip-over impact orientations evaluated are summarized in Table 11.A.2.12-3. The allowable P_m and P_m+P_b stress intensities for the support disks are based on 17-4 PH material properties at a bounding temperature of 500°F. The results of the basket tip-over stress analysis show that the lowest design margins for P_m and P_m+P_b are 0.20 and 0.55, respectively.

Basket Support Disk Buckling Analysis

Buckling of the MPC-LACBWR support disk is evaluated for the tip-over condition in accordance with the methods and acceptance criteria of NUREG/CR-6322. The support disks are fabricated from 17-4 PH ferritic steel. Therefore, the formulas for non-austenitic steel presented in MPC FSAR Section 11.2.12.2.2 are used for the support disk buckling analysis.

The support disk buckling analysis considers the highest ligament stresses in the two support disks located nearest the top end of the basket (i.e., 25th and 26th support disks) resulting from each of the impact orientations shown in Figure 11.A.2.12-5. The support disk buckling analysis is conservatively performed using the smallest ligament cross-section dimensions and the largest ligament length for all disk ligaments. Table 11.A.2.12-4 summarizes the calculated and allowable forces and moments at the stress sections in support disks 25 and 26 with the lowest margins of safety against buckling for each concrete cask tip-over impact orientation evaluated. The results show that the lowest margin of safety against buckling of 0.16 occurs at section 111 of support disk number 25 for the 15.2° impact orientation. Therefore, the MPC-LACBWR support disks satisfy the buckling design criteria of NUREG/CR-6322 for the tip-over condition.

Basket Fuel Tube Analysis

The MPC-LACBWR fuel tube stresses and deformation resulting from the concrete cask tip-over load are bounded by those calculated for the MPC-CY fuel tubes in MPC FSAR Section 11.4.5 for a 55*g* side impact load. This conclusion is based on a comparison of the MPC-LACBWR and MPC-CY fuel tube loads and boundary conditions considered in the concrete cask tip-over stress analysis.

The MPC-LACBWR fuel tubes are similar to the MPC-CY fuel tubes, having the same 0.048-inch tube thickness, but are shorter, have smaller openings, and contain much lighter payloads than the MPC-CY fuel tubes. The MPC-LACBWR fuel tubes are 98.25 inches long compared to 131.95 inches for the MPC-CY fuel tubes. The MPC-LACBWR standard and oversized fuel tubes have square 5.75-inch and 6.00-inch openings, whereas the MPC-CY fuel tube has a square 9.12-inch opening. The lateral pressure loading on the MPC-LACBWR standard and oversized fuel tubes due to the 25*g* tip-over are 17.7 psi (i.e., 25*g* × 400 lb/(98.25×5.75)) and 19.0 psi (i.e., 25*g* × 449 lb/(98.25×6.00), respectively, whereas the MPC-CY fuel tubes are designed for lateral pressure load of 72.67 psi, as discussed in MPC

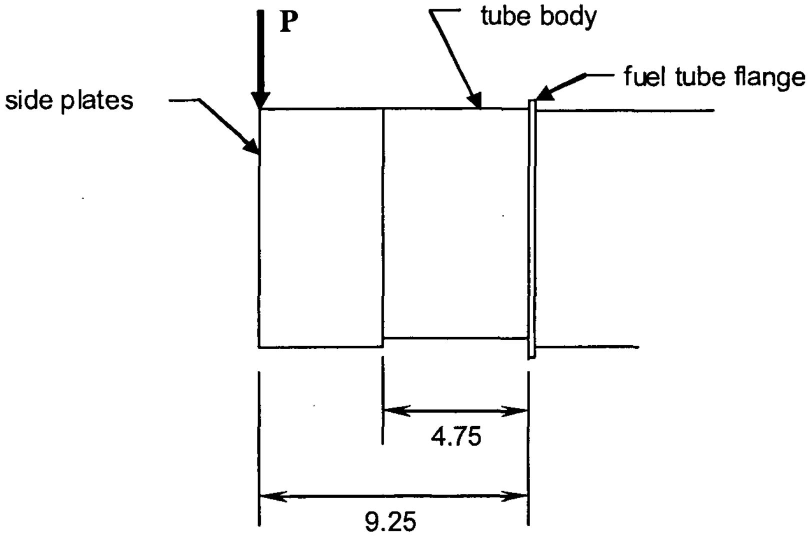
FSAR Section 11.4.5. Furthermore, the axial spacing (or pitch) of the support disks, and therefore the unsupported span length of the MPC-LACBWR fuel tubes, is smaller than that of the MPC-CY basket (i.e., 3.83-inch vs. 4.59-inch).

Therefore, the maximum stresses and deformation of the MPC-LACBWR fuel tubes due to the concrete cask tip-over are much lower than those calculated for the MPC-CY fuel tubes due to the 55*g* side impact load in MPC FSAR Section 11.4.5.

Damaged Fuel Can Analysis

The majority of the damaged fuel can body is contained within the fuel tube in the basket assembly. Because both the can tube body and the fuel tube have square cross-sections, they will be in full contact (for 95.24 inches longitudinally) during the cask tip-over condition, and no significant bending stress will be introduced into the can body. However, the top 4.75 inches of the can tube body and the 4.5-inch-long side plates are unsupported past the fuel tube flange.

The unsupported can tube body is evaluated as a cantilevered beam with the combined weight (P) of the overhanging can tube body, lid and side plates using a conservative deceleration of 60g. The combined loading is conservatively applied at the top end of the side plates.



The maximum bending stress (f_b) is determined as follows.

$$f_b = \frac{M_{max} c}{I} = \frac{33{,}300(2.93)}{6.5} = 15{,}011 \text{ psi}$$

where:

$M_{max} = Pg \times L = 60(60)(9.25) = 33{,}300$ lb-inch

$g = 60$

The shear stress (τ) is

$$\tau = \frac{Pg}{A} = \frac{60(60)}{1.16} = 3{,}103 \text{ psi}$$

$$\sigma_1, \sigma_2 = \frac{1}{2}\left(f_b \pm \sqrt{f_b^2 + 4\tau^2}\right) = \frac{1}{2}\left(15{,}011 \pm \sqrt{15{,}011^2 + 4(3{,}103)^2}\right) = 15{,}627 \text{ psi and } -616 \text{ psi}$$

The stress intensity (σ_{max}) = $|\sigma_1 - \sigma_2|$ = 16,243 psi

The margin of safety (MS) is

$$MS = \frac{1.0\ (3.6S_m)}{\sigma_{max}} - 1 = \frac{1.0(3.6)(16{,}700)}{16{,}243} - 1 = 2.70$$

The welds joining the can tube body to the side plates are full-penetration welds. The weld quality factor (n) for a Type III weld with visual surface inspection is 0.5. The margin of safety (MS) for the welds is

$$MS = \frac{(1.0)n \cdot 3.6S_m}{\sigma_{max}} - 1 = \frac{(1.0)(0.5)(3.6)(16{,}700 \text{ psi})}{16{,}243 \text{ psi}} - 1 = 0.85$$

11.A.2.12.3 Radiological Consequences

There is an adverse radiological consequence in the hypothetical tip-over event, since the bottom end of the storage cask and the canister have significantly less shielding than the sides and tops of these same components. In previous calculations for the Yankee-MPC, the dose rate at 1 meter is calculated to be approximately 156 rem/hour, and the dose rate at 5 meters is calculated to be approximately 32 rem/hour. These does rates are bounding for the MPC-LACBWR system due to the smaller source in the LACBWR payload. Regardless of the MPC system configuration, high dose rates expected at the cask bottom following the tip-over event would dictate the use of supplemental shielding until the concrete cask can be uprighted. Stringent access controls must be applied to ensure that personnel do not enter the area of radiation shine from the exposed bottom of the tipped over concrete cask. As previously noted in the tip-over analysis, tip-over is not a credible event.

11.A.2.12.4 NAC-MPC Performance

Following a tip-over event, the MPC-LACBWR canister will maintain confinement of radioactive material and continue to provide criticality control. Minor damage to the exterior surface of the concrete cask, such as cracking or spalling of cover concrete, may result from the tip-over event. The damage to the concrete cask exterior may result in local increases to the concrete cask exterior dose rates. The radiological consequences of the MPC-LACBWR concrete cask tip-over are evaluated in Section 11.A.2.12.3.

11.A.2.12.5 Recovery and/or Corrective Actions

The actions required for recovery from the concrete cask tip-over event are discussed in MPC FSAR Section 11.2.12.8.

Figure 11.A.2.12-1 MPC-LACBWR Canister Tip-Over Finite Element Model

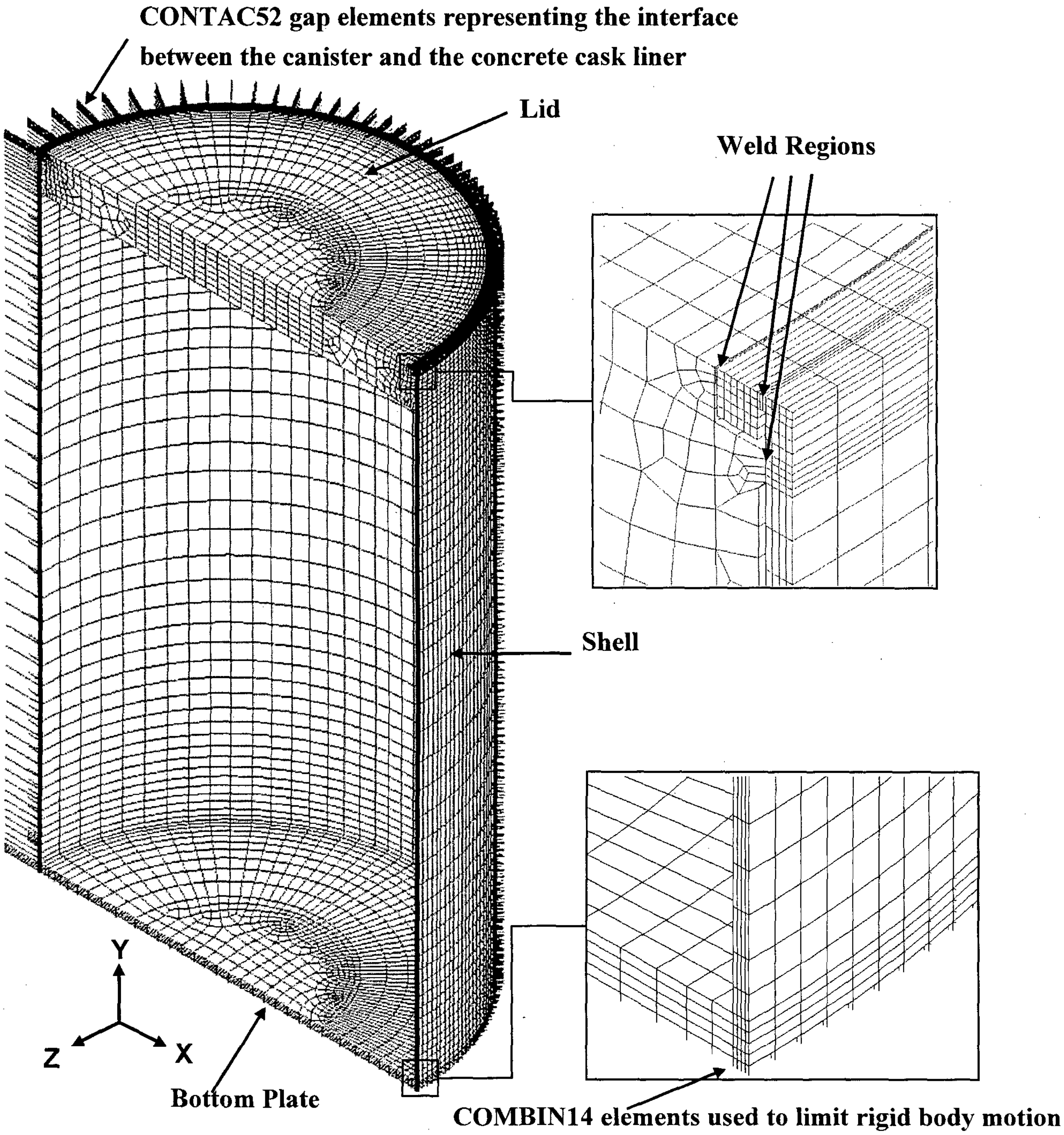


Figure 11.A.2.12-2 MPC-LACBWR Basket Tip-Over Finite Element Model

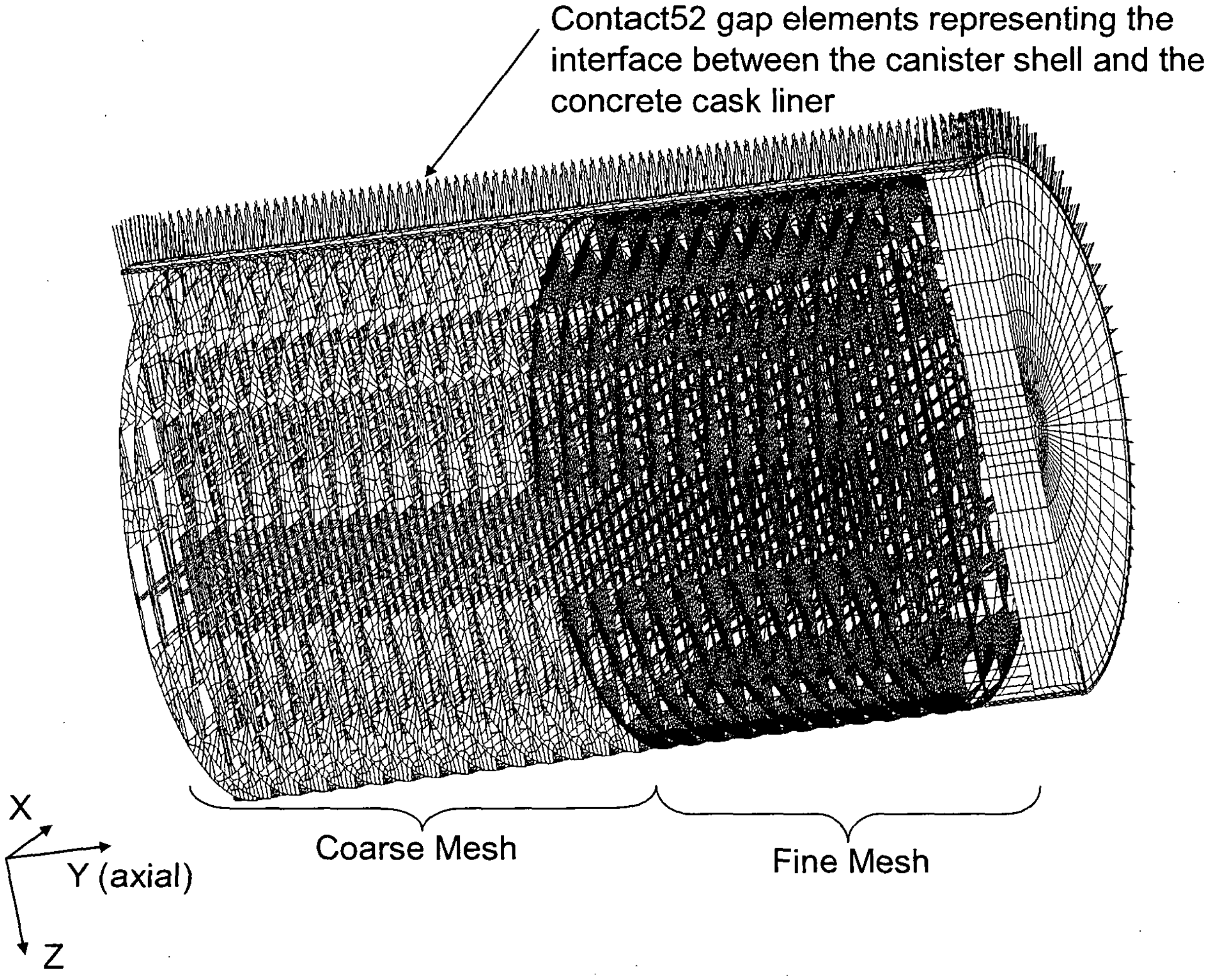


Figure 11.A.2.12-3 MPC-LACBWR Basket Tip-Over Finite Element Model – Coarse Disk Mesh

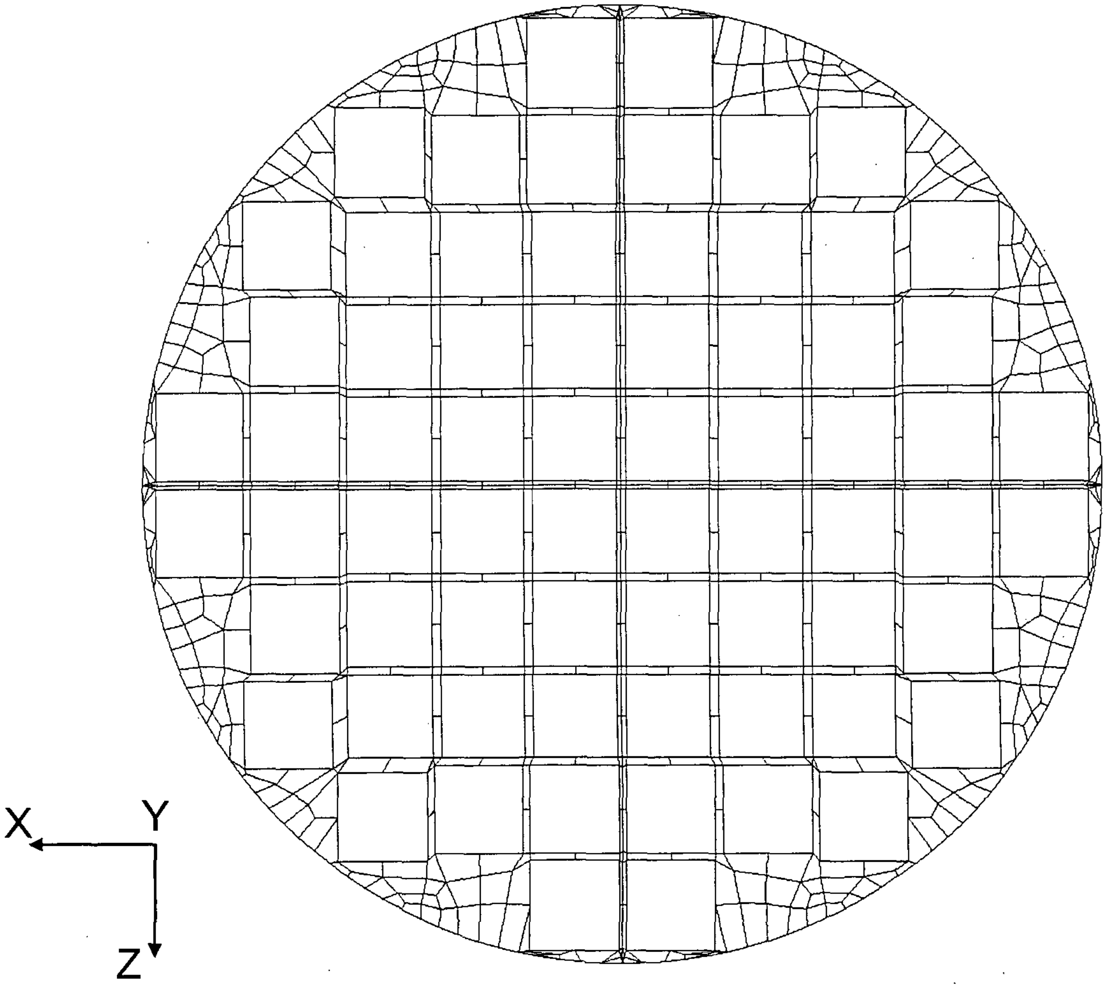


Figure 11.A.2.12-4 MPC-LACBWR Basket Tip-Over Finite Element Model – Fine Disk Mesh

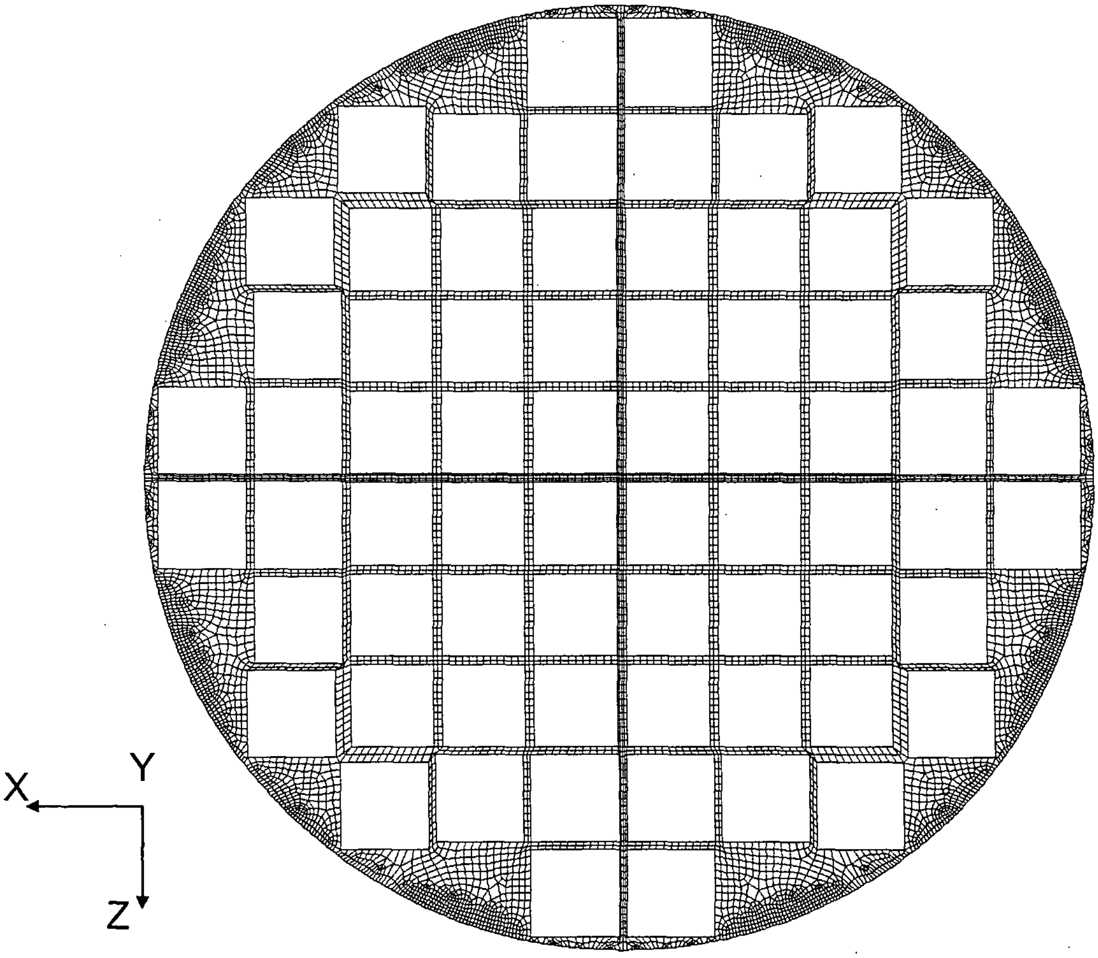


Figure 11.A.2.12-5 MPC-LACBWR Basket Tip-Over Impact Orientations Evaluated

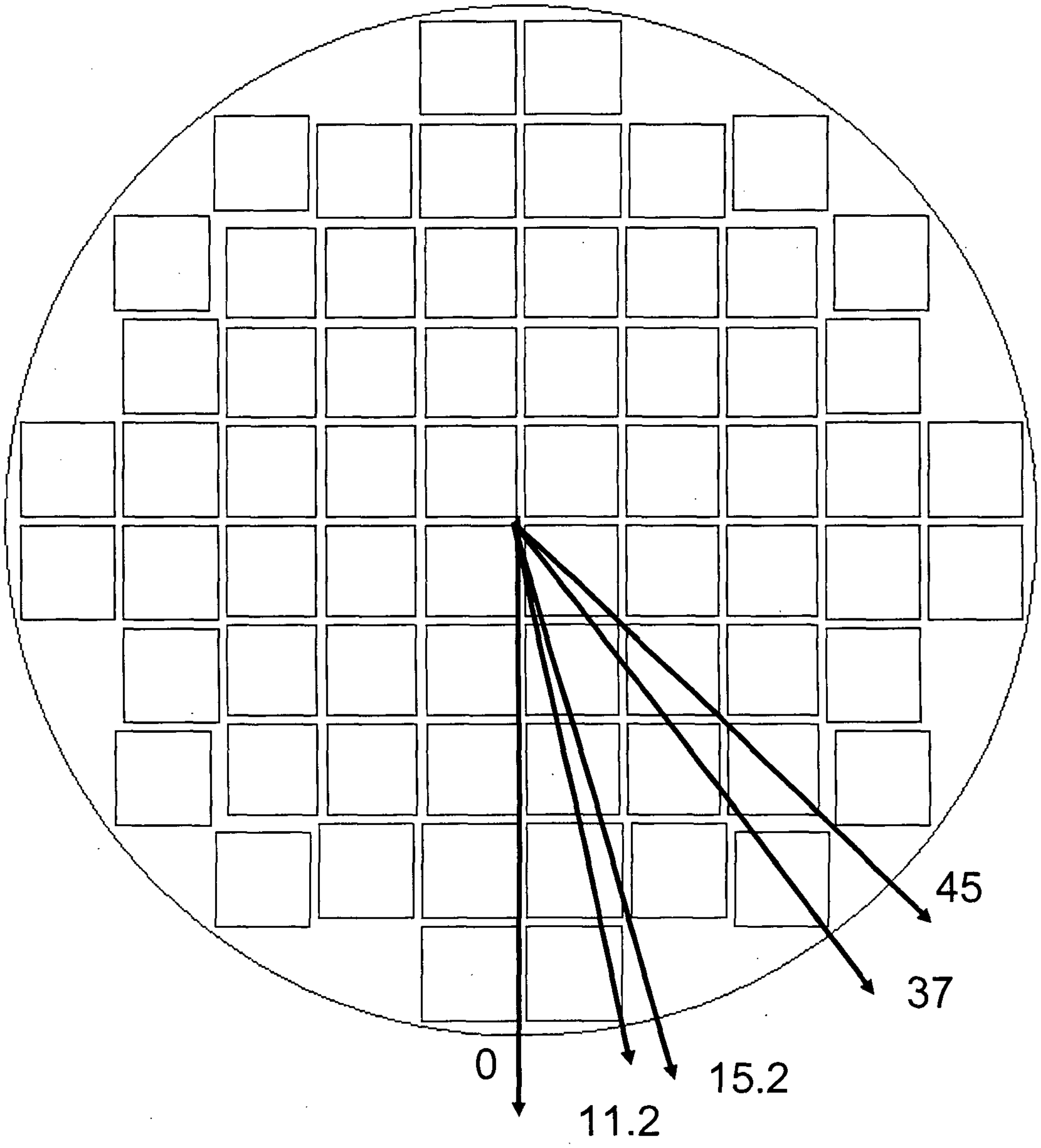


Figure 11.A.2.12-6 MPC-LACBWR Support Disk Stress Sections

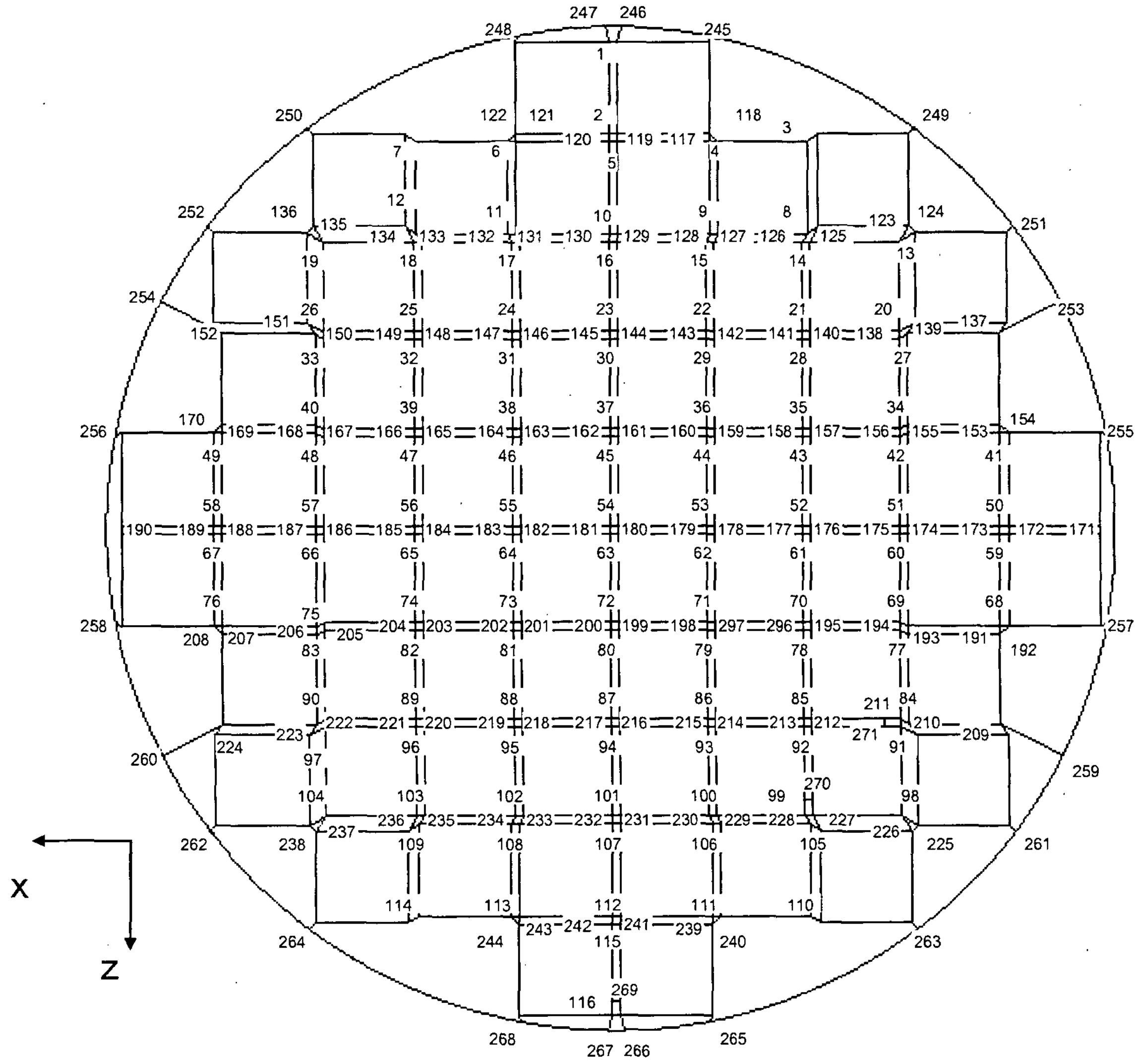


Table 11.A.2.12-1 Summary of MPC-LACBWR Canister Primary Membrane (P_m) Stresses, Concrete Cask Tip-Over + Internal Pressure

Section No.(1)	Stress Components (ksi)						Stress Intensity (ksi)	Stress Allowable (ksi)	Margin of Safety
	SX	SY	SZ	SXY	SYZ	SXZ			
1	-26.13	-16.39	-1.00	0.74	0.75	-1.30	25.35	45.64	0.80
2	-14.36	-24.53	-4.68	0.46	0.23	-3.51	21.02	45.64	1.17
3	0.02	-10.47	3.16	-0.46	1.15	-0.20	13.87	45.64	2.29
4	-0.55	3.47	5.19	1.43	-0.61	-0.06	6.44	45.08	6.00
5	-0.63	2.04	5.46	1.20	0.01	-0.01	6.55	45.08	5.88
6	-0.62	1.97	5.17	1.15	0.16	0.00	6.24	45.08	6.23
7	-0.64	3.07	4.29	1.41	0.61	0.04	5.74	45.08	6.86
8	0.00	1.32	-0.13	-0.01	5.28	0.06	10.66	46.20	3.34
9	-21.77	-8.88	4.66	-0.09	0.02	2.71	26.98	46.20	0.71
10	-20.01	-10.04	1.05	-0.08	-0.08	-7.79	26.20	46.20	0.76
11	-21.40	-10.38	-0.79	0.12	0.00	3.17	21.57	46.20	1.14
12	-31.19	-18.76	-6.27	-0.04	0.01	-4.26	26.34	36.96(2)	0.40
13	-30.31	-16.18	-1.76	0.01	-0.06	0.61	28.58	46.20	0.62
14	-1.31	0.73	-0.01	0.07	-0.01	0.01	2.04	45.08	21.05
15	-0.56	0.18	-0.01	0.02	0.00	-0.04	0.74	46.20	61.58

1. *Refer to Figure 3.A.4.4.1-2 for canister section locations.*
2. Section 12 allowable multiplied by a weld strength reduction factor of 0.8.

Table 11.A.2.12-2 Summary of MPC-LACBWR Canister Primary Membrane + Bending (P_m+P_b) Stresses, Concrete Cask Tip-Over + Internal Pressure

Section No.[(1)]	**Stress Components (ksi)**						**Stress Intensity (ksi)**	**Stress Allowable (ksi)**	**Margin of Safety**
	SX	**SY**	**SZ**	**SXY**	**SYZ**	**SXZ**			
1	-27.68	-16.02	-0.79	0.85	0.63	0.46	27.00	58.68	1.17
2	0.81	-15.94	-32.59	-0.07	-2.00	-2.91	34.14	58.68	0.72
3	0.12	6.56	30.86	0.48	-6.89	2.26	33.04	58.68	0.78
4	-0.11	31.04	14.77	-0.23	-1.97	-0.01	31.39	57.96	0.85
5	-0.14	31.85	15.17	-0.20	-0.49	0.00	32.01	57.96	0.81
6	-0.15	31.63	14.85	-0.18	0.43	0.00	31.79	57.96	0.82
7	-0.14	31.18	14.00	-0.23	1.76	0.01	31.50	57.96	0.84
8	0.13	-27.47	-6.59	0.28	-0.18	0.08	27.61	59.40	1.15
9	-15.80	-2.21	12.44	-0.13	-0.04	1.67	28.44	59.40	1.09
10	-22.25	-14.41	-6.61	0.01	-0.06	-12.49	29.48	59.40	1.02
11	-28.42	-8.56	1.90	-0.35	0.04	5.13	32.02	59.40	0.86
12	-27.34	-16.68	-5.94	-0.02	-0.02	-9.83	29.07	47.52[(2)]	0.63
13	-36.42	-21.37	-6.32	-0.05	-0.04	5.73	32.20	59.40	0.84
14	-8.80	-6.71	-0.01	0.08	-0.01	0.01	8.80	57.96	5.59
15	-0.92	0.46	0.00	0.04	0.00	-0.04	1.38	59.40	41.97

1. Refer to Figure 3.A.4.4.1-2 for canister section locations.
2. Section 12 allowable multiplied by a weld strength reduction factor of 0.8.

Table 11.A.2.12-3 Summary of MPC-LACBWR Support Disk Stresses, Concrete Cask Tip-Over

Support Disk	Impact Angle(3)	Stress Type	Section Number(4)	Stress Intensity	Allowable S.I. (ksi)	Margin of Safety
25(1)	0°	P_m	112	57.92	90.0	0.55
		P_m+P_b	265	105.67	128.6	0.22
	11.2°	P_m	111	55.25	90.0	0.63
		P_m+P_b	269	102.4	128.6	0.26
	15.2°	P_m	111	56.25	90.0	0.60
		P_m+P_b	179	101.75	128.6	0.26
	37°	P_m	72	39.49	90.0	1.28
		P_m+P_b	99	90.91	128.6	0.41
	45°	P_m	72	39.34	90.0	1.29
		P_m+P_b	99	95.95	128.6	0.34
26(2)	0°	P_m	112	57.62	90.0	0.56
		P_m+P_b	265	107.19	128.6	0.20
	11.2°	P_m	111	51.34	90.0	0.75
		P_m+P_b	269	95.43	128.6	0.35
	15.2°	P_m	111	52.05	90.0	0.73
		P_m+P_b	179	97.88	128.6	0.31
	37°	P_m	72	37.9	90.0	1.37
		P_m+P_b	99	86.78	128.6	0.48
	45°	P_m	72	37.82	90.0	1.38
		P_m+P_b	99	91.56	128.6	0.40

1. Support disk 25 is the 5/8-inch thick support disk located nearest the top end of the basket.
2. Support disk 26 is the 1 ¼-inch thick support disk located at the top end of the basket.
3. Tip-over impact orientations are shown in Figure 11.A.2.12-5.
4. Support disk section locations are shown in Figure 11.A.2.12-6.

Table 11.A.2.12-4 Summary of MPC-LACBWR Support Disk Ligament Buckling Analysis Results, Concrete Cask Tip-Over

Support Disk			**Calculated Forces and Moments**			**Allowable Forces and Moments[5]**			**Margin of Safety[5]**	
	Impact Angle[3]	**Section Number[4]**	**P (kip)**	**P_y (kip)**	**M (in-kip)**	**P_{cr} (kip)**	**M_p (in-kip)**	**M_m (in-kip)**	**MS1**	**MS2**
25[1]	0°	241	9.95	28.11	1.87	42.64	4.39	4.68	0.75	0.40
	11.2°	269	10.21	28.11	2.40	42.64	4.39	4.68	0.48	0.21
	15.2°	111	14.88	28.11	1.71	42.64	4.39	4.68	0.52	0.16
	37°	72	5.60	28.11	3.13	42.64	4.39	4.68	0.43	0.24
	45°	72	6.13	28.11	2.92	42.64	4.39	4.68	0.48	0.28
26[2]	0°	269	30.27	56.22	1.46	84.93	17.57	18.69	1.36	0.64
	11.2°	111	26.05	56.22	2.30	84.93	17.57	18.69	1.43	0.74
	15.2°	111	26.46	56.22	3.22	84.93	17.57	18.69	1.18	0.60
	37°	72	10.89	56.22	6.23	84.93	17.57	18.69	1.43	1.02
	45°	72	12.08	56.22	5.80	84.93	17.57	18.69	1.46	1.02

1. Support disk 25 is the 5/8-inch thick support disk located nearest the top end of the basket.
2. Support disk 26 is the 1 ¼-inch thick support disk located at the top end of the basket.
3. Tip-over impact orientations are shown in Figure 11.A.2.12-5.
4. Support disk section locations are shown in Figure 11.A.2.12-6.
5. Allowable forces and moments and margins of safety are calculated as described in Section 11.2.12.2.2.

11.A.2.13 Tornado and Tornado-Driven Missiles

The MPC-LACBWR Concrete Cask is evaluated for tornado wind and tornado-generated missile impact loads that are based on the design basis tornado wind and tornado-generated missiles characteristics described in Section 2.2.1. The evaluation, which is performed using the same classical techniques used for the evaluation of the Yankee-MPC concrete cask, demonstrates that the MPC-LACBWR concrete cask remains structurally intact and upright when subjected to the design basis tornado wind and tornado-generated missile loads. The extent of local damage of the MPC-LACBWR storage system caused by the design basis tornado-generated missile impacts is identical to that of the Yankee-MPC storage system (i.e., local dislodge of concrete on the concrete cask exterior to a depth of 5.68 inches.) Furthermore, since the MPC-LACBWR canister is adequately protected by the concrete cask from the effects of tornado loading, the tornado event has no significant effect on the canister.

The cause and detection of the tornado event and the corrective actions for recovery from the tornado event are essentially the same as those described in MPC FSAR Sections 11.2.13.1 and 11.2.13.5, respectively. The radiological consequences of the tornado event for the MPC-LACBWR storage system are addressed in Section 11.A.2.13.3.

11.A.2.13.2 Analysis of the Tornado Event

The analyses of the MPC-LACBWR storage system for tornado wind and tornado-generated missile impact loads are described in the following sections. Section 11.A.2.13.2.1 describes the stress analysis of the MPC-LACBWR concrete cask reinforced concrete shell for tornado wind loading. Section 11.A.2.13.2.2 describes the local damage analysis of the MPC-LACBWR concrete cask for tornado-generated missile impact loads and the overall damage analysis of the MPC-LACBWR concrete cask for the combined effects of tornado wind and tornado-generated missile impact loads.

11.A.2.13.2.1 Tornado Wind Loading

This section describes the evaluation of the maximum stresses in the MPC-LACBWR concrete cask resulting from the design basis tornado wind load. The evaluation of the overturning stability of the MPC-LACBWR concrete cask under the combined effects of tornado wind and tornado-generated missile impact loading is described in Section 11.A.2.13.2.2.

Tornado wind loading for the MPC-LACBWR concrete cask is identical to that of the Yankee-MPC concrete cask because the two cask designs have the same outside diameter and height.

Therefore, the MPC-LACBWR concrete cask is subjected to the same lateral tornado wind force as the Yankee-MPC concrete cask. As shown in MPC FSAR Section 11.2.13.2.1.1, the 23.59 kip lateral wind force results in an overturning moment of 157.3 kip-feet on the concrete cask. The stresses in the Yankee-MPC concrete cask resulting from the tornado wind load are calculated in MPC FSAR Section 11.2.13.2.1.1 using classical small-deformation beam theory, conservatively assuming that the concrete cask steel liner does not provide any structural support of the concrete shell.

The stresses in the MPC-LACBWR concrete cask, calculated using the same analysis approach as that used for the Yankee-MPC concrete cask, are lower since the MPC-LACBWR cask concrete shell is thicker and has higher section properties than the Yankee-MPC cask concrete shell. However, the bounding stresses calculated for the Yankee-MPC concrete cask are conservatively used for the evaluation of the MPC-LACBWR concrete cask. These stresses, when evaluated in combination with the maximum stresses resulting from dead load, live load, and normal thermal load, as discussed in Section 3.A.4.4.1.5, are shown to satisfy the applicable allowable stress criteria.

11.A.2.13.2.2 Tornado Missile Loading

The MPC-LACBWR concrete cask is designed to withstand the effects of impacts from the design basis tornado-generated missiles described in MPC FSAR Section 2.2.1.3, consisting of: (1) a high-kinetic energy missile (i.e., 4,000-pound automobile with a frontal area of 20 ft^2); (2) a 275-pound, 8-inch-diameter armor piercing artillery shell; and (3) a 1-inch-diameter solid steel sphere. All missiles have an impact velocity of 126 mph and are assumed to impact the cask in a manner that produces maximum damage.

The evaluation of the MPC-LACBWR concrete cask for tornado-generated missile impacts includes analyses of local damage and overall damage (i.e., overturning stability). The evaluation demonstrates that the MPC-LACBWR concrete cask will not overturn and satisfies the applicable allowable stress design criteria.

Local Damage Prediction

Local damage to the MPC-LACBWR concrete cask is predicted to be the same as the damage calculated for the Yankee-MPC MPC in MPC FSAR Section 11.2.13.2.1.2 since the exterior members of the MPC-LACBWR concrete cask are either the same as, or stronger (i.e., thicker) than those of the Yankee-MPC. Furthermore, the MPC-LACBWR concrete cask, which has essentially the same inlet and outlet structure as the Yankee-MPC MPC, prevents the 1-inch diameter solid steel sphere missile from directly impacting the MPC-LACBWR canister.

The 1.5-inch-thick steel lid of the MPC-LACBWR concrete cask is greater than the plate thickness recommended to prevent perforation by the 8-inch-diameter armor piercing artillery shell. The thickness of the MPC-LACBWR concrete cask reinforced concrete shell is over three times greater than the predicted 5.68-inch penetration depth of the 8-inch-diameter armor piercing artillery shell missile. Therefore, the thickness of the MPC-LACBWR concrete cask reinforced concrete shell, even without structural credit for backing support provided by the concrete cask steel liner, is sufficient to prevent scabbing.

Overall Damage Prediction

The MPC-LACBWR storage system is evaluated for potential overturning due to the combined effects of tornado wind and tornado-generated missile loading using the same approach used for the Yankee-MPC storage system, as described in MPC FSAR Section 11.2.13.2.1.2. The design basis tornado-generated missile with the highest kinetic energy (i.e., 4,000-pound automobile) is conservatively assumed to impact the top edge of the concrete cask, causing the concrete cask to rotate about its bottom edge, as illustrated in the figure at the end of this section. The evaluation demonstrates that the MPC-LACBWR concrete cask will not tip over under the most severe combination of tornado wind and tornado-generated missile impact loads.

As discussed in MPC FSAR Section 11.2.13.2.1.2, the following equation, which is based on principle of conservation of momentum, is used to determine the angular velocity of the missile following impact:

$$M_m(v_2 - v_1) = \frac{I_m(\varpi_1 - \varpi_2)}{H}$$

where (with reference to the figure at the end of this section):

M_M = 10.35 lb-s^2/in (4,000 lbf), Mass of missile

v_2 = 0, Velocity of missile at time t_2

v_1 = 2,220 in/sec (185 ft/sec = 126 mph), Velocity of missile time of impact, t_1

I_m = $6.917\text{x}10^6$ lb-in-s^2, mass moment of inertia of the concrete cask about the point of rotation

= $I_{mx} + (M_{VCC})(d_{cg})^2$

ϖ_1 = 0, angular velocity of the concrete cask at time of impact, t_1

ϖ_2 = angular velocity of the concrete cask at time t_2

H = 160 in., height of concrete cask

I_{mx} = $1.601\text{x}10^6$ lb-in-s^2, mass moment of inertia of loaded concrete cask about the horizontal axis through the center of gravity

= $(M_{VCC})(3r^2 + H^2)/12$

M_{VCC} = 507 lb-s^2/in (195,800 lbf), mass of loaded concrete cask

d_{CG} = 102.4 in., Radial distance from point of rotation to concrete cask center of gravity

= $\sqrt{(h_{CG})^2 + (r - c)^2}$

= $\sqrt{(83.0)^2 + (64 - 4)^2}$

r = 64 in., Radius of concrete cask

During the restitution phase the final velocity of the missile will depend upon the coefficient of restitution of the missile, the geometry of the missile and target, the angle of incidence, and the amount of energy dissipated in deforming the missile and target. It is conservatively assumed that the final velocity of the missile following the impact, v_f, is zero and that all of the missile's kinetic energy is transferred to the concrete cask. Thus, the angular velocity of the concrete cask at time t_2 is determined by setting $v_2 = 0$ in the previous equation, as follows:

$$(10.35)(0 - 2{,}220) = \frac{(6.917\text{x}10^6)(0 - \varpi_2)}{160}$$

Rearranging terms and solving for ϖ_2 yields:

ϖ_2 = 0.531 rad/sec

thus,

$$v_2 = (\varpi_2)\sqrt{H^2 + (2r - c)^2} = 107.5 \text{ in/sec}$$

where ϖ_2, H, and r are defined previously, and c is the chamfer size at the bottom end of the concrete cask (i.e., c = 4 in.).

Setting the impulse of the force on the missile during restitution equal to the impulse of the force on the cask, as follows, yields the angular velocity of the concrete cask following the impact (ϖ_f).

$$-M_m(v_f - v_2) = \frac{I_m(\varpi_f - \varpi_2)}{H}$$

Substituting the values of M_m, I_m, and H from above and setting $v_f = 0$, $v_2 = 107.5$ in/second, and $\varpi_2 = 0.531$ rad/second gives:

$$-(10.35)(0 - 107.5) = \frac{(6.917\text{x}10^6)(\varpi_f - 0.531)}{160}$$

Solving the equation yields the angular velocity of the concrete cask following the impact:

$$\varpi_f = 0.557 \text{ rad/sec}$$

Thus, the final kinetic energy of the concrete cask following the impact, E_k, is:

$$E_k = (I_m)(\varpi_f)^2/2 = 1.073\text{x}10^6 \text{ lb-in}$$

Based on the conservation of energy, the kinetic energy of the concrete cask following impact will cause the center of gravity to increase by:

$$h_{KE} = E_k/W_{VCC} = 5.5 \text{ in.}$$

Thus, the maximum angle of rotation of the cask due to the high-energy tornado-generated missile impact is (with reference to the figure at the end of this section):

$$\theta = \alpha - \beta = 5.7°$$

where:

$\alpha \quad = \cos^{-1}(h_{CG}/d_{CG}) = 35.9°$

$\beta \quad = \cos^{-1}[(h_{CG} + h_{KE})/d_{CG}] = 30.2°$

The total energy required to overturn the concrete cask, E_p, is:

$E_p \quad = (W_{VCC})(h_{PE}) = 3.80\text{x}10^6$ lb-in.

where:

h_{PE} = 19.4 in., Increase in height of the concrete cask system center of gravity required to overturn the cask.
= $d_{CG} - h_{CG}$

Therefore, the high-energy tornado-generated missile impact will not cause the MPC-LACBWR concrete cask to overturn.

As a result of the rotation due to the missile impact, the restoring moment of the MPC-LACBWR concrete cask available to counteract the overturning moment due to tornado wind loading is reduced slightly. The reduced horizontal moment arm caused by the concrete cask rotation is calculated as follows:

$e \quad = (d_{CG}) \text{ x } \sin(\beta) = 51.5$ in (4.29 ft)

Thus, the available gravity restoration moment after missile impact is:

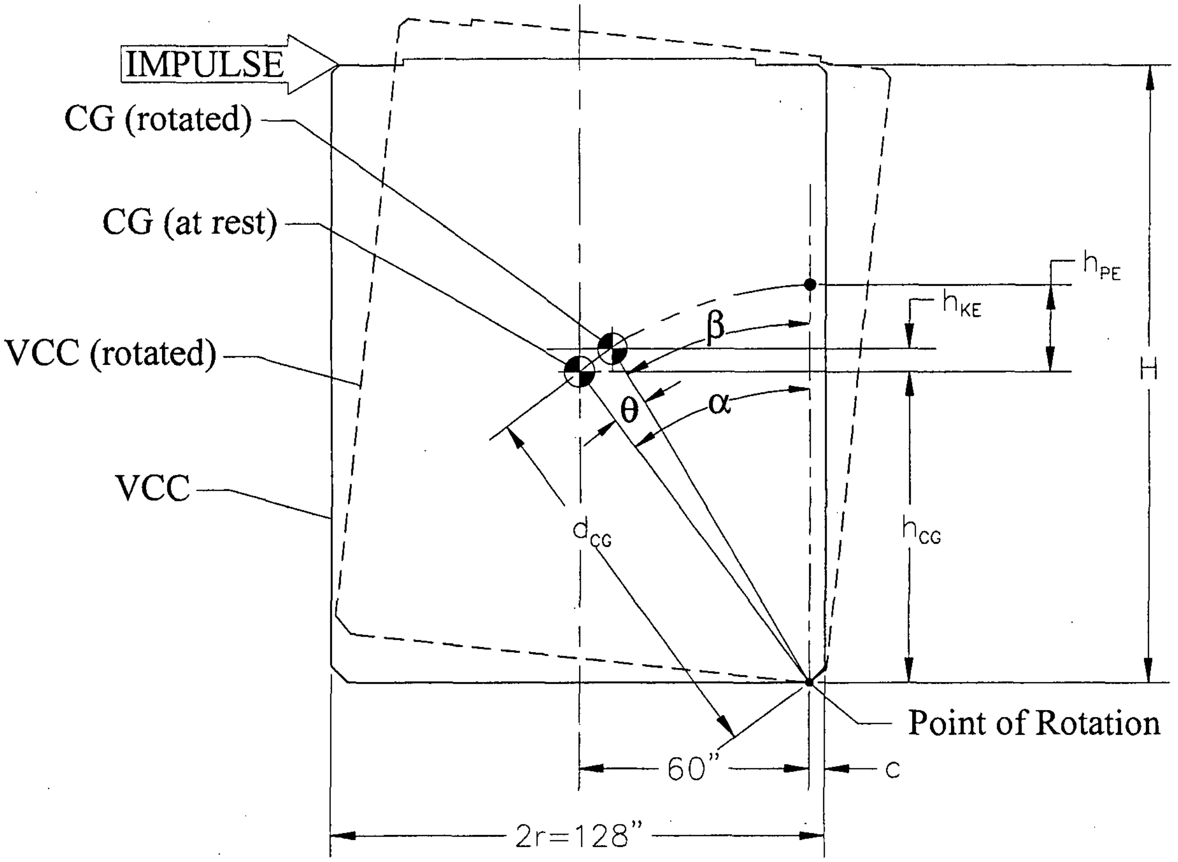
$M_R \quad = (W_{VCC})(e) = 840.0$ kip-ft

Since the restoring moment is much greater than the overturning moment due to the tornado wind force of 157.3 kip-feet, the MPC-LACBWR concrete cask will not tip over under the combined effects of tornado wind loading and tornado-generated missile impact loading. The factor of safety provided by the MPC-LACBWR concrete cask against overturning due to the combined effects of tornado wind and missile loading is 5.34 (= 840.0/157.3).

11.A.2.13.3 Radiological Consequences

This evaluation shows that there is little potential for significant damage to the concrete cask, which provides radiation shielding.

Under the most severe tornado missile impact for the MPC-LACBWR, a penetration of 5.68 inches into the concrete shield is possible. A conservative dose rate calculation was performed assuming a 6 inch penetration into the shield. This would result in a local surface radiation dose rate at the point of penetration of approximately 278 mrem/hr. Since the area of reduced shielding is very small, there would not be a noticeable increase in the dose rate at the site boundary. Repair of the damage would likely require two persons to set up forms in the damaged area and apply grout. This is estimated to require 30 minutes. The estimated extremity dose is 278 mrem. The whole body dose would be less. The extremity dose rate of clearing inlets and outlets has been estimated in Section 11.A.2.8.3 at a total of 150 mrem.



11.A.3 Design Basis Loading of the MPC-LACBWR Transportable Storage Canister

In addition to normal and accident storage conditions, The MPC-LACBWR canister is also designed for the transportation Hypothetical Accident Conditions (HAC) defined in 10 CFR 71.73. This section describes two governing structural evaluations for the transport conditions: (1) Basket support disk evaluation for the 30-foot side drop condition, and, (2) basket top weldment evaluaiton for the 30-ft top end drop condition.

11.A.3.1 Basket Support Disk Evaluation for 30-ft Side Drop

The basket support disks are evaluated for the 30-foot side drop conditions of transport using the finite element model described in Section 11.A.2.12.2.2 for the support disk evaluations for the concrete cask tip-over accident with the following changes: (1) The gap size for the CONTA52 elements at the exterior surface of the canister is adjusted based on the gap between the canister and the transport cask inner shell; (2) The top two disks, 16 disks at the middle section of the basket and the bottom disk are modeled with more refined mesh; and (3) The acceleration loading is changed to a 55g load applied uniformly in the transverse direction of the canister to simulate a side drop. The pressure loading on the disks is made to reflect the higher loading on the central disks as a result of supporting the heat transfer disks. The loading on the top support disk is also modified to simulate the load from the damaged fuel cans sliding up to the bottom of the canister lid.

Two cases were considered to ensure that the worst possible loading condition was captured. Case 1 assumes that all the damaged fuel cans shifted toward the top of the canister to give the top disk the maximum possible loading. Case 2 assumes that the damaged fuel cans shifted toward the bottom of the canister to give the bottom disk the maximum possible loading. The shift in position of the damaged fuel cans was modeled by changing the pressures on the disks based on the positions of the damaged fuel cans. For each case, the analysis is performed for five basket orientation as shown in Figure 11.A.2.12-5. For Case 1, the maximum stress occurs at the top disk with 0° basket orientation. The minimum margin of safety is 0.06 for the primary membrane and 0.17 for the Primary membrane plus bending stresses for Case 1. For Case 2, the maximum stress occurs at the bottom disk with 0° basket orientation. The minimum margin of safety is 0.09 for primary membrane stress and 0.24 for primary membrane plus bending stresses for Case 2.

A buckling analysis was also performed for the top disk for Case 1 when the damaged fuel cans are shifted to the top of the canister and for the bottom disk for Case 2 when the damaged fuel cans are shifted to the bottom of the canister. Details of the formulas used in this analysis are shown in Section 11.2.12.2.2. The minimum margin of safety for buckling is 0.46.

11.A.3.2 Basket Top Weldment Evaluation for 30-ft Top End Drop

The only MPC-LACBWR canister component that is more heavily loaded due to the 60*g* top end drop than the 60*g* bottom end drop is the basket top weldment. The bottom end drop is bounding for the canister because the ½-inch-thick shell supports the entire weight of the lid under this load, as opposed to supporting the much lighter canister bottom plate under the top end drop load. The basket support disks support only their own weight for both top and bottom end drop conditions. Therefore, the support disk stresses are the same for the 60*g* top end drop as they are for the 60*g* bottom end drop. The bottom end drop is bounding for the basket bottom weldment because it must support the weight of all fuel tubes for the bottom end drop, whereas, it only supports its own weight for the top end drop.

The MPC-LACBWR basket top weldment is evaluated for a 60*g* bottom end drop load, as described in Section 11.A.2.11. This section discusses the structural evaluation of the top weldment for a 60*g* top end drop condition, for which the top weldment loading and boundary conditions differ significantly from the bottom end drop condition. For the bottom end drop, the top weldment is supported axially by the eight basket tie-rods and loaded only by its own weight. Under the top end drop loading, the basket top weldment not only supports its own weight, but also the weight of all 68 fuel tubes. Furthermore, the top weldment is supported axially by the ligament support plates and stiffener angles that are welded to its top surface, as well as the eight basket tie-rods.

The maximum stresses in the MPC-LACBWR top weldment due to a 60*g* top end drop load are calculated using the finite element model described in Section 3.A.4.4.2.2 and shown in Figure 3.A.4.4.2-2. The top weldment model nodes located at the centerline of each tie-rod are restrained in the vertical direction (i.e., UY=0.) In addition, gap elements are modeled at the top ends of the ligament support plates and stiffener angles to capture the potentially nonlinear contact with the canister shield lid. A 60*g* vertical acceleration is applied to the top weldment model to account for self-weight. In addition, a vertical line load is applied to the perimeter of each opening in the top weldment to account for the load from the fuel tubes.

Linearized stresses in the MPC-LACBWR canister top weldment are evaluated at its critical sections; those which are located at the mid-length and ends of the hole ligaments and between the corners of the perimeter holes and the outer edge. The results of the analysis show that the maximum primary membrane (P_m) and primary membrane plus bending (P_m+P_b) stress intensities in the top weldment due to the 60*g* top end drop are 3.7 ksi and 58.5 ksi, respectively. The corresponding allowable P_m and P_m+P_b stress intensities, conservatively based on the top weldment Type 304 stainless steel material properties at an upper bound temperature of 400°F, are 44.9 ksi and 64.4 ksi, respectively. Therefore, the minimum design margin of safety for P_m and P_m+P_b stress intensities in the top weldment due to the 60*g* top end drop load are 11.1 and 0.10, respectively.

The top weldment stiffener angles are also evaluated for buckling due to the 60*g* top end drop loading. The critical buckling load in these members is calculated using classical methods (Euler buckling), treating it as a fixed-free column, where the effective length is conservatively taken as twice the length, as follows:

$$P_{cr} = \frac{\pi^2 EI}{(KL)^2} = 9.0 \text{ kips}$$

where:

I = $bt^3/12$, moment of inertia about weak axis.
= 0.00457 in^4

E = $26.5\text{x}10^6$ psi, modulus of elasticity of Type 304 stainless steel at 400°F

L = 5.75 in., length of the column (stiffener angle)

K = Effective length factor (K=2 for a fixed-free ends column)

b = 1.0, unit width of plate

t = 0.38 in, stiffener angle plate thicknesses

The total axial load supported by each stiffener angle is obtained from the reaction solution of the 60*g* top end drop finite element analysis. The most heavily loaded stiffener angle is shown to support a total axial load of 11.5 kips, or 1.2 kips/inch based on 9.38 inches of total width of stiffener angle plate. Therefore, the top weldment stiffener angles provide a factor of safety against buckling for the 60*g* top end drop of 7.5 (= 9.0/1.2), which is much higher than the required factor of safety of 1.5 for accident conditions.

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11.A.4 Evaluation of Site-Specific Fuel Components

Site-specific fuel components are structures designed to hold fuel assemblies, individual fuel rods or fuel debris configurations that are not in a standard fuel assembly. The LACBWR spent fuel assemblies are classified as LACBWR undamaged fuel assemblies and LACBWR damaged fuel assemblies that may contain fuel debris.

This section presents the evaluation of the LACBWR site-specific components used with the MPC-LACBWR storage system.

End Drop Evaluation

This section presents the buckling evaluation for the LACBWR fuel rods. The analysis shows that the maximum stresses in the fuel remain below the yield strength in the design basis event and confirm that the fuel rods will return to their original configuration. An end drop orientation is considered with an acceleration of 21g, which subjects the fuel rods to axial loading. This 21g acceleration bounds the maximum end drop acceleration calculated for the 6-inch concrete cask end drop.

In the end drop orientation, the fuel rods are laterally restrained by the grids and come into contact with the fuel assembly base. The only vertical constraint for the fuel rod is the base of the assembly.

Fuel Assembly	**Cladding Diameter (in)**	**Cladding Thickness (in)**	**Fuel Rod Pitch (in)**	**Maximum Gap Between Fuel Assembly and Fuel Tube Wall (in)**
ENC 10 × 10	0.394	0.022	0.557	0.343

Review of the design basis fuel indicates that the largest gap between a straight fuel assembly and the basket fuel tube inner wall could be 0.343 inch. It is physically possible for a fuel rod to have a bow of 0.343 inch and still be able to fit into the larger basket cell. Actual fuel assembly bow is expected to be much less than this maximum value and on the order of 0.125 to 0.25 inch. The clad is modeled with shell elements. The fuel is not explicitly modeled, but the fuel pellet weight is included with the clad by increasing the density of the clad elements as required. Properties are used for the fuel pellet and the clad as shown in the following table.

	Modulus of Elasticity (10^6 psi)	**Density (lb/in^3)**
Rod Clad	25.3	0.291
Fuel Pellet	-	0.396

To implement a bow of 0.25 inch into the fuel assembly, a half-symmetry ANSYS model is used in which lateral forces are applied at the 3rd grid at the approximate mid-length of the fuel to develop a 0.25-inch lateral displacement. The fuel rod is simply supported at each end. The purpose of the ANSYS model and solution is to provide the coordinates of the clad for the LS-DYNA model. This is accomplished by obtaining a static solution with the ANSYS model, and then using the option to update the coordinates of the nodes with the displacements from the solution.

Figures 11.A.4-1 and 11.A.4-2 show the LS-DYNA model. Each grid is modeled using spring elements (with a stiffness of 1.0E6 lb/in) to maintain the spacing between the fuel rods at the grid locations. No restriction in axial movement or rotation at the attachment to the fuel rods is provided by the spring elements. The LS-DYNA model employs the same nodes and elements as the ANSYS model (with the incorporation of the 0.25-inch bow). The shell elements in LS-DYNA use additional integration points to ensure that the maximum shear stress at the surface of the shell elements is accurately computed. Elastic properties used in the LS-DYNA model are the same as those used in the ANSYS model. An initial downward velocity of 68.1 in/sec (corresponding to a 6-inch drop) is assigned to all nodes in the model. The deceleration applied to the base of the model has a duration of 0.0087 second and a 21g maximum value, which provide bounding acceleration for the 6-inch end drop of the concrete cask.

The LS-DYNA analysis was performed for a duration of 0.015 second to capture the response of the fuel after the 0.0087-second loading duration. Post-processing identifies the maximum shear stress occurring at the shell surface. The maximum shear stress result from LS-DYNA is factored by two to determine the maximum stress intensity. The maximum stress intensity in the fuel cladding is shown to be 7.83 ksi, which gives a factor of safety against yield of 4.73.

The temperature of the fuel at the bottom end of the basket is bounded by 662°F (350°C) and the static yield strength for irradiated stainless at 662°F is 37.0 ksi. This conservatively neglects any strengthening effect due to the dynamic loading.

The analysis results confirm that the LACBWR fuel will remain undamaged for design basis cask end drop load condition.

Tip-Over Evaluation

The tip-over condition is considered as a uniform side drop in the LS-DYNA analysis. The LS-DYNA model used for the tip over analysis of the fuel rod assembly is similar to that used for the end drop analysis. No fuel rod bow is considered. A uniform gap is used along the length of the fuel rod and fuel tube, with a small gap of 0.005-inch between the rod and tube in the loading direction. Model details are shown in Figure 11.A.4-3.

The deceleration time history is applied in the lateral direction. This time history, which is shown in Figure 11.A.4-4, was computed at the top of the cask and is conservatively applied uniformly along the length of the fuel tube. An initial lateral velocity of 243.6 in/sec is assigned to the model, and is calculated from integrating the acceleration time history curve.

The maximum stress intensity in the fuel cladding is shown to be 29.6 ksi, which gives a factor of safety against yield of 1.25. This confirms that the LACBWR fuel rod will remain intact for a tip-over condition.

Figure 11.A.4-1 LS-DYNA End Drop Model for the LACBWR Fuel Rod

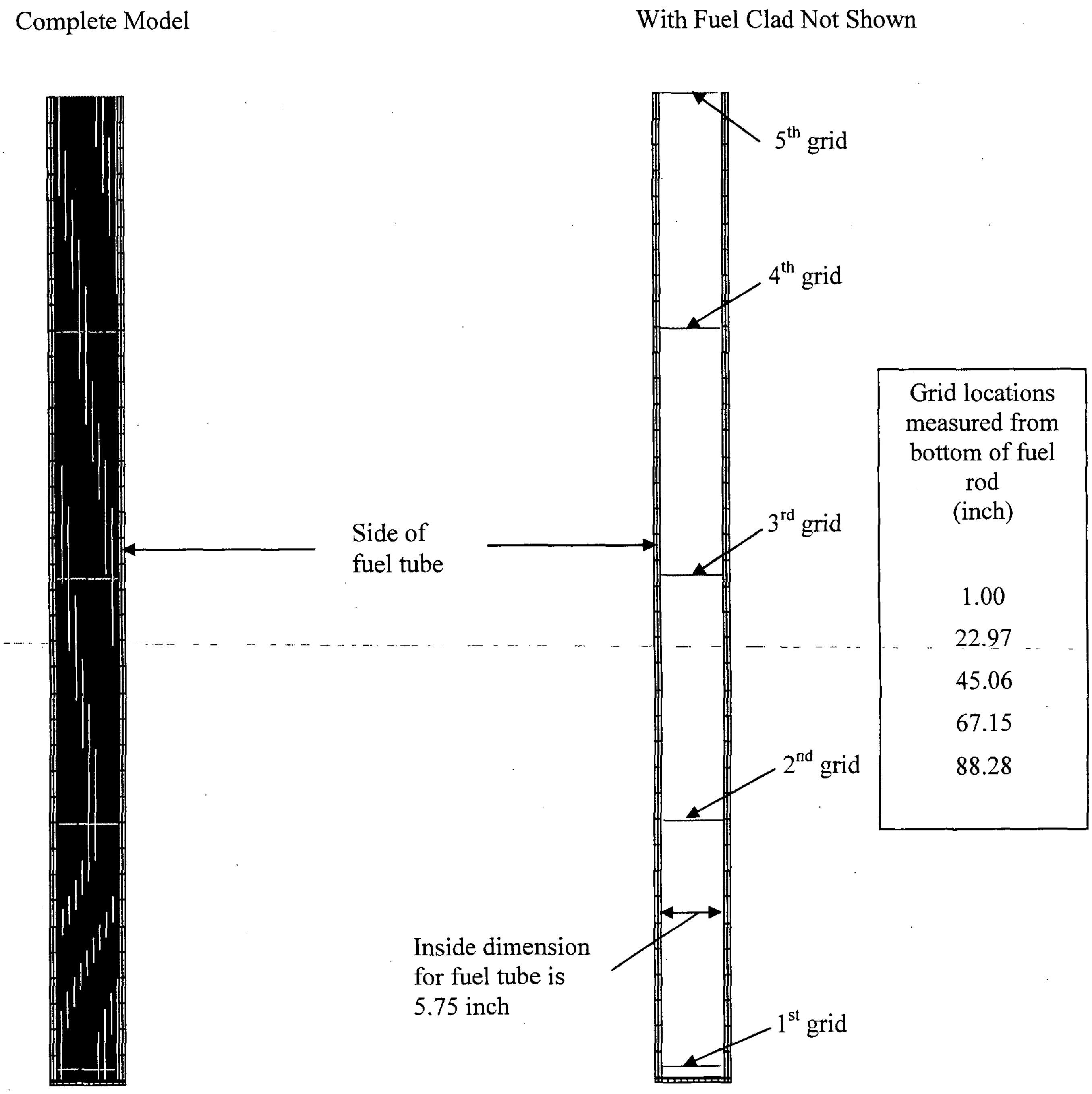


Figure 11.A.4-2 Detail of LS-DYNA End Drop Model for the LACBWR Fuel Rod

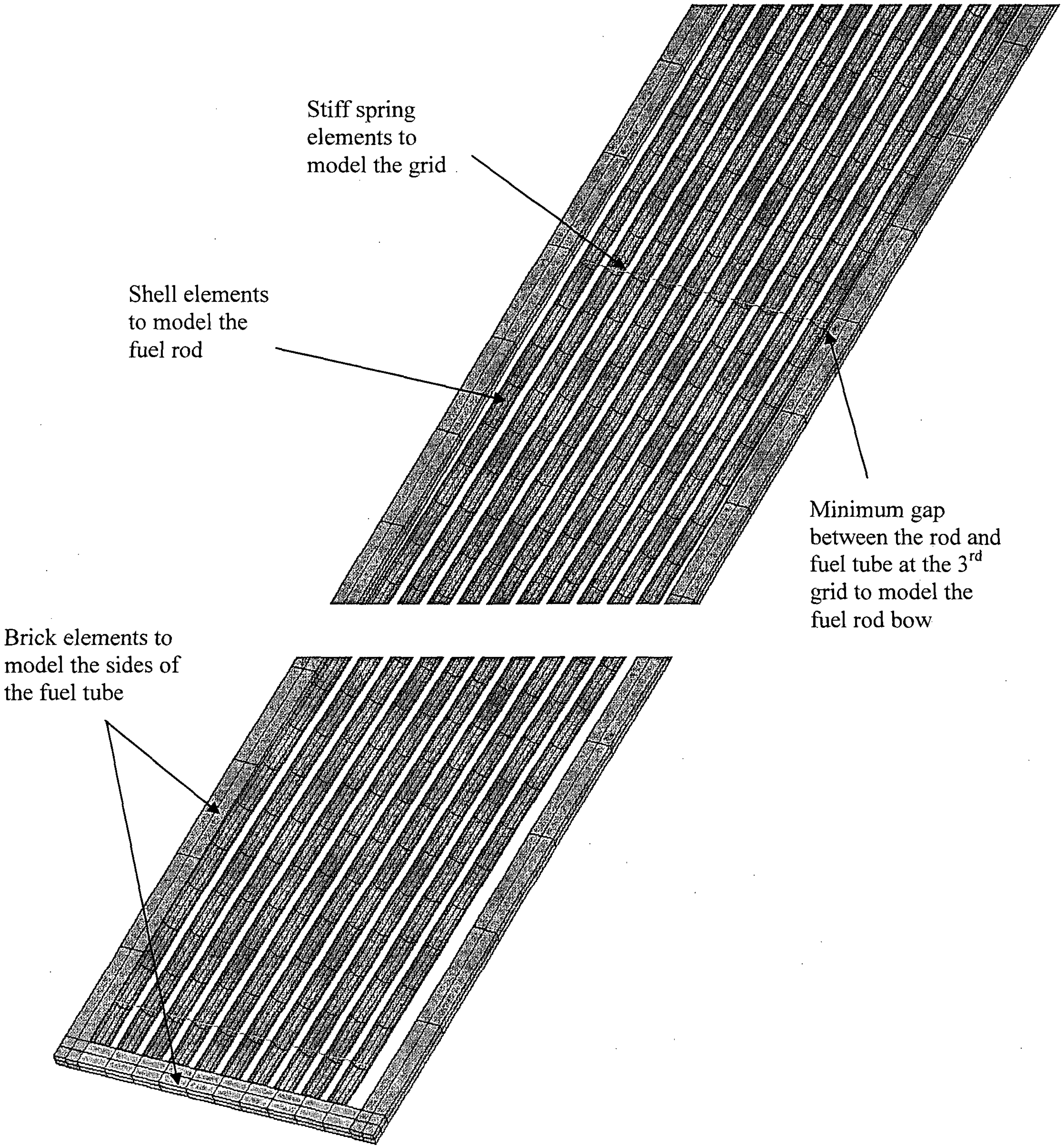


Figure 11.A.4-3 LS-DYNA Tip-Over Model for the LACBWR Fuel Rod

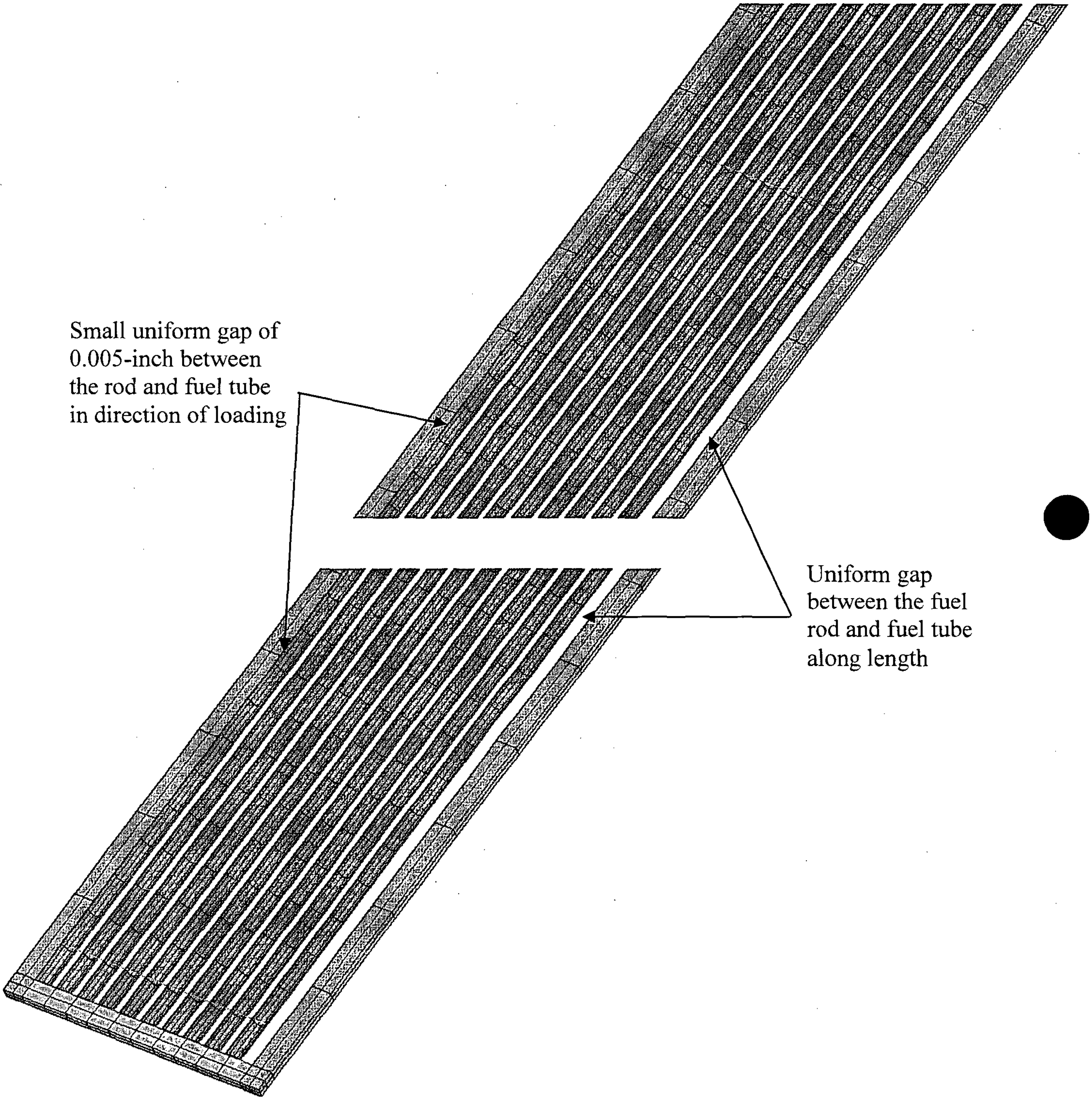
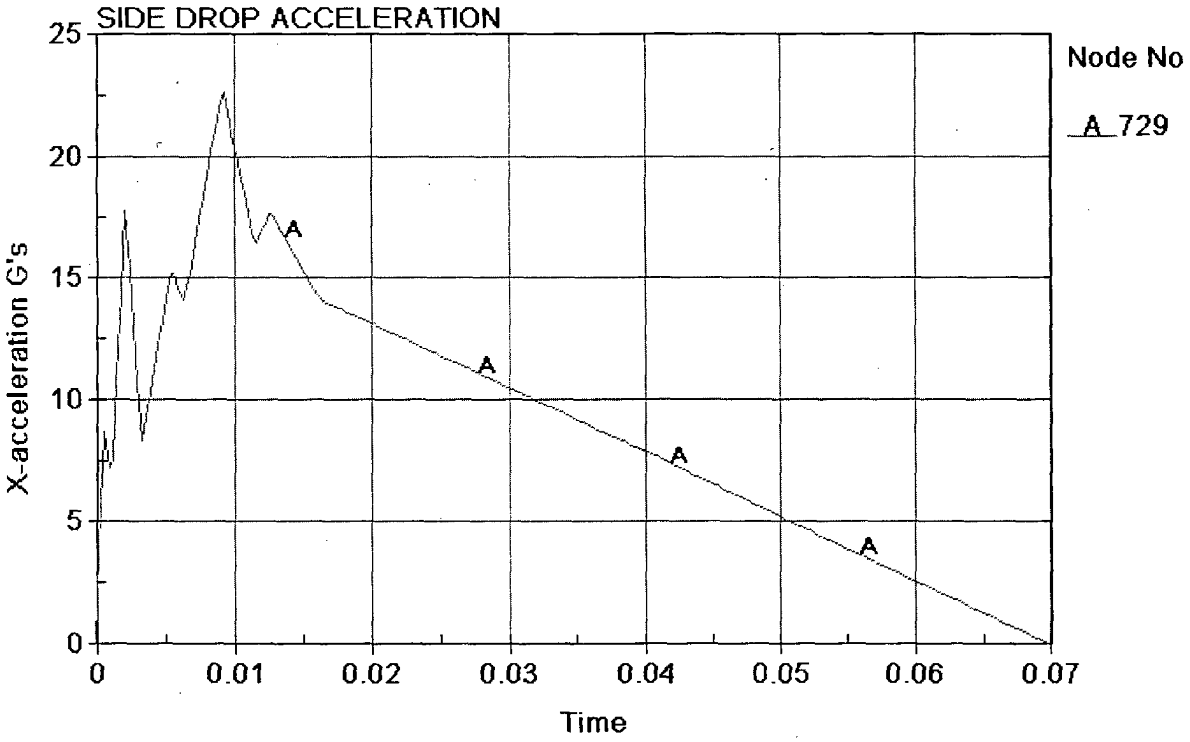


Figure 11.A.4-4 Applied Acceleration Time History for Tip-Over Analysis



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11.A.5 Canister Closure Weld Evaluation – Accident Conditions

This section discusses the results of the MPC-LACBWR canister closure weld stress analysis for accident conditions of storage. In addition, this section discusses the closure weld critical flaw size evaluation. The corresponding evaluation for normal conditions is presented in Section 3.A.6. This evaluation confirms that the canister closure weld is acceptable accident conditions of storage and that the NDE of the canister closure weld is sufficient to detect a critical flaw.

Closure Weld Stress Evaluation:

The MPC-LACBWR canister closure weld is a ½-inch thick partial penetration groove weld that is designed using a weld stress reduction factor of 0.8 per ISG-4. This stress reduction factor is incorporated by applying a factor of 0.8 to the allowable stesses for the closure weld. The results of the MPC-LACBWR canister stress analyses for accident conditions demonstrate that the maximum stresses in the closure weld satsify the applicable allowable stress design criteria, which includes the 0.8 stress reduction factor.

The stress evaluation of the MPC-LACBWR canister for accident conditions considers a range of off-normal and accident conditions for analysis. The results of the MPC-LACBWR canister accident analyses show that the maximum stresses in the closure weld are much lower than the corresponding allowable stresses for most off-normal and accident conditions and load combinations. The highest primary membrane (P_m) and primary membrane plus bending (P_m+P_b) stress intensities in the canister closure weld result from the postulated concrete cask tip-over accident, which is evaluated with a bounding internal pressure load of 12 psig, are 26.34 psi and 29.07 psi, respectively. The corresponding accident condition allowable stress intensities for the closure weld, which are based on Type 304 stainless steel material properties at an upper bound temperature of 300°F and include the 0.8 stress reduction factor, are 36.96 ksi and 47.52 ksi, respectively. Therefore, the maximum stresses in the MPC-LACBWR canister closure weld due to accident conditions satisfy the allowable stress design criteria.

Closure Weld Critical Flaw Size Evaluation:

The MPC-LACBWR canister closure weld is comprised of multiple weld beads using a compatible weld material for Type 304 stainless steel base metal. The ½-inch thick closure weld is PT-examined on the root, mid-plane, and final passes. An allowable (critical) flaw evaluation has been performed to determine the critical flaw size in the weld region. The results of the flaw evaluation are used to define the minimum flaw size that must be identifiable in the nondestructive examination (NDE) of the weld. Due to the inherent toughness associated with Type 304 stainless steel, a limit load analysis is conservatively used in conjunction with a J-integral/tearing modulus approach. The maximum radial tensile stress in the closure weld (i.e., SX at Section 12 in Figure 3.A.4.4.1-2) is used for the critical flaw size evaluation. The safety margins used in this evaluation correspond to the stress limits contained in Section XI of the ASME Code. In accordance with ASME Code Section XI, the required safety factor for accident condition is 1.414 ($\sqrt{2}$).

The maximum radial tensile stress for accident conditions is 1.61 ksi due to the combined concrete cask 6-inch drop and internal pressure loads. To perform the flaw evaluation, a bounding 4.17 ksi tensile stress is conservatively used, resulting in a significantly larger safety factor than the required safety factor of 1.414. The results of the analysis show that the critical flaw size is 0.34 inch for a flaw that extends 360° around the circumference of the canister. The 360° flaw employed for the circumferential direction is considered to be bounding with respect to any partial flaw in the weld, which could occur in the radial and horizontal directions. Therefore, using a minimum detectable flaw size of 0.30 inches is acceptable, since it is less than the conservatively determined 0.34-inch critical flaw size.

11.A.6 References

The references for the MPC-LACBWR storage system accident analysis are the same as those listed in MPC FSAR Section 11.6, and supplemented as follows:

[A1] ANSI/ANS-57.9-1992, "Design Criteria for an Independent Spent Fuel Storage Installation (Dry Type)," American Nuclear Society, May 1992.

[A2] NUREG/CR-6865, "Parametric Evaluation of Seismic Behavior of Freestanding Spent Fuel Drop Cask Storage Systems," Sandia National Laboratories, February 2005.

[A3] Tennessee Valley Authority, Division of Engineering Design, Thermal Power Project, Report No. CEB 77-46, "All Projects Steel to Concrete Coefficient of Friction Preliminary Tests," December 1977.

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List of Tables

12.0 OPERATING CONTROLS AND LIMITS

This chapter identifies operating controls and limits, technical parameters and surveillance requirements imposed to ensure the safe operation of the NAC-MPC SYSTEM.

Controls used by NAC International (NAC) as part of the NAC-MPC design and fabrication are provided in the NAC Quality Assurance Manual and Quality Procedures. The NAC Quality Assurance Program is discussed in Chapter 13.0. If procurement and fabrication of the NAC-MPC SYSTEM is performed by others, a Quality Assurance Program prepared in accordance with 10 CFR 72 Subpart G shall be implemented. Site specific controls for the organization, administrative system, procedures, record keeping, review, audit and reporting necessary to ensure that the NAC-MPC storage system installation is operated in a safe manner, are the responsibility of the User.

The NAC-MPC is provided in three configurations. The first is designed to store up to 36 intact Yankee Class spent fuel and reconfigured fuel assemblies and is referred to as the Yankee-MPC. The second configuration, referred to as the CY-MPC, is designed to store up to 26 Connecticut Yankee fuel assemblies, CY-MPC reconfigured fuel assemblies or CY-MPC damaged fuel cans. The CY-MPC is provided with a 24-assembly or 26-assembly basket. The third configuration, referred to as the MPC-LACBWR system, is designed to store up to 68 Dairyland Power Cooperative (DPC) La Crosse Boiling Water Reactor (LACBWR) spent fuel assemblies with up to 32 damaged fuel cans. Certain Connecticut Yankee spent fuel, including fuel assemblies with non-fuel hardware and CY-MPC damaged fuel cans, require preferential loading as described in Appendix B of the Certificate of Compliance.

The NAC-MPC storage system operating controls and limits are summarized in Table 12-1. Appendix A of the Certificate of Compliance provides the Limiting Conditions for Operations (LCO) for the Yankee-MPC and the CY-MPC configurations of the NAC-MPC storage system. Appendix 12.A provides the combined LCOs for all three configurations of the NAC-MPC SYSTEM. The Approved Contents and Design Features for the NAC-MPC SYSTEM are presented in Technical Specification format in Appendix 12.B. The Bases for the specified controls and limits are presented in Appendix 12.C. Separate controls or limits are specified for each NAC-MPC configuration as appropriate.

Table 12-1 NAC-MPC SYSTEM Controls and Limits

Control or Limit	**Applicable Technical Specification**	**Condition or Item Controlled**
1. Fuel Characteristics	Table B.2-1	Yankee Class Fuel Assembly Limits
	Table B.2-2	Yankee Class INTACT FUEL ASSEMBLY Characteristics
	Table B.2-3	Connecticut Yankee Fuel Assembly Limits
	Table B.2-4	Connecticut Yankee INTACT FUEL ASSEMBLY Characteristics
	Table B.2-5	Connecticut Yankee Fuel and CANISTER Heat LOADING CATEGORY Limits
	Table B.2-6	Heat Load Matrix Used to Determine LOADING CATEGORY Limits
	Table B.2-7	MPC-LACBWR Fuel Assembly Limits
	Table B.2-8	MPC-LACBWR Fuel Assembly Characteristics
2. Canister	LCO 3.1.4	Maximum Time in TRANSFER CASK
Drying	LCO 3.1.2	Vacuum Drying Pressure
Backfilling	LCO 3.1.3	Helium Backfill Pressure
Sealing	LCO 3.1.5	Helium Leak Rate
Vacuum	LCO 3.1.1	Maximum Time in Vacuum Drying
External Surface	LCO 3.2.1	Surface Contamination
Unloading	LCO 3.1.7	Fuel Cooldown Requirements
3. Concrete Cask	LCO 3.2.2	Average Surface Dose Rates
	Note 1	Cask Spacing
	Note 2	Cask Handling Height
	LCO 3.1.6	Heat Removal System
4. Transfer Cask	B 3.4(8)	Minimum Temperature
5. ISFSI Concrete Pad	Note 3	Pad Concrete Thickness
	Note 3	Pad Subsoil Thickness
	Note 3	Pad Concrete Compressive Strength

1. Limits are presented in the Operating Procedures of Chapter 8.
2. Lifting height and handling restrictions are provided in Section A5.5 of Appendix 12.A of the Technical Specifications.
3. Limits are verified at the time of construction of the ISFSI in accordance with Section B3.4(6) of Appendix 12.B of the Technical Specifications.

APPENDIX 12.A

TECHNICAL SPECIFICATIONS FOR THE NAC-MPC SYSTEM

The Technical Specifications for the Yankee-MPC and the CY-MPC configurations of the NAC-MPC storage system, including the Limiting Conditions for Operations (LCOs), Surveillance Requirements (SRs), and the Administrative Controls and Programs, are incorporated in Appendix A of Certificate of Compliance No. 1025, Amendment 5.

The Technical Specifications included herein have been expanded to include the LCOs, SRs and Administrative Controls and Programs for the MPC-LACBWR storage system.

Appendix 12.A
Table of Contents

A 1.0 USE AND APPLICATION

A 1.1 Definitions

---NOTE---

The defined terms of this section appear in capitalized type and are applicable to the Technical Specifications and description of the Approved Contents and NAC-MPC Design Features.

Term	Definition
ACTIONS	ACTIONS shall be that part of a Specification that prescribes Required Actions to be taken under designated Conditions within specified Completion Times.
CANISTER	See TRANSPORTABLE STORAGE CANISTER
CANISTER HANDLING FACILITY	The CANISTER HANDLING FACILITY includes the following components and equipment: (1) a canister transfer station that allows the staging of the TRANSFER CASK with the CONCRETE CASK or transport cask to facilitate CANISTER lifts involving spent fuel handling not covered by 10 CFR 50; and (2) either a stationary lift device or mobile lifting device used to lift the TRANSFER CASK and CANISTER.
CONCRETE CASK	See VERTICAL CONCRETE CASK
CY-MPC	CY-MPC is a NAC-MPC SYSTEM having a fuel basket designed to accommodate Connecticut Yankee reactor spent fuel. The CY-MPC meets the NAC-MPC SYSTEM requirements.
CY-MPC DAMAGED FUEL CAN	A stainless steel container that confines a damaged Connecticut Yankee spent fuel assembly, but allows gaseous and liquid media to escape, while minimizing the dispersal of gross particulates. Connecticut Yankee DAMAGED FUEL ASSEMBLIES must be loaded in a CY-MPC DAMAGED FUEL CAN. The CY-MPC DAMAGED FUEL CAN may also hold an INTACT FUEL ASSEMBLY, LATTICE or a FAILED ROD STORAGE CANISTER.

(continued)

CY-MPC RECONFIGURED FUEL ASSEMBLY	A stainless steel container, having external dimensions that are slightly larger than a standard Connecticut Yankee fuel assembly, that ensures criticality control geometry and which permits gaseous and liquid media to escape while minimizing dispersal of gross particulate. It may contain a maximum of 100 INTACT FUEL RODS or DAMAGED FUEL RODS, or FUEL DEBRIS from any Connecticut Yankee spent fuel assembly.
DAMAGED FUEL ASSEMBLY (applicable for Yankee-MPC and CY-MPC fuel assembly contents only)	A fuel assembly containing at least one DAMAGED FUEL ROD or that cannot be handled by normal means, or both. Yankee class fuel assemblies containing up to 20 fuel rod positions that are either missing or that are holding DAMAGED FUEL RODS.
DAMAGED FUEL ROD	DAMAGED FUEL ROD is a fuel rod with a known or suspected cladding defect greater than a hairline crack or pinhole leak.
FAILED ROD STORAGE CANISTER	A handling container for moving up to 60 individual INTACT FUEL RODS or DAMAGED FUEL RODS in stainless steel tubes into a CY-MPC DAMAGED FUEL CAN. The steel tubes are held in place by regularly spaced plates welded in an open stainless steel frame. The FAILED ROD STORAGE CANISTER, which is closed at the top end by a bolted closure and at the bottom by a welded plate to capture the fuel rods in the tubes, must be loaded in a CY-MPC DAMAGED FUEL CAN.
FORCED AIR COOLING	Air delivered to the bottom eight ports of the TRANSFER CASK at a minimum rate of 250 CFM and a maximum air temperature of 75°F for Yankee-MPC, and at a minimum rate of 375 CFM and a maximum air temperature of 75°F for CY-MPC. The canister must be backfilled with helium.
FUEL DEBRIS	FUEL DEBRIS is fuel in the form of particles, loose pellets, and fragmented rods or assemblies. FUEL DEBRIS may be loaded in a handling container.
INDEPENDENT SPENT FUEL STORAGE INSTALLATION (ISFSI)	The facility within the perimeter fence licensed for storage of spent fuel within NAC-MPC SYSTEMs (see also 10 CFR 72.3).

(continued)

INTACT FUEL ASSEMBLY (applicable for Yankee-MPC and CY-MPC fuel assembly contents only)	INTACT FUEL ASSEMBLY is a fuel assembly without DAMAGED FUEL RODS. Connecticut Yankee fuel assemblies with missing fuel rods, or with missing fuel rods replaced with solid filler rods, or with structural damage, are considered INTACT FUEL ASSEMBLIES provided that they have no DAMAGED FUEL RODS. Yankee Class fuel assemblies with missing fuel rods replaced with Zircaloy or stainless steel rods, or with structural damage, are considered INTACT FUEL ASSEMBLIES provided they have no DAMAGED FUEL RODS.
INTACT FUEL ROD	INTACT FUEL ROD is a fuel rod without known or suspected cladding defects greater than a pinhole leak or hairline crack.
LACBWR DAMAGED FUEL ASSEMBLY	Spent nuclear fuel (SNF) that cannot fulfill its fuel-specific or system-related function. SNF is classified as a LACBWR DAMAGED FUEL ASSEMBLY under the following conditions. 1. There is visible deformation of the rods in the SNF assembly. Note: This is not referring to the uniform bowing that occurs in the reactor; this refers to bowing that significantly opens up the lattice spacing. 2. Individual fuel rods are missing from the assembly and the missing rods are not replaced by a solid dummy rod that displaces a volume equal to, or greater than, the original fuel rod. 3. The SNF assembly has missing, displaced or damaged structural components such that either radiological and/or criticality safety is adversely affected (e.g., significantly changed rod pitch); or the assembly cannot be handled by normal means (i.e., crane and grapple). 4. Any SNF assembly that contains fuel rods for which reactor operating records (or other records or tests) cannot support the conclusion that they do not contain gross breaches. Note: Breached fuel rods with minor cladding defects (i.e., pinhole leaks or hairline cracks that will not permit significant release of particulate matter from the spent fuel rod) are classified as undamaged. 5. The SNF is no longer in the form of an intact fuel bundle (e.g., consists of or contains debris such as loose fuel pellets or rod segments).

(continued)

LACBWR DAMAGED FUEL CAN	A stainless steel container that confines a LACBWR DAMAGED FUEL ASSEMBLY, DAMAGED FUEL ROD or FUEL DEBRIS, while allowing gaseous and liquid media to escape and minimizing the dispersal of gross particulates. LACBWR DAMAGED FUEL ASSEMBLIES must be loaded in a LACBWR DAMAGED FUEL CAN.
LACBWR UNDAMAGED FUEL ASSEMBLY	A spent nuclear fuel assembly that can meet all fuel-specific and system-related functions. A LACBWR UNDAMAGED FUEL ASSEMBLY is spent nuclear fuel that is not a LACBWR DAMAGED FUEL ASSEMBLY, as defined herein, and does not contain assembly structural defects that adversely affect radiological and/or criticality safety. As such, a LACBWR UNDAMAGED FUEL ASSEMBLY may contain breached spent fuel rods (i.e., rods with minor defects up to hairline cracks or pinholes), but cannot contain grossly breached fuel rods.
LATTICE	A fuel assembly structure that is used to hold up to 204 INTACT FUEL RODS or DAMAGED FUEL RODS from other fuel assemblies. A LATTICE is sometimes called a fuel skeleton, cage or structural cage. It is built from the same components as a standard fuel assembly, but some of those components may be modified slightly, such as relaxed grids, to accommodate the distortion that may be present in a DAMAGED FUEL ROD. The outside dimensions are identical to a standard fuel assembly.
LOADING CATEGORY (LOADING CATEGORIES)	The LOADING CATEGORY defines allowable combinations of maximum total canister decay heat and maximum fuel assembly decay heat for the CY-MPC. They are used to determine operational time limits during LOADING OPERATIONS or TRANSFER OPERATIONS.

(continued)

LOADING OPERATIONS	LOADING OPERATIONS include all activities on an NAC-MPC SYSTEM while it is being loaded with fuel assemblies. LOADING OPERATIONS begin when the first fuel assembly is placed in the CANISTER and end when the NAC-MPC SYSTEM is secured on the transporter. LOADING OPERATIONS do not include post-storage operations, i.e., CANISTER transfer operations between the TRANSFER CASK and the CONCRETE CASK or transport cask after STORAGE OPERATIONS.
MPC-LACBWR	MPC-LACBWR is a NAC-MPC SYSTEM having a fuel basket designed to accommodate La Crosse BWR (LACBWR) reactor spent fuel. The MPC-LACBWR meets the NAC-MPC SYSTEM requirements.
NAC-MPC SYSTEM	NAC-MPC SYSTEM includes the components approved for loading and storage of spent fuel assemblies at the ISFSI. The NAC-MPC SYSTEM consists of a CONCRETE CASK, a TRANSFER CASK, and a CANISTER. The NAC-MPC SYSTEM is provided in three configurations: the YANKEE-MPC, CY-MPC, and MPC-LACBWR.
OPERABLE	An OPERABLE CONCRETE CASK heat removal system transfers sufficient heat away from the fuel assemblies such that the fuel cladding, CANISTER component and CONCRETE CASK temperatures do not exceed applicable limits. The CONCRETE CASK heat removal system is considered OPERABLE if the difference between the ISFSI ambient temperature and the average outlet air temperature is ≤ 92°F for the YANKEE-MPC and for the MPC-LACBWR; or ≤ 110°F for the CY-MPC, or if all four air inlet and outlet screens are visually verified to be unobstructed. Failing this, a CONCRETE CASK heat removal system may be declared OPERABLE if an engineering evaluation determines the CONCRETE CASK has adequate heat transfer capabilities to assure continued spent fuel, CANISTER and CONCRETE CASK integrity.

(continued)

RETAINER	A retainer used for the Gulf United Nuclear Fuel (GUNF) lead test assemblies to retain the removable fuel rods within the fuel assembly.
STORAGE OPERATIONS	STORAGE OPERATIONS include all activities that are performed at the ISFSI, while an NAC-MPC SYSTEM containing spent fuel is located on the storage pad within the ISFSI perimeter.
STRUCTURAL DAMAGE	Damage to the fuel assembly that does not prevent handling the fuel assembly by normal means. STRUCTURAL DAMAGE is defined as partially torn, abraded, dented or bent grid straps, end fittings or guide tubes. The damaged grid straps or end fittings must continue to provide support to the fuel rods, as designed, and may not be completely torn or missing. Guide tubes cannot be ruptured and must be continuous between the upper and lower end fittings. Fuel assemblies with STRUCTURAL DAMAGE are considered to be INTACT FUEL ASSEMBLIES provided that they do not have failed or DAMAGED FUEL RODS.
TRANSFER CASK	TRANSFER CASK is a shielded lifting device that holds the CANISTER during LOADING and UNLOADING OPERATIONS and during closure welding, vacuum drying, leak testing, and non-destructive examination of the CANISTER closure welds. The TRANSFER CASK is also used to transfer the CANISTER into and from the CONCRETE CASK and into the transport cask.
TRANSFER OPERATIONS	TRANSFER OPERATIONS include all activities involved in transferring a loaded CANISTER from a CONCRETE CASK to another CONCRETE CASK, to a TRANSPORT CASK, or to an appropriate location for unloading.
TRANSPORTABLE STORAGE CANISTER (CANISTER)	TRANSPORTABLE STORAGE CANISTER is a container consisting of a tube and disk fuel basket in a cylindrical canister shell welded to a baseplate. When the shield lid with welded port covers and the structural lid are welded in place, or the closure lid with port covers is welded in place, the CANISTER provides the confinement boundary for the confined spent fuel.

(continued)

TRANSPORT OPERATIONS	TRANSPORT OPERATIONS include all activities involved in moving a loaded NAC-MPC CONCRETE CASK and CANISTER to and from the ISFSI. TRANSPORT OPERATIONS begin when the NAC-MPC SYSTEM is positioned on the transporter, and end when the NAC-MPC SYSTEM is at its destination and no longer on the transporter.
UNLOADING OPERATIONS	UNLOADING OPERATIONS include all activities on a NAC-MPC SYSTEM to be unloaded of the contained fuel assemblies. UNLOADING OPERATIONS begin when the NAC-MPC SYSTEM is no longer secured on the transporter and end when the last fuel assembly is removed from the NAC-MPC SYSTEM.
VERTICAL CONCRETE CASK (CONCRETE CASK)	VERTICAL CONCRETE CASK is the cask that receives and holds the sealed CANISTER. It provides the gamma and neutron shielding and convective cooling of the spent fuel confined in the CANISTER.
WATER COOLING	Placement of the TRANSFER CASK holding an NAC-MPC CANISTER in the spent fuel pool. The canister must be backfilled with helium. WATER COOLING shall be maintained for a minimum of 24 hours, once initiated.
YANKEE-MPC	YANKEE-MPC is a NAC-MPC SYSTEM having a fuel basket designed to accommodate Yankee Class spent fuel. The YANKEE-MPC meets the requirements designated for the NAC-MPC SYSTEM.
YANKEE-MPC DAMAGED FUEL CAN	A stainless steel container that is similar to an enlarged fuel tube and that confines a Yankee Class INTACT FUEL ASSEMBLY, DAMAGED FUEL ASSEMBLY, RECAGED FUEL ASSEMBLY or a RECONFIGURED FUEL ASSEMBLY. A damaged fuel can is closed on its end by screened openings that allow gaseous and liquid media to escape, but minimize the dispersal of gross particulate. Use of the damaged fuel can requires that four cans be used in the canister in conjunction with a special shield lid machined to accept the cans.

(continued)

YANKEE-MPC RECAGED FUEL ASSEMBLY	A Yankee Class Combustion Engineering fuel assembly LATTICE (skeleton) holding United Nuclear fuel rods with no empty fuel rod positions.
YANKEE-MPC RECONFIGURED FUEL ASSEMBLY	A stainless steel canister having the same external dimensions as a standard Yankee Class fuel assembly, that ensures criticality control geometry and which permits gaseous and liquid media to escape while minimizing dispersal of gross particulates. It may contain a maximum of 64 INTACT FUEL RODS or DAMAGED FUEL RODS, or FUEL DEBRIS from any type of Yankee Class spent fuel assembly.

A 1.0 USE AND APPLICATION

A 1.2 Logical Connectors

PURPOSE	The purpose of this section is to explain the meaning of logical connectors. Logical connectors are used in Technical Specifications (TS) to discriminate between, and yet connect, discrete Conditions, Required Actions, Completion Times, Surveillances, and Frequencies. The only logical connectors that appear in Technical Specifications are "AND" and "OR." The physical arrangement of these connectors constitutes logical conventions with specific meanings.
BACKGROUND	Several levels of logic may be used to state Required Actions. These levels are identified by the placement (or nesting) of the logical connectors and by the number assigned to each Required Action. The first level of logic is identified by the first digit of the number assigned to a Required Action and the placement of the logical connector in the first level of nesting (i.e., left justified with the number of the Required Action). The successive levels of logic are identified by additional digits of the Required Action number and by successive indentations of the logical connectors. When logical connectors are used to state a Condition, Completion Time, Surveillance, or Frequency, only the first level of logic is used; the logical connector is left justified with the statement of the Condition, Completion Time, Surveillance, or Frequency.

(continued)

EXAMPLES The following examples illustrate the use of logical connectors.

EXAMPLES EXAMPLE 1.2-1

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. LCO not met	A.1 Verify. . . AND A.2 Restore. . .	

In this example, the logical connector "AND" is used to indicate that when in Condition A, both Required Actions A.1 and A.2 must be completed.

(continued)

EXAMPLES (continued)

EXAMPLE 1.2-2

ACTIONS

CONDITION	REQUIRED ACTION		COMPLETION TIME
A. LCO not met	A.1	Stop …	
	OR		
	A.2	Complete …	
	A.2.1	Verify …	
	AND		
	A.2.2	Check …	
	A.2.2.1	Reduce …	
		OR	
	A.2.2.2	Perform …	
	OR		
	A.3	Remove …	

This example represents a more complicated use of logical connectors. Required Actions A.1, A.2, and A.3 are alternative choices, only one of which must be performed as indicated by the use of the logical connector "OR" and the left justified placement. Any one of these three Actions may be chosen. If A.2 is chosen, then both A.2.1 and A.2.2 must be performed as indicated by the logical connector "AND." Required Action A.2.2 is met by performing A.2.2.1 or A.2.2.2. The indented position of the logical connector "OR" indicated that A.2.2.1 and A.2.2.2 are alternative choices, only one of which must be performed.

A 1.0 USE AND APPLICATION

A 1.3 Completion Times

PURPOSE

The purpose of this section is to establish the Completion Time convention and to provide guidance for its use.

BACKGROUND

Limiting Conditions for Operations (LCOs) specify the lowest functional capability or performance levels of equipment required for safe operation of the NAC-MPC SYSTEM. The ACTIONS associated with an LCO state conditions that typically describe the ways in which the requirements of the LCO can fail to be met. Specified with each stated Condition are Required Action(s) and Completion Time(s).

DESCRIPTION

The Completion Time is the amount of time allowed for completing a Required Action. It is referenced to the time of discovery of a situation (e.g., equipment or variable not within limits) that requires entering an ACTIONS Condition, unless otherwise specified, provided that the NAC-MPC SYSTEM is in a specified Condition stated in the Applicability of the LCO. Prior to the expiration of the specified Completion Time, Required Actions must be completed. An ACTIONS Condition remains in effect and the Required Actions apply until the Condition no longer exists or the NAC-MPC SYSTEM is not within the LCO Applicability.

Once a Condition has been entered, subsequent subsystems, components, or variables expressed in the Condition, discovered to be not within limits, will <u>not</u> result in separate entry into the Condition, unless specifically stated. The Required Actions of the Condition continue to apply to each additional failure, with Completion Times based on initial entry into the Condition.

(continued)

EXAMPLES

The following examples illustrate the use of Completion Times with different types of Conditions and changing Conditions.

EXAMPLE 1.3-1

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
B. Required Action and associated Completion Time not met	B.1 Perform Action B.1	12 hours
	AND	
	B.2 Perform Action B.2	36 hours

Condition B has two Required Actions. Each Required Action has its own Completion Time. Each Completion Time is referenced to the time that Condition B is entered.

The Required Actions of Condition B are to complete action B.1 within 12 hours AND complete action B.2 within 36 hours. A total of 12 hours is allowed for completing action B.1 and a total of 36 hours (not 48 hours) is allowed for completing action B.2 from the time that Condition B was entered. If action B.1 is completed within six hours, the time allowed for completing action B.2 is the next 30 hours because the total time allowed for completing action B.2 is 36 hours.

(continued)

EXAMPLES (continued)

EXAMPLE 1.3-2

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. One System not within limit	A.1 Restore System to within limit	7 days
B. Required Action and associated Completion Time not met	B.1 Complete action B.1	12 hours
	AND	
	B.2 Complete action B.2	36 hours

When a System is determined not to meet the LCO, Condition A is entered. If the System is not restored within seven days, Condition B is also entered, and the Completion Time clocks for Required Actions B.1 and B.2 start. If the System is restored after Condition B is entered, Conditions A and B are exited; therefore, the Required Actions of Condition B may be terminated.

(continued)

EXAMPLES (continued)

EXAMPLE 1.3-3

ACTIONS

--NOTE--

Separate Condition entry is allowed for each component.

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. LCO not met	A.1 Restore compliance with LCO	4 hours
B. Required Action and associated Completion Time not met	B.1 Complete action B.1	6 hours
	AND	
	B.2 Complete action B.2	12 hours

The Note above the ACTIONS table is a method of modifying how the Completion Time is tracked. If this method of modifying how the Completion Time is tracked was applicable only to a specific Condition, the Note would appear in that Condition rather than at the top of the ACTIONS Table.

The Note allows Condition A to be entered separately for each component, and Completion Times to be tracked on a per component basis. When a component is determined to not meet the LCO, Condition A is entered and its Completion Time starts. If subsequent components are determined to not meet the LCO, Condition A is entered for each component and separate Completion Times are tracked for each component.

IMMEDIATE COMPLETION TIME	When "Immediately" is used as a Completion Time, the Required Action should be pursued without delay and in a controlled manner.

A 1.0 USE AND APPLICATION

A 1.4 Frequency

PURPOSE

The purpose of this section is to define the proper use and application of Frequency requirements.

DESCRIPTION

Each Surveillance Requirement (SR) has a specified Frequency in which the Surveillance must be met in order to meet the associated Limiting Condition for Operation (LCO). An understanding of the correct application of the specified Frequency is necessary for compliance with the SR.

Each "specified Frequency" is referred to throughout this section and each of the Specifications of Section 3.0, Surveillance Requirement (SR) Applicability. The "specified Frequency" consists of requirements of the Frequency column of each SR.

Situations where a Surveillance could be required (i.e., its Frequency could expire), but where it is not possible or not desired that it be performed until sometime after the associated LCO is within its Applicability, represent potential SR 3.0.4 conflicts. To avoid these conflicts, the SR (i.e., the Surveillance or the Frequency) is stated such that it is only "required" when it can be and should be performed. With an SR satisfied, SR 3.0.4 imposes no restriction.

The use of "met" or "performed" in these instances conveys specific meanings. A Surveillance is "met" only after the acceptance criteria are satisfied. Known failure of the requirements of a Surveillance, even without a Surveillance specifically being "performed," constitutes a Surveillance not "met."

(continued)

EXAMPLES The following examples illustrate the various ways that Frequencies are specified.

EXAMPLE 1.4-1

SURVEILLANCE REQUIREMENTS

SURVEILLANCE	FREQUENCY
Verify pressure within limit	12 hours

Example 1.4-1 contains the type of SR most often encountered in the Technical Specifications (TS). The Frequency specifies an interval (12 hours) during which the associated Surveillance must be performed at least one time. Performance of the Surveillance initiates the subsequent interval. Although the Frequency is stated as 12 hours, SR 3.0.2 allows an extension of the time interval to 1.25 times the interval specified in the Frequency for operational flexibility. The measurement of this interval continues at all times, even when the SR is not required to be met per SR 3.0.1 (such as when the equipment or variables are outside specified limits, or the facility is outside the Applicability of the LCO). If the interval specified by SR 3.0.2 is exceeded while the facility is in a condition specified in the Applicability of the LCO, the LCO is not met in accordance with SR 3.0.1.

If the interval as specified by SR 3.0.2 is exceeded while the facility is not in a condition specified in the Applicability of the LCO for which performance of the SR is required, the Surveillance must be performed within the Frequency requirements of SR 3.0.2, prior to entry into the specified condition. Failure to do so would result in a violation of SR 3.0.4.

(continued)

EXAMPLE 1.4-2

SURVEILLANCE REQUIREMENTS

SURVEILLANCE	FREQUENCY
Verify flow is within limits	Once within 12 hours prior to starting activity AND 24 hours thereafter

Example 1.4-2 has two Frequencies. The first is a one time performance Frequency, and the second is of the type shown in Example 1.4-1. The logical connector "AND" indicates that both Frequency requirements must be met. Each time the example activity is to be performed, the Surveillance must be performed within 12 hours prior to starting the activity.

The use of "once" indicates a single performance will satisfy the specified Frequency (assuming no other Frequencies are connected by "AND"). This type of Frequency does not qualify for the 25% extension allowed by SR 3.0.2.

"Thereafter" indicates future performances must be established per SR 3.0.2, but only after a specified condition is first met (i.e., the "once" performance in this example). If the specified activity is canceled or not performed, the measurement of both intervals stops. New intervals start upon preparing to restart the specified activity.

A 2.0 [Reserved]

A 3.0 LIMITING CONDITION FOR OPERATION (LCO) APPLICABILITY

LCO 3.0.1	LCOs shall be met during specified conditions in the Applicability, except as provided in LCO 3.0.2.
LCO 3.0.2	Upon failure to meet an LCO, the Required Actions of the associated Conditions shall be met, except as provided in LCO 3.0.5. If the LCO is met or is no longer applicable prior to expiration of the specified Completion Time(s), completion of the Required Action(s) is not required, unless otherwise stated.
LCO 3.0.3	Not applicable to a NAC-MPC SYSTEM.
LCO 3.0.4	When an LCO is not met, entry into a specified condition in the Applicability shall not be made except when the associated ACTIONS to be entered permit continued operation in the specified condition in the Applicability for an unlimited period of time. This Specification shall not prevent changes in specified conditions in the Applicability that are required to comply with ACTIONS or that are related to the unloading of an NAC-MPC SYSTEM. Exceptions to this Condition are stated in the individual Specifications. These exceptions allow entry into specified conditions in the Applicability where the associated ACTIONS to be entered allow operation in the specified conditions in the Applicability only for a limited period of time.
LCO 3.0.5	Equipment removed from service or not in service in compliance with ACTIONS may be returned to service under administrative control solely to perform testing required to demonstrate it meets the LCO or that other equipment meets the LCO. This is an exception to LCO 3.0.2 for the System to return to service under administrative control to perform the testing.

A 3.0 SURVEILLANCE REQUIREMENT (SR) APPLICABILITY

SR 3.0.1	SRs shall be met during the specified conditions in the Applicability for individual LCOs, unless otherwise stated in the SR. Failure to meet a Surveillance, whether such failure is experienced during the performance of the Surveillance or between performances of the Surveillance, shall be a failure to meet the LCO. Failure to perform a Surveillance within the specified Frequency shall be a failure to meet the LCO, except as provided in SR 3.0.3. Surveillances do not have to be performed on equipment or variables outside specified limits.
SR 3.0.2	The specified Frequency for each SR is met if the Surveillance is performed within 1.25 times the interval specified in the Frequency, as measured from the previous performance or as measured from the time a specified condition of the Frequency is met. For Frequencies specified as "once," the above interval extension does not apply. If a Completion Time requires periodic performance on a "once per…" basis, the above Frequency extension applies to each performance after the initial performance. Exceptions to this Specification are stated in the individual Specifications.
SR 3.0.3	If it is discovered that a Surveillance was not performed within its specified Frequency, then compliance with the requirement to declare the LCO not met may be delayed from the time of discovery up to 24 hours or up to the limit of the specified Frequency, whichever is less. This delay period is permitted to allow performance of the Surveillance. If the Surveillance is not performed within the delay period, the LCO must immediately be declared not met, and the applicable Condition(s) must be entered.

(continued)

SR 3.0.3 (continued)	When the Surveillance is performed within the delay period and the Surveillance is not met, the LCO must immediately be declared not met, and the applicable Condition(s) must be entered.
SR 3.0.4	Entry into a specified Condition in the Applicability of an LCO shall not be made, unless the LCO's Surveillances have been met within their specified Frequency. This provision shall not prevent entry into specified conditions in the Applicability that are required to comply with Actions or that are related to the unloading of a NAC-MPC SYSTEM.

A 3.1 NAC-MPC SYSTEM Integrity

A 3.1.1 CANISTER Maximum Time in Vacuum Drying

LCO 3.1.1

1. The following limits for vacuum drying time shall be met, as appropriate:

1.a For the YANKEE-MPC configuration, the time duration from completion of draining the CANISTER through completion of vacuum dryness testing and the introduction of helium backfill shall not exceed the time shown for the specified heat loads:

Total Heat Load (L) (kW)	Time Limit (Hours)
10.5 < L ≤ 12.5	38
8.5 < L ≤ 10.5	48
6.5 < L ≤ 8.5	58
4.5 < L ≤ 6.5	83
L ≤ 4.5	Not Limited

1.b For the CY-MPC configuration, the time duration from completion of draining the CANISTER through completion of vacuum dryness testing and the introduction of helium backfill shall not exceed the time shown for the specified LOADING CATEGORY (Tables B2-5 and B2-6):

LOADING CATEGORY	Time Limit (Hours)
A	21
B	23
C	33
D	72

1.c For MPC-LACBWR configuration, the time duration from completion of draining the CANISTER through completion of vacuum dryness testing and the introduction of helium backfill shall not exceed the time shown for the specified heat loads:

Total Heat Load (L) (kW)	Time Limit (Hours)
L ≤ 4.5	Not Limited

2. The time duration from the end of a minimum of 24 hours of WATER COOLING or of FORCED AIR COOLING of the CANISTER through completion of vacuum dryness testing and the introduction of helium backfill shall not exceed the following limits.

(continued)

LCO 3.1.1 (continued)

2.a For the Yankee-MPC configuration, the time duration shall not exceed the time shown for the specified heat loads:

Total Heat Load (L) (kW)	Time Limit (Hours) After FORCED AIR COOLING or WATER COOLING
10.5 < L ≤ 12.5	10
8.5 < L ≤ 10.5	12
6.5 < L ≤ 8.5	16
4.5 < L ≤ 6.5	40

2.b For the CY-MPC configuration, the time duration shall not exceed the time shown for the specified LOADING CATEGORY (reference Tables B2-5 and B2-6):

LOADING CATEGORY	Time Limit (Hours) After WATER COOLING	Time limit (Hours) After FORCED AIR COOLING
A	12	8
B	15	12
C	24	21
D	66	60

APPLICABILITY: During LOADING OPERATIONS

ACTIONS

---NOTE---

Separate Condition entry is allowed for each NAC-MPC SYSTEM.

(continued)

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. LCO Condition 1 or Condition 2 (if applicable) time limits not met	A.1 Commence filling CANISTER with helium to 0 (+1, -0) psig	2 hours
	AND A.2.1 Commence WATER COOLING	2 hours
	AND A.2.2 Maintain WATER COOLING for a minimum of 24 hours	Prior to restart of LOADING OPERATIONS
	OR A.2.3 Commence FORCED AIR COOLING.	2 hours
	AND A.2.4 Maintain FORCED AIR COOLING for a minimum of 24 hours	Prior to restart of LOADING OPERATIONS

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.1.1.1	For NAC-MPC systems having limited vacuum drying times in LCO Condition 1, monitor elapsed time from completion of CANISTER draining operations until start of helium backfill	Once at the completion of CANISTER draining AND 2 hours thereafter
SR 3.1.1.2	For NAC-MPC systems having limited vacuum drying times in LCO Condition 2, monitor elapsed time from the end of WATER COOLING or FORCED AIR COOLING until start of helium backfill	Once at end of WATER COOLING or FORCED AIR COOLING AND 2 hours thereafter

A 3.1 NAC-MPC SYSTEM Integrity

A 3.1.2 CANISTER Vacuum Drying Pressure

LCO 3.1.2	The CANISTER vacuum drying pressure shall be ≤ 10 torr. Vacuum pressure shall be held for a minimum of 10 minutes with pressure remaining below 10 torr during the 10-minute period.
APPLICABILITY:	During LOADING OPERATIONS

ACTIONS

-----NOTE-----

10-minute period shall commence following system pressure stabilization at a vacuum pressure at or below 10 torr. Separate Condition entry is allowed for each NAC-MPC SYSTEM.

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. CANISTER vacuum drying pressure limit not met	A.1 Establish CANISTER cavity vacuum drying pressure within limit	25 days
B. Required Action and associated Completion Time not met	B.1 Remove all fuel assemblies from the NAC-MPC SYSTEM	5 days

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.1.2.1	Verify CANISTER cavity vacuum drying pressure is within limit	Once prior to TRANSPORT OPERATIONS

A 3.1 NAC-MPC SYSTEM Integrity

A 3.1.3 CANISTER Helium Backfill Pressure

LCO 3.1.3 The CANISTER helium backfill pressure shall be 15 (+2, -0) psia. Prior to helium backfill, the CANISTER vacuum pressure shall be ≤ 3 torr.

APPLICABILITY: During LOADING OPERATIONS

ACTIONS

------------------------------NOTE------------------------------

Separate Condition entry is allowed for each NAC-MPC SYSTEM.

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. CANISTER helium backfill pressure limit not met	A.1 Establish CANISTER helium backfill pressure within limit	25 days
B. Required Action and associated Completion Time not met	B.1 Remove all fuel assemblies from the NAC-MPC SYSTEM	5 days

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.1.3.1	Verify CANISTER helium backfill pressure is within limit.	Once prior to TRANSPORT OPERATIONS

A 3.1 NAC-MPC SYSTEM Integrity

A 3.1.4 CANISTER Maximum Time in TRANSFER CASK

LCO 3.1.4

The CANISTER shall be transferred from the TRANSFER CASK to a CONCRETE CASK, or to a transport cask, or returned to an appropriate location for UNLOADING OPERATIONS.

APPLICABILITY: During LOADING OPERATIONS, TRANSFER OPERATIONS, or UNLOADING OPERATIONS

ACTIONS:

--NOTE--

Separate Condition entry is allowed for each NAC-MPC SYSTEM.

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. CANISTER transfer not completed	A.1 Complete CANISTER TRANSFER OPERATIONS	25 days
B. Required Action and associated completion time not met	B.1 Remove all fuel assemblies from the CANISTER	5 days

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.1.4.1	Verify CANISTER transfer completed	Once within 25 days

A 3.1 NAC-MPC SYSTEM Integrity

A 3.1.5 CANISTER Helium Leak Rate

LCO 3.1.5	The CANISTER shield lid to CANISTER shell confinement weld shall be tested to demonstrate a helium leak rate less than 2 x 10^{-7} cm^3/sec (helium). The test sensitivity shall be 1 x 10^{-7} cm^3/sec (helium).
APPLICABILITY:	During LOADING OPERATIONS of YANKEE-MPC and CY-MPC CANISTERS only

ACTIONS

---NOTE---

Separate Condition entry is allowed for each NAC-MPC SYSTEM.

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. CANISTER helium leak rate limit not met	A.1 Establish CANISTER helium leak rate within limit	25 days
B. Required Action and associated Completion Time not met	B.1 Remove all fuel assemblies from the NAC-MPC SYSTEM	5 days

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.1.5.1	Verify CANISTER helium leak rate is within limit	Once prior to TRANSPORT OPERATIONS.

A 3.1 NAC-MPC SYSTEM Integrity

A 3.1.6 CONCRETE CASK Heat Removal System

LCO 3.1.6 The CONCRETE CASK Heat Removal System shall be OPERABLE.

APPLICABILITY: During STORAGE OPERATIONS

ACTIONS

--NOTE--
Separate Condition entry is allowed for each NAC-MPC SYSTEM.

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. LCO not met	A.1 Restore CONCRETE CASK Heat Removal System to OPERABLE status	8 hours
B. Required Action and associated Completion Time not met	B.1 Perform SR 3.1.6.1	Immediately and every 6 hours thereafter
	AND	
	B.2.1 Perform an engineering evaluation to determine that the CONCRETE CASK Heat Removal System is OPERABLE	12 hours
	OR	
	B.2.2 Place the NAC-MPC SYSTEM in a safe condition	12 hours

(continued)

SURVEILLANCE REQUIREMENTS

	SURVEILLANCE	FREQUENCY
SR 3.1.6.1	Verify the difference between the average CONCRETE CASK air outlet temperature and ISFSI ambient temperature is ≤92°F for the YANKEE-MPC CANISTER and the MPC-LACBWR CANISTER or ≤110°F for the CY-MPC CANISTER.	24 hours
	<u>OR</u>	
	Visually verify all four air inlet and outlet screens are unobstructed.	24 hours

A 3.1 NAC-MPC SYSTEM Integrity

A 3.1.7 Fuel Cooldown Requirements

LCO 3.1.7 Fuel cooldown requirements for UNLOADING a CANISTER installed in the TRANSFER CASK shall be met as appropriate.

1. Initiate CANISTER internal cooldown
   a. Start nitrogen gas flush and maintain for a minimum of 10 minutes.
   b. Start cooling water flow rate of 5 (+3, -0) gallons per minute at inlet pressure of 25 (+10, -0) psig. Minimum cooling water temperature is 70°F.
   c. Limit the CANISTER pressure to ≤ 50 psig.
   d. Maintain cooling water flow through CANISTER until outlet water temperature is ≤ 200°F.

APPLICABILITY: During UNLOADING OPERATIONS

-----NOTES-----

The LCO is only applicable to wet UNLOADING OPERATIONS. Separate Condition entry is allowed for each NAC-MPC SYSTEM.

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. CANISTER internal cooldown requirements not met	A.1 Complete CANISTER internal cooldown steps	Prior to removal of CANISTER shield lid or closure lid

(continued)

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.1.7.1	Condition 1.a Monitor Nitrogen gas flush time.	Within 10 minutes of start of Nitrogen gas flow.
SR 3.1.7.1	Condition 1.b Monitor cooling water temperature and flow rate.	Verify temperature prior to start of flow. Verify flow rate within 10 minutes of start of water flow and hourly thereafter.
SR 3.1.7.1	Condition 1.c Monitor CANISTER internal pressure.	At start of flow and every 30 minutes thereafter until cooling water begins to exit the CANISTER.
SR 3.1.7.1	Condition 1.d Monitor CANISTER water discharge temperature.	Once at start of discharge flow and hourly thereafter.

A 3.2 NAC-MPC SYSTEM Radiation Protection

A 3.2.1 CANISTER Surface Contamination

LCO 3.2.1 Removable contamination on the exterior surfaces of the CANISTER shall each not exceed:

a. 10,000 dpm/100 cm^2 from beta and gamma sources; and

b. 100 dpm/100 cm^2 from alpha sources.

APPLICABILITY: During LOADING OPERATIONS

ACTIONS

-------------------------NOTE-------------------------

Separate Condition entry is allowed for each NAC-MPC SYSTEM.

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. CANISTER removable surface contamination limits not met	A.1 Restore CANISTER removable surface contamination to within limits	Prior to TRANSPORT OPERATIONS

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.2.1.1	Verify by either direct or indirect methods that the removable contamination on the exterior surfaces of the CANISTER is within limits	Once, prior to TRANSPORT OPERATIONS

A 3.2 NAC-MPC SYSTEM Radiation Protection

A 3.2.2 CONCRETE CASK Average Surface Dose Rates

LCO 3.2.2

A. The average surface dose rates of each YANKEE-MPC CONCRETE CASK shall not exceed:

- 50 mrem/hour (neutron + gamma) on the side (on the concrete surfaces);
- 55 mrem/hour (neutron + gamma) on the top; and,
- 200 mrem/hour (neutron + gamma), an average of the measurements at air inlets and outlets.

B. The average surface dose rates of each CY-MPC CONCRETE CASK shall not exceed:

- 170 mrem/hour (neutron + gamma) on the side (on the concrete surfaces);
- 100 mrem/hour (neutron + gamma) on the top; and,
- 110 mrem/hour (neutron + gamma), an average of the measurements at air inlets and outlets.

C. The average surface dose rates of each MPC-LACBWR CONCRETE CASK shall not exceed the following limits unless required ACTIONS A.1 and A.2 are met:

- 20 mrem/hour (neutron + gamma) on the side (on the concrete surfaces);
- 25 mrem/hour (neutron + gamma) on the top;
- 100 mrem/hour (neutron + gamma), an average of the measurements at air inlets and outlets.

APPLICABILITY: Prior to or at the beginning of STORAGE OPERATIONS

ACTIONS

---NOTE---

Separate Condition entry is allowed for each NAC-MPC SYSTEM.

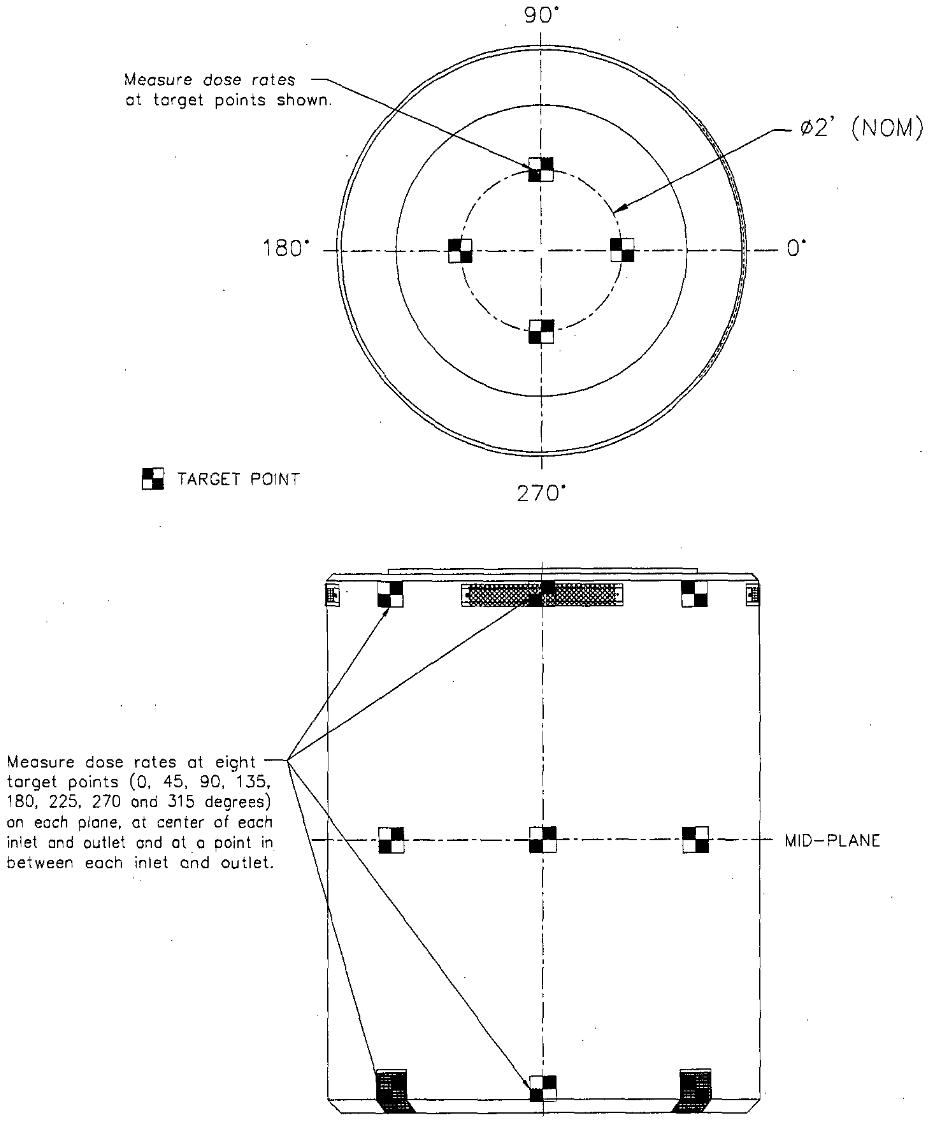
(continued)

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. CONCRETE CASK average surface dose rate limits not met	A.1 Administratively verify correct fuel loading	24 hours
	AND	
	A.2 Perform analysis to verify compliance with the ISFSI offsite radiation protection requirements of 10 CFR 20 and 10 CFR 72.	7 days
B. Required Action and associated Completion Time not met.	B.1 Remove all fuel assemblies from the NAC-MPC SYSTEM	30 days

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.2.2.1	Verify average surface dose rates of CONCRETE CASK loaded with a CANISTER containing fuel assemblies are within limits. Dose rates shall be measured at the locations shown in Figure A.3-1.	Prior to STORAGE OPERATIONS

Figure A.3-1 CONCRETE CASK Average Surface Dose Rates



A 4.0 [Reserved]

A 5.0 ADMINISTRATIVE CONTROLS AND PROGRAMS

A 5.1 Training Program

A training program for the NAC-MPC SYSTEM shall be developed under the general licensee's Systems Approach to Training Program. Training modules shall include comprehensive instructions for all activities related to the NAC-MPC SYSTEM and the independent spent fuel storage installation (ISFSI).

A 5.2 Preoperational Testing and Training Exercises

A dry run training exercise on loading, closure, handling, unloading, and transfer of the NAC-MPC SYSTEM shall be conducted by the licensee prior to the first use of the system to load spent fuel assemblies. The training exercise shall not be conducted with spent fuel in the CANISTER. The dry run may be performed in an alternate step sequence from the actual procedures, but all steps must be performed. The dry run shall include, but is not limited to the following:

a. Moving the CONCRETE CASK into its designated loading area
b. Moving the TRANSFER CASK containing the empty CANISTER into the spent fuel pool
c. Loading one or more dummy fuel assemblies into the CANISTER, including independent verification
d. Selection and verification of fuel assemblies requiring preferential loading
e. Installing the shield lid or closure lid, as applicable
f. Removal of the TRANSFER CASK from the spent fuel pool
g. Closing and sealing of the CANISTER to demonstrate pressure testing, vacuum drying, helium backfilling, welding, weld inspection and documentation, and leak testing
h. TRANSFER CASK movement through the designated load path
i. TRANSFER CASK installation on the CONCRETE CASK
j. Transfer of the CANISTER to the CONCRETE CASK

(continued)

A 5.2 Preoperational Testing and Training Exercises (continued)

k. CONCRETE CASK shield plug and lid (or lid only for MPC-LACBWR) installation
l. Transport of the CONCRETE CASK to the ISFSI
m. CANISTER unloading, including reflooding and weld removal or cutting
n. CANISTER removal from the CONCRETE CASK

A 5.3 Surveillance After an Off-Normal, Accident, or Natural Phenomena Event

A Response Surveillance is required following off-normal, accident or natural phenomena events. The NAC-MPC SYSTEMs in use at an ISFSI shall be inspected within 4 hours after the occurrence of an off-normal, accident or natural phenomena event in the area of the ISFSI. This inspection must specifically verify that all the CONCRETE CASK inlets and outlets are not blocked or obstructed. At least one-half of the inlets and outlets on each CONCRETE CASK must be cleared of blockage or debris within 24 hours to restore air circulation.

The CONCRETE CASK and CANISTER shall be inspected if they experience a drop or a tip-over.

Following a natural phenomena event, the ISFSI shall be inspected to determine if movement or damage to the CONCRETE CASKS has resulted in unacceptable site boundary dose rates.

(continued)

A 5.4 Radioactive Effluent Control Program

The program implements the requirements of 10 CFR 72.44(d).

a. The NAC-MPC SYSTEM does not create any radioactive materials or have any radioactive waste treatment systems. Therefore, specific operating procedures for the control of radioactive effluents are not required.

b. This program includes an environmental monitoring program. Each general licensee may incorporate NAC-MPC SYSTEM operations into their environmental monitoring program for 10 CFR Part 50 operations.

c. An annual report shall be submitted pursuant to 10 CFR 72.44(d)(3) or 10 CFR 50.36(a).

A 5.5 NAC-MPC SYSTEM Transport Evaluation Program

This program provides a means for evaluating various transport configurations and transport route conditions to ensure that the design basis drop limits are met. For lifting of the loaded TRANSFER CASK or CONCRETE CASK using devices, which are integral to a structure governed by 10 CFR Part 50 regulations, 10 CFR 50 requirements apply. This program is not applicable when the TRANSFER CASK or CONCRETE CASK is in the fuel building or is being handled by a device providing support from underneath (i.e., on a rail car, heavy haul trailer, air pads, etc.).

Pursuant to 10 CFR 72.212, this program shall evaluate the site specific transport route conditions.

(continued)

A 5.5 NAC-MPC SYSTEM Transport Evaluation Program (continued)

a. The program shall ensure that the transport route surfaces will not cause impact loading due to a design basis drop event in excess of 60g.

b. For site specific transport conditions, which are not bounded by the ISFSI pad surface characteristics, the program may evaluate the site specific conditions to ensure that the impact loading due to design basis drop events does not exceed 60g. This alternative analysis shall be commensurate with the drop analyses described in the Final Safety Analysis Report for the NAC-MPC SYSTEM. The program shall ensure that these alternative analyses are documented and controlled.

c. The TRANSFER CASK may be lifted in the vertical orientation to those heights necessary to perform cask handling operations, including CANISTER transfer, provided the lifts are made with structures and components designed in accordance with the criteria specified in Section B3.5. The TRANSFER CASK is not permitted to be lifted in the horizontal orientation.

d. The CONCRETE CASK is not permitted to be lifted in the horizontal orientation and is limited to 6 inches in the vertical orientation.

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APPENDIX 12.B

APPROVED CONTENTS AND DESIGN FEATURES FOR THE NAC-MPC SYSTEM

The Approved Contents and Design Features for the Yankee-MPC and the CY-MPC configurations of the NAC-MPC storage system are incorporated in Appendix B of Certificate of Compliance No. 1025, Amendment 5.

The Technical Specifications presented in this Appendix have been expanded to include the Approved Contents and Design Features for the MPC-LACBWR storage system.

Appendix 12.B
Table of Contents

B 1.0 [Reserved]

B 2.0 CONTENTS

B 2.1 Fuel Specifications and Loading Conditions

The NAC-MPC SYSTEM is provided in three configurations. The first, designated the YANKEE-MPC, is designed to store up to 36 Yankee Class fuel assemblies or YANKEE-MPC RECONFIGURED FUEL ASSEMBLIES. The YANKEE-MPC contents are described in Section B 2.1.1. There is no preferential fuel loading requirement for the YANKEE-MPC configuration.

The second NAC-MPC SYSTEM configuration is designated the CY-MPC. This configuration is designed to store up to 26 Connecticut Yankee INTACT FUEL ASSEMBLIES, with up to four of these assemblies replaced with CY-MPC RECONFIGURED FUEL ASSEMBLIES or loaded CY-MPC DAMAGED FUEL CANS. The CY-MPC contents are described in Section B 2.1.2. To ensure the efficient accommodation of Connecticut Yankee fuel, the CY-MPC is provided with two basket configurations – one designed for 26 assemblies and one designed for 24 assemblies. With these basket configurations, preferential loading is used to ensure the accommodation of the contents within the design basis limits of the CY-MPC System. The preferential loading requirements are described in Section B 2.1.2.

The third NAC-MPC SYSTEM configuration is designated as MPC-LACBWR. MPC-LACBWR is designed to store up to 68 Dairyland Power Cooperative (DPC) La Crosse Boiling Water Reactor (LACBWR) spent fuel assemblies. The MPC-LACBWR configuration accommodates up to 32 LACBWR DAMAGED FUEL CANS in the basket. The MPC-LACBWR fuel contents are described in Section B 2.1.3.

B 2.1.1 Fuel to be Stored in the YANKEE-MPC System

INTACT and DAMAGED FUEL ASSEMBLIES, INTACT FUEL RODS, DAMAGED FUEL RODS and FUEL DEBRIS placed in a RECONFIGURED FUEL ASSEMBLY meeting the limits specified in Table B.2-1 may be stored in the YANKEE-MPC System.

Preferential loading of Yankee Class fuel is used to establish reduced total decay heat loads in the CANISTER. The reduced heat load configurations allow the use of extended operating times in vacuum drying as specified in LCO 3.1.1. The reduced heat load configurations are based on loading Yankee Class fuel assemblies having a maximum decay heat of 320 watts and the total CANISTER decay heat load.

The values shown in Tables B.2-1 and B.2-2 are design nominal record values.

B 2.1.2 Fuel to be Stored in the CY-MPC System

INTACT FUEL ASSEMBLIES; CY-MPC RECONFIGURED FUEL ASSEMBLIES holding INTACT FUEL RODS, DAMAGED FUEL RODS, or FUEL DEBRIS; and CY-MPC DAMAGED FUEL CANS holding INTACT FUEL ASSEMBLIES or DAMAGED FUEL ASSEMBLIES, meeting the limits specified in Table B.2-3 may be stored in the CY-MPC System. As shown in Section II of Table B.2-3, certain fuel must be preferentially loaded to ensure satisfactory performance of the CY-MPC System.

The values shown in Tables B.2-3 and B.2-4 are design nominal record values.

B. 2.1.3 Fuel to be Stored in the MPC-LACBWR System

LACBWR UNDAMAGED FUEL ASSEMBLIES and LACBWR DAMAGED FUEL ASSEMBLIES and FUEL DEBRIS placed in a LACBWR DAMAGED FUEL CAN meeting the limits specified in Table B.2-7 may be stored in the MPC-LACBWR system.

The values shown in Table B.2-7 and Table B.2-8 are design nominal record values.

Table B.2-1
Yankee Class Fuel Assembly Limits

I. YANKEE-MPC CANISTER

A. Allowable Contents

1. Uranium oxide Yankee Class INTACT FUEL ASSEMBLIES listed in Table B.2-2 and RECAGED FUEL ASSEMBLIES that meet the following specifications:

a. Cladding Type:	Zircaloy or Stainless Steel as specified in Table B.2-2 for the applicable fuel assembly class (Note: Type A and Type B configurations in Table B.2-2 identify variations in the arrangement of the outer row of fuel rods that accommodate the insertion of control blades in the reactor).
b. Enrichment:	As specified in Table B.2-2 for the applicable fuel assembly type.
c. Decay Heat Per Assembly:	
i. Zircaloy-Clad Fuel:	≤ 347 Watts
ii. Stainless Steel-Clad Fuel:	≤ 264 Watts
d. Post-irradiation Cooling Time and Average Burnup Per Assembly:	
i. Zircaloy-Clad Fuel:	As specified in Table B.2-2 for the applicable fuel assembly type.
ii. Stainless Steel-Clad Fuel:	As specified in Table B.2-2 for the applicable fuel assembly type.

Table B.2-1
Yankee Class Fuel Assembly Limits (continued)

1. Unirradiated Fuel Assembly Length:	Maximum = 111.8 inches Minimum = 109.0 inches
f. Unirradiated Fuel Assembly Width:	≤ 7.64 inches
g. Fuel Assembly Weight:	≤ 950 lbs.
h. Minimum Length of Bottom Fuel Nozzle:	6.7 inches (17.0 cm)

2. Uranium oxide Yankee Class INTACT FUEL RODS, DAMAGED FUEL RODS or FUEL DEBRIS placed in YANKEE-MPC RECONFIGURED FUEL ASSEMBLIES (RFA) and DAMAGED FUEL ASSEMBLIES with up to 20 DAMAGED FUEL RODS in each, placed in a damaged fuel can. The original fuel assemblies for the INTACT FUEL RODS, DAMAGED FUEL RODS, FUEL DEBRIS and damaged fuel cans shall meet the criteria specified in Table B.2-2 for the fuel assembly class, and meet the following additional specifications:

a. Cladding Type:	Zircaloy or Stainless Steel as specified in Table B.2-2 for the applicable fuel assembly type.
b. Enrichment:	As specified in Table B.2-2 for the applicable fuel assembly type.
c. Decay Heat Per YANKEE-MPC RECONFIGURED FUEL ASSEMBLY	≤ 102 Watts
d. Post-irradiation Cooling Time and Average Burnup Per Original Assembly:	
i. Zircaloy-Clad Fuel:	As specified in Table B.2-2 for the applicable fuel assembly type.

Table B.2-1

Yankee Class Fuel Assembly Limits (continued)

ii. Stainless Steel-Clad Fuel:	As specified in Table B.2-2 for the applicable fuel assembly type.
e. Unirradiated Original Fuel Assembly Length:	≤ 111.8 inches
f. Unirradiated Original Fuel Assembly Width:	≤ 7.64 inches
g. Maximum Weight:	≤ 950 lbs, including YANKEE-MPC RECONFIGURED FUEL ASSEMBLY
h. Maximum mass U per YANKEE-MPC RECONFIGURED FUEL ASSEMBLY:	66.33 kg

3. Uranium oxide Yankee Class fuel requiring preferential loading to meet CANISTER reduced heat load configurations.
   - a. Fuel shall be as described in Items A.1 and/or A.2, except that the maximum fuel assembly decay heat is limited to 320 watts.
   - b. Fuel assemblies having a decay heat up to 320 watts may be loaded in any fuel loading position.

B. Quantity per CANISTER:
Up to 36 fuel assemblies, RFAs, and RECAGED FUEL ASSEMBLIES, or up to 32 fuel assemblies, RFAs. And RECAGED FUEL ASSEMBLIES, and 4 damaged fuel cans. The maximum contents weight limit is 30,600 pounds, not including the weight of the damaged fuel cans.

C. Fuel assemblies, RFAs, RECAGED FUEL ASSEMBLIES and damaged fuel cans shall not contain control components.

D. INTACT FUEL ASSEMBLIES shall not contain empty fuel rod positions. A solid Zircaloy or stainless steel rod that would displace an equivalent amount of water as an intact fuel rod or a Zircaloy rod containing a stainless steel or Zircaloy slug shall replace any missing fuel rod.

Table B.2-1
Yankee Class Fuel Assembly Limits (continued)

E. DAMAGED FUEL RODS and FUEL DEBRIS must be loaded in the YANKEE-MPC RECONFIGURED FUEL ASSEMBLY.

F. One or more Combustion Engineering fuel assembly lattices holding United Nuclear fuel rods with no empty fuel rod positions (RECAGED FUEL ASSEMBLY).

G. Up to 4 INTACT or RECAGED fuel assemblies or RFAs in damaged fuel cans loaded in a corner position of the basket. A DAMAGED FUEL ASSEMBLY may not have more than 20 fuel rod positions that are either empty or holding fuel rods classified as damaged and must be loaded in a damaged fuel can.

H. One or more United Nuclear fuel assemblies having removable fuel rods secured with a RETAINER in the top end fitting.

Table B.2-2 Yankee Class INTACT FUEL ASSEMBLY Characteristics

Fuel Assembly Type	**Combustion Engineering Type A**	**Combustion Engineering Type B**	**Exxon Type A[3]**	**Exxon Type B[3]**	**Exxon Type A[4]**	**Exxon Type B[4]**	**Westinghouse Type A**	**Westinghouse Type B**	**United Nuclear Type A**	**United Nuclear Type B**
ASSEMBLY CONFIGURATION[2]										
Assembly Length (cm)	283.9	283.9	283.3	283.3	283.9	283.9	282.6	282.6	282.4	282.4
Assembly Width (cm)	19.2	19.2	19.3	19.3	19.3	19.3	19.3	19.3	19.4	19.4
Assembly Weight (kg)	352	350.6	372	372	372	372	408.2	408.2	385.5	385.5
Enrichment-wt. % ^{235}U										
Maximum	3.93	3.93	4.03	4.03	4.03	4.03	4.97	4.97	4.03	4.03
Minimum	3.66	3.66	3.46	3.46	3.46	3.46	4.90	4.90	3.96	3.96
Max. Burnup (MWd/MTU)	36,000[1]	36,000[1]	36,000	36,000	36,000	36,000	32,000	32,000	32,000	32,000
Max. Initial Heavy Metal KgU/assembly	239.4	238.4	239.4	238.4	239.4	238.4	286.9	286.0	245.6	244.6
Min. Cool Time (yr)	8.1[1]	8.1[1]	16.0	16.0	10.0	10.0	24.0	24.0	13.0	13.0
Max. Decay Heat (kW)	0.347[1]	0.347[1]	0.269	0.269	0.331	0.331	0.264	0.264	0.257	0.257
FUEL ROD CONFIGURATION										
Fuel Rod Pitch (cm)	1.20	1.20	1.20	1.20	1.20	1.20	1.07	1.07	1.19	1.19
Active Fuel Length (cm)	231.1	231.1	231.1	231.1	231.1	231.1	234.0	234.0	231.1	231.1
Rod OD (cm)	0.93	0.93	0.93	0.93	0.93	0.93	0.86	0.86	0.93	0.93
Clad ID (cm)	0.81	0.81	0.81	0.81	0.81	0.81	0.76	0.76	0.81	0.81
Clad Material	Zircaloy	Zircaloy	Zircaloy	Zircaloy	Zircaloy	Zircaloy	SS	SS	Zircaloy	Zircaloy
Pellet OD (cm)	0.79	0.79	0.79	0.79	0.79	0.79	0.75	0.75	0.79	0.79
Rods per Assembly	231	230	231	230	231	230	305	304	237	236

1. Combustion Engineering fuel may be loaded at a maximum burnup of 32,000 MWd/MTU, a minimum enrichment of 3.5 wt % ^{235}U and cool time of 8.0 years. The maximum decay heat for this assembly is 0.304 kW.

2. Type A and Type B configurations identify variations in the arrangement of the outer row of fuel rods that accommodate the insertion of control blades in the reactor.

3. Exxon Type A or Type B fuel assembly with stainless steel fuel rod spacer grids.

4. Exxon Type A or Type B fuel assembly with Zircaloy fuel rod spacer grids.

Table B.2-3
Connecticut Yankee Fuel Assembly Limits

I. CY-MPC CANISTER – 24-Assembly Basket Configuration

- A. Allowable Contents
  - 1. Uranium oxide Connecticut Yankee INTACT FUEL ASSEMBLIES listed in Table B.2-4 and meeting the following specifications:
    - a. Cladding Type: Zircaloy or stainless steel as specified in Table B.2-4 for the applicable fuel assembly type.
    - b. Initial Enrichment:
      - i. Zircaloy-Clad Fuel: ≤ 4.61 wt. % ^{235}U
      - ii. Stainless Steel-Clad Fuel: ≤ 4.03 wt. % ^{235}U
    - c. Decay Heat Per Assembly:
      - i. Zircaloy-Clad Fuel: ≤ 674 Watts
      - ii. Stainless Steel-Clad Fuel: ≤ 674 Watts
    - d. Post-irradiation Cooling Time: ≥ 6 Years
    - e. Average Burnup Per Assembly:
      - i. Zircaloy-Clad Fuel: $\leq 43{,}000$ MWd/MTU
      - ii. Stainless Steel-Clad Fuel: $\leq 38{,}000$ MWd/MTU
    - f. Original Fuel Assembly Length: ≤ 137.1 inches
    - g. Original Fuel Assembly Width: ≤ 8.47 inches
    - h. Fuel Assembly Weight: $\leq 1{,}490$ lbs
    - i. Minimum Length of Bottom Fuel Nozzle: 3.2 inches

Table B.2-3

Connecticut Yankee Fuel Assembly Limits (continued)

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2. Uranium oxide Connecticut Yankee INTACT FUEL ASSEMBLIES, DAMAGED FUEL ASSEMBLIES, INTACT FUEL RODS, DAMAGED FUEL RODS, or FUEL DEBRIS placed in a CY-MPC DAMAGED FUEL CAN or CY-MPC RECONFIGURED FUEL ASSEMBLY. The Connecticut Yankee INTACT FUEL ASSEMBLIES, DAMAGED FUEL ASSEMBLIES, INTACT FUEL RODS, DAMAGED FUEL RODS, or FUEL DEBRIS shall be, or shall be from, assemblies that meet the criteria specified in Table B2-4 for the fuel assembly type or vendor, and meet the following additional specifications:

a. Cladding Type:	Zircaloy or Stainless Steel as specified in Table B.2-4 for the applicable fuel assembly.
b. Initial Enrichment:	
i. Zircaloy-Clad Fuel:	≤ 4.61 wt. % ^{235}U
ii. Stainless Steel-Clad Fuel:	≤ 4.03 wt. % ^{235}U
c. Decay Heat Per CY-MPC RECONFIGURED FUEL ASSEMBLY or CY-MPC DAMAGED FUEL CAN:	≤ 674 Watts
d. Post-irradiation Cooling Time:	≥ 6 Years
e. Average Burnup Per Original Assembly:	
i. Zircaloy-Clad Fuel:	≤ 43,000 MWd/MTU
ii. Stainless Steel-Clad Fuel:	≤ 38,000 MWd/MTU
f. Original Fuel Assembly Length:	≤ 137.1 inches

Table B.2-3

Connecticut Yankee Fuel Assembly Limits (continued)

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g. Original Fuel Assembly Width: ≤ 8.47 inches

h. Maximum Loaded Weight:
   - i. CY-MPC RECONFIGURED FUEL ASSEMBLY: 1,200 lbs
   - ii. CY-MPC DAMAGED FUEL CAN: 1,590 lbs

i. Maximum Mass U
   - i. CY-MPC RECONFIGURED FUEL ASSEMBLY: 212 kg
   - ii. CY-MPC DAMAGED FUEL CAN: 433.7 kg

B. Quantity per CANISTER:
   1. Up to 24 Connecticut Yankee INTACT FUEL ASSEMBLIES.
   2. Up to 4 CY-MPC RECONFIGURED FUEL ASSEMBLIES or CY-MPC DAMAGED FUEL CANS that are preferentially loaded into fuel tube locations 1, 4, 21, or 24 on Figure B.2-1, with the remaining available locations loaded with up to 23 Connecticut Yankee INTACT FUEL ASSEMBLIES.
   3. Maximum contents weight limit of 35,100 lbs.
   4. Decay heat loading must conform to the LOADING CATEGORIES in Table B.2-5 for total canister and individual fuel assembly heat load, where the LOADING CATEGORY corresponds to the time limits shown in LCOs 3.1.1 and 3.1.4.

C. CY-MPC RECONFIGURED FUEL ASSEMBLIES and CY-MPC DAMAGED FUEL CANS shall not contain control components.

D. Connecticut Yankee INTACT FUEL ASSEMBLIES with one or more missing fuel rods not replaced with solid filler rods, shall be preferentially loaded in fuel tube positions 1, 4, 21, or 24 on Figure B.2-1.

E. Connecticut Yankee INTACT FUEL ASSEMBLIES (not loaded in CY-MPC DAMAGED FUEL CANS) may each have an inserted reactor control component (reactor control cluster or flow mixer), up to the canister payload weight limit of 35,100 lbs.

Table B.2-3

Connecticut Yankee Fuel Assembly Limits (continued)

F. Up to 6 Connecticut Yankee INTACT FUEL ASSEMBLIES loaded in fuel tube positions 7, 8, 12, 13, 17, or 18 as shown in Figure B.2-1 in each CANISTER may each have an inserted flow mixer up to the CANISTER contents weight limit of 35,100 lbs.

G. Individual DAMAGED FUEL RODS and FUEL DEBRIS must be loaded in the CY-MPC RECONFIGURED FUEL ASSEMBLY.

H. DAMAGED FUEL ASSEMBLIES, LATTICES holding INTACT FUEL RODS or DAMAGED FUEL RODS and FAILED ROD STORAGE CANISTER holding INTACT FUEL RODS or DAMAGED FUEL RODS must be loaded in the CY-MPC DAMAGED FUEL CAN.

I. INTACT FUEL ASSEMBLIES and DAMAGED FUEL ASSEMBLIES may have stainless steel rods inserted into each of the 20 RCCA guide tubes. The weight of the contents, including the installed stainless steel rods, shall not exceed the authorized contents weight limit of 35,100 pounds.

II. CY-MPC CANISTER – 26-Assembly Basket Configuration

A. Allowable Contents

1. Uranium oxide Connecticut Yankee INTACT FUEL ASSEMBLIES listed in Table B.2-4, excluding Westinghouse Vantage 5 fuel, and meeting the following specifications:

a. Cladding Type:	Zircaloy or stainless steel as specified in Table B.2-4 for the applicable fuel assembly type.	
b. Initial Enrichment:		
i. Zircaloy-Clad Fuel:	≤ 3.93 wt. % ^{235}U	
ii. Stainless Steel-Clad Fuel:	≤ 4.03 wt. % ^{235}U	
c. Decay Heat Per Assembly:		
i. Uniform Heat Loading:	≤ 674 Watts	
	Fuel Loading Positions	Assembly Limit
1. Preferential Loading: (See Figure B.2-2)	7, 8, 12, 13, 14, 15, 19 and 20	≤ 840 Watts
	1, 2, 3, 4, 5, 6, 9, 10, 11, 16, 17, 18, 21, 22, 23, 24, 25 and 26	≤ 600 Watts
d. Post-irradiation Cooling Time:	≥ 6 Years	

Table B.2-3

Connecticut Yankee Fuel Assembly Limits (continued)

e. Average Burnup Per Original Assembly:	
i. Zircaloy-Clad Fuel:	≤ 43,000 MWd/MTU
ii. Stainless Steel-Clad Fuel:	≤ 38,000 MWd/MTU
f. Original Fuel Assembly Length:	≤ 137.1 inches
g. Original Fuel Assembly Width:	≤ 8.47 inches
h. Fuel Assembly Weight:	≤ 1,490 lbs
i. Minimum Length of Bottom Fuel Nozzle:	3.2 inches

2. Uranium oxide Connecticut Yankee INTACT FUEL ASSEMBLIES, DAMAGED FUEL ASSEMBLIES, INTACT FUEL RODS, DAMAGED FUEL RODS, or FUEL DEBRIS placed in a CY-MPC DAMAGED FUEL CAN or CY-MPC RECONFIGURED FUEL ASSEMBLY. The Connecticut Yankee INTACT FUEL ASSEMBLIES, DAMAGED FUEL ASSEMBLIES, INTACT FUEL RODS, DAMAGED FUEL RODS, or FUEL DEBRIS shall be, or shall be from, assemblies that meet the criteria specified in Table B.2-4 for the fuel assembly type or vendor, and meet the following additional specifications:

a. Cladding Type:	Zircaloy or stainless steel as specified in Table B2-4 for the applicable fuel assembly type.	
b. Initial Enrichment:		
i. Zircaloy-Clad Fuel:	≤ 3.93 wt. % ^{235}U	
ii. Stainless Steel-Clad Fuel:	≤ 4.03 wt. % ^{235}U	
c. Decay Heat Per CY-MPC RECONFIGURED FUEL ASSEMBLY or DAMAGED FUEL CAN:		
i. Uniform Heat Loading:	≤ 674 Watts	
ii. Preferential Loading	<u>Fuel Loading Position</u>	<u>Thermal Limit</u>
(See Figure B.2-2)	1, 4, 23, 26	≤ 600 Watts

Table B.2-3

Connecticut Yankee Fuel Assembly Limits (continued)

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d. Post-irradiation Cooling Time: ≥ 6 Years

e. Average Burnup Per Original Assembly:
   i. Zircaloy-Clad Fuel: ≤ 43,000 MWd/MTU
   ii. Stainless Steel-Clad Fuel: ≤ 38,000 MWd/MTU

f. Original Fuel Assembly Length: ≤ 137.1 inches

g. Original Fuel Assembly Width: ≤ 8.47 inches

h. Maximum Weight:
   i. CY-MPC RECONFIGURED FUEL ASSEMBLY: 1,200 lbs
   ii. CY-MPC DAMAGED FUEL CAN: 1,590 lbs

i. Maximum Mass U
   i. CY-MPC RECONFIGURED FUEL ASSEMBLY: 212 kg
   ii. CY-MPC DAMAGED FUEL CAN: 433.7 kg

B. Quantity per CANISTER:

1. Up to 26 Connecticut Yankee INTACT FUEL ASSEMBLIES.
2. Up to 4 CY-MPC RECONFIGURED FUEL ASSEMBLIES or CY-MPC DAMAGED FUEL CANS that are preferentially loaded into fuel tube locations 1, 4, 23 or 26 on Figure B.2-2, with the remaining available locations loaded with up to 25 Connecticut Yankee INTACT FUEL ASSEMBLIES.
3. Maximum contents weight limit of 35,100 lbs.
4. Decay heat loading must conform to the LOADING CATEGORIES in Table B.2-5 for total canister and individual fuel assembly heat load, where the LOADING CATEGORY corresponds to the time limits shown in LCOs 3.1.1 and 3.1.4.

Table B.2-3

Connecticut Yankee Fuel Assembly Limits (continued)

C. CY-MPC RECONFIGURED FUEL ASSEMBLIES and CY-MPC DAMAGED FUEL CANS shall not contain control components.

D. Connecticut Yankee INTACT FUEL ASSEMBLIES with one or more missing fuel rods not replaced with solid filler rods, shall be preferentially loaded in fuel tube positions 1, 4, 23, or 26 on Figure B.2-2.

E. Connecticut Yankee INTACT FUEL ASSEMBLIES may each have an inserted reactor control component (reactor control cluster or flow mixer), up to the CANISTER contents weight limit of 35,100 lbs.

F. Up to 8 Connecticut Yankee INTACT FUEL ASSEMBLIES loaded in fuel tube positions 7, 8, 12, 13, 14, 15, 19 or 20 as shown in Figure B.2-2 in each CANISTER may each have an inserted flow mixer up to the CANISTER contents weight limit of 35,100 lbs.

G. In the preferential loading configuration, Zircaloy clad fuel assemblies with cooling times less than 7 years shall not be loaded into fuel tube positions 13 or 14 as shown in Figure B.2-2.

H. Individual DAMAGED FUEL RODS and FUEL DEBRIS must be loaded in the CY-MPC RECONFIGURED FUEL ASSEMBLY.

I. DAMAGED FUEL ASSEMBLIES, LATTICES holding INTACT FUEL RODS or DAMAGED FUEL RODS and FAILED ROD STORAGE CANISTER holding INTACT FUEL RODS or DAMAGED FUEL RODS must be loaded in the CY-MPC DAMAGED FUEL CAN.

J. INTACT FUEL ASSEMBLIES and DAMAGED FUEL ASSEMBLIES may have stainless steel rods inserted into each of the 20 RCCA guide tubes. The weight of the contents, including the installed stainless steel rods, shall not exceed the authorized contents weight limit of 35,100 pounds.

Table B.2-4 Connecticut Yankee INTACT FUEL ASSEMBLY Characteristics

Parameter	**West.**	**NUMEC**	**B & W (GUNF)**	**B & W**	**Gulf General Atomic**	**NUMEC**	**B & W**	**B & W**	**West. Vantage 5H**[1]
Assembly Array	15 x 15	15 x 15	15 x 15	15 x 15	15 x 15	15 x 15	15 x 15	15 x 15	15 x 15
Fuel Rod Cladding	Stainless Steel	Stainless Steel	Stainless Steel	Stainless Steel	Zircaloy	Zircaloy	Zircaloy	Zircaloy	Zircaloy
Fuel Rods per Assembly	204	204	204	204	204	204	204	204	204
Guide Tubes per Assembly	20	20	20	20	20	20	20	20	20
Instrument Tubes per Assembly	1	1	1	1	1	1	1	1	1
Nominal Unirradiated Assembly Length (in)	137.1	137.1	137.1	137.1	137.1	137.1	137.1	137.1	137.1
Maximum Assembly Cross Section (in)	8.47	8.47	8.47	8.47	8.47	8.47	8.47	8.47	8.47
Maximum Enrichment (wt. % ^{235}U)	4.03	4.03	4.03	4.03	3.42	3.42	3.42	3.93	4.61
Maximum Initial Uranium Mass (MTU/ Assembly)	0.4337	0.4337	0.4337	0.4337	0.3971	0.3971	0.3971	0.3742	0.3900
Max. Burnup (MWd/MTU)	38,000	30,000	38,000	38,000	30,000	30,000	40,000	43,000	30,000

1. Westinghouse Vantage 5 fuel must be loaded in the 24-assembly basket.

Table B.2-5 Connecticut Yankee Fuel and CANISTER Heat LOADING CATEGORY Limits

LOADING CATEGORY	Canister Maximum Total Heat Load (kW)	Fuel Assembly Maximum Heat Load (Watts)
A	17.5	840
B	13.0	840
C	13.0	674
D	9.0	500

Table B.2-6 Heat Load Matrix Used to Determine LOADING CATEGORY Limits

Maximum Total Canister Heat Load (kW)	Maximum Individual Fuel Assembly Heat Load (Watts)		
	840	674	500
≤ 17.5	A	A	A
≤ 13.0	B	C	C
≤ 9.0	B	C	D

Note: Establish LOADING CATEGORY by determining the total heat load for all of the fuel assemblies to be loaded into a CANISTER and then determining the maximum individual fuel assembly heat load for these assemblies. These values are used to look up the first column ("Maximum Total Canister Heat Load"), starting at the lowest heat load, until the loading condition is met, then across that row starting from the right, until the individual fuel assembly condition ("Maximum Individual Fuel Assembly Heat Load") is met. The intersection of the row and column specifies the LOADING CATEGORY for the CANISTER. For the preferential loading configuration, the maximum CANISTER heat load is 17.5 kW.

Table B.2-7
MPC-LACBWR Fuel Assembly Limits

I. MPC-LACBWR CANISTER

A Allowable Contents

1. Uranium oxide LACBWR UNDAMAGED FUEL ASSEMBLIES and LACBWR DAMAGED FUEL ASSEMBLIES and FUEL DEBRIS listed in Table B.2-8 without channels that meet the following specifications:

a. Cladding Type:	Stainless Steel
b. Enrichment:	As specified in Table B.2-8 for the applicable fuel assembly type
c. Decay Heat Per Assembly:	As specified in Table B.2-8 for the applicable fuel assembly type
d. Post-irradiation Cooling Time and Average Burnup per Assembly:	As specified in Table B.2-8 for the applicable fuel assembly type
e. Unirradiated Fuel Assembly Length:	Maximum = 103 inches
f. Unirradiated Fuel Assembly Width:	≤ 5.62 inches
g. Fuel Assembly Weight:	≤ 400 lbs.

B. Quantity per CANISTER:

Up to 68 fuel assemblies, of which up to 32 may be loaded in LACBWR DAMAGED FUEL CANS. The maximum contents weight limit is 28,870 pounds, including the weight of the damaged fuel cans.

C. LACBWR UNDAMAGED FUEL ASSEMBLIES shall not contain empty fuel rod positions. A solid stainless steel rod that would displace an equivalent amount of water as an intact fuel rod or a stainless steel rod containing a Zircaloy slug shall replace any missing fuel rod.

(continued)

D. LACBWR DAMAGED FUEL ASSEMBLIES and FUEL DEBRIS must be loaded in the LACBWR DAMAGED FUEL CAN.

E. LACBWR UNDAMAGED FUEL ASSEMBLIES and LACBWR DAMAGED FUEL CANS must be loaded according to the Figure B.2-3 loading pattern.

Table B.2-8

MPC-LACBWR FUEL ASSEMBLY Characteristics

Fuel Assembly Type	**Allis Chalmers**	**Exxon**
Fuel Assembly Array	10×10	10×10
Fuel Rods per Assembly	100	96
Max. Assembly Weight (lb)	400	400
Active Length (in)	83	83
Rod Pitch (in)	0.565	0.557
Rod Diameter (in)	0.396	0.394
Pellet Diameter (in)	0.350	0.343
Clad Thickness (in)	0.020	0.022
Max. MTU(5)	0.1214	0.1119
Number of Inert Rods(1,2)	0	4
Inert Rod OD (in)	N/A	0.3940
Max. Enrichment (wt % ^{235}U)	3.64/3.94(4)	3.71(3)
Heat Load (watts)	63	62
Max. Burnup (MWd/MTU)	22,000	21,000
Min. Cool Time (yrs)	28	23

Notes:

(1) Not required for fuel assemblies located in LACBWR DAMAGED FUEL CANS.
(2) Inert rods comprised of stainless steel clad tube containing zirconium alloy slug.
(3) Planar average enrichment.
(4) Two AC fuel types, Type 1 at an enrichment of 3.64 wt % ^{235}U and Type 2 at 3.94 wt % ^{235}U.
(5) LACBWR DAMAGED FUEL CANS are allowed to contain an additional 5% fissile material to account for loose pellets not necessarily associated with the as-built assembly.

General Note: All dimensions represent nominal, cold, unirradiated values.

Figure B.2-1 CY-MPC 24-Assembly Basket Fuel Loading Positions

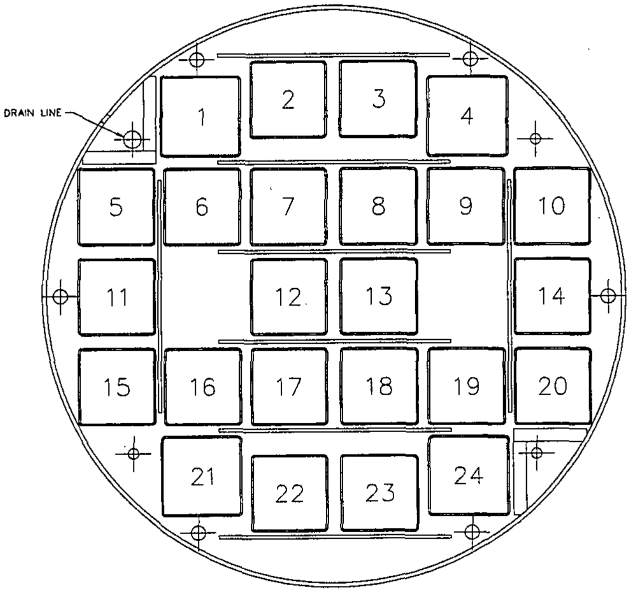


Figure B.2-2 CY-MPC 26-Assembly Basket Fuel Loading Positions

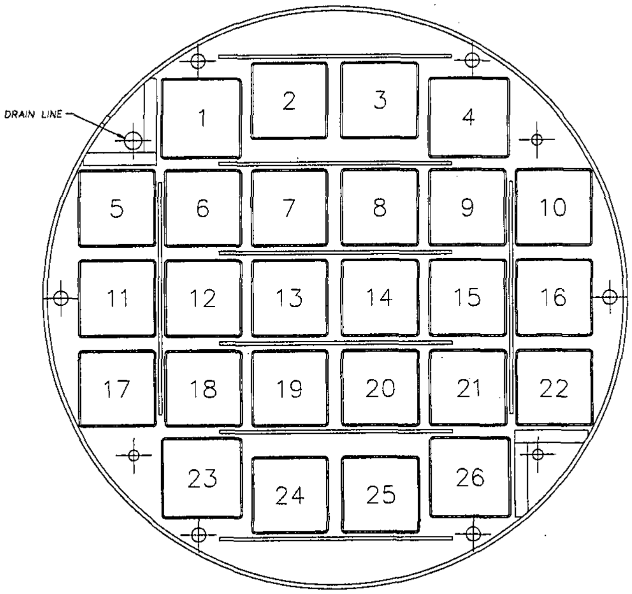
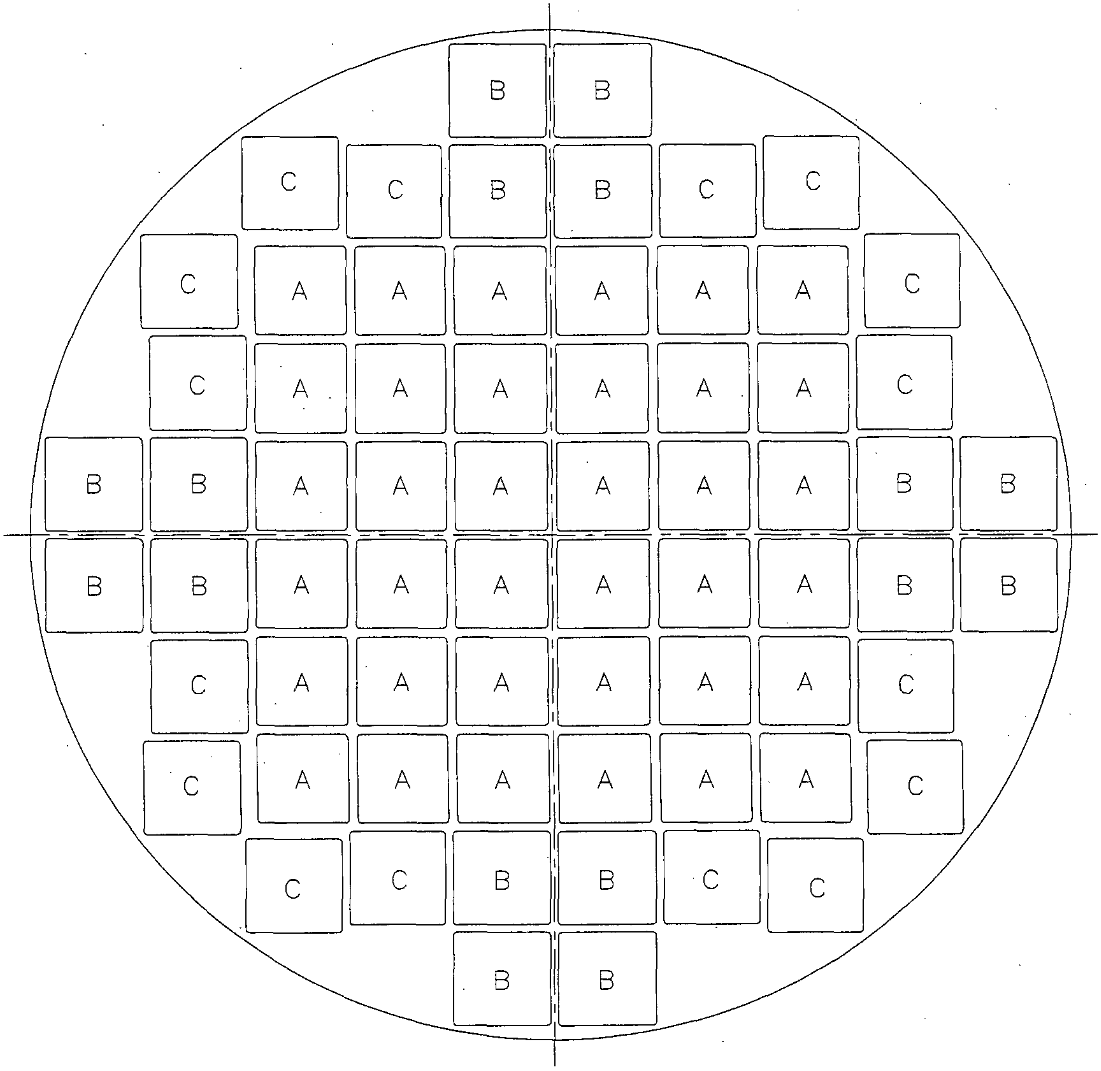


Figure B.2-3 MPC-LACBWR Loading Pattern



Slot A: Undamaged Exxon fuel maximum planar average enrichment 3.71 wt % ^{235}U.

Slot B: Undamaged or damaged Exxon fuel maximum planar average enrichment 3.71 wt % ^{235}U.

Damaged Allis Chalmers fuel maximum enrichment 3.64 wt % ^{235}U.

Slot C: Undamaged or damaged Exxon fuel maximum planar average enrichment 3.71 wt % ^{235}U.

Damaged Allis Chalmers fuel maximum enrichment 3.94 wt % ^{235}U.

B 2.2 Violations

If any Fuel Specification or Loading Conditions of this section are violated, the following actions shall be completed:

B 2.2.1 The affected fuel assemblies shall be placed in a safe condition.
B 2.2.2 Within 24 hours, notify the NRC Operations Center.
B 2.2.3 Within 60 days, submit a special report in accordance with the applicable requirements of 10 CFR 72.75 (g).

B 3.0 DESIGN FEATURES

B 3.1 Site

B 3.1.1 Site Location

The NAC-MPC SYSTEM is authorized for use by 10 CFR 50 license holders at various site locations under the general license provisions of 10 CFR Part 72, Subpart K.

B 3.2 Design Features Significant to Safety

B 3.2.1 CRITICALITY CONTROL

a) Minimum ^{10}B loading in the Boral neutron absorbers:
   1. YANKEE-MPC – 0.01 g/cm^2
   2. CY-MPC – 0.02 g/cm^2
   3. MPC-LACBWR – 0.02 g/cm^2

b) Minimum length of INTACT FUEL ASSEMBLY internal structure and bottom end fitting and/or spacers shall ensure the minimum distance to the fuel region from the base of the CANISTER is:

   1. YANKEE-MPC – 6.7 inches
   2. CY-MPC – 3.2 inches

c) For the MPC-LACBWR, minimum length of LACBWR UNDAMAGED FUEL ASSEMBLY internal structure and bottom end fitting and/or spacers shall ensure the minimum distance to the fuel region from the base of the CANISTER is 3.5 inches.

d) Minimum flux trap (support disk web) thickness is presented in Figure B.3-1 for MPC-LACBWR.

B 3.2.2 FUEL CLADDING INTEGRITY

The licensee shall ensure that fuel oxidation and the resultant consequences are precluded during canister loading and unloading operations.

B 3.3 Codes and Standards

The American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), 1995 Edition with Addenda through 1995, is the governing Code for the NAC-MPC SYSTEM CANISTER except that Addenda through 1997 are applied for the critical flaw evaluation of the CANISTER closure weld.

The American Concrete Institute Specifications ACI 349 (1985) and ACI 318 (1995) govern the NAC-MPC SYSTEM CONCRETE CASK design and construction, respectively.

(continued)

The American National Standards Institute ANSI N14.6 (1993) and NUREG-0612 govern the NAC-MPC SYSTEM TRANSFER CASK design, operation, fabrication, testing, inspection and maintenance.

B 3.3.1 Alternatives to the ASME Code

Codes and Standards

The NAC-MPC CANISTER and fuel basket structure are designed and fabricated in accordance with the ASME Code, Section III, Division 1, Subsections NB and NG, respectively. Alternatives to the applicable ASME Code requirements are listed in Table B.3-1.

Proposed alternatives to ASME Code Section III, 1995 Edition with Addenda, including alternatives allowed by Table B.3-1, may be used as authorized by the Director of the Office of Nuclear Material Safety and Safeguards or Designee. The justification in Table B.3-1 demonstrates that:

1. The proposed alternatives will provide an acceptable level of quality and safety, or
2. Compliance with the specified requirements of ASME Code, Section III, 1995 Edition with Addenda would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

Figure B.3-1 MPC-LACBWR Minimum Web Thickness (inches)

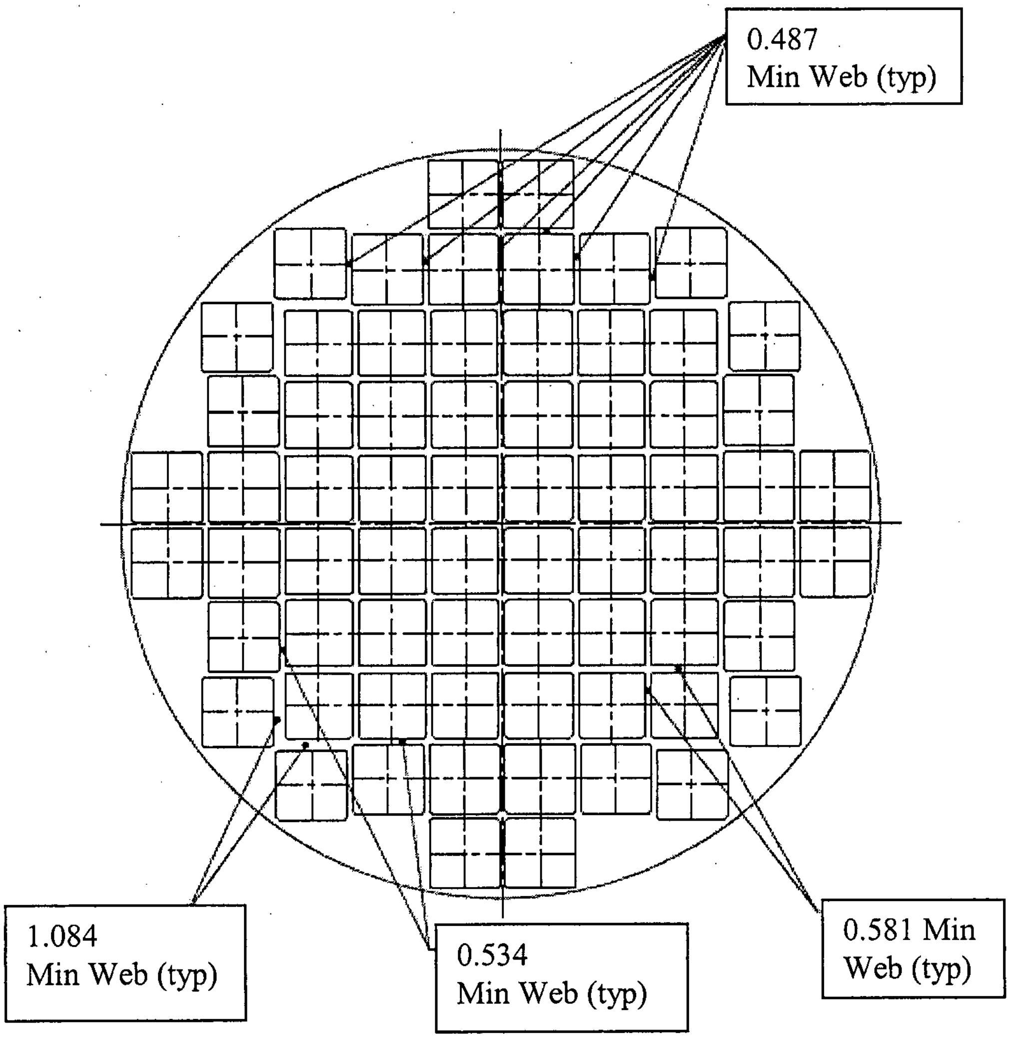


Table B.3-1 List of ASME Code Alternatives for the NAC-MPC SYSTEM

Component	**Reference ASME Code Section/Article**	**Code Requirement**	**Alternative, Justification and Compensatory Measures**
CANISTER	NB-1100	Statement of requirements for Code stamping of components.	CANISTER is designed and will be fabricated in accordance with ASME Code, Section III, Subsection NB to the maximum practical extent, but Code stamping is not required.
CANISTER	NB-2000	Requirements to be supplied by ASME-approved material supplier.	Materials are supplied by vendors approved under the NAC Quality Assurance Program. Materials are procured using ASME material specifications. CMTRs for the material are required in accordance with NB-2000.
CANISTER Shield Lid and Structural Lid Welds, or CANISTER Closure Lid Welds (MPC-LACBWR only)	NB-4243	Full penetration welds required for Category C joints (flat head to main shell per NB-3352.3).	For MPC-YR and CY-MPC, shield lid and structural lid to CANISTER shell welds are not full penetration welds. These field welds are performed independently to provide a redundant closure. Leaktightness of the CANISTER is verified by testing. For MPC-LACBWR the closure lid to CANISTER weld, CANISTER to closure ring to closure lid, and outer port cover plate to closure lid welds are not a full penetration welds. These field welds are performed independently to provide redundant confinement closure. Weld integrity is confirmed by multi-pass and surface liquid penetrant examination.
CANISTER Structural Lid Weld (CY-MPC and Yankee-MPC only)	NB-4421	Requires removal of backing ring. Requires that the backing ring be continuous.	Structural lid to CANISTER shell weld uses a backing ring that is not removed. The backing ring permits completion of the groove weld; it is not considered in any analyses; and it has no detrimental effect on the CANISTER's function.
CANISTER Vent Port Cover and Drain Port Cover to Shield Lid Welds; Shield Lid to Canister Shell Weld (Applicable to CY-MPC and YANKEE-MPC only).	NB-5230	Radiographic (RT) or ultrasonic (UT) examination required.	Root and final surface liquid penetrant examination to be performed per ASME Code Section V, Article 6, with acceptance in accordance with ASME Code, Section III, NB-5350. If the weld is completed in a single weld-pass, only a final surface liquid penetrant examination is performed.
Closure ring to CANISTER and closure ring to closure lid welds, and inner and outer port cover plate to closure lid welds (applicable to MPC-LACBWR only)	NB-5230	Radiographic (RT) or ultrasonic (UT) examination required.	Root and final surface liquid penetrant examination to be performed per ASME Code Section V, Article 6, with acceptance in accordance with ASME Code, Section III, NB-5350. If the weld is completed in a single weld-pass, only a final surface liquid penetrant examination is performed.

Table B.3-1 List of ASME Code Alternatives for the NAC-MPC SYSTEM (continued)

Component	Reference ASME Code Section/Article	Code Requirement	Alternative, Justification and Compensatory Measures
CANISTER Structural Lid to Shell Weld or CANISTER to Closure Lid Weld (MPC-LACBWR only)	NB-5230	Radiographic (RT) or ultrasonic (UT) examination required.	The CY-MPC and Yankee-MPC CANISTER structural lid to CANISTER shell closure weld is performed in the field following fuel assembly loading. The structural lid-to-shell weld will be verified by either ultrasonic (UT) or progressive liquid penetrant (PT) examination. If progressive PT examination is used, at a minimum, it must include the root and final layers and each approximately 3/8 inch of weld depth. If UT examination is used, it will be followed by a final surface PT examination. For either UT or PT examination, the maximum, undetectable flaw size is demonstrated to be smaller than the critical flaw size. The critical flaw size is determined in accordance with ASME Code, Section XI methods. The examination of the weld will be performed by qualified personnel per ASME Code Section V, Articles 5 (UT) and 6 (PT) with acceptance per ASME Code Section III, NB-5332 (UT) per 1997 Addenda, and NB-5350 for (PT). The MPC-LACBWR CANISTER Closure Lid to CANISTER shell weld is performed in the field following fuel assembly loading. The Closure Lid-to-shell weld is verified by progressive liquid penetrant (PT) examination of the root, mid-plane and final surface in accordance with the guidance of ISG-18. The critical flaw size was determined in accordance with the requirements of ISG-15. The examination of the weld will be performed by qualified personnel per ASME Code Section V, Articles 1 and 6 with acceptance per ASME Code, Section III, NB-5350.

Table B.3-1 List of ASME Code Alternatives for the NAC-MPC SYSTEM (continued)

Component	Reference ASME Code Section/Article	Code Requirement	Alternative, Justification and Compensatory Measures
CANISTER Vessel and Shield Lid, and CANISTER Vessel and Closure Lid (MPC-LACBWR only)	NB-6111	All completed pressure retaining systems shall be pressure tested.	The CY-MPC and Yankee-MPC CANISTER shield lid to shell weld is performed in the field following fuel assembly loading. The CANISTER is then pneumatically pressure tested as defined in Chapter 9 and described in Chapter 8. Accessibility for leakage inspections precludes a Code compliant hydrostatic test. The shield lid-to-shell weld is also leak tested to the leaktight criteria of ANSI N14.5. The vent port and drain port cover welds are examined by root and final PT examination. If the weld is completed in a single weld pass, only a final surface liquid penetrant examination is performed. The vent port and drain port cover welds are not pressure tested, but are tested to the leaktight criteria of ANSI N14.5. The structural lid enclosure weld is not pressure tested, but is examined by progressive PT or UT and final surface PT. The CANISTER closure lid-to-shell weld (MPC-LACBWR only) is performed in the field following fuel loading. The CANISTER is then hydrostatic pressure tested as defined in Appendix 9.A and described in Appendix 8.A. Accessibility for visual inspection of CANISTER shell welds precludes a Code compliant hydrostatic test. The closure lid to shell weld is examined by progressive PT examination (e.g., root, mid-plane and final surface). The single-pass vent and drain redundant port cover plate to closure lid welds and the closure lid and shell to closure ring welds are PT examined at the final surface.
CANISTER Vessel	NB-7000	Vessels are required to have overpressure protection.	No overpressure protection is provided. The function of the CANISTER is to confine radioactive contents under normal, off-normal, and accident conditions of storage. The CANISTER vessel is designed to withstand a maximum internal pressure considering 100% fuel rod failure and maximum accident temperatures.

Table B.3-1 List of ASME Code Alternatives for the NAC-MPC SYSTEM (continued)

Component	Reference ASME Code Section/Article	Code Requirement	Alternative, Justification and Compensatory Measures
CANISTER Vessel	NB-8000	States requirements for nameplates, stamping and reports per NCA-8000.	The NAC-MPC SYSTEM is marked and identified in accordance with 10 CFR 72 requirements. Code stamping is not required. The QA data package will be in accordance with NAC's approved QA program.
CANISTER Basket Assembly	NG-2000	Requires materials to be supplied by ASME-approved material supplier.	Materials are supplied by vendors approved under the NAC Quality Assurance Program. Materials are procured using ASME material specifications. CMTRs for the material are required in accordance with NG-2000.
CANISTER Basket Assembly	NG-8000	States requirements for nameplates, stamping and reports per NCA-8000.	The NAC-MPC SYSTEM will be marked and identified in accordance with 10 CFR 72 requirements. No Code stamping is required. The CANISTER basket data package will be in accordance with NAC's approved QA program.
CANISTER Vessel and Basket Assembly Material	NB-2130/ NG-2130	States requirements for certification of material organizations and materials to NCA-3861 and NCA-3862, respectively.	The NAC-MPC CANISTER and Basket Assembly component materials are procured in accordance with the specifications for materials in ASME Code Section II with Certified Material Test Reports. The component materials will be obtained from NAC approved Suppliers in accordance with NAC's approved QA program.

B 3.4 Site Specific Parameters and Analyses

Site-specific parameters and analyses that will require verification by the NAC-MPC SYSTEM user are, as a minimum, as follows:

1. The temperature of 75°F is the maximum average yearly temperature. The 3-day average ambient temperature shall be 100°F or less for YANKEE-MPC and CY-MPC, and 105°F or less for MPC-LACBWR.

2. The allowed temperature extremes, averaged over a 3-day period, shall be greater than –40°F and less than 125°F.

3. a) The design basis earthquake horizontal acceleration at the top surface of the ISFSI pad is 0.25g in each orthogonal direction and is (0.25g x 0.667 =) 0.167g in the vertical direction.

   b) Alternatively, the design basis earthquake motion of the ISFSI pad may be limited so that the acceleration g-load resulting from the collision of two sliding casks remains bounded by the accident condition analyses presented in Chapter 11 of the FSAR.

   Site-specific analysis by the cask user shall demonstrate that a cask does not slide off the ISFSI pad.

4. The analyzed flood condition of 15 fps water velocity and a height of 50 feet of water (full submergence of the loaded cask) are not exceeded.

5. The potential for fire and explosion shall be addressed, based on site-specific considerations. This includes the condition that the fuel tank of the cask handling equipment used to move the loaded CONCRETE CASK onto or from the ISFSI site contains no more than 50 gallons of fuel.

(continued)

B 3.4 Site Specific Parameters and Analyses (continued)

6. In addition to the requirements of 10 CFR 72.212(b)(2)(ii), the ISFSI pads and foundation shall include the following characteristics as applicable to the end drop and tip-over analyses:

Parameter	**YANKEE-MPC**	**CY-MPC**	**MPC-LACBWR**
Concrete thickness	36 inches maximum	36 inches maximum	36 inches maximum
Pad subsoil thickness	72 inches minimum	60 inches minimum	60 inches minimum
Specified concrete compressive strength	≤ 4,000 psi at 28 days	≤ 4,000 psi at 28 days	≤ 4,000 psi at 28 days
Concrete dry density (ρ)	$125 \leq \rho \leq 150$ lbs/ft^3	$135 \leq \rho \leq 150$ lbs/ft^3	$125 \leq \rho \leq 150$ lbs/ft^3
Soil in place density (ρ)	$85 \leq \rho \leq 130$ lbs/ft^3	$85 \leq \rho \leq 130$ lbs/ft^3	$110 \leq \rho \leq 120$ lbs/ft^3
Soil Stiffness	$k \leq 300$ psi/in	--	--
Soil Modulus of Elasticity	--	≤ 30,000 psi	≤ 10,000 psi

The concrete pad maximum thickness excludes the ISFSI pad footer. The compressive strength of the concrete should be determined according to the test method given in Section 5.6 of ACI 318. Steel reinforcement is used in the pad footer. The basis for acceptance of concrete shall be as described in Section 5.6 of ACI 318. The soil modulus of elasticity should be determined according to the test method described in ASTM D4719 or in ASTM D1196. The soil stiffness should be determined according to the test method described in Chapter 9 of the Civil Engineering Reference Manual, 6th Edition.

7. In cases where engineered features (i.e., berms, shield walls) are used to ensure that requirements of 10 CFR 72.104(a) are met, such features are to be considered important to safety and must be evaluated to determine the applicable Quality Assurance Category on a site specific basis.

8. TRANSFER CASK OPERATIONS shall only be conducted with surrounding air temperatures ≥ 0°F for the Yankee-MPC and CY-MPC systems. Air temperatures ≥ 32°F are required for the MPC-LACBWR system.

B 3.5 CANISTER HANDLING FACILITY (CHF)

B 3.5.1 TRANSFER CASK and CANISTER Lifting Devices

Movements of the TRANSFER CASK and CANISTER outside of the 10 CFR 50 licensed facilities, when loaded with spent fuel are not permitted unless the movements are made with a CANISTER HANDLING FACILITY designed, operated, fabricated, tested, inspected and maintained in accordance with the guidelines of NUREG-0612, "Control of Heavy Loads at Nuclear Power Plants," and the below clarifications. This Technical Specification does not apply to handling heavy loads under a 10 CFR 50 license.

B 3.5.2 CANISTER HANDLING FACILITY Structure Requirements

B 3.5.2.1 CANISTER Station and Stationary Lifting Devices

1. The weldment structure of the CANISTER HANDLING FACILITY shall be designed to comply with the stress limits of ASME Code, Section III, Subsection NF, Class 3 for linear structures. The applicable loads, load combinations, and associated service condition definitions are provided in Table B.3-2. All compression loaded members shall satisfy the buckling criteria of ASME Code, Section III, Subsection NF.
2. If a portion of the CANISTER HANDLING FACILITY structure is constructed of reinforced concrete, then the factored load combinations set forth in ACI 318 (1995) for the loads defined in Table B.3-2 shall apply.
3. The TRANSFER CASK and CANISTER lifting device used with the CANISTER HANDLING FACILITY shall be designed, fabricated, operated, tested, inspected and maintained in accordance with NUREG-0612, Section 5.1.

(continued)

B 3.5.2.2 Mobile Lifting Devices

If a mobile lifting device is used as the lifting device, in lieu of a stationary lifting device, it shall meet the guidelines of NUREG-0612, Section 5.1, with the following clarifications:

1. Mobile lifting devices shall have a minimum safety factor of two over the allowable load table for the lifting device in accordance with the guidance of NUREG-0612, Section 5.1.6(1)(a) and shall be capable of stopping and holding the load during a Design Basis Earthquake (DBE) event.
2. Mobile lifting devices shall conform to the requirements of ANSI B30.5, "Mobile and Locomotive Cranes," in lieu of the requirements of ANSI B30.2, "Overhead and Gantry Cranes."
3. Mobile cranes are not required to meet the requirements of NUREG-0612, Section 5.1.6(2) for new cranes.

Table B.3-2 Load Combinations and Service Condition Definitions for the CANISTER HANDLING FACILITY (CHF) Structure

Load Combination	ASME Section III Service Condition for Definition of Allowable Stress	Comment
D*	Level A	All primary load bearing members must satisfy Level A stress limits
D + S	Level A	
D + M + W	Level D	Factor of safety against overturning shall be ≥ 1.1
D + F	Level D	
D + E	Level D	
D + Y	Level D	

D* = Apparent dead load
D = Dead load
S = Snow and ice load for the CHF site
M = Tornado missile load of the CHF site[1]
W = Tornado wind load for the CHF site[1]
F = Flood load for the CHF site
E = Seismic load for the CHF site
Y = Tsunami load for the CHF site[1]

Note:

1. Tornado wind (W) and missile (M) loads and Tsunami (Y) load may be reduced or eliminated based on a Probability Risk Assessment for the CHF site.

APPENDIX 12.C

TECHNICAL SPECIFICATION BASES FOR THE NAC-MPC SYSTEM

Appendix 12.C
Table of Contents

C 1.0 Introduction

The design or operational condition, or regulatory requirement, which establishes the Bases for the Technical Specifications provided in Appendix A of the Certificate of Compliance for the Yankee-MPC and the CY-MPC configurations of the NAC-MPC storage system are presented in this Appendix. Different conditions or requirements may exist for the MPC-LACBWR system. Those differences are noted as appropriate and the Bases have been expanded to include the LCOs, SRs and Administrative Controls and Programs for the MPC-LACBWR storage system.

The section and paragraph numbering used in this Appendix is consistent with the numbering used in Appendix 12.A, Technical Specifications for the NAC-MPC SYSTEM, and Appendix 12.B, Approved Contents and Design Features for the NAC-MPC SYSTEM.

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C 2.0 CONTENTS

C 2.1 Fuel to be Stored in the NAC-MPC SYSTEM

BASES

BACKGROUND

The NAC-MPC SYSTEM design requires specifications for the spent fuel to be stored, such as the type of spent fuel, minimum and maximum allowable enrichment prior to irradiation, maximum burnup, minimum acceptable post-irradiation cooling time prior to storage, maximum decay heat, and condition of the spent fuel (e.g., INTACT FUEL ASSEMBLY). Other important limitations are the dimensions and weight of the fuel assemblies.

The approved contents, which can be loaded into the NAC-MPC SYSTEM for the Yankee-MPC and the CY-MPC storage systems, are specified in Appendix B of Amendment No. 5 of Certificate of Compliance No. 1025. The proposed contents, which can be loaded into the MPC-LACBWR storage system, are specified in Appendix 12.B.

Actions required to respond to violations of any Approved Contents limits are provided in Section B2.2 of Appendix B of Amendment No. 5 of Certificate of Compliance No. 1025 for the Yankee-MPC and the CY-MPC storage systems and in Section B2.2 of Appendix 12.B for the MPC-LACBWR storage system.

Specific limitations for the NAC-MPC SYSTEM are specified in Section B3.0 of Appendix B of the Certificate of Compliance for the Yankee-MPC and the CY-MPC storage systems. Specific limitations for the MPC-LACBWR storage system are specified in Section B3.0 of Appendix 12.B. These limitations support the assumptions and inputs used in the thermal, structural, shielding and criticality evaluations performed for the NAC-MPC SYSTEMs.

APPLICABLE SAFETY ANALYSES

To ensure that the shield lid or closure lid is not placed on a CANISTER containing an unauthorized fuel assembly, facility procedures require verification of the loaded fuel assemblies to ensure that the correct fuel assemblies have been loaded in the allowed locations in the canister.

APPROVED CONTENTS

C 2.1.1

Approved Contents, Section B2.0 of Appendix B of the Technical Specifications refers to Tables B2-1 through B2-6 for the specific fuel assembly characteristics for Yankee Class fuel and the Connecticut Yankee fuel authorized for loading into the NAC-MPC SYSTEM.

(continued)

APPROVED CONTENTS (continued)

Contents, Section B2.0 of Appendix 12.B, refers to Tables B.2.7 and B.2.8 for the specific fuel assembly characteristics for MPC-LACBWR fuel assemblies authorized for loading into the MPC-LACBWR storage system. These fuel assembly characteristics include parameters such as cladding material, minimum and maximum enrichment, decay heat generation, post-irradiation cooling time, burnup, and fuel assembly length, width and weight. Tables B2-2, B2-4 and B.2-8 are referenced from Tables B2-1, B2-3 and B.2-7, respectively, and provide additional specific fuel characteristic limits for the fuel assemblies based on the fuel assembly type, enrichment, burnup and cooling time, for the NAC-MPC configurations.

The fuel assembly characteristic limits of Tables B2-1 through B2-6 of the Certificate of Compliance and Tables B.2-7 and B.2-8 in Appendix 12.B must be met, as appropriate, to ensure that the thermal, structural, shielding and criticality analyses supporting the NAC-MPC SYSTEM Safety Analysis Report are bounding.

C 2.1.2

Approved Contents Section B2.0 in Appendix B requires CY-MPC preferential loading of fuel assemblies with significantly different post-irradiation cooling times. This preferential loading is required to prevent a cooler assembly from heating up due to being surrounded by hotter fuel assemblies. For the purposes of complying with this Approved Contents limit, only fuel assemblies with heat loads greater than 808 watts need to be loaded preferentially. This is based on the fact that the heat-up phenomenon can only occur with significant differences in decay heat generation characteristics between adjacent fuel assemblies.

C 2.1.3

Approved Contents Section B2.0 in Appendix 12.B requires MPC-LACBWR preferential loading of fuel assemblies with different enrichment values to assure control of criticality in LACBWR DAMAGED FUEL CAN positions.

(continued)

APPROVED CONTENT LIMITS AND VIOLATIONS

C 2.2.1

If any Approved Contents limit of B2.1.1 or B2.1.2 in Appendix B or of B2.1.3 in Appendix 12.B is violated, the limitations on fuel assemblies to be loaded are not met. Action must be taken to place the affected fuel assembly(s) in a safe condition. This safe condition may be established by returning the affected fuel assembly(s) to the spent fuel pool. However, it is acceptable for the affected fuel assemblies to temporarily remain in the NAC-MPC SYSTEM, in a wet or dry condition, if that is determined to be a safe condition.

C 2.2.2 and C 2.2.3

NRC notification of the Approved Contents limit violation is required within 24 hours. A written report on the violation must be submitted to the NRC within 30 days. This notification and written report is required by 10 CFR 72.75 and is independent of any reports and notifications that may be required by 10 CFR 72.242.

REFERENCES

1. FSAR Sections 2.1, 4.4 and 4.5, and Chapters 5 and 6.
2. Proposed MPC-LACBWR Revision 08A, Sections 2.A.1, 4.A.4 and 4.A.5 and Appendices 5.A and 6.A.

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C 3.0 LIMITING CONDITION FOR OPERATION (LCO) APPLICABILITY

BASES

LCOs

LCO 3.0.1, 3.0.2, 3.0.4, and 3.0.5, presented in Section 3.0 of Appendix A of the Certificate of Compliance and Section 3.0 in Appendix 12.A establish the general requirements applicable to all Specifications and apply at all times, unless otherwise stated.

LCO 3.0.1

LCO 3.0.1 establishes the Applicability statement within each individual Specification as the requirement for when the LCO is required to be met (i.e., when the NAC-MPC SYSTEM is in the specified conditions of the Applicability statement of each Specification).

LCO 3.0.2

LCO 3.0.2 establishes that upon discovery of a failure to meet an LCO, the associated ACTIONS shall be met. The Completion Time of each Required Action for an ACTIONS Condition is applicable from the point in time that an ACTIONS Condition is entered. The Required Actions establish those remedial measures that must be taken within the specified Completion Times when the requirements of an LCO are not met. This Specification establishes that:

a. Completion of the Required Actions within the specified Completion Times constitutes compliance with a Specification; and,

b. Completion of the Required Actions is not required when an LCO is met within the specified Completion Time, unless otherwise specified.

There are two basic Required Action types. The first Required Action type specifies a time limit, the Completion Time to restore a system or component or to restore variables to within specified limits, in which the LCO must be met. Whether stated as a Required Action or not, correction of the entered Condition is an action that may always be considered upon entering ACTIONS. The second Required Action type specifies the remedial measures that permit continued activities that are not further restricted by the Completion Time. In this case, compliance with the Required Actions provides an acceptable level of safety for continued operation.

(continued)

LCO 3.0.2 (continued)

Completing the Required Actions is not required when an LCO is met or is no longer applicable, unless otherwise stated in the individual Specifications.

The Completion Times of the Required Actions are also applicable when a system or component is removed from service intentionally. The reasons for intentionally relying on the ACTIONS include, but are not limited to, performance of Surveillance, preventive maintenance, corrective maintenance, or investigation of operational problems. Entering ACTIONS for these reasons must be done in a manner that does not compromise safety. Intentional entry into ACTIONS should not be made for operational convenience.

LCO 3.0.3

This specification is not applicable to the NAC-MPC SYSTEM because it describes conditions under which a power reactor must be shut down when an LCO is not met and an associated ACTION is not met or provided. The placeholder is retained for consistency with the power reactor technical specifications.

LCO 3.0.4

LCO 3.0.4 establishes limitations on changes in specified conditions in the Applicability when an LCO is not met. It precludes placing the facility in a specified condition stated in that Applicability (e.g., Applicability desired to be entered) when the following exist:

a. NAC-MPC SYSTEM conditions are such that the requirements of the LCO would not be met in the Applicability desired to be entered; and

b. Continued noncompliance with the LCO requirements, if the Applicability were entered, would result in NAC-MPC SYSTEM activities being required to exit the Applicability desired to be entered to comply with the Required Actions.

Compliance with Required Actions that permit continued operation for an unlimited period of time in a specified condition provides an acceptable level of safety for continued operation. This is without regard to the status of the NAC-MPC SYSTEM. Therefore, in such cases, entry into a specified condition in the Applicability may be made in accordance with the provisions of the Required Actions.

(continued)

LCO 3.0.4 (continued)

The provisions of this Specification should not be interpreted as endorsing the failure to exercise the good practice of restoring systems or components before entering an associated specified condition in the Applicability.

The provisions of LCO 3.0.4 shall not prevent changes in specified conditions in the Applicability that are required to comply with ACTIONS. In addition, the provisions of LCO 3.0.4 shall not prevent changes in specified conditions in the Applicability that are related to the unloading of the NAC-MPC SYSTEM.

Exceptions to LCO 3.0.4 are stated in the individual Specifications. Exceptions may apply to all the ACTIONS or to a specific Required Action of a Specification.

LCO 3.0.5

LCO 3.0.5 establishes the allowance for restoring equipment to service under administrative controls when it has been removed from service or determined to not meet the LCO to comply with the ACTIONS. The sole purpose of the Specification is to provide an exception to LCO 3.0.2 (e.g., to not comply with the applicable Required Action[s]) to allow the performance of testing to demonstrate:

a. The equipment being returned to service meets the LCO; or

b. Other equipment meets the applicable LCOs.

The administrative controls ensure the time the equipment is returned to service in conflict with the requirements of the ACTIONS is limited to the time absolutely necessary to perform the allowed testing. This Specification does not provide time to perform any other preventive or corrective maintenance.

C 3.0 SURVEILLANCE REQUIREMENT (SR) APPLICABILITY

BASES

Surveillance Requirements (SRs)

SR 3.0.1 through SR 3.0.4 in Section 3.0 of Appendix A of the Certificate of Compliance and Section 3.0 in Appendix 12.A establish the general requirements applicable to all Specifications and apply at all times, unless otherwise stated.

SR 3.0.1

SR 3.0.1 establishes the requirement that SRs must be met during the specified conditions in the Applicability for which the requirements of the LCO apply, unless otherwise specified in the individual SRs. This Specification is to ensure that Surveillance is performed to verify that systems and components meet the LCO and variables are within specified limits. Failure to meet Surveillance within the specified Frequency, in accordance with SR 3.0.2, constitutes a failure to meet an LCO.

Systems and components are assumed to meet the LCO when the associated SRs have been met. Nothing in this Specification, however, is to be construed as implying that systems or components meet the associated LCO when:

a. The systems or components are known to not meet the LCO, although still meeting the SRs; or,

b. The requirements of the Surveillance(s) are known to be not met between required Surveillance performances.

Surveillances do not have to be performed when the NAC-MPC SYSTEM is in a specified condition for which the requirements of the associated LCO are not applicable, unless otherwise specified.

Surveillances, including those invoked by Required Actions, do not have to be performed on equipment that has been determined to not meet the LCO because the ACTIONS define the remedial measures that apply. Surveillances have to be met and performed in accordance with SR 3.0.2, prior to returning equipment to service. Upon completion of maintenance, appropriate post maintenance testing is required. This includes ensuring applicable Surveillances are not failed and their most recent performance is in accordance with SR 3.0.2. Post-maintenance

(continued)

SR 3.0.1 (continued)

testing may not be possible in the current specified conditions in the Applicability, due to the necessary NAC-MPC SYSTEM parameters not having been established. In these situations, the equipment may be considered to meet the LCO provided testing has been satisfactorily completed to the extent possible and the equipment is not otherwise believed to be incapable of performing its function. This will allow operation to proceed to a specified condition where other necessary post maintenance tests can be completed.

SR 3.0.2

SR 3.0.2 establishes the requirements for meeting the specified Frequency for Surveillances and any Required Action with a Completion Time that requires the periodic performance of the Required Action on a "once per…" interval.

This extension facilitates Surveillance scheduling and considers facility conditions that may not be suitable for conducting the Surveillance (e.g., transient conditions or other ongoing Surveillance or maintenance activities).

The 25% extension does not significantly degrade the reliability that results from performing the Surveillance at its specified Frequency. This is based on the recognition that the most probable result of any particular Surveillance being performed is the verification of conformance with the SRs. The exceptions to SR 3.0.2 are those Surveillances for which the 25% extension of the interval specified in the Frequency does not apply. These exceptions are stated in the individual Specifications as a Note in the Frequency stating, "SR 3.0.2 is not applicable."

As stated in SR 3.0.2, the 25% extension also does not apply to the initial portion of a periodic Completion Time that requires performance on a "once per…" basis. The 25% extension applies to each performance after the initial performance. The initial performance of the Required Action, whether it is a particular Surveillance or some other remedial action, is considered a single action with a single Completion time. One reason for not allowing the 25% extension to this Completion Time is that such an action usually verifies that no loss of function has occurred by checking the status of redundant or diverse components or accomplishes the function of the affected equipment in an alternative manner.

(continued)

SR 3.0.2 (continued)

The provisions of SR 3.0.2 are not intended to be used repeatedly, merely as an operational convenience to extend Surveillance intervals or periodic Completion Time intervals beyond those specified.

SR 3.0.3

SR 3.0.3 establishes the flexibility to defer declaring affected equipment as not meeting the LCO or an affected variable outside the specified limits when a Surveillance has not been completed within the specified Frequency. A delay period of up to 24 hours or up to the limit of the specified Frequency, whichever is less, applies from the point in time that it is discovered that the Surveillance has not been performed in accordance with SR 3.0.2, and not at the time that the specified Frequency was not met.

This delay period provides adequate time to complete Surveillances that have been missed. This delay period permits the completion of a Surveillance before complying with Required Actions or other remedial measures that might preclude completion of the Surveillance.

The basis for this delay period includes: consideration of facility conditions, adequate planning, availability of personnel, the time required to perform the Surveillance, the safety significance of the delay in completing the required Surveillance, and the recognition that the most probable result of any particular Surveillance being performed is the verification of conformance with the requirements. When a Surveillance with a Frequency, based not on time intervals, but upon specified NAC-MPC SYSTEM conditions, is discovered not to have been performed when specified, SR 3.0.3 allows the full delay period of 24 hours to perform the Surveillance.

SR 3.0.3 also provides a time limit for completion of Surveillances that become applicable as a consequence of changes in the specified conditions in the Applicability imposed by the Required Actions.

Failure to comply with specified Frequencies for SRs is expected to be an infrequent occurrence. Use of the delay period established by SR 3.0.3 is a flexibility, which is not intended to be used as an operational convenience to extend Surveillance intervals.

(continued)

SR 3.0.3 (continued)

If a Surveillance is not completed within the allowed delay period, then the equipment is considered to not meet the LCO or the variable is considered outside the specified limits and the Completion Times of the Required Actions for the applicable LCO Conditions begin immediately upon expiration of the delay period. If a Surveillance is failed within the delay period, then the equipment does not meet the LCO, or the variable is outside the specified limits and the Completion Times of the Required Actions for the applicable LCO Conditions begin immediately upon the failure of the Surveillance.

Completion of the Surveillance within the delay period allowed by this Specification, or within the Completion Time of the ACTIONS, restores compliance with SR 3.0.1.

SR 3.0.4

SR 3.0.4 establishes the requirement that all applicable SRs must be met before entry into a specified condition in the Applicability.

This Specification ensures that system and component requirements and variable limits are met before entry into specified conditions in the Applicability for which these systems and components ensure safe operation of NAC-MPC SYSTEM activities.

The provisions of this Specification should not be interpreted as endorsing the failure to exercise the good practice of restoring systems or components before entering an associated specified condition in the Applicability.

However, in certain circumstances, failing to meet an SR will not result in SR 3.0.4 restricting a change in specified condition. When a system, subsystem, division, component, device, or variable is outside its specified limits, the associated SR(s) are not required to be performed per SR 3.0.1, which states that Surveillances do not have to be performed on equipment that has been determined to not meet the LCO.

(continued)

SR 3.0.4 (continued)

When equipment does not meet the LCO, SR 3.0.4 does not apply to the associated SR(s), since the requirement for the SR(s) to be performed is removed. Therefore, failing to perform the Surveillance(s) within the specified Frequency does not result in a SR 3.0.4 restriction to changing specified conditions of the Applicability. However, since the LCO is not in this situation, LCO 3.0.4 will govern any restrictions that may be (or may not) apply to specified condition changes.

The provisions of SR 3.0.4 shall not prevent changes in specified conditions in the Applicability that are required to comply with ACTIONS. In addition, the provisions of LCO 3.0.4 shall not prevent changes in specified conditions in the Applicability that are related to the unloading of the NAC-MPC SYSTEM.

The precise requirements for performance of SRs are specified such that exceptions to SR 3.0.4 are not necessary. The specific time frames and conditions necessary for meeting the SRs are specified in the Frequency, in the Surveillance, or both. This allows performance of Surveillances, when the prerequisite condition(s) specified in a Surveillance procedure require entry into the specified condition in the Applicability of the associated LCO, prior to the performance or completion of a Surveillance. A Surveillance that could not be performed until after entering LCO Applicability, would have its Frequency specified such that is not "due" until the specific conditions needed are met.

Alternately, the Surveillance may be stated in the form of a Note as not required (to be met or to be performed) until a particular event, condition, or time has been reached. Further discussion of the specific formats of SRs' annotation is found in Section 1.4, Frequency.

C 3.1 NAC-MPC SYSTEM Integrity

C 3.1.1 CANISTER Maximum Time in Vacuum Drying

BASES

BACKGROUND

A TRANSFER CASK with an empty CANISTER is placed into the spent fuel pool and loaded with fuel assemblies meeting the requirements of the Approved Contents limits. A shield lid or closure lid is then placed on the CANISTER. The TRANSFER CASK and CANISTER are raised out of the spent fuel pool. The TRANSFER CASK and CANISTER are then moved into the cask decontamination area and the CANISTER shield lid or closure lid is welded to the CANISTER shell and the lid weld is examined, pressure tested and leak tested (Yankee-MPC and CY-MPC only). For the MPC-LACBWR storage system, the closure ring is installed and welded. The water is drained from the CANISTER, and CANISTER cavity vacuum drying is performed. The CANISTER cavity is then backfilled with helium. In the MPC-LACBWR system, a helium cover gas is maintained in the CANISTER during draining. The CANISTER vent port and drain port covers are installed and welded. For the Yankee-MPC and the CY-MPC storage systems, the structural lid is installed and welded. Nondestructive examinations are performed on the welds and leak testing is performed for the inner port cover welds. The TRANSFER CASK and CANISTER are moved into position to transfer the CANISTER to the CONCRETE CASK. After the CANISTER is transferred, the CONCRETE CASK top lid is installed and the cask is then moved to the ISFSI.

Limiting the elapsed time for the Yankee-MPC and CY-MPC systems from the end of CANISTER draining operations through dryness verification testing and subsequent backfilling of the CANISTER with helium ensures that the short-term temperature limits established in the Safety Analysis Report for the spent fuel cladding and CANISTER materials are not exceeded.

For the MPC-LACBWR, the maximum time in vacuum drying is unlimited. The thermal analysis shows that for the low heat load of ≤4.5 kW, the maximum fuel cladding temperature does not exceed the temperature limits for stainless steel clad fuel in EPRI TR-106440.

(continued)

APPLICABLE SAFETY ANALYSIS

Limiting the total time for the Yankee-MPC and CY-MPC loaded CANISTER vacuum drying operations ensures that the short-term temperature limits for the fuel cladding and CANISTER materials are not exceeded. If vacuum drying operations are not completed in the required time period, per LCO 3.1.1.1.a or 3.1.1.1.b, the CANISTER is backfilled with helium and either WATER COOLING or FORCED AIR COOLING is initiated. The WATER COOLING or FORCED AIR COOLING of the loaded CANISTER is maintained for a minimum of 24 hours.

Thermal analysis for the MPC-LACBWR design with heat load limited to 4.5 kW validates system temperature limits are not exceeded with no time limits imposed.

<u>FORCED AIR COOLING</u>
The basis for FORCED AIR COOLING is the application of forced convection cooling of the CANISTER with cool air at flow rates exceeding the CONCRETE CASK natural convection cooling flow rate. Because of the small annulus between the TRANSFER CASK and CANISTER, this results in a high flow velocity. The high flow velocity results in improved heat transfer from the CANISTER compared to normal storage conditions in the CONCRETE CASK. For the Yankee-MPC the time limits for FORCED AIR COOLING are conservatively applied to the WATER COOLING condition, as the FORCED AIR COOLING evaluation bounds that for WATER COOLING.

<u>YANKEE-MPC</u>
Analyses reported in the Final Safety Analysis Report conclude that spent fuel cladding and CANISTER material short-term temperature limits will not be exceeded for total elapsed times less than 40 hours in vacuum drying and for an unlimited time with the CANISTER filled with helium in the TRANSFER CASK. Since the rate of heat-up is lower for lower total heat loads, the time required to reach component temperature limits is longer than for the design basis heat load. Consequently, longer time limits are specified for heat loads below the design basis heat load, as shown in LCO 3.1.1.1.a. The times specified in the LCO are reduced by 2 hours to allow commencement of the REQUIRED ACTIONS should the LCO time limits not be met.

(continued)

APPLICABLE SAFETY ANALYSIS (continued)

After a minimum of 24 hours of WATER COOLING or FORCED AIR COOLING operations, the spent fuel cladding temperature will be below 552°F. Analyses in the Final Safety Analysis Report show that short-term limits will not be reached for a minimum of 10 hours under vacuum drying conditions for the design basis heat load. For reduced heat loads, the time duration is longer, as shown in LCO 3.1.1.2.a.

CY-MPC

Analyses reported in the Final Safety Analysis Report conclude that spent fuel cladding and CANISTER material short-term temperature limits will not be exceeded for total elapsed time less than 21 hours in vacuum drying and for 25 days (600 hrs) with the CANISTER filled with helium in the TRANSFER CASK. Since the rate of heat-up is lower for the lower total heat loads (LOADING CATEGORIES B through D), the time required to reach component limits is longer. Consequently, longer time limits are specified for these categories as shown in LCO 3.1.1.1.b. The times specified in the LCO are reduced by 2 hours from the calculated times to allow for commencement of the REQUIRED ACTIONS should the LCO time limits not be met.

After 24 hours of WATER COOLING or FORCED AIR COOLING, the time limits for additional vacuum drying of the CY-MPC are 12 hours following WATER COOLING and 8 hours following FORCED AIR COOLING for the design basis heat load of LOADING CATEGORY A. Since the rate of heat-up is lower for the lower total heat loads (LOADING CATEGORIES B through D), the time required to reach component limits is longer than for the design basis heat load. Consequently, longer time limits are specified for these categories for the CY-MPC configuration as shown in LCO 3.1.1.2.b.

In the event of a FORCED AIR COOLING interruption(s) during LCO 3.1.1, ACTIONS, remedial action to extend the FORCED AIR COOLING time to account for the interruption in air cooling is required. The extension of FORCED AIR COOLING assures that the temperatures of the fuel cladding and critical fuel basket components evaluated in the thermal analysis for the restart of the vacuum drying are achieved. The period of additional FORCED AIR COOLING required is based on the duration of the interruption as shown in the following table.

(continued)

APPLICABLE SAFETY ANALYSIS (continued)

Duration of Interruption(s) T (hr)	Additional FORCED AIR COOLING Time (hr)
T ≤ 0.5	0
0.5 < T ≤ 1	2
1 < T ≤ 2	4
2 < T ≤ 3	6
3 < T ≤ 4	8

Note that the preceding table is established for short periods (up to 4 hours) of interruption. The "Duration of Interruption(s)" corresponds to the cumulative time of interruption events. The "Additional FORCED AIR COOLING Time" is to be added to the time remaining in the LCO action prior to the first interruption (i.e., the original 24 hours of cooling must be completed plus the additional cooling time corresponding to the duration of the interruption). Additional FORCED AIR COOLING time is not required if the duration of interruption(s) is 30 minutes or less. The additional FORCED AIR COOLING time determinations are based on the design heat load for the CY-MPC system and, consequently, all other heat loads are bounded.

For an interruption(s) with a duration greater than 4 hours, a minimum duration of 30 hours of FORCED AIR COOLING is required following the end of the last interruption event. (Note: the original 24 hours of FORCED AIR COOLING does not need to be completed.) The minimum duration of 30 hours of FORCED AIR COOLING is conservatively determined based on the required cooling time to ensure that the fuel clad and component temperatures are acceptable for the restart of the vacuum drying for the durations listed in the LCO for all heat load cases following FORCED AIR COOLING.

MPC-LACBWR
Analyses reported in the FSAR conclude that the spent fuel cladding and CANISTER material long-term temperature limits will not be exceeded for operational boundary conditions with no time limits imposed. Based on system draining with helium backfill and limited heat load at 4.5 kW, LCO time limits are not required.

LCO

Limiting the length of time for the Yankee-MPC and CY-MPC vacuum drying operations for the CANISTER ensures that the spent fuel cladding and CANISTER material temperatures remain below the short-term temperature limits in the FSAR for the NAC-MPC SYSTEM.

(continued)

APPLICABILITY

The restrictions for Yankee-MPC and CY-MPC vacuum drying operations on a loaded CANISTER apply during LOADING OPERATIONS from the completion point of CANISTER draining operations through the completion point of the CANISTER dryness verification testing and the backfilling of the CANISTER with helium for long-term STORAGE OPERATIONS. The LCO is not applicable to TRANSPORT OPERATIONS or STORAGE OPERATIONS.

ACTIONS

A note has been added to the ACTIONS, which states that, for this LCO, separate Condition entry is allowed for each NAC-MPC SYSTEM. This is acceptable, since the Required Actions for each Condition provide appropriate compensatory measures for each NAC-MPC SYSTEM not meeting the LCO. Subsequent NAC-MPC SYSTEMS that do not meet the LCO are governed by subsequent Condition entry and application of associated Required Actions.

A.1 Commence filling CANISTER with helium to a pressure of 0 (+1, -0) psig.

AND Commence WATER COOLING.

A.2.1 AND

Maintain WATER COOLING for a minimum of 24 hours.

A.2.2

OR

A.2.3 Commence FORCED AIR COOLING.

AND

A.2.4 Maintain FORCED AIR COOLING for a minimum of 24 hours.

(continued)

SURVEILLANCE REQUIREMENTS	SR 3.1.1.1 The elapsed time shall be monitored from completion of CANISTER draining through completion of the CANISTER vacuum dryness verification testing. Monitoring the elapsed time ensures that helium backfill and cooling operations can be initiated in a timely manner during LOADING OPERATIONS to prevent fuel cladding and CANISTER materials from exceeding short-term temperature limits. The times specified in the LCO are reduced by 2 hours from the calculated times to allow commencement of the REQUIRED ACTIONS should the LCO time limits not be met. SR 3.1.1.2 The elapsed time shall be monitored from the end of WATER COOLING or FORCED AIR COOLING through completion of the CANISTER vacuum dryness verification testing. Monitoring the elapsed time ensures that helium backfill and cooling operations can be initiated in a timely manner during LOADING OPERATIONS to prevent fuel cladding and CANISTER materials from exceeding short-term temperature limits. The times specified in the LCO are reduced by 2 hours from the calculated times to allow commencement of the REQUIRED ACTIONS should the LCO time limits not be met.
REFERENCES	1. FSAR Sections 4.4, 4.5, 4.A.3, 8.1 and 8.A.1.

C 3.1 NAC-MPC SYSTEM Integrity

C 3.1.2 CANISTER Vacuum Drying Pressure

BASES

BACKGROUND

A TRANSFER CASK with a CANISTER is placed into the spent fuel pool and loaded with fuel assemblies meeting the requirements of the Approved Contents limits. A shield lid or closure lid is then placed on the CANISTER. The TRANSFER CASK and CANISTER are raised out of the spent fuel pool. The TRANSFER CASK and CANISTER are then moved into the cask decontamination area. The CANISTER shield lid or closure lid is welded to the CANISTER shell and the lid weld is examined, pressure tested and leak tested (Yankee-MPC and CY-MPC only). For the MPC-LACBWR storage system, the closure ring is installed and welded. The water is drained from the CANISTER, and CANISTER cavity vacuum drying is performed. The CANISTER cavity is then backfilled with helium. In the MPC-LACBWR system, a helium cover gas is maintained in the CANISTER during draining. The CANISTER vent port and drain port covers are installed and welded. For the Yankee-MPC and the CY-MPC storage systems, the structural lid is installed and welded. Nondestructive examinations are performed on the welds and leak testing is performed for the inner port cover welds. The TRANSFER CASK and CANISTER are moved into position to transfer the CANISTER to the CONCRETE CASK. After the CANISTER is transferred, the CONCRETE CASK top lid is installed and the cask is then moved to the ISFSI.

CANISTER cavity vacuum drying is utilized to remove residual moisture from the CANISTER cavity after the water is drained from the CANISTER. Any water not drained from the CANISTER cavity evaporates due to the vacuum. This is aided by the temperature increase, due to the heat generation of the fuel.

APPLICABLE SAFETY ANALYSIS

The confinement of radioactivity (including fission product gases, fuel fines, volatiles, and crud) during the storage of design basis spent fuel in the CANISTER is ensured by the multiple confinement boundaries and systems. The barriers relied on are: the fuel pellet matrix, the metallic fuel cladding tubes where the fuel pellets are contained, and the CANISTER where the fuel assemblies are stored. Long-term integrity of the fuel cladding depends on removal of oxidizing gases and on storage in an inert atmosphere. This is accomplished by removing water from the CANISTER, evacuating the CANISTER to a pressure of ≤ 3 torr and backfilling the cavity with helium. The thermal analysis assumes that the CANISTER cavity is dry and filled with helium.

(continued)

APPLICABLE SAFETY ANALYSIS (continued)	The heat-up of the CANISTER and contents will occur during CANISTER vacuum drying, but is controlled by LCO 3.1.1. Dryness of the CANISTER (e.g., no free water) is verified by holding a vacuum of ≤ 10 torr for a period of not less than 10 minutes. The vapor pressure of water at 70°F is approximately 30 mm Hg. Selecting a maximum pressure (10 torr) that is 1/3 of the vapor pressure at 70°F ensures that all of the free water in the CANISTER is removed. The actual temperatures in the loaded CANISTER are expected to be above 70°F, which would result in a higher vapor pressure. Consequently, the maximum vacuum pressure of 10 torr is conservatively selected. Holding the vacuum pressure for 10 minutes demonstrates that there is no free water since the presence of any free water will result in a pressure exceeding 10 torr within the CANISTER. The removal of oxidizing gases that could lead to fuel cladding deterioration is assured by evacuation to ≤ 3 torr (minimum). After this vacuum condition is achieved, the CANISTER is backfilled with helium to approximately one atmosphere. After the first backfill, the CANISTER is evacuated again to a ≤ 3 torr and backfilled with helium to approximate atmospheric pressure and sealed. The removal of oxidizing gases and the establishment of an inert helium atmosphere in the CANISTER is controlled by LCO 3.1.3. These vacuum and helium backfill cycles ensure that the CANISTER contents are dry and that the atmosphere in the canister is essentially free (< one mole) of any oxidizing gases that could affect the fuel cladding, as recommended by PNL-6365.
LCO	A vacuum pressure of ≤ 10 torr indicates that liquid water has evaporated and been removed from the CANISTER cavity. Removing water from the CANISTER cavity helps to ensure the long-term maintenance of fuel cladding integrity.
APPLICABILITY	Cavity vacuum drying is performed during LOADING OPERATIONS before the TRANSFER CASK holding the CANISTER is moved to transfer the CANISTER into the CONCRETE CASK. Therefore, the vacuum requirements do not apply after the CANISTER is backfilled with helium and leak tested prior to TRANSPORT OPERATIONS and STORAGE OPERATIONS.

(continued)

ACTIONS

A note has been added to the ACTIONS, which states that, for this LCO, separate Condition entry is allowed for each CANISTER. This is acceptable, since the Required Actions for each Condition provide appropriate compensatory measures for each CANISTER not meeting the LCO. Subsequent CANISTERs that do not meet the LCO are governed by subsequent Condition entry and application of associated Required Actions.

A.1

If the CANISTER cavity vacuum drying pressure limit cannot be met, actions must be taken to meet the LCO. Failure to successfully complete cavity vacuum drying could have many causes, such as failure of the vacuum drying system, inadequate draining, ice clogging of the drain lines, or leaking CANISTER welds. The Completion Time is sufficient to determine and correct most failure mechanisms. Excessive heat-up of the CANISTER and contents is precluded by LCO 3.1.1.

B.1

If the CANISTER cannot be successfully vacuum dried, the fuel must be placed in a safe condition. Corrective actions may be taken after the fuel is placed in a safe condition to perform the A.1 action provided that the initial conditions for performing A.1 are met. A.1 may be repeated as necessary prior to performing B.1. The time frame for completing B.1 can not be extended by re-performing A.1. The Completion Time is reasonable, based on the time required to reflood the CANISTER, perform fuel cooldown operations, cut the shield lid weld, move the TRANSFER CASK into the spent fuel pool, and remove the CANISTER shield lid in an orderly manner and without challenging personnel.

Corrective action leading to system reflood and return to the spent fuel pool is not applicable to MPC-LACBWR since the system temperature limits are maintained by helium cavity gas and TRANSFER CASK boundary conditions.

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SURVEILLANCE REQUIREMENTS

SR 3.1.2.1

The long-term integrity of the stored fuel is dependent on storage in a dry, inert environment. Cavity dryness is demonstrated by evacuating the cavity to a very low absolute pressure and verifying that the pressure is held over a specified period of time. The maintenance of low vacuum pressure for the specified time indicates that the cavity is dry. The surveillance must be performed prior to TRANSPORT OPERATIONS, as the vacuum drying pressure must be achieved before the CANISTER is sealed. This allows sufficient time to backfill the CANISTER cavity with helium, while minimizing the time the fuel is in the CANISTER without water or an inert atmosphere in the cavity. In addition, the CANISTER can be maintained in a safe condition based on the use of FORCED AIR COOLING or WATER COOLING.

REFERENCES

1. FSAR Sections 4.4, 4.5, 4.A.3, 7.1, 7.A.1, 8.1 and 8.A.1 and PNL-6365.

C 3.1 NAC-MPC SYSTEM Integrity

C 3.1.3 CANISTER Helium Backfill Pressure

BASES

BACKGROUND

A TRANSFER CASK with a CANISTER is placed into the spent fuel pool and loaded with fuel assemblies meeting the requirements of the Approved Contents limits. A shield lid or closure lid is then placed on the CANISTER. The TRANSFER CASK and CANISTER are raised out of the spent fuel pool. The TRANSFER CASK and CANISTER are then moved into the cask decontamination area. The CANISTER shield lid or closure lid is welded to the CANISTER shell and the lid weld is examined, pressure tested and leak tested (Yankee-MPC and CY-MPC only). For the MPC-LACBWR storage system, the closure ring is installed and welded. The water is drained from the CANISTER, and CANISTER cavity vacuum drying is performed. The CANISTER cavity is then backfilled with helium. In the MPC-LACBWR system, a helium cover gas is maintained in the CANISTER during draining. The CANISTER vent port and drain port covers are installed and welded. For the Yankee-MPC and the CY-MPC storage systems, the structural lid is installed and welded. Nondestructive examinations are performed on the welds and leak testing is performed for the inner port cover welds. The TRANSFER CASK and CANISTER are moved into position to transfer the CANISTER to the CONCRETE CASK. After the CANISTER is transferred, the CONCRETE CASK top lid is installed and the cask is then moved to the ISFSI.

Backfilling of the CANISTER cavity with helium provides for heat transfer from the spent fuel to the CANISTER structure and the inert atmosphere protects the fuel cladding. Providing a helium pressure equal to atmospheric pressure ensures that there will be no in-leakage of air over the life of the CANISTER, which might be harmful to the heat transfer features of the NAC-MPC SYSTEM and to the stored spent fuel.

APPLICABLE SAFETY ANALYSIS

The confinement of radioactivity (including fission product gases, fuel fines, volatiles, and crud) during the storage of spent fuel in the CANISTER is ensured by the multiple confinement boundaries and systems. The barriers relied on are: the fuel pellet matrix, the metallic fuel cladding tubes where the fuel pellets are contained, and the CANISTER where the fuel assemblies are stored. Long-term integrity of the fuel and cladding depends on the ability of the NAC-MPC SYSTEM to remove heat from the CANISTER and reject it to the environment. This is

(continued)

APPLICABLE SAFETY ANALYSIS (continued)	accomplished by removing water from the CANISTER cavity and backfilling the cavity with an inert gas. Removal of free water from the CANISTER is verified by LCO 3.1.2. The removal of oxidizing gases that could lead to fuel cladding deterioration is by evacuation of the CANISTER to a pressure of ≤3 torr. After this vacuum condition is achieved, the CANISTER is backfilled with helium to one atmosphere. After the backfill, the CANISTER is evacuated again to ≤3 torr and the CANISTER is then backfilled with helium to approximately one atmosphere (0 [+1, -0] psig) and sealed. These vacuum cycles ensure that the canister contents are dry and that the atmosphere in the canister is essentially free (< one mole) of any oxidizing gases, as recommended by PNL-6365. The duration that the CANISTER and contents may remain in the TRANSFER CASK following backfilling with helium is controlled by LCO 3.1.4. The thermal analyses of the CANISTER assume that the CANISTER cavity is dry and filled with dry helium.
LCO	Backfilling the CANISTER cavity with helium at a pressure equal to atmospheric pressure ensures that there is no air in-leakage into the CANISTER, which could decrease the heat transfer properties and result in increased cladding temperatures and damage to the fuel cladding over the storage period. The helium backfill pressure of one atmosphere (0 [+2, -0] psig) was selected based on a minimum helium purity of 99.9% for the Yankee-MPC and the CY-MPC systems and 99.995% for the MPC-LACBWR system to ensure that the CANISTER internal pressure and heat transfer from the CANISTER to the environment are maintained consistent with the design and analysis basis of the CANISTER.
APPLICABILITY	Helium backfill is performed during LOADING OPERATIONS, before the TRANSFER CASK and CANISTER are moved to the CONCRETE CASK for transfer of the CANISTER.

(continued)

ACTIONS

A note has been added to the ACTIONS, which states that, for this LCO, separate Condition entry is allowed for each CANISTER. This is acceptable, since the Required Actions for each Condition provide appropriate compensatory measures for each CANISTER not meeting the LCO. Subsequent CANISTERs that do not meet the LCO are governed by subsequent condition entry and application of associated Required Actions.

A.1

If the backfill pressure cannot be established within limits, actions must be taken to meet the LCO. The Completion Time is sufficient to determine and correct most failures, which would prevent backfilling of the CANISTER cavity with helium. These actions include identification and repair of helium leak paths or replacement of the helium backfill equipment.

B.1

If the CANISTER cavity cannot be backfilled with helium to the specified pressure, the fuel must be placed in a safe condition. Corrective actions may be taken after the fuel is placed in a safe condition to perform the A.1 action provided that the initial conditions for performing A.1 are met. A.1 may be repeated as necessary prior to performing B.1. The time frame for completing B.1 can not be extended by reperforming A.1. The Completion Time is reasonable based on the time required to re-flood the CANISTER, perform cooldown operations, cut the CANISTER shield lid weld, move the TRANSFER CASK and CANISTER into the spent fuel pool, remove the CANISTER shield lid, and remove the spent fuel assemblies in an orderly manner and without challenging personnel.

SURVEILLANCE REQUIREMENTS

SR 3.1.3.1

The long-term integrity of the stored fuel is dependent on storage in a dry, inert atmosphere and maintenance of adequate heat transfer mechanisms. Filling the CANISTER cavity with helium at a pressure of one atmosphere will ensure that there will be no air in-leakage, which could potentially damage the fuel. This pressure of helium gas is sufficient to maintain fuel cladding temperatures within acceptable levels.

(continued)

SURVEILLANCE REQUIREMENTS (continued)	Backfilling of the CANISTER cavity with helium must be performed successfully on each CANISTER before placing it in storage. The surveillance must be performed prior to TRANSPORT OPERATIONS, as the helium atmosphere must be established before the CANISTER can be moved to storage.
REFERENCES	1. FSAR Sections 4.5, 4.A.3, 7.1, 7.A.1, 8.1 and 8.A.1.

C 3.1 NAC-MPC SYSTEM Integrity

C 3.1.4 CANISTER Maximum Time in the TRANSFER CASK

BASES

BACKGROUND

During LOADING OPERATIONS, a TRANSFER CASK with a CANISTER is placed into the spent fuel pool and loaded with fuel assemblies meeting the requirements of the Approved Contents limits. A shield lid or closure lid is then placed on the CANISTER. The TRANSFER CASK and CANISTER are raised out of the spent fuel pool. The TRANSFER CASK and CANISTER are then moved into the cask decontamination area. The CANISTER shield lid or closure lid is welded to the CANISTER shell and the lid weld is examined, pressure tested and leak tested (Yankee-MPC and CY-MPC only). For the MPC-LACBWR storage system, the closure ring is installed and welded. The water is drained from the CANISTER, and CANISTER cavity vacuum drying is performed. The CANISTER cavity is then backfilled with helium. In the MPC-LACBWR system, a helium cover gas is maintained in the CANISTER during draining. The CANISTER vent port and drain port covers are installed and welded. For the Yankee-MPC and the CY-MPC storage systems, the structural lid is installed and welded. Nondestructive examinations are performed on the welds and leak testing is performed for the inner port cover welds. The TRANSFER CASK and CANISTER are moved into position to transfer the CANISTER to the CONCRETE CASK. After the CANISTER is transferred, the CONCRETE CASK top lid is installed and the cask is then moved to the ISFSI.

During TRANSFER OPERATIONS, a loaded CANISTER is transferred from one CONCRETE CASK to another CONCRETE CASK (or a TRANSPORT CASK) using the TRANSFER CASK. The TRANSFER CASK is placed on the CONCRETE CASK, the bottom doors are opened, the loaded CANISTER is lifted into the TRANSFER CASK cavity, the bottom shield doors are closed and the CANISTER is lowered until it rests on the bottom doors. Subsequently, the loaded TRANSFER CASK is placed on another CONCRETE CASK (or TRANSPORT CASK) and the procedure is reversed, lowering the loaded CANISTER into another CONCRETE CASK (or TRANSPORT CASK).

During UNLOADING OPERATIONS, a loaded CANISTER is removed from a CONCRETE CASK (or TRANSPORT CASK) using the same procedure used during TRANSFER OPERATONS. After removal from the CONCRETE CASK, the loaded CANISTER is moved to a cask handling area, unsealed, cooled and unloaded.

(continued)

BACKGROUND (continued)

Backfilling the CANISTER cavity with helium provides sufficient heat transfer from the fuel and ensures that the short-term temperature limits for the fuel cladding and CANIISTER components are not exceeded. The LCO limits the total time a CANISTER can be maintained in the TRANSFER CASK to 25 days (600 hrs).

APPLICABLE SAFETY ANALYSIS

Limiting the total time that a loaded CANISTER backfilled with helium may be in the TRANSFER CASK, prior to placement in a CONCRETE CASK, TRANSPORT CASK, or returned for UNLOADING OPERATIONS, precludes the inappropriate use of the TRANSFER CASK as a storage component. The thermal analyses in the Final Safety Analysis Report show that the short-term temperature limits for the spent fuel cladding are not exceeded for an unlimited period of time (steady state analysis). The duration of 25 days (600 hrs) is defined based on a test time of 30 days for abnormal regimes as described in PNL-4835.

LCO

Limiting the length of time that the loaded CANISTER backfilled with helium is allowed to remain in the TRANSFER CASK ensures that the TRANSFER CASK is not inappropriately used as a storage component.

APPLICABILITY

The elapsed time restrictions on a loaded CANISTER in the TRANSFER CASK apply during: LOADING OPERATIONS (beginning with backfilling of the CANISTER with helium per LCO 3.1.3); TRANSFER OPERATIONS (beginning with closure of the bottom doors of the TRANSFER CASK containing a loaded CANISTER); and UNLOADING OPERATIONS (beginning with closure of the bottom doors of the TRANSFER CASK containing a loaded CANISTER).

(continued)

ACTIONS

A note has been added to the ACTIONS, which states that, for this LCO, separate Condition entry is allowed for each NAC-MPC SYSTEM. This is acceptable, since the Required Actions for each Condition provide appropriate compensatory measures for each NAC-MPC SYSTEM not meeting the LCO. Subsequent NAC-MPC SYSTEMS that do not meet the LCO are governed by subsequent Condition entry and application of associated Required Actions.

The CANISTER is backfilled with helium to 0 (+2, -0) psig in accordance with the conditions and requirements of LCO 3.1.3. The ACTIONS and SURVEILLANCES of LCO 3.1.3 apply until the helium backfill activity is complete.

A.1 Complete CANISTER transfer.

B.1 Remove all fuel assemblies from the CANISTER.

SURVEILLANCE REQUIREMENTS

SR 3.1.4.1

Verify CANISTER transfer complete.

REFERENCES

1. FSAR Sections 4.4, 4.5, 4.A.3, 8.1, 8.2, 8.3, 8.A.1, 8.A.2 and 8.A.3.

C 3.1 NAC-MPC SYSTEM Integrity

C 3.1.5 CANISTER Helium Leak Rate

BASES

BACKGROUND

A TRANSFER CASK with a CANISTER is placed into the spent fuel pool and loaded with fuel assemblies meeting the requirements of the Approved Contents limits. A shield lid or closure lid is then placed on the CANISTER. The TRANSFER CASK and CANISTER are raised out of the spent fuel pool. The TRANSFER CASK and CANISTER are then moved into the cask decontamination area. The CANISTER shield lid or closure lid is welded to the CANISTER shell and the lid weld is examined, pressure tested and leak tested (Yankee-MPC and CY-MPC only). For the MPC-LACBWR storage system, the closure ring is installed and welded. The water is drained from the CANISTER, and CANISTER cavity vacuum drying is performed. The CANISTER cavity is then backfilled with helium. In the MPC-LACBWR system, a helium cover gas is maintained in the CANISTER during draining. The CANISTER vent port and drain port covers are installed and welded. For the Yankee-MPC and the CY-MPC storage systems, the structural lid is installed and welded. Nondestructive examinations are performed on the welds and leak testing is performed for the inner port cover welds. The TRANSFER CASK and CANISTER are moved into position to transfer the CANISTER to the CONCRETE CASK. After the CANISTER is transferred, the CONCRETE CASK top lid is installed and the cask is then moved to the ISFSI.

Backfilling the CANISTER cavity with helium promotes heat transfer from the fuel to the CANISTER shell. The inert atmosphere protects the fuel cladding. Prior to transferring the CANISTER to the CONCRETE CASK, the CANISTER shield lid closure welds and port cover weld are helium leakage rate tested to verify the closure meets leaktight requirements. Successful test performance ensures that the fuel and helium backfill gas are confined during STORAGE OPERATIONS.

(continued)

APPLICABLE SAFETY ANALYSIS

The confinement of radioactivity (including fission product gases, fuel fines, volatiles, and crud) during the storage of spent fuel in the CANISTER is ensured by the multiple confinement boundaries and systems. The barriers relied on are: the fuel pellet matrix, the metallic fuel cladding tubes where the fuel pellets are contained, and the CANISTER where the fuel assemblies are stored. Long-term integrity of the fuel and cladding depends on maintaining an inert atmosphere, and maintaining the cladding temperatures below established long-term limits. This is accomplished by removing water from the CANISTER, backfilling the CANISTER cavity with helium, leakage rate testing the CANISTER shield lid closure welds for the Yankee-MPC system, and leakage rate testing of the inner port cover of all NAC-MPC systems.

Verification of the leaktight condition is achieved for the CY-MPC and MPC-LACBWR systems based on demonstrating a helium leak rate less than 2×10^{-7} cm^3/sec (helium) using a leak test sensitivity of 1×10^{-7} cm^3/sec (helium). Verification of the leaktight condition is achieved for the Yankee-MPC system based on demonstrating a helium leak rate less than 8×10^{-8} cm^3/sec (helium) using a leak test sensitivity of 4×10^{-8} cm^3/sec (helium). Both test conditions result in a leaktight configuration of the CANISTER.

LCO

Verifying that the CANISTER cavity helium leak rate is below the leaktight limit ensures that the CANISTER shield lid is sealed. Verifying that the helium leak rate is below leaktight levels will also ensure that the assumptions in the accident analyses and radiological evaluations are maintained.

APPLICABILITY

The helium leakage rate test is performed during LOADING OPERATIONS before the TRANSFER CASK and integral CANISTER are moved for transfer operations to the CONCRETE CASK. TRANSPORT OPERATIONS would not commence if the CANISTER helium leak rate was not below the test sensitivity. Therefore, CANISTER leak rate testing is not required during TRANSPORT OPERATIONS or STORAGE OPERATIONS.

ACTIONS

A note has been added to the ACTIONS, which states that, for this LCO, separate Condition entry is allowed for each CANISTER. This is acceptable, since the Required Actions for each Condition provide appropriate compensatory measures for each CANISTER not meeting the LCO. Subsequent CANISTERs that do not meet the LCO are governed by subsequent Condition entry and application of associated Required Actions.

(continued)

ACTIONS

A.1

If the helium leak rate limit is not met, actions must be taken to meet the LCO. The Completion Time is sufficient to determine and correct most failures, which could cause a helium leak rate in excess of the limit. Actions to correct a failure to meet the helium leak rate limit would include, in ascending order of performance, 1) verification of helium leak test system performance; 2) inspection of weld surfaces to locate helium leakage paths using a helium sniffer probe; and 3) weld repairs, as required, to eliminate the helium leakage. Following corrective actions, the helium leakage rate test shall be reperformed.

B.1

If the CANISTER leak rate cannot be brought within the limit, the fuel must be placed in a safe condition. Corrective actions may be taken after the fuel is placed in a safe condition to perform the A.1 action provided that the initial conditions for performing A.1 are met. A.1 may be repeated as necessary prior to performing B.1. The time frame for completing B.1 cannot be extended by re-performing A.1. The Completion Time is reasonable based on the time required to re-flood the CANISTER, perform fuel cooldown operations, cut the CANISTER shield lid weld, move the TRANSFER CASK into the spent fuel pool, remove the CANISTER shield lid, and remove the spent fuel assemblies in an orderly manner and without challenging personnel.

SURVEILLANCE REQUIREMENTS

SR 3.1.5.1

The primary design consideration of the CANISTER is that it is leaktight to ensure that off-site dose limits are not exceeded and to ensure that the helium remains in the CANISTER during long-term storage. Long-term integrity of the stored fuel is dependent on storage in a dry, inert environment.

Verifying that the helium leakage rate meets leaktight requirements must be performed successfully on each CANISTER during LOADING OPERATIONS and prior to TRANSPORT OPERATIONS. The Surveillance Frequency allows sufficient time to backfill the CANISTER cavity with helium and perform the leakage rate test, while minimizing the time the fuel is in the CANISTER and loaded in the TRANSFER CASK.

REFERENCES

1. FSAR Sections 7.1, 7.A.1, 8.1 and 8.A.1.

C 3.1 NAC-MPC SYSTEM Integrity

C 3.1.6 CONCRETE CASK Heat Removal System

BASES

BACKGROUND	The CONCRETE CASK Heat Removal System is a passive, air-cooled convective heat transfer system, which ensures that heat from the CANISTER is transferred to the environment by the upward flow of air through the CONCRETE CASK. Relatively cool air is drawn into the annulus between the CONCRETE CASK and the CANISTER through the four air inlets at the bottom of the CONCRETE CASK. The CANISTER transfers its heat from the CANISTER surface to the air via natural convection. The buoyancy created by the heating of the air creates a chimney effect and the air flows back into the environment through the four air outlets at the top of the CONCRETE CASK.
APPLICABLE SAFETY ANALYSIS	The thermal analyses of the CONCRETE CASK take credit for the decay heat from the spent fuel assemblies being ultimately transferred to the ambient environment surrounding the CONCRETE CASK. Transfer of heat away from the fuel assemblies ensures that the fuel cladding and CANISTER component temperatures do not exceed applicable limits. Under normal storage conditions, the four air inlets and four air outlets are unobstructed and full air flow (i.e., maximum heat transfer for the given ambient temperature) occurs. Analyses have been performed for the complete obstruction of all of the air inlets and outlets. The complete blockage of all air inlets and outlets stops air cooling of the CANISTER. The CANISTER will continue to radiate heat to the relatively cooler inner shell of the CONCRETE CASK. With the loss of air cooling, the CANISTER component temperatures will increase toward their respective short-term temperature limits. The limiting component is the CANISTER basket support and heat transfer disks, which, by analysis, approach their temperature limits in 24 hours for Yankee-MPC and CY-MPC systems, if no action is taken to restore air flow to the heat removal system. The MPC-LACBWR analysis for all inlets and outlets blocked shows system temperatures remain below long-term limits for the 4.5 kW total heat load. Thermal performance of the MPC-LACBWR system is provided by radiation between the CANISTER and CONCRETE CASK, and air cooling convection heat transfer is not required to maintain system safety limits.

(continued)

LCO	The CONCRETE CASK Heat Removal System must be verified to be OPERABLE for Yankee-MPC and CY-MPC Systems to preserve the assumptions of the thermal analyses. Operability of the heat removal system ensures that the decay heat generated by the stored fuel assemblies is transferred to the environment at a sufficient rate to maintain fuel cladding and CANISTER component temperatures within design limits for the Yankee-MPC and CY-MPC systems.
APPLICABILITY	The LCO is applicable during STORAGE OPERATIONS. Once a CONCRETE CASK containing a CANISTER loaded with spent fuel has been placed in storage, the heat removal system must be OPERABLE to ensure adequate heat transfer of the decay heat away from the fuel assemblies for the Yankee-MPC and CY-MPC systems.
ACTIONS	A note has been added to ACTIONS that states for this LCO, separate Condition entry is allowed for each CONCRETE CASK. This is acceptable since the Required Actions for each Condition provide appropriate compensatory measures for each CONCRETE CASK not meeting the LCO. Subsequent CONCRETE CASKs that do not meet the LCO are governed by subsequent Condition entry and application of associated Required Actions. <u>A.1</u> If the CONCRETE CASK heat removal system has been determined to be not OPERABLE, it must be restored to OPERABLE status within 8 hours. Eight hours is reasonable based on the accident analysis that shows that the limiting CONCRETE CASK component temperatures will not reach their temperature limits for 24 hours after a complete blockage of all inlets and outlets. This time frame allows for the 4-hour Response Surveillance required following an off-normal, accident or natural phenomena event established in Section A 5.3 of the Technical Specifications, plus 8 hours (typically, one operating shift) to take action to remove the obstructions in the air flow path. <u>B.1</u> Until the completion of Required Action A.1, performance of SR 3.1.6.1 shall be performed on an increased Completion Time Frequency of 6 hours to document the OPERABLE status of the CONCRETE CASK heat removal system. <u>AND</u>

(continued)

ACTIONS
(continued)

B.2.1

If Required Action A.1 cannot be met, an engineering evaluation is performed to verify that the CONCRETE CASK heat removal system is OPERABLE. The Completion Time for this Required Action of 12 hours will ensure that the CANISTER remains in a safe, analyzed condition.

OR

B.2.2

Place the affected NAC-MPC SYSTEM in a safe condition. The Completion Time for this Required Action of 12 hours will ensure that the NAC-MPC SYSTEM is maintained in a safe condition.

SURVEILLANCE
REQUIREMENTS

SR 3.1.6.1

The long-term integrity of the stored fuel is dependent on the ability of the CONCRETE CASK to reject heat from the CANISTER to the environment. Visual observation that all four air inlet and outlet screens are unobstructed and intact ensures that air flow past the CANISTER is occurring and heat transfer is taking place. Complete blockage of two or more air inlet or outlet screens renders the heat removal system not OPERABLE and this LCO is not met. Partial blockage of one or more air inlet or outlet screens does not result in the heat removal system being not OPERABLE. However, corrective actions should be taken promptly to remove the obstruction and restore full flow through the affected air inlet and outlet screens. Alternatively, based on the thermal analyses, if the air temperature rise is less than the limits stated in the SR, adequate air flow and, therefore, adequate heat transfer is occurring to provide assurance of long-term fuel cladding integrity. The reference ambient temperature used to perform this Surveillance shall be measured at the ISFSI facility.

The Frequency of 24 hours is reasonable based on the time necessary for CONCRETE CASK and CANISTER components to heat up to unacceptable temperatures assuming design basis heat loads, and allowing for corrective actions to take place upon discovery of the blockage of the air inlet and outlet screens.

(continued)

REFERENCES	1. FSAR Chapter 4, Appendix 4.A and Chapter 11, Section 11.1.1, Section 11.2.8 and Appendix 11.A.

C 3.1 NAC-MPC SYSTEM Integrity

C 3.1.7 Fuel Cooldown Requirements

BASES

BACKGROUND

In the event that a CANISTER must be unloaded, the CONCRETE CASK with its enclosed CANISTER is returned to the fuel building or similar facility, the CANISTER is removed from the CONCRETE CASK using the TRANSFER CASK, and the TRANSFER CASK and CANISTER are placed in the cask preparation area to begin the process of fuel unloading. The Yankee-MPC and the CY-MPC structural lids and vent and drain port cover welds on all NAC-MPC systems are removed. The CANISTER cavity gas is sampled to determine the level of radioactive gases in the cavity. A flow of nitrogen gas is established to flush radioactive gases from the cavity. A cooldown system is attached to the drain connection (inlet) and vent connection (outlet). A controlled water flow rate with a specified minimum water temperature is established to the drain connection with the steam and water being discharged from the vent to the spent fuel pool or radioactive water treatment system. Cooling water flow is maintained until the CANISTER is filled and the contents sufficiently cooled down to allow placement of the TRANSFER CASK and CANISTER in the spent fuel pool, or similar water filled space.

Following cooldown, the Yankee-MPC and the CY-MPC shield lid welds and the MPC-LACBWR closure ring and closure lid welds are removed and the TRANSFER CASK and CANISTER are placed in the fuel pool. The shield lid or closure lid is removed and the fuel assemblies are removed and placed in storage rack locations. The TRANSFER CASK and CANISTER are removed from the spent fuel pool and decontaminated.

During the time that the CANISTER is in the TRANSFER CASK prior to the start of internal cooldown of the CANISTER cavity, the CANISTER begins to heat up due to the decay heat of the contents and the reduced heat transfer provided by the TRANSFER CASK compared to the CONCRETE CASK. Note that the conditions of LCO 3.1.4 also apply.

(continued)

APPLICABLE SAFETY ANALYSIS	The use of a controlled cooldown process allows the reflooding of the CANISTER and cooling of the stored fuel assemblies in a manner which precludes the creation of excessive thermal stresses in the fuel cladding, which could result in cladding rupture and steam pressures in the cavity that could exceed the CANISTER's design pressure.
LCO	Controlling the inlet water flow rate and temperature ensures that there is no excessive thermally induced stress in the fuel cladding leading to failure, and that the steam pressure will be maintained below analyzed design values. The exit water temperature is monitored to ensure that the CANISTER contents are sufficiently cooled down to allow return of the CANISTER to the spent fuel pool for fuel assembly unloading.
APPLICABILITY	The elapsed time restrictions on the sealed, loaded CANISTER in the TRANSFER CASK apply during UNLOADING OPERATIONS from the completion point of the closing of the TRANSFER CASK shield doors through the initiation of internal cooling of the CANISTER per LCO 3.1.4. The inlet water flow rate and temperature and water/steam outlet temperatures are controlled and measured during UNLOADING OPERATIONS after the CANISTER has been transferred to the TRANSFER CASK from the CONCRETE CASK. Therefore, the CANISTER fuel cooldown LCO does not apply during TRANSPORT OPERATIONS and STORAGE OPERATIONS. A note has been added to the Applicability for LCO 3.1.7, which states that the APPLICABILITY is only applicable to wet UNLOADING OPERATIONS. This is acceptable, since the intent of the LCO is to avoid uncontrolled CANISTER pressurization due to steam creation during CANISTER reflooding, which is not a concern for dry UNLOADING OPERATIONS.

(continued)

ACTIONS

A note has been added to the ACTIONS that states that separate Condition entry is allowed for each NAC-MPC SYSTEM. Separate condition entry is acceptable, since the Required Actions for each Condition provide appropriate compensatory measures for each CANISTER not meeting the LCO. Subsequent CANISTERs that do not meet the LCO are governed by subsequent Condition entry and application of associated Required Actions.

A.1

If the inlet water flow rate and minimum temperature requirements are not met, actions must be taken to restore the parameters to within the limits. If any of the required cooldown parameters are not met (e.g., minimum water temperature, flow rate, or maximum pressure), appropriate actions, including changing of water supply source, and repositioning of inlet and outlet flow valves on the cooldown system, shall be taken to restore the cooldown parameters to be within the limits. The Completion Time for verification of water temperature and flow rate is short to ensure actions are taken to correct the LCO before fuel cladding damage or overpressurization of the CANISTER has occurred. No additional actions are appropriate, since this LCO applies during UNLOADING OPERATIONS, which cannot proceed until the LCO is met.

SURVEILLANCE REQUIREMENTS

SR 3.1.7.1

These SURVEILLANCE REQUIREMENTS apply to Condition A.1. This SR ensures that short-term temperature limits of the spent fuel cladding and CANISTER components are not exceeded by limiting sudden changes in temperature in the CANISTER and fuel components and by limiting the pressure excursion within the CANISTER that may occur due to the formation of steam.

(continued)

SURVEILLANCE REQUIREMENTS (continued)

The time duration for the flow of nitrogen is specified as a minimum of 10 minutes, but longer flow is allowed since it provides for heat removal and is not reactive with the spent fuel or CANISTER components.

Cooling water temperature is determined prior to the start of flow. Flow rate is determined soon after water flow starts to limit the thermal shock and pressure excursion that could occur as a result of higher than evaluated water flow.

CANISTER pressure is monitored continuously until water flows out of the CANISTER to ensure that the evaluated conditions of pressure are not exceeded.

Water discharge temperature is monitored to determine when adequate cooling of the spent fuel has been achieved so that opening of the CANISTER for fuel removal can continue.

REFERENCES

1. FSAR Sections 4.4, 4.5, 4.A.3, 8.2, 8.3, 8.A.2 and 8.A.3 and Chapter 3.

C 3.1 NAC-MPC SYSTEM Integrity

C 3.1.8 CANISTER Removal from the CONCRETE CASK

BASES

[Deleted]

C 3.2 NAC-MPC SYSTEM Radiation Protection

C 3.2.1 CANISTER Surface Contamination

BASES

BACKGROUND	A TRANSFER CASK containing a CANISTER is immersed in the spent fuel pool in order to load the spent fuel assemblies. The external surfaces of the CANISTER are maintained clean by the application of clean water to the annulus of the TRANSFER CASK. However, there is potential for the surface of the CANISTER to become contaminated with the radioactive material in the spent fuel pool water. This contamination is reduced to acceptable levels on exterior surfaces of the CANISTER prior to moving the CONCRETE CASK containing the CANISTER to the ISFSI in order to minimize the radioactive contamination to personnel or the environment. This allows the ISFSI to be entered without additional radiological controls to prevent the spread of contamination and reduces personnel dose due to the spread of loose contamination or airborne contamination. This is consistent with ALARA practices.
APPLICABLE SAFETY ANALYSIS	The radiation protection measures implemented at the ISFSI are based on the assumption that the exterior surfaces of the CANISTER are within acceptable contamination levels on accessible surfaces. Failure to decontaminate the surfaces of the CANISTER could lead to higher-than-projected occupational dose and potential site contamination.
LCO	Removable surface contamination on exterior surfaces of the CANISTER is limited to 10,000 dpm/100 cm^2 from beta and gamma sources and 100 dpm/100 cm^2 from alpha sources. These limits are one-half of the values shown in Section 11.1.5 (Section 11.A.1.5 for MPC-LABWR) to produce a minimum site boundary dose of less than 1 mrem annually. Only removable contamination is controlled, as fixed contamination will not result from the CANISTER loading process. Experience has shown that these limits are low enough to prevent the spread of contamination to clean areas and are significantly less than the levels, which would cause significant personnel skin dose.

(continued)

LCO (continued)

LCO 3.2.1 requires removable contamination to be within the specified limits for the exterior surfaces of the CANISTER. The location and number of CANISTER surface swipes used to determine compliance with this LCO are determined based on standard industry practice and the user's plant-specific contamination measurement program for objects of this size. The objective is to determine a removable contamination value representative of the entire upper circumference of the CANISTER and the structural or closure lid, while implementing sound ALARA practices.

APPLICABILITY

Verification that the exterior surface contamination of the CANISTER is less than the LCO limits is performed during LOADING OPERATIONS. This occurs before TRANSPORT OPERATIONS and STORAGE OPERATIONS. Measurement of the CANISTER surface contamination is unnecessary during UNLOADING OPERATIONS as surface contamination would have been measured prior to moving the subject CANISTER to the ISFSI.

ACTIONS

A note has been added to the ACTIONS, which states that, for this LCO, separate Condition entry is allowed for each CANISTER LOADING OPERATION. This is acceptable, since the Required Actions for each Condition provide appropriate compensatory measures for each CANISTER not meeting the LCO. Subsequent CANISTERs that do not meet the LCO are governed by subsequent Condition entry and application of associated Required Actions.

A.1

If the removable surface contamination of the CANISTER that has been loaded with spent fuel is not within the LCO limits, action must be initiated to decontaminate the CANISTER and bring the removable surface contamination to within limits. The Completion Time of 25 days (600 hours) is appropriate, given that the time needed to complete the decontamination varies with the extent of the contamination and surface contamination does not affect temperatures or otherwise affect the spent fuel assemblies.

(continued)

SURVEILLANCE REQUIREMENTS	SR 3.2.1.1 This SR verifies that the removable surface contamination on the exterior surfaces of the CANISTER is less than the limits in the LCO. The Surveillance is performed using smear surveys to detect removable surface contamination. The Frequency requires performing the verification prior to initiating TRANSPORT OPERATIONS in order to confirm that the CANISTER can be moved to the ISFSI without spreading loose contamination.
REFERENCES	1. FSAR Sections 8.1 and 8.A.1. 2. FSAR Sections 11.1.5 and 11.A.1.5.

C 3.2 NAC-MPC SYSTEM Radiation Protection

C 3.2.2 CONCRETE CASK Average Surface Dose Rates

BASES

BACKGROUND

The regulations governing the operation of an ISFSI set limits on the control of occupational radiation exposure and radiation doses to the general public (Ref. 1). Occupational radiation exposure should be kept as low as reasonably achievable (ALARA) and within the limits of 10 CFR Part 20. Radiation doses to the public are limited for both normal and accident conditions in accordance with 10 CFR 72.

APPLICABLE SAFETY ANALYSIS

The CONCRETE CASK average surface dose rates are not an assumption in any accident analysis, but are used to ensure compliance with regulatory limits on occupational dose and dose to the public.

LCO

The limits on CONCRETE CASK average surface dose rates are based on the Safety Analysis Report shielding analysis of the NAC-MPC SYSTEM (Ref. 2). The limits are selected to minimize radiation exposure to the public and to maintain occupational dose ALARA to personnel working in the vicinity of the NAC-MPC SYSTEM. The LCO specifies sufficient locations for taking dose rate measurements to ensure the dose rates measured are indicative of the effectiveness of the shielding materials.

APPLICABILITY

The CONCRETE CASK average surface dose rates apply during STORAGE OPERATIONS. These limits ensure that the CONCRETE CASK average surface dose rates during STORAGE OPERATIONS are bounded by the shielding safety analyses. Radiation doses during STORAGE OPERATIONS are monitored by the NAC-MPC SYSTEM user in accordance with the plant-specific radiation protection program as required by 10 CFR 72.212(b)(6) and 10 CFR 20 (Reference 1).

ACTIONS

A note has been added to the ACTIONS, which states that, for this LCO, separate Condition entry is allowed for each loaded CONCRETE CASK. This is acceptable, since the Required Actions for each Condition provide appropriate compensatory measures for each CONCRETE CASK not meeting the LCO. Subsequent NAC-MPC

(continued)

ACTIONS (continued)

SYSTEMs that do not meet the LCO are governed by subsequent Condition entry and application of associated Required Actions.

A.1

If the CONCRETE CASK average surface dose rates are not within limits, it could be an indication that a fuel assembly that did not meet the Approved Contents Limits in Section B2.0 of Appendix B of the Certificate of Compliance, or in Section B2.0 of Appendix 12.B for the MPC-LACBWR, was inadvertently loaded into the CANISTER. Administrative verification of the CANISTER fuel loading, by means such as review of video recordings and records of the loaded fuel assembly serial numbers, can establish whether a misloaded fuel assembly is the cause of the out-of-limit condition. The Completion time is based on the time required to perform such a verification.

A.2

If the CONCRETE CASK average surface dose rates are not within limits and it is determined that the CONCRETE CASK was loaded with the correct fuel assemblies, an analysis may be performed. This analysis will determine if the CONCRETE CASK would result in the ISFSI offsite or occupational calculated doses exceeding regulatory limits in 10 CFR Part 72 or 10 CFR Part 20, respectively. If it is determined that the measured average surface dose rates do not result in the regulatory limits being exceeded, STORAGE OPERATIONS may continue.

B.1

If it is verified that the fuel was misloaded, or that the ISFSI offsite radiation protection requirements of 10 CFR Part 20 or 10 CFR Part 72 will not be met with the CONCRETE CASK average surface dose rates above the LCO limit, the fuel assemblies must be placed in a safe condition in the spent fuel pool. The Completion Time is reasonable, based on the time required to transport the CONCRETE CASK, transfer the CANISTER to the TRANSFER CASK, remove the structural lid (MPC-Yankee and CY-MPC) and vent and drain port cover welds (all NAC-MPC systems), perform fuel cooldown operations, cut the shield lid weld (closure lid for the MPC-LACBWR), move the TRANSFER CASK and CANISTER into the spent fuel pool, remove the shield or closure lid, and remove the spent fuel assemblies in an orderly manner and without challenging personnel.

(continued)

SURVEILLANCE REQUIREMENTS

SR 3.2.2.1

This SR ensures that the CONCRETE CASK average surface dose rates are within the LCO limits prior to the beginning of STORAGE OPERATIONS. This Frequency is acceptable as corrective actions can be taken before off-site dose limits are compromised. The surface dose rates are measured approximately at the locations indicated on Figure A.3-1, following standard industry practices for determining average surface dose rates for large containers.

REFERENCES

1. 10 CFR Parts 20 and 72.
2. FSAR Sections 5.1, 5.A.1, 8.2 and 8.A.2.

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13.0 QUALITY ASSURANCE

13.1 Introduction

The NAC International (NAC) Quality Assurance (QA) Program is designed and administered to meet all Quality Assurance criteria of 10 CFR 72, Subpart G [1], 10 CFR 50, Appendix B [2], 10 CFR 71, Subpart H [3], and NQA-1 (Basic and Supplemental Requirements) [4]. The Nuclear Regulatory Commission (NRC) has reviewed and approved (Approval No. 0018) NAC's QA Program description.

The NAC QA Manual (as approved by the company's President) describes the policy NAC follows to comply with the applicable regulatory quality assurance criteria. The policy described in the NAC QA Manual is implemented by detailed procedures presented in the Quality Procedures Manual.

Employing a graded methodology, as described in U.S. NRC Regulatory Guide 7.10 [5], NAC applies quality controls to items and activities consistent with their safety significance. Table 13.1-1 identifies the NAC QA Manual sections that address the applicable quality criteria.

Table 13.1-1 Correlation of Regulatory Quality Assurance Criteria to the NAC Quality Assurance Program

Regulatory Quality Assurance Criteria[a]	Corresponding NAC QA Manual Section Number
Organization	1.0
Quality Assurance Program	2.0
Design Control	3.0
Procurement Document Control	4.0
Procedures, Instructions, and Drawings	5.0
Document Control	6.0
Control of Purchased Items and Services	7.0
Identification and Control of Material, Parts and Components	8.0
Control of Special Processes	9.0
Inspection	10.0
Test Control	11.0
Control of Measuring and Test Equipment	12.0
Handling, Storage and Shipping	13.0
Inspection, Test and Operating Status	14.0
Control of Nonconforming Items	15.0
Corrective Action	16.0
Records	17.0
Audits	18.0

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[a] The criteria are obtained from 10 CFR 50, Appendix B; 10 CFR 71, Subpart H; and 10 CFR 72, Subpart G

13.2 NAC Quality Assurance Program Synopsis

Eighteen applicable Quality Assurance criteria are identified in 10 CFR 72, Subpart G; 10 CFR 50, Appendix B; 10 CFR 71, Subpart H; and ASME NQA-1 (Basic and Supplemental Requirements). Refer to the following sections for NAC's compliance with each of these criteria.

13.2.1 Organization

The President of NAC has the ultimate authority and responsibility over all organizations and their functions within the corporation. However, the President delegates and empowers qualified personnel with the authority and responsibility over selected key areas, as identified in the NAC Organization Chart (see Figure 13.2-1).

The Vice President, Quality, is responsible for definition, development, implementation, and administration of the NAC QA Program. The QA organization is independent from other organizations within NAC and has complete authority to assure adequate and effective program execution, including problem identification, satisfactory corrective action implementation and the authority to stop work, if necessary. The Vice President, Quality, reports directly to the President of NAC. The Vice President, Quality, has sufficient expertise in the field of quality to direct the quality function and qualifies as a lead auditor.

Strategic Business Unit (SBU) Vice Presidents direct operations and use project teams as appropriate for a particular work scope. SBU Vice Presidents are responsible to the President for the proper implementation of the NAC QA Program.

13.2.2 Quality Assurance Program

Employing a grading methodology consistent with U.S. NRC Regulatory Guide 7.10, the QA Program provides control over activities affecting quality from the design to fabrication, operation, and maintenance of nuclear products and services for nuclear applications. The QA Program is documented in the QA Manual and implemented via Quality Procedures. These documents are approved by the Vice President, Quality and the applicable Vice President from each SBU performing activities within the scope of the NAC QA Manual.

Personnel assigned responsibilities by the QA Program may delegate performance of activities associated with that responsibility to other personnel in their group when those individuals are qualified to perform those activities by virtue of their education, experience, and training. Such delegations need not be in writing. The person assigned responsibility by the QA Program retains full accountability for the activities.

13.2.3 Design Control

The established Quality Procedures covering design control ensure that the design activity is planned, controlled, verified, and documented so that applicable regulatory and design basis requirements are correctly translated into specifications, drawings, and procedures with appropriate acceptance criteria for inspection and test delineated.

All software used to perform engineering calculations is verified for computational accuracy and error tracking, and is controlled in accordance with approved Quality Procedures.

Design interface control is established and adequate to ensure that the review, approval, release, distribution, and revision of design documents involving interfaces are performed by appropriately trained and cognizant design personnel, using approved procedures.

Design verification is performed by individuals other than those who performed the original design. These verifications may include design reviews, alternate calculations, or qualification tests. Selection of the design verification method is based on regulatory, contractual, or design complexity requirements. When qualification testing is selected, the "worst case" scenario will be used. The verification may be performed by the originator's supervisor, provided the supervisor did not specify a singular design approach, rule out certain design considerations, or establish the design inputs used in the design, or unless the supervisor is the only individual in the organization competent to perform the verification. When verification is provided by the supervisor, the need and basis shall be so documented in advance and evaluated after performance by internal audit.

Design changes are controlled and require the same review and approvals as the original design.

13.2.4 Procurement Document Control

Procurement documents and their authorized changes are generated, reviewed, and approved in accordance with the Quality Procedures. These procedures ensure that all purchased material, components, equipment, and services adhere to design specification, regulatory, and contractual requirements including QA Program and documentation requirements.

NAC QA personnel review and approve all procurement actions invoking compliance with the QA Program for inclusion of quality-related requirements in the procurement documents.

13.2.5 Procedures, Instructions and Drawings

All activities affecting quality are delineated in the Quality Procedures, Specifications, Inspection/Verification Plans, or on appropriate drawings. These documents are developed via approved Quality Procedures and include appropriate quantitative and qualitative acceptance criteria. These documents are reviewed and approved by QA personnel prior to use.

13.2.6 Document Control

All documents affecting quality, including revisions, are reviewed and approved by authorized personnel, and are issued and controlled in accordance with Quality Procedures by those responsible persons or groups. Transmittal forms, with provisions for receipt acknowledgment, are used and controlled document distribution logs are maintained.

All required support documentation for prescribed activities is available at the work location prior to initiation of the work effort.

13.2.7 Control of Purchased Items and Services

Items and services affecting quality are procured from qualified suppliers. These suppliers have been evaluated and selected in accordance with the Quality Procedures based on their capability to comply with applicable regulatory and contractual requirements.

Objective evidence attesting to the quality of items and services furnished by NAC suppliers is provided with the delivered item or service, and is based on contract requirements and item or service complexity. This vendor documentation requirement is delineated in the procurement documents.

Source inspection, receipt inspection, vendor audits, and vendor surveillance are performed as required to assure product quality, documentation integrity, and supplier compliance to the procurement, regulatory and contractual requirements.

13.2.8 Identification and Control of Material, Parts and Components

Identification is maintained either on the item or in quality records traceable to the item throughout fabrication and construction to prevent the use of incorrect or defective items.

Identification, in accordance with drawings and inspection plans, is verified by QA personnel prior to releasing the item for further processing or delivery.

13.2.9 Control of Special Processes

Special processes, such as welding, heat treating, and nondestructive testing, are performed in accordance with applicable codes, standards, specifications, and contract requirements by qualified personnel. NAC and NAC suppliers' special process procedures and personnel certifications are reviewed and approved by NAC QA prior to their use.

13.2.10 Inspection

NAC has an established and documented inspection program that identifies activities affecting quality and verifies their conformance with documented instructions, plans, procedures, and drawings.

Inspections are performed by individuals other than those who performed the activity being inspected. Inspection personnel report directly to the Vice President, Quality.

Process monitoring may also be used in conjunction with identified inspections, if beneficial to achieve required quality.

Mandatory inspection hold points assure verification of critical characteristics. Such hold points are delineated in appropriate process control documents.

13.2.11 Test Control

NAC testing requirements are developed and applied in order to demonstrate satisfactory performance of the tested items to design/contract requirements.

The NAC test program is established to ensure that preoperational or operational tests are performed in accordance with written test procedures. Test procedures developed in accordance with approved Quality Procedures identify test prerequisites, test equipment and instrumentation, and suitable environmental test conditions. Test procedures are reviewed and approved by NAC QA personnel.

Test results are documented, evaluated, and accepted by qualified personnel as required by the QA inspection instructions prepared for the test, as approved by cognizant quality personnel.

13.2.12 Control of Measuring and Testing Equipment

Control of measuring and testing equipment/instrumentation is established to assure that devices used in activities affecting quality are calibrated and properly adjusted at specified time intervals to maintain their accuracy.

Calibrated equipment is identified and traceable to calibration records, which are maintained as quality records. Calibration accuracy is traceable to national standards when such standards exist. The basis of calibration shall always be documented.

Whenever measuring and testing equipment is found to be out of calibration, an evaluation shall be made and documented of the validity of inspection or test results performed and of the acceptability of items inspected or tested since the previous calibration.

13.2.13 Handling, Storage and Shipping

Requirements for handling, storage and shipping are documented in specifications and applicable procedures or instructions. These requirements are designed to prevent damage or deterioration to items and materials.

Information pertaining to shelf life, environment, packaging, temperature, cleaning and preservation are also delineated as required.

QA Surveillance/Inspection personnel are responsible for verifying that approved handling, storage and shipping requirements are met.

13.2.14 Inspection, Test and Operating Status

Procedures are established to indicate the means of identifying inspection and test status on the item and/or on records traceable to the item. These procedures assure identification of items that have satisfactorily passed required inspections and/or tests to preclude inadvertent bypassing of the inspection/test.

Inspection, test and operating status indicators may only be applied or modified by Quality Assurance personnel or with formal Quality Assurance concurrence.

13.2.15 Control of Nonconforming Items

NAC has established and implemented procedures that assure appropriate identification, segregation, documentation, notification and disposition of items that do not conform to specified requirements. These measures prevent inadvertent usage of the item and assure appropriate authorization or approval of the item's disposition.

All nonconformances are reviewed and accepted, rejected, repaired or reworked in accordance with documented approved procedures. If necessary, a Review Board is convened, consisting of engineering, licensing, quality, operations and testing personnel, as applicable, to provide disposition of nonconforming conditions.

NAC procurement documents provide for control, review and approval of nonconformances noted on NAC items, including associated dispositions.

13.2.16 Corrective Action

Conditions adverse to quality, such as failures, malfunctions, deficiencies, defective material/ equipment and nonconformances, are promptly identified, documented and corrected.

Significant conditions adverse to quality will have their cause determined and sufficient corrective action taken to preclude recurrence. These conditions are documented and reported to the Vice President, Quality, who assures awareness by the President.

13.2.17 Records

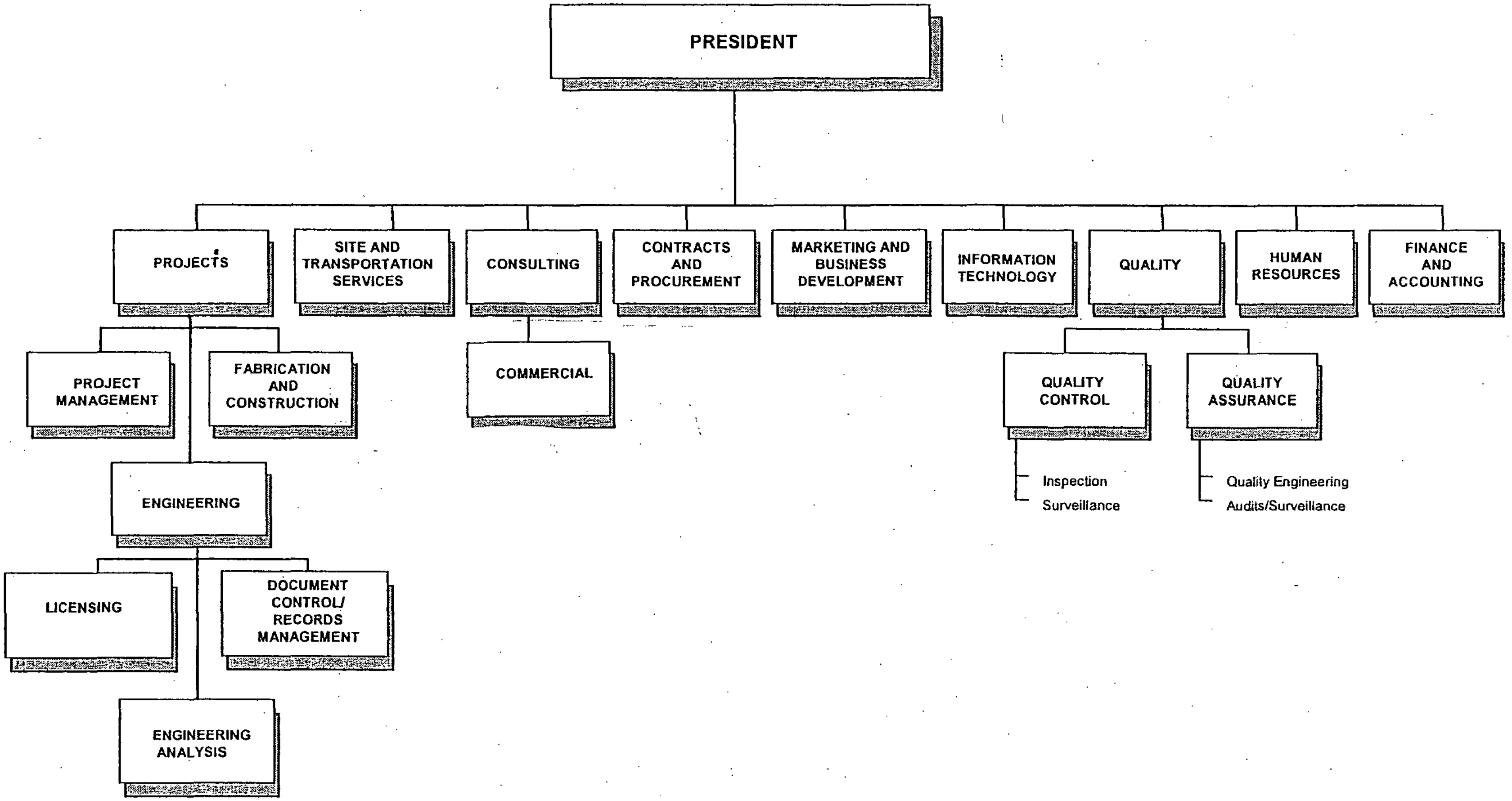
NAC maintains a records system in accordance with approved procedures to ensure that documented objective evidence pertaining to quality-related activities is identifiable, retrievable and retained to meet regulatory and contract requirements, including retention duration, location and responsibility.

Quality records include, but are not limited to, inspection and test reports, audit reports, quality personnel qualifications, design documents, purchase orders, supplier evaluations, fabrication documents, nonconformance reports, drawings, specifications and related documents. QA maintains a complete list of records and provides for record storage and disposition to meet regulatory and contractual requirements.

13.2.18 Audits

Approved Quality Procedures provide for a comprehensive system of planned and periodic audits performed by qualified personnel, independent of activities being audited. These audits are performed in accordance with written procedures and are intended to verify program adequacy and its effective implementation and compliance, both internally and at approved-supplier locations. Internal audits are conducted annually, and approved suppliers are audited on a triennial basis, as a minimum.

Figure 13.2-1 NAC Functional Organization Chart



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13.3 References

1. 10 CFR 72, Code of Federal Regulations, "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel, High-Level Radioactive Waste and Reactor-Related Greater than Class C Waste," Subpart G, "Quality Assurance Requirements," US Government, Washington, DC.
2. 10 CFR 50, Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," Code of Federal Regulations, US Government, Washington, DC.
3. 10 CFR 71, Code of Federal Regulations, "Packaging and Transportation of Radioactive Material," Subpart H, "Quality Assurance," US Government, Washington, DC.
4. ASME NQA-1, Part 1, Basic and Supplemental Requirements (as referenced by the ASME Code, including latest accepted addenda), Quality Assurance Requirements for Nuclear Facility Applications.
5. Regulatory Guide 7.10, "Establishing Quality Assurance Programs for Packaging Used in Transport of Radioactive Material," US Nuclear Regulatory Commission, Washington, DC.

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