6.6.1 Criticality Evaluation for Maine Yankee Site Specific Spent Fuel

In Section 6.4, loading the storage cask with the standard CE 14 × 14 fuel assembly is shown to be less reactive than loading the cask with the most reactive Westinghouse 17 × 17 OFA design basis spent fuel. This analysis addresses variations in fuel assembly dimensions, variable enrichment axial zoning patterns, annular axial fuel blankets, removed fuel rods or empty rod positions, fuel rods placed in guide tubes, fuel assemblies with a start-up source or other components in a guide tube, consolidated fuel assemblies, and damaged fuel and fuel debris. These configurations are not included in the standard fuel analysis, but are present in the site fuel inventory that must be stored.

6.6.1.1 Maine Yankee Fuel Criticality Model

The criticality evaluations of the Maine Yankee fuel inventory require the basket cell and basket in cask models described in Section 6.3 and 6.4. The basket cell model is principally employed in the most reactive dimension evaluation for the Maine Yankee intact fuel types. The basket cell model represents an infinite array of fuel tubes separated by one-inch flux traps and neglects the radial neutron leakage of the basket. This will result in k_{eff} values greater than 0.95. The basket cell model is, therefore, only used to determine relative reactivities of the various physical dimensions of the Maine Yankee fuel inventory, not to establish maximum k_s values for the basket loaded with Maine Yankee fuel assemblies. The basket-in-cask model is used for the evaluation of the remaining fuel configurations. The basket criticality model uses the nominal basket configuration with full moderation under accident conditions, where accident conditions implying the loss of fuel cladding integrity and flooding of the pellet to cladding gap in all fuel rods. The analyses presented are performed using the UMS® transport cask shield geometry. Based on the evaluation presented in Section 6.4 and the licensing analysis of the transport overpack, the most reactive transportable storage canister configuration is independent of the canister outer shell geometry (i.e., different casks – transport, transfer, or storage). Since the criticality evaluation is not sensitive to the shielding geometry outside of the canister, this result is applicable to the concrete storage cask and the transfer cask. The transport cask criticality model is identical to the transfer cask and storage cask models with the exception that the radial shielding outside of the canister is comprised of a total of 4.75 inches of steel, 2.75 inches of NS-4-FR neutron shielding and 2.75 inches of lead. The $k_{eff} + 2\sigma$ of this configuration is 0.9210, which is slightly lower than the wet gap $k_{eff} + 2\sigma$ values of 0.9238 and 0.9234 reported in Tables 6.4-6 and 6.4-7 for the transfer cask and storage cask, respectively.

6.6.1.2 Maine Yankee Intact Spent Fuel

The evaluation of the intact Maine Yankee spent fuel inventory demonstrates that, under all conditions, the maximum reactivity of the UMS® basket loaded with Maine Yankee fuel assemblies is bounded by the Westinghouse 17 × 17 OFA evaluation presented in Section 6.4. The intact fuel assembly evaluation includes the determination of maximum reactivity dimensions of the Maine Yankee fuel assemblies, and the reactivity effects of variably enriched assemblies, annular axial end blankets, removed rods, fuel in guide tubes, and consolidated fuel assemblies. Where necessary, loading restrictions are applied to limit the number and location of the basket payload evaluated.

6.6.1.2.1 Fuel Assembly Lattice Dimensional Variations

Maine Yankee 14 × 14 PWR fuel has been provided by Combustion Engineering, Exxon/ANF, and Westinghouse. The range of fuel assembly dimensions evaluated for Maine Yankee is shown in Table 6.6.1-1. Bounding fuel assembly dimensions are determined using the guidelines presented in Section 6.4.4 and are reported in Table 6.6.1-2. The dimensional perturbations that can increase the reactivity of an undermoderated array of fuel assemblies in a flooded system (including flooding the fuel-cladding gap) are:

- Decreasing the cladding outside diameter (OD)
- Increasing the cladding inside diameter (ID) (i.e., increasing the gap)
- Decreasing the pellet diameter
- Decreasing the guide tube thickness

To conservatively model the cladding thickness of the Maine Yankee standard fuel, the outside diameter of the cladding is decreased until the cladding thickness reaches the minimum. The pellet diameter is studied separately to determine which diameter maximizes the reactivity of the assembly. This study is performed using an infinite array of hybrid 14 × 14 fuel assemblies. These hybrid assemblies have the combination of the most reactive dimensions listed in Table 6.6.1-2 and are used in the evaluation of site specific fuel configurations as described in the following sections. The pellet diameter is modeled first at the maximum diameter; then it is iteratively decreased until a peak reactivity (H/U ratio) is reached. The results of this study are reported in Table 6.6.1-3. The maximum reactivity occurs at a pellet diameter of 0.3527 inches. This pellet diameter is conservatively used in the analyses of an assembly with 176 fuel rods.

The reactivity of an infinite array of basket unit cells containing infinitely tall, hybrid 14 × 14 fuel assemblies and a flooded fuel-cladding gap is $k_{eff} + 2\sigma = 0.96268$. This is less reactive than the same array of Westinghouse 17 × 17 OFA assemblies ($k_{eff} + 2\sigma = 0.9751$ from Table 6.4-1). Therefore, the design basis Westinghouse 17 × 17 OFA fuel criticality evaluation is bounding. The conservatism obtained by decreasing the pellet diameter below that of the reported Maine Yankee fuel pellet diameter is equivalent to a Δk_{eff} of 0.00247.

The most reactive lattice dimensions determined by the basket cell model are incorporated into the basket in cask model. Evaluating 24 hybrid 14 × 14 fuel assemblies with the most reactive pellet diameter for the accident condition produces a $k_{eff} + 2\sigma$ of 0.91014. This is less reactive than the accident condition for the transport cask loaded with the Westinghouse 17 × 17 OFA assemblies ($k_{eff} + 2\sigma$ of 0.9210). Therefore, the Westinghouse 17 × 17 OFA fuel criticality evaluation is bounding.

6.6.1.2.2 Variably Enriched Fuel Assemblies

Two batches of fuel used at Maine Yankee contain variably enriched fuel rods. Fuel rod enrichments of one batch are 4.21 wt % ^{235}U and 3.5 wt % ^{235}U. The maximum planar average enrichment of this batch is 3.99 wt %. In the other batch, the fuel rod enrichments are 4.0 wt % and 3.4 wt % ^{235}U. The maximum planar average enrichment of this batch is 3.92 wt %. Loading 24 variably enriched fuel assemblies having both a maximum fuel rod enrichment of 4.21 wt % and a maximum planar average enrichment of 3.99 wt % results in a $k_{eff} + 2\sigma$ of 0.89940. Using a planar fuel rod enrichment of 4.2 wt % results in a $k_{eff} + 2\sigma$ of 0.91014. Therefore, all of the fuel rods are conservatively modeled as if enriched to 4.2 wt % ^{235}U for the remaining Maine Yankee analyses.

6.6.1.2.3 Assemblies with Annular Axial End Blankets

One batch of variably enriched fuel also incorporates 2.6 wt % ^{235}U axial end blankets with annular fuel pellets. The top and bottom 5% of the active fuel length of each fuel rod in this batch contains annular fuel pellets having an inner diameter of 0.183 inches.

This geometry is discretely modeled as approximately 5% annular fuel, 90% solid fuel and then 5% annular fuel, with all fuel materials enriched to 4.2 wt % ^{235}U. The diameter of all pellets is initially modeled as the most reactive pellet diameter. The accident case model, which includes flooding of the fuel cladding annulus, is used in this evaluation. Axial periodic boundary conditions are placed on the model, retaining the conservatism of the infinite fuel length. Use of a smaller pellet diameter is not considered to be conservative when evaluating the annular fuel pellets. The smaller pellet diameter is the most reactive diameter under the assumption that it is solid and not an annulus. Flooding the axial end blanket annulus provides additional moderator to the fuel lattice. Therefore, the diameter of the annular pellets is also modeled as the maximum pellet diameter of 0.380 inch. The 0.380-inch diameter is applied to the annular pellets, while the smaller diameter is applied to the solid pellets. The results of both evaluations are reported in Table 6.6.1-4.

The most reactive annular fuel model for the annular axial end blankets results in a slightly more reactive system than the hybrid fuel accident evaluation, the annular condition is less reactive than the evaluation including Westinghouse 17 × 17 OFA assemblies. Therefore, the Westinghouse 17 × 17 OFA fuel criticality evaluation is bounding.

6.6.1.2.4 Assemblies with Removed Fuel Rods

Some of the Maine Yankee fuel assemblies have had fuel rods removed from the 14 × 14 lattice or have had poison rods replaced by hollow Zircaloy rods. The exact number and location of removed rods and hollow rods differs from one assembly to another. To determine a bounding reactivity for these assemblies, an analysis changing the location and the number of removed rods is performed. The removed rod analysis bounds that of the hollow rod analysis, since the Zircaloy tubes displace moderator in the under moderated assembly lattice. For each case, all 24 assemblies are centered in the fuel tubes and have the same number and location of removed fuel rods. Various patterns of removed fuel rod locations are analyzed when the number of removed fuel rods is small enough to allow a different and possibly more reactive geometry. As the number of removed fuel rods increases, the number of possible highly reactive locations for these removed rods decreases. The fuel pellet diameter is modeled first at the most reactive diameter (0.3527 inches as determined in Section 6.6.1.2.1), and then at the maximum diameter of 0.380 inches.

The results of these analyses, which determine the most reactive number and geometry of removed rods for any Maine Yankee assembly, are presented in Tables 6.6.1-5 and 6.6.1-6. Table 6.6.1-5 contains the results based on a 0.3527-inch fuel pellet. All of the removed fuel rod cases using the smaller pellet diameter show cask reactivity levels lower than those of Westinghouse 17 × 17 OFA fuel. Table 6.6.1-6 contains the results of the evaluation using the maximum pellet diameter of 0.380 inch. Using the maximum pellet diameter provides for a more reactive system, since moderator is added (at the removed rod locations), to an assembly that contains more fuel. The most reactive removed fuel rod case occurs when 24 fuel rods are removed in the diamond shaped geometry shown in Figure 6.6.1-1, from the model containing the largest allowed pellet diameter.

This case represents the bounding number and geometry of removed fuel rods for the Maine Yankee fuel assemblies. It results in a more reactive system than either the Maine Yankee hybrid 14 × 14 fuel accident case or the Westinghouse 17 × 17 OFA accident case assuming unrestricted loading. However, as shown in Table 6.6.1-6, when the loading of any assembly with less than 176 fuel rods or filler rods is restricted to the four corner fuel tubes, the reactivity of the worse case drops well below that of the Westinghouse 17 × 17 OFA fuel assemblies. Therefore, loading of Maine Yankee fuel assemblies with removed fuel rods, or with hollow Zircaloy rods, is restricted to the four corner fuel tube positions of the basket. With this loading restriction, the Westinghouse 17 × 17 OFA criticality evaluation remains bounding.

6.6.1.2.5 Assemblies with Fuel Rods in the Guide Tubes

A few of the Maine Yankee intact assemblies may contain up to two intact fuel rods in some of the guide tubes (i.e., allowing for the potential storage of individual intact fuel rods in an intact fuel assembly). To evaluate loading of these assemblies into the canister, an analysis adding 1 and then 2 intact fuel rods into 1, 2, 3 and then 5 guide tubes is made. This approach considers a fuel assembly with up to 186 fuel rods. The results of the evaluation of these configurations are shown in Table 6.6.1-7. While higher in reactivity than the Maine Yankee hybrid base case, any fuel configuration with up to 2 fuel rods per guide tube is less reactive than the accident case for the Westinghouse 17 × 17 OFA fuel assemblies. Therefore, the Westinghouse 17 × 17 OFA fuel criticality evaluation is bounding.

Fuel rods may also be inserted in the guide tubes of fuel assemblies from which the fuel rods were removed (i.e., fuel rods removed from a fuel assembly and re-installed in the guide tubes of the same fuel assembly). These fuel rods may be intact or damaged. The maximum number of fuel rods in these assemblies, including fuel rods in the guide tubes remains 176. These configurations are restricted to loading in a Maine Yankee fuel can in a corner fuel position in the basket. As shown in Section 6.6.1.2.4 for the removed fuel rods, and Section 6.6.1.3 for the damaged fuel, the maximum reactivity of Maine Yankee assemblies containing 176 fuel rods in various configurations is bounded by the Westinghouse 17 × 17 OFA evaluation. These non-standard Maine Yankee assemblies are restricted to the corner fuel positions.

In addition to the fuel rods, some Maine Yankee assemblies may contain poison shim rods in guide tubes. These solid fill rods will serve as parasitic absorber and displace moderator and are, therefore, not included in the criticality model but are bounded by the evaluation performed.

6.6.1.2.6 Consolidated Fuel

The consolidated fuel is a 17 × 17 array of intact fuel rods with a pitch of 0.492 inches. Some of the locations in the array contain solid fill rods and some are empty. To determine the reactivity of the consolidated fuel lattice with empty fuel rod positions, an analysis changing the location and the number of empty positions is performed. This analysis considers 24 consolidated fuel lattices in the basket. All 24 consolidated fuel lattices are centered in the fuel tubes and have the same number and location of empty fuel rod positions.

As shown in Section 6.6.1.2.4, the removed fuel rod configuration with a 0.380-inch pellet diameter provides a more reactive system than a system using the optimum pellet diameter from Section 6.6.1.2.1. The larger pellet cases are more reactive, since moderator is added at the empty fuel rod positions to an assembly that contains more fuel. Therefore, the consolidated assembly empty rod position evaluation is performed with the 0.380-inch pellet diameter.

The results of this evaluation are shown in Table 6.6.1-8. Configurations having more than 73 empty positions result in a more reactive system than the Westinghouse 17 × 17 OFA model. The most reactive consolidated assembly case occurs with 113 empty rod positions in the geometry shown in Figure 6.6.1-2. However, when the loading of the consolidated fuel is restricted to the four corner fuel tubes, the reactivity of the system is lower than the accident condition of the basket loaded with Westinghouse 17 × 17 OFA assemblies. Therefore, loading of the consolidated fuel is restricted to the four corner fuel tube positions of the basket. With this loading restriction, the Westinghouse 17 × 17 OFA fuel criticality evaluation is bounding.

6.6.1.2.7 Conclusions

The criticality analyses for the Maine Yankee site specific fuel demonstrate that the UMS® basket loaded with these fuel assemblies results in a system that is less reactive than loading the basket with the Westinghouse 17 × 17 OFA fuel assemblies, provided that loading is restricted to the four corner fuel tube positions in the basket for:

- All 14 × 14 fuel assemblies with less than 176 fuel rods or solid filler rods
- All 14 × 14 fuel assemblies with hollow rods
- All 17 × 17 consolidated fuel lattices
- All 14 × 14 fuel assemblies with fuel rods in the guide tubes and a maximum of 176 fuel rods or solid rods and fuel rods.

The following Maine Yankee fuels are not restricted as to loading position within the basket:

- All 14 × 14 fuel assemblies with 176 fuel rods or solid filler rods at a maximum enrichment of 4.2 wt % ^{235}U.
- Variably enriched fuel with a maximum fuel rod enrichment of 4.21 wt % ^{235}U with a maximum planar average enrichment of 3.99 wt % ^{235}U.
- Fuel with solid stainless steel filler rods, solid Zircaloy filler rods or solid poison shim rods in any location.
- Fuel with annular axial end blankets of up to 4.2 wt % ^{235}U.
- Fuel with a maximum of 2 intact fuel rods in each guide tube for a total of 186 fuel rods.

Assemblies defined as unrestricted may be loaded into the basket in any basket location and may be mixed in the same basket. While not analyzed in detail, CEAs and ICI thimble assemblies may be loaded into any intact assemblies. These components displace a significant amount of water in the fuel lattice while adding parasitic absorber, thereby reducing system reactivity.

Since the storage cask and the transfer cask loaded with the Westinghouse 17 × 17 OFA fuel assemblies is criticality safe, it is inherent that the same cask loaded with the less reactive fuel assemblies employed at Maine Yankee, using the fuel assembly loading restrictions presented above, is also criticality safe.

6.6.1.3 Maine Yankee Damaged Spent Fuel and Fuel Debris

Damaged fuel assemblies are placed in a Maine Yankee fuel can prior to loading in the basket (see Drawings 412-501 and 412-502). The Maine Yankee fuel can has screened openings in the baseplate and the lid to permit drainage, vacuum drying, and inerting of the can. This evaluation conservatively considers 100% of the fuel rods in the fuel can as damaged.

Fuel debris can be loaded in a rod or tube structure that is subsequently loaded into a Maine Yankee fuel can. The mass of fuel debris placed in the rod or tube is restricted to the mass equivalent of a fuel rod of an intact fuel assembly.

The Maine Yankee spent fuel inventory includes fuel assemblies with fuel rods inserted in the guide tubes of the assembly. If the integrity of the cladding of the fuel rods in the guide tubes cannot be ascertained, then those fuel rods are assumed to be damaged.

6.6.1.3.1 Damaged Fuel Rods

All of the spent fuel classified as damaged, and all of the spent fuel not in its original lattice, are stored in a Maine Yankee fuel can. This fuel is analyzed using a 100% fuel rod failure assumption. The screened fuel can is designed to preclude the release of pellets and gross particulate to the canister cavity. Evaluation of the canister with four (4) Maine Yankee fuel cans containing CE 14 × 14 fuel assemblies that have up to 176 damaged fuel rods, or consolidated fuel consisting of up to 289 fuel rods, considers 100% dispersal of the fuel from these rods within the fuel can. The Maine Yankee fuel can is restricted to loading in the four corner positions of the basket.

All loose fuel in each analysis is modeled as a homogeneous mixture of fuel and water of which the volume fractions of the fuel versus the water are varied from 0 - 100. By varying the fuel fraction up to 100%, this evaluation addresses fuel masses significantly larger than those available in a standard or consolidated fuel assembly. First, loose fuel from damaged fuel rods within a fuel assembly is evaluated between the remaining rods of the most reactive missing rod array. The results of this analysis, provided in Table 6.6.1-9, show a slight decrease in the reactivity of the system. This results from adding fuel to the already optimized H/U ratio of the bounding missing rod array. This effectively returns the system to an undermoderated state. Second, loose fuel is considered above and below the active fuel region of this most reactive missing rod array. This analysis is performed within a finite cask model. The results of this study, provided in Table 6.6.1-10, show that any possible mixture combination of fuel and water above and below the active fuel region, and hence, above and below the neutron absorber sheet coverage, will not significantly increase the reactivity of the system beyond that of the missing rod array. Loose fuel is also considered to replace all contents of the Maine Yankee fuel can in each four corner fuel tube location. The results of this study, provided in Table 6.6.1-11, show that any mixture of fuel and water within this cavity will not significantly increase the reactivity of the system beyond that of the missing rod array.

Damaged fuel within the fuel can may also result from a loss of integrity of a consolidated fuel assembly. As described in Section 6.6.1.2.6, the consolidated assembly missing rod study shows that a potentially higher reactivity heterogeneous configuration does not increase the overall reactivity of the system beyond that of loading 24 Westinghouse 17 × 17 OFA assemblies when this configuration is restricted to the four corner locations. The homogeneous mixture study of loose fuel and water replacing the contents of the Maine Yankee fuel can (in each of the four corner fuel tube locations) considers more fuel than is present in the 289 fuel rod consolidated assembly. This study shows that a homogeneous mixture at an optimal H/U ratio within the fuel can also does not affect the reactivity of the system.

The transfer and the storage casks loaded with the Westinghouse 17 × 17 OFA fuel assemblies remain subcritical. Therefore, it is inherent that a statistically equivalent, or less reactive, canister loading of 4 Maine Yankee fuel cans containing assemblies with up to 176 damaged rods, or consolidated assemblies with up to 289 rods and 20 of the most reactive Maine Yankee fuel assemblies, will remain subcritical. Consequently, assemblies with up to 176 damaged rods and consolidated assemblies with up to 289 rods are allowed contents as long as they are loaded into Maine Yankee fuel cans.

6.6.1.3.2 Fuel Debris

Prior to loading fuel debris into the screened Maine Yankee fuel can, fuel debris must be placed into a rod type structure. Placing the debris into rods confines the spent nuclear material to a known volume and allows the fuel debris to be treated identically to the damaged fuel for criticality analysis.

Based on the arguments presented in Section 6.6.1.3.1, the maximum k_s of the UMS® canister with fuel debris will be less than 0.95, including associated uncertainty and bias.

6.6.1.4 Fuel Assemblies with a Source or Other Component in Guide Tubes

The effect on reactivity from loading Maine Yankee fuel assemblies with components inserted in the center or corner guide tube positions is also evaluated. These components include start-up sources, Control Element Assembly (CEA) fingertips, and a 24-inch ICI segment. Start-up sources must be inserted in the center guide tube. The CEA fingertips and ICI segment must be inserted in a corner guide tube that is closed at the bottom end of the assembly and closed at the top using a CEA flow plug.

6.6.1.4.1 Assemblies with Start-up Sources

Maine Yankee has three Pu-Be sources and two Sb-Be sources that will be installed in the center guide tubes of 14 × 14 assemblies that subsequently must be loaded in one of the four corner fuel positions of the basket. Each source is designed to fit in the center guide tube of an assembly. All five of these start-up sources contain Sb-Be pellets, which are 50% beryllium (Be) by volume. The moderation potential of the Be is evaluated to ensure that this material will not increase the reactivity of the system beyond that reported for the accident condition. The antimony (Sb) content is ignored. The start-up source is assumed to remain within the center guide tube for all conditions. The base case infinite height model used for comparison is the bounding Maine Yankee geometry with fuel assemblies that have 24 empty rod positions in the most reactive geometry, in the four corner locations of the basket, i.e., Case "24 (Four Corners)" reported in Table 6.6.1-6. The center guide tube of this model is filled with 50% water and 50% Be. The analysis assumes that assemblies with start-up sources are loaded in all four of the basket corner fuel positions. This configuration, resulting in a system reactivity of $k_{eff} \pm \sigma$, or 0.91085 ± 0.00087, shows that loading Sb-Be sources or the used Pu-Be sources into the center guide tubes of the assemblies in the four corner locations of the basket does not significantly impact the reactivity of the system.

One of the three Pu-Be sources was never irradiated. Analysis of this source is equivalent to assuming that the spent Pu-Be sources are fresh. The unused source has 1.4 grams of plutonium in two capsules. All of this material is conservatively assumed to be in one capsule and is modeled as ^{239}Pu. The diameter of the capsule cavity is 0.270 inch and its length is 9.75 inches. This corresponds to a capsule volume of approximately 9.148 cubic centimeters. Thus, the 1.4 grams of ^{239}Pu occupies ~0.77% of the volume at a density of 19.84 g/cc. This material composition is then conservatively assumed to fill the entire center guide tube, which models considerably more ^{239}Pu than is actually present within the Pu-Be source. The remaining volume of the guide tube is analyzed at various fractions of Be, water and/or void to ensure that any combination of these materials is considered. The results of these analyses, provided in Table 6.6.1-12, show that loading a fresh Pu-Be start-up source into the center guide tube of each of the four corner assemblies does not significantly impact the reactivity of the system. Both heterogeneous and homogeneous analyses are performed.

6.6.1.4.2 Fuel Assemblies with Inserted CEA Fingertips or ICI String Segment

Maine Yankee fuel assemblies may have CEA finger ends (fingertips) or an ICI segment inserted in one of the four corner guide tubes of the same 14 × 14 assembly. The ICI segment is approximately 24 inches long. These components do not contain fissile or moderating material. Therefore, it is conservative to ignore these components, as they displace moderator when the basket is flooded, thereby reducing reactivity.

6.6.1.4.3 Maine Yankee Miscellaneous Component Loading Restrictions

Based on the evaluation of Maine Yankee fuel assemblies with start-up sources, CEA fingertips, or an ICI segment inserted in guide tubes, the following loading restrictions apply:

1) Any Maine Yankee fuel assembly having a component evaluated in this section inserted in a corner or center guide tube must be loaded in one of the four corner fuel loading positions of the UMS® basket. Basket corner positions are also peripheral positions and are marked "P/C" in Figure 2.1.3.1-1.
2) Start-up sources shall be restricted to loading in the center guide tubes of fuel assemblies classified as intact and must be loaded in a Class 1 canister.
3) Only one start-up source may be loaded into any intact fuel assembly.
4) The CEA finger tips and ICI segment must be loaded in a guide tube location that is closed at the bottom end (corner guide tubes) of an intact fuel assembly. The guide tube must be closed at the top end using a CEA flow plug.
5) Fuel assemblies having a CEA flow plug installed must be loaded in a Class 2 canister.
6) Up to four intact fuel assemblies with inserted start-up sources may be loaded in any canister (using the four corner positions of the basket).

When loaded in accordance with these restrictions, the evaluated components do not significantly impact the reactivity of the system.

6.6.1.5 Maine Yankee Fuel Comparison to Criticality Benchmarks

The most reactive system configuration parameters for Maine Yankee fuel have been compared to the range of applicability of the critical benchmarks evaluated using the KENO-Va code of the SCALE 4.3 CSAS sequence. As shown below, all of the Maine Yankee fuel parameters fall within the benchmark range.

Parameter	Benchmark Minimum Value	Benchmark Maximum Value	Maine Yankee Fuel Most Reactive Configuration
Enrichment (wt. % ^{235}U)	2.35	4.74	4.2
Rod pitch (cm)	1.26	2.54	1.50
H/U volume ratio	1.6	11.5	2.6
^{10}B areal density (g/cm^2)	0.00	0.45	0.025
Average energy group causing fission	21.7	24.2	22.5
Flux gap thickness (cm)	0.64	5.16	2.22 to 3.81
Fuel diameter (cm)	0.790	1.265	0.896
Clad diameter (cm)	0.940	1.415	1.111

The H/U volume ratio for the assembly is shown. The lattice H/U volume ratio is 2.2 for the clad gap flooded scenario.

The results of the NAC-UMS® Storage System benchmark calculations are provided in Section 6.5.1.

Figure 6.6.1-1 24 Removed Fuel Rods - Diamond Shaped Geometry, Maine Yankee Site Specific Fuel

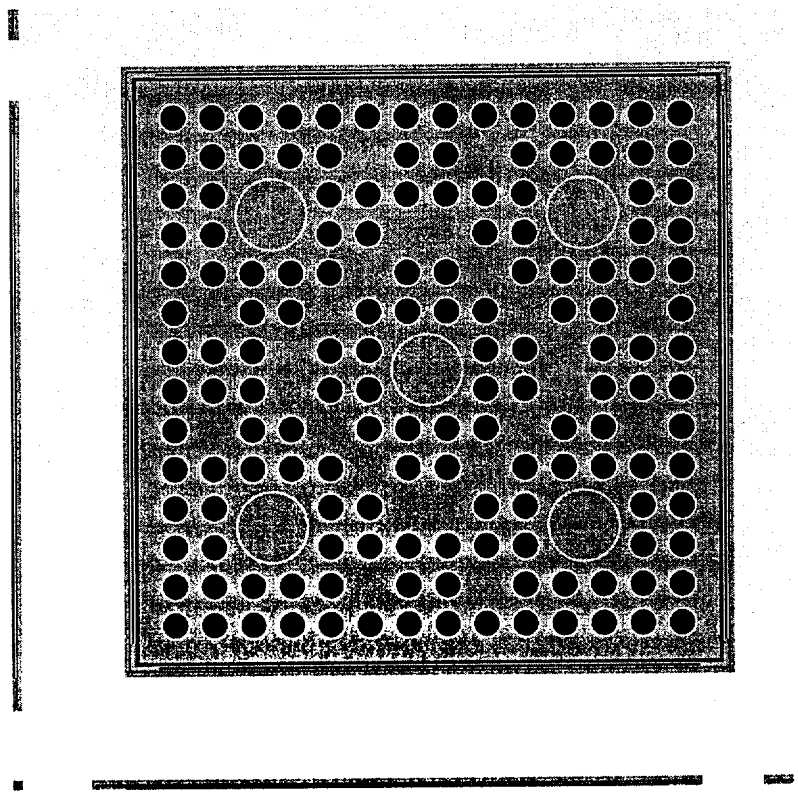


Figure 6.6.1-2 Consolidated Fuel Geometry, 113 Empty Fuel Rod Positions, Maine Yankee Site Specific Fuel

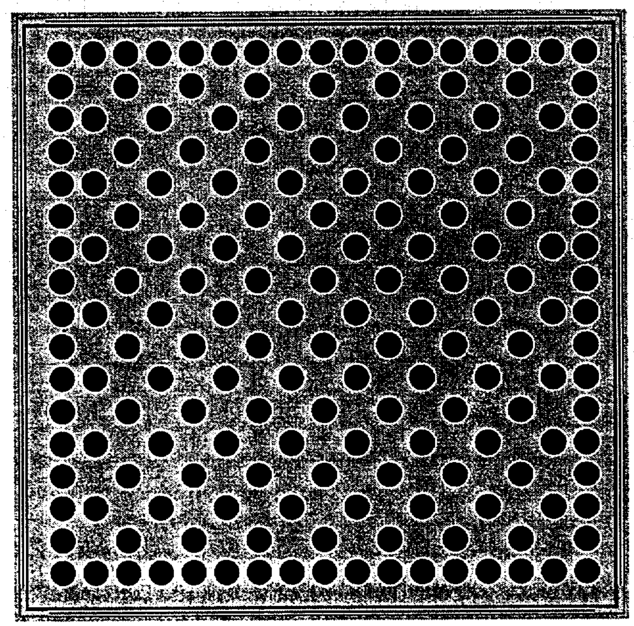


Table 6.6.1-1 Maine Yankee Standard Fuel Characteristics

Fuel Class[1]	Vendor	Array	Version	Number of Fuel Rods	Pitch (in.)	Rod Diameter (in.)	Clad ID (in.)	Clad Thickness (in.)	Pellet Diameter (in.)	GT[2] Thickness (in.)
1	CE	14×14	Std.	160[3]-176	0.570-0.590	0.438-0.442	0.3825-0.3895	0.024-0.028	0.376-0.380	0.036-0.040
1	Ex/ANF	14×14	CE	164[4]-176	0.580	0.438-0.442	0.3715-0.3795	0.0294-0.031	0.3695-0.3705	0.036-0.040
1	WE	14×14	CE	176	0.575-0.585	0.438-0.442	0.3825-0.3855	0.0262-0.028	0.376-0.377	0.034-0.038

1. All fuel rods are Zircaloy clad.
2. Guide Tube thickness.
3. Up to 16 fuel rod positions may have solid filler rods or burnable poison rods.
4. Up to 12 fuel rod positions may have solid filler rods or burnable poison rods.

Table 6.6.1-2 Maine Yankee Most Reactive Fuel Dimensions

Parameter	Bounding Dimensional Value
Maximum Rod Enrichment[1]	4.2 wt % ^{235}U
Maximum Number of Fuel Rods[2]	176
Maximum Pitch (in.)	0.590
Maximum Active Length (in.)	N/A – Infinite Model
Minimum Clad OD (in.)	0.4375
Maximum Clad ID (in.)	0.3895
Minimum Clad Thickness (in.)	0.024
Maximum Pellet Diameter (in.)	0.3800 - Study
Minimum Guide Tube OD (in.)	1.108
Maximum Guide Tube ID (in.)	1.040
Minimum Guide Tube Thickness (in.)	0.034

1. Variably enriched fuel assemblies may have a maximum fuel rod enrichment of 4.21 wt % ^{235}U with a maximum planar average enrichment of 3.99 wt % ^{235}U.
2. Assemblies with less than 176 fuel rods or solid dummy rods are addressed after the determination of the most reactive dimensions.

Table 6.6.1-3 Maine Yankee Pellet Diameter Study

Diameter (inches)	k_{eff}	σ	$k_{eff}+2\sigma$
0.3800	0.95585	0.00085	0.95755
0.3779	0.95784	0.00080	0.95944
0.3758	0.95714	0.00085	0.95884
0.3737	0.95863	0.00082	0.96027
0.3716	0.95862	0.00084	0.96030
0.3695	0.95855	0.00083	0.96021
0.3674	0.95863	0.00085	0.96033
0.3653	0.95982	0.00084	0.96150
0.3632	0.95854	0.00088	0.96030
0.3611	0.95966	0.00083	0.96132
0.3590	0.95990	0.00084	0.96158
0.3569	0.96082	0.00082	0.96246
0.3548	0.96053	0.00083	0.96219
0.3527	0.96104	0.00082	0.96268
0.3506	0.95964	0.00087	0.96138
0.3485	0.95993	0.00086	0.96165
0.3464	0.95916	0.00084	0.96084
0.3443	0.95847	0.00083	0.96013
0.3422	0.95876	0.00083	0.96042
0.3401	0.95865	0.00081	0.96027
0.3380	0.95734	0.00084	0.95902

Table 6.6.1-4 Maine Yankee Annular Fuel Results

Case Description	k_{eff}	σ	$k_{eff}+2\sigma$
All pellets with a diameter of 0.3527 inches	0.90896	0.00083	0.91061
Annular pellet diameter changed to 0.3800 inches	0.91013	0.00087	0.91187

Table 6.6.1-5 Maine Yankee Removed Rod Results with Small Pellet Diameter

Number of Removed Rods	Number of Fuel Rods	k_{eff}	σ	$k_{eff} + 2\sigma$
4	172	0.91171	0.00088	0.91347
4	172	0.91292	0.00086	0.91464
4	172	0.91479	0.00081	0.91640
4	172	0.91125	0.00087	0.91299
6	170	0.91418	0.00087	0.91592
6	170	0.91264	0.00085	0.91435
6	170	0.91314	0.00086	0.91487
6	170	0.90322	0.00086	0.90493
8	168	0.91555	0.00087	0.91729
8	168	0.91490	0.00093	0.91676
8	168	0.91457	0.00088	0.91633
8	168	0.91590	0.00087	0.91764
8	168	0.89729	0.00088	0.89905
12	164	0.91654	0.00086	0.91827
12	164	0.91469	0.00085	0.91639
12	164	0.91149	0.00083	0.91315
16	160	0.91725	0.00084	0.91893
16	160	0.91567	0.00084	0.91735
16	160	0.90986	0.00088	0.91162
16	160	0.90849	0.00083	0.91015
16	160	0.90704	0.00086	0.90876
24	152	0.91572	0.00083	0.91739
32	144	0.91037	0.00088	0.91213
48	128	0.89385	0.00085	0.89554
48	128	0.84727	0.00079	0.84886
64	112	0.79602	0.00083	0.79768
96	80	0.69249	0.00077	0.69402
Westinghouse 17 × 17 OFA		0.9192	0.0009	0.9210

Table 6.6.1-6 Maine Yankee Removed Fuel Rod Results with Maximum Pellet Diameter

Number of Removed Rods	Number of Fuel Rods	k_{eff}	σ	$k_{eff} + 2\sigma$
4	172	0.91078	0.00086	0.91250
4	172	0.90916	0.00085	0.91085
4	172	0.91164	0.00087	0.91338
4	172	0.90809	0.00085	0.90979
6	170	0.91223	0.00085	0.91393
6	170	0.91223	0.00080	0.91384
6	170	0.91270	0.00086	0.91442
6	170	0.90245	0.00086	0.90416
6	170	0.89801	0.00086	0.89972
8	168	0.91567	0.00085	0.91736
8	168	0.91448	0.00085	0.91618
8	168	0.91355	0.00086	0.91526
8	168	0.91293	0.00085	0.91463
12	164	0.91639	0.00090	0.91818
12	164	0.91803	0.00086	0.91974
12	164	0.91235	0.00083	0.91401
16	160	0.91665	0.00091	0.91847
16	160	0.92136	0.00087	0.92310
16	160	0.91231	0.00084	0.91400
16	160	0.90883	0.00087	0.91057
24	152	0.92227	0.00087	0.92400
32	144	0.92164	0.00088	0.92340
48	128	0.91212	0.00081	0.91373
48	128	0.86308	0.00082	0.86472
64	112	0.81978	0.00080	0.82138
88	88	0.72087	0.00083	0.72247
24 (Four Corners)	152	0.91153	0.00085	0.91323
Westinghouse 17 × 17 OFA		0.9192	0.0009	0.9210

Table 6.6.1-7 Maine Yankee Fuel Rods in Guide Tube Results

Number of Guide Tubes with Rods	Number of Rods in Each	k_{eff}	σ	$k_{eff} + 2\sigma$
1	1	0.91102	0.00089	0.91280
2	1	0.91059	0.00088	0.91234
3	1	0.91172	0.00087	0.91346
5	1	0.91411	0.00086	0.91583
1	2	0.91169	0.00090	0.91349
2	2	0.91201	0.00087	0.91375
3	2	0.91173	0.00086	0.91344
5	2	0.91357	0.00086	0.91529
Design Basis Westinghouse 17 × 17 OFA		0.9192	0.0009	0.9210

Table 6.6.1-8 Maine Yankee Consolidated Fuel Empty Fuel Rod Position Results

Number of Empty Positions	Number of Fuel Rods	k_{eff}	σ	$k_{eff} + 2\sigma$
4	285	0.79684	0.00082	0.79848
9	280	0.80455	0.00081	0.80616
9	280	0.80812	0.00079	0.80970
13	276	0.81573	0.00083	0.81739
24	265	0.84187	0.00080	0.84347
25	264	0.84017	0.00083	0.84182
25	264	0.84634	0.00081	0.84795
25	264	0.84583	0.00083	0.84750
25	264	0.85524	0.00083	0.85690
25	264	0.83396	0.00081	0.83558
25	264	0.84625	0.00083	0.84790
27	262	0.85438	0.00083	0.85604
29	260	0.85179	0.00081	0.85340
31	258	0.85930	0.00084	0.86098
33	256	0.86407	0.00082	0.86571
35	254	0.86740	0.00082	0.86904
37	252	0.87372	0.00084	0.87541
45	244	0.88630	0.00081	0.88793
45	244	0.87687	0.00079	0.87844
52	237	0.90062	0.00083	0.90228
57	232	0.87975	0.00087	0.88149
61	258	0.89055	0.00083	0.89221
73	216	0.90967	0.00082	0.91131
84	205	0.93261	0.00091	0.93443
85	204	0.94326	0.00086	0.94499
113	176	0.95626	0.00084	0.95794
117	172	0.95373	0.00088	0.95549
119	170	0.95315	0.00085	0.95485
125	164	0.95020	0.00086	0.95192
141	148	0.94348	0.00086	0.94521
145	144	0.93868	0.00089	0.94047
113 (Four Corners)	176	0.91292	0.00087	0.91466
Design Basis Westinghouse 17 × 17 OFA		0.9192	0.0009	0.9210

Table 6.6.1-9 Fuel Can Infinite Height Model Results of Fuel - Water Mixture Between Rods

Volume Fraction of UO_2 in Water	k_{eff}	Δk_{eff} to 24 (Four Corners)[1]
0.000	0.91090	-0.00063
0.001	0.91138	-0.00015
0.002	0.91120	-0.00033
0.003	0.91177	0.00024
0.004	0.91285	0.00132
0.005	0.90908	-0.00245
0.006	0.91001	-0.00152
0.007	0.90895	-0.00258
0.008	0.91005	-0.00148
0.009	0.90986	-0.00167
0.010	0.90864	-0.00289
0.020	0.91003	-0.00150
0.030	0.90963	-0.00190
0.040	0.91063	-0.00090
0.050	0.90931	-0.00222
0.060	0.90765	-0.00388
0.070	0.90753	-0.00400
0.080	0.91088	-0.00065
0.090	0.91122	-0.00031
0.100	0.90879	-0.00274
0.150	0.90968	-0.00185
0.200	0.90952	-0.00201
0.250	0.90815	-0.00338
0.300	0.90748	-0.00405
0.350	0.90581	-0.00572
0.400	0.90963	-0.00190
0.450	0.90547	-0.00606
0.500	0.90603	-0.00550
0.550	0.90753	-0.00400
0.600	0.90674	-0.00479
0.650	0.90589	-0.00564
0.700	0.90594	-0.00559
0.750	0.90568	-0.00585
0.800	0.90532	-0.00621
0.850	0.90693	-0.00460
0.900	0.90639	-0.00514
0.950	0.90684	-0.00469
1.000	0.90677	-0.00476

Table 6.6.1-10 Fuel Can Finite Model Results of Fuel-Water Mixture Outside BORAL Coverage

Volume Fraction of UO_2 in Water	k_{eff}	Δk_{eff} to 0.00 UO_2 in Water	Δk_{eff} to 24 (Four Corners)[1]
0.00	0.91045[2]	NA	-0.00108
0.05	0.90781	-0.00264	-0.00372
0.10	0.90978	-0.00067	-0.00175
0.15	0.91048	0.00003	-0.00105
0.20	0.90916	-0.00129	-0.00237
0.25	0.90834	-0.00211	-0.00319
0.30	0.90935	-0.00110	-0.00218
0.35	0.90786	-0.00259	-0.00367
0.40	0.90892	-0.00153	-0.00261
0.45	0.91015	-0.00030	-0.00138
0.50	0.91011	-0.00034	-0.00142
0.55	0.91003	-0.00042	-0.00150
0.60	0.90874	-0.00171	-0.00279
0.65	0.91165	0.00120	0.00012
0.70	0.90977	-0.00068	-0.00176
0.75	0.90813	-0.00232	-0.00340
0.80	0.90909	-0.00136	-0.00244
0.85	0.91028	-0.00017	-0.00125
0.90	0.91061	0.00016	-0.00092
0.95	0.91129	0.00084	-0.00024
1.00	0.91076	0.00031	-0.00077

1. See Table 6.6.1-6.
2. $\sigma = 0.00084$.

Table 6.6.1-11 Fuel Can Finite Model Results of Replacing All Rods with Fuel-Water Mixture

Volume Fraction of UO_2 in Water	k_{eff}	Δk_{eff} to 24 (Four Corners) Finite Height Model[1]	Δk_{eff} to 24 (Four Corners) Infinite Height Model[2]
0	0.90071	-0.00974	-0.01082
5	0.90194	-0.00851	-0.00959
10	0.90584	-0.00461	-0.00569
15	0.90837	-0.00208	-0.00316
20	0.91008	-0.00037	-0.00145
25	0.91086	0.00041	-0.00067
30	0.90964	-0.00081	-0.00189
35	0.90828	-0.00217	-0.00325
40	0.90805	-0.00240	-0.00348
45	0.90730	-0.00315	-0.00423
50	0.90637	-0.00408	-0.00516
55	0.90672	-0.00373	-0.00481
60	0.90649	-0.00396	-0.00504
65	0.90632	-0.00413	-0.00521
70	0.90435	-0.00610	-0.00718
75	0.90792	-0.00253	-0.00361
80	0.90376	-0.00669	-0.00777
85	0.90528	-0.00517	-0.00625
90	0.90454	-0.00591	-0.00699
95	0.90360	-0.00685	-0.00793
100	0.90416	-0.00629	-0.00737

1. The k_{eff} comparison basis for this column is the finite height model with the four corner locations of the basket loaded with Maine Yankee assemblies in the most reactive missing rod geometry. This case is the first case presented in Table 6.6.1-10 with 0% UO_2 in the water above and below the active fuel of the missing rod array.
2. The k_{eff} comparison basis for this column is the infinite height model with the four corner locations of the basket loaded with Maine Yankee assemblies in the most reactive missing rod geometry, the case presented in Table 6.6.1-6 labeled "24 (Four Corners)", k_{eff} = 0.91153.

Table 6.6.1-12 Infinite Height Analysis of Maine Yankee Start-up Sources

Pu Vf	Be Vf	H_2O Vf	Void Vf	k_{eff}	sd	k_{eff}+2sd	Delta K*
0	0.5	0.5	0	0.91085	0.00087	0.91259	-0.00068
0.008	0.992	0	0	0.91034	0.00089	0.91212	-0.00119
0.008	0.9	0.092	0	0.91151	0.00087	0.91325	-0.00002
0.008	0.8	0.192	0	0.91138	0.00087	0.91312	-0.00015
0.008	0.7	0.292	0	0.91042	0.00085	0.91212	-0.00111
0.008	0.6	0.392	0	0.91231	0.00086	0.91403	0.00078
0.008	0.5	0.492	0	0.90922	0.00083	0.91088	-0.00231
0.008	0.4	0.592	0	0.91197	0.00087	0.91371	0.00044
0.008	0.3	0.692	0	0.91203	0.00086	0.91375	0.00050
0.008	0.2	0.792	0	0.90922	0.00084	0.91090	-0.00231
0.008	0.1	0.892	0	0.91140	0.00085	0.91310	-0.00013
0.008	0	0.992	0	0.91149	0.00086	0.91321	-0.00004
0.008	0.9	0	0.092	0.91075	0.00087	0.91249	-0.00078
0.008	0.8	0	0.192	0.91143	0.00091	0.91325	-0.00010
0.008	0.7	0	0.292	0.91182	0.00086	0.91354	0.00029
0.008	0.6	0	0.392	0.91072	0.00082	0.91236	-0.00081
0.008	0.5	0	0.492	0.90984	0.00085	0.91154	-0.00169
0.008	0.4	0	0.592	0.90982	0.00091	0.91164	-0.00171
0.008	0.3	0	0.692	0.91055	0.00087	0.91229	-0.00098
0.008	0.2	0	0.792	0.91054	0.00085	0.91224	-0.00099
0.008	0.1	0	0.892	0.91006	0.00088	0.91182	-0.00147
0.008	0	0	0.992	0.90957	0.00086	0.91129	-0.00196

*Change in reactivity from case "24 (Four Corners)" in Table 6.6.1-6.

6.7 References

1. Code of Federal Regulations, "Licensing Requirements for the Independent Storage of Spent Nuclear Fuel and High Level Radioactive Waste," Part 72, Title 10, January 1996.

2. Nuclear Regulatory Commission, "Standard Review Plan for Dry Cask Storage Systems," NUREG-1536, January 1997.

3. ORNL CCC-545, "SCALE 4.3: Modular Code System for Performing Standardized Computer Analyses for Licensing Evaluation for Workstations and Personal Computers," September 1995.

4. ORNL/NUREG/CSD-2/V1/R5, Section C4, "CSAS: Control Module For Enhanced Criticality Safety Analysis Sequences," Landers, N.F., and Petrie L.M., September 1995.

5. ORNL/NUREG/CSD-2/V2/R5, Section F11, "KENO-Va: An Improved Monte Carlo Criticality Program with Supergrouping," Landers, N.F., and Petrie L.M., September 1995.

6. ORNL/NUREG/CSD-2/V3/R5, Section M4, "Scale Cross-Section Libraries," Jordan, W.C., September 1995.

7. ORNL/NUREG/CSD-2/V3/R5, Section M7, "The Material Information Processor For Scale," Bucholz, J.A., Landers, N.F., and Petrie, L.M., September 1995.

8. ORNL/NUREG/CSD-2/V2/R5, Section F2, "BONAMI: Resonance Self-Shielding By The Bondarenko Method," Greene, M., September 1995.

9. ORNL/NUREG/CSD-2/V2/R5, "NITAWL-II: Scale System Module For Performing Resonance Shielding And Working Library Production" Westfall, R.M., Greene, M., and L.M. Petrie, September 1995.

10. Code of Federal Regulations, "Packaging and Transportation of Radioactive Materials," Part 71, Title 10, April 1996.

11. ANSI/ANS - 8.1-1983, "Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors," American Nuclear Society.

12. ANSI/ANS - 8.17-1984, "Criticality Safety Criteria for the Handling, Storage, and Transportation of LWR Fuel Outside Reactors," American Nuclear Society.

13. B&W-1484-7, "Critical Experiments Supporting Close Proximity Water Storage of Power Reactor Fuel," Baldwin, N.M, Hoovler, G.S., Eng, R.L., and Welfare, F.G., July 1979.

14. NUREG/CR-1547, "Criticality Experiments with Subcritical Clusters of 2.35 Wt % and 4.31 Wt % ^{235}U Enriched UO_2 Rods in Water at a Water-to-Fuel Volume Ratio of 1.6," Bierman, S.R., Clayton, E.D., July 1980.

15. Bierman, S.R., and E. D. Clayton, "Criticality Experiments with Subcritical Clusters of 2.35 Wt % and 4.31 Wt % ^{235}U Enriched UO_2 Rods in Water with Steel Reflecting Walls," Nuclear Technology, Volume 54, pp 131-144, August 1981.

16. NUREG/CR-0796, "Criticality Experiments with Subcritical Clusters of 2.35 Wt % and 4.31 Wt % ^{235}U Enriched UO_2 Rods in Water with Uranium or Lead Reflecting Walls," Bierman, S.R., Durst, B.M., and Clayton, E.D., April 1979.

17. Bierman, B.M., "Criticality Experiments to Provide Benchmark Data on Neutron Flux Traps," PNL-6205/UC-714, June 1988.

18. Manaranche, J.C. et al, "Dissolution and Storage Experiment with 4.75 Wt % U^{235} Enriched UO2 Rods," Nuclear Technology, Volume 50, September 1980.

19. Owen, D. B., "Factors for One-Sided Tolerance Limits and for Variables Sampling Plans," SCR-607, 1963.

20. Serco Assurance, "MCBEND, A Monte Carlo Program for General Radiation Transport Solutions, User Guide for Version 9," ANSWERS/MCBEND (94) 15, June 2000.

6.8 CSAS Inputs

The CSAS25 input files for the criticality analyses of the Universal Storage System standard transfer and concrete casks containing PWR or BWR fuel, under normal and accident conditions, are provided in Figures 6.8-1 through 6.8-8. A standard transfer cask PWR Westinghouse 17×17 OFA (we17b) input file containing soluble boron at 1000 ppm, with a fuel initial enrichment of 5.0 wt. % ^{235}U, is shown in Figure 6.8-9. A BWR standard transfer cask model input containing 56 Exxon/ANF 9×9 79-fuel rod assemblies (ex09c) at 4.4 wt. % ^{235}U is shown in Figure 6.8-10.

The CSAS25 input files refer to BORAL as the neutron absorber material. BORAL is a trade name for one of the neutron absorber materials used in the fuel tube design. As described in the license drawings in Chapter 1, either BORAL or METAMIC neutron absorber sheet may be used as a neutron absorber material. These materials are specified with the ^{10}B areal density appropriate to the PWR or BWR fuel tube design.

Figure 6.8-1 CSAS Input for Normal Conditions - Transfer Cask Containing PWR Fuel

```
=CSAS25
UMS PWR TFR; NORMAL OP; ARRAY; 1.0 GM/CC IN - 1.0 GM/CC EX; 250 CM PITCH
27GROUPNDF4 LATTICECELL
UO2  1  0.95 293.0 92235 4.20 92238 95.80 END
ZIRCALLOY   2  1.0  293.0  END
H2O  3  1.0  293.0  END
AL   4  1.0  293.0  END
SS304 5 1.0  293.0  END
AL     6 DEN=2.6000 0.4627 293.0 END
B-10   6 DEN=2.6000 0.0568 293.0 END
B-11   6 DEN=2.6000 0.3449 293.0 END
C      6 DEN=2.6000 0.1167 293.0 END
PB     7 1.0 293.0  END
B-10   8 0.0 8.553-5 293.0 END
B-11   8 0.0 3.422-4 293.0 END
AL     8 0.0 7.763-3 293.0 END
H      8 0.0 5.854-2 293.0 END
O      8 0.0 2.609-2 293.0 END
C      8 0.0 2.264-2 293.0 END
N      8 0.0 1.394-3 293.0 END
H2O   9 1.0 293.0 END
H2O  10 1.0 293.0 END
CARBONSTEEL 11 1.0 293.0 END
END COMP
SQUAREPITCH  1.2598 0.7844 1 3 0.9144 2 0.8001 0 END
UMS PWR TFR; NORMAL OP; ARRAY; 1.0 GM/CC IN - 1.0 GM/CC EX; 250 CM PITCH
READ PARAM RUN=YES PLT=NO TME=5000 GEN=203 NPG=1000 END PARAM
READ GEOM
UNIT  1
COM='FUEL PIN CELL - BETWEEN DISKS'
CYLINDER   1 1  0.3922    2P2.4892
CYLINDER   0 1  0.4001    2P2.4892
CYLINDER   2 1  0.4572    2P2.4892
CUBOID     3 1  4P0.6299 2P2.4892
UNIT  2
COM='WATER ROD CELL - BETWEEN DISKS'
CYLINDER  3 1  0.5715   2P2.4892
CYLINDER  2 1  0.6121   2P2.4892
CUBOID    3 1  4P0.6299 2P2.4892
UNIT  3
COM='FUEL PIN CELL - FOR DISK SLICE OF CASK'
CYLINDER   1 1  0.3922    2P0.6350
CYLINDER   0 1  0.4001    2P0.6350
CYLINDER   2 1  0.4572    2P0.6350
CUBOID     3 1  4P0.6299 2P0.6350
UNIT  4
COM='WATER ROD CELL - FOR DISK SLICE OF CASK'
CYLINDER  3 1  0.5715   2P0.6350
CYLINDER  2 1  0.6121   2P0.6350
CUBOID    3 1  4P0.6299 2P0.6350
UNIT 5
COM='X-X BORAL SHEET BETWEEN DISKS'
CUBOID 6 1 2P10.4140 2P0.0635 2P2.4892
CUBOID 4 1 2P10.4140 2P0.0951 2P2.4892
UNIT 6
COM='Y-Y BORAL SHEET BETWEEN DISKS'
CUBOID 6 1 2P0.0635 2P10.4140 2P2.4892
CUBOID 4 1 2P0.0951 2P10.4140 2P2.4892
UNIT 7
COM='X-X BORAL SHEET WITH DISKS'
CUBOID 6 1 2P10.4140 2P0.0635 2P0.6350
CUBOID 4 1 2P10.4140 2P0.0951 2P0.6350
UNIT 8
COM='Y-Y BORAL SHEET WITH DISKS'
CUBOID 6 1 2P0.0635 2P10.4140 2P0.6350
CUBOID 4 1 2P0.0951 2P10.4140 2P0.6350
UNIT 10
COM='TUBE CELL IN H2O BETWEEN DISKS (A)'
ARRAY  1  -10.7083 -10.7083 -2.4892
CUBOID 3 1 4P11.2141 2P2.4892
CUBOID 5 1 4P11.3355 2P2.4892
CUBOID 3 1 4P11.5260 2P2.4892
HOLE  5 0.0 +11.4308 0.0
HOLE  5 0.0 -11.4308 0.0
HOLE  6 +11.4308 0.0 0.0
HOLE  6  11.4308 0.0 0.0
CUBOID 5 1 4P11.5715 2P2.4892
CUBOID 3 1 +12.0176 -11.5715 +12.0176 -11.5715 2P2.4892
UNIT 11
COM='TUBE CELL IN H2O BETWEEN DISKS (B)'
ARRAY  1  -10.7083 -10.7083 -2.4892
CUBOID 3 1 4P11.2141 2P2.4892
CUBOID 5 1 4P11.3355 2P2.4892
CUBOID 3 1 4P11.5260 2P2.4892
HOLE  5 0.0 +11.4308 0.0
HOLE  5 0.0 -11.4308 0.0
HOLE  6 +11.4308 0.0 0.0
HOLE  6 -11.4308 0.0 0.0
```

Figure 6.8-1 (continued)

```
CUBOID 5 1 4P11.5715 2P2.4892
CUBOID 3 1 +11.5715 -12.0176 +12.0176 -11.5715 2P2.4892
UNIT 12
COM='TUBE CELL IN H2O BETWEEN DISKS (C)'
ARRAY  1  -10.7083 -10.7083 -2.4892
CUBOID 3 1 4P11.2141 2P2.4892
CUBOID 5 1 4P11.3355 2P2.4892
CUBOID 3 1 4P11.5260 2P2.4892
HOLE  5 0.0 +11.4308 0.0
HOLE  5 0.0 -11.4308 0.0
HOLE  6 +11.4308 0.0 0.0
HOLE  6 -11.4308 0.0 0.0
CUBOID 5 1 4P11.5715 2P2.4892
CUBOID 3 1 +11.5715 -12.0176 +11.5715 -12.0176 2P2.4892
UNIT 13
COM='TUBE CELL IN H2O BETWEEN DISKS (D)'
ARRAY  1  -10.7083 -10.7083 -2.4892
CUBOID 3 1 4P11.2141 2P2.4892
CUBOID 5 1 4P11.3355 2P2.4892
CUBOID 3 1 4P11.5260 2P2.4892
HOLE  5 0.0 +11.4308 0.0
HOLE  5 0.0 -11.4308 0.0
HOLE  6 +11.4308 0.0 0.0
HOLE  6 -11.4308 0.0 0.0
CUBOID 5 1 4P11.5715 2P2.4892
CUBOID 3 1 +12.0176 -11.5715 +11.5715 -12.0176 2P2.4892
UNIT 14
COM='WEB UNIT (1.5" WEB) - BETWEEN DISKS'
CUBOID 3 1  2P11.7946 2P1.8725 2P2.4892
UNIT 15
COM='WEB UNIT (1.0" WEB) - BETWEEN DISKS'
CUBOID 3 1  2P11.7946 2P1.2510 2P2.4892
UNIT 16
COM='WEB UNIT (0.875" WEB) - BETWEEN DISKS'
CUBOID 3 1  2P11.7946 2P1.0923 2P2.4892
UNIT 17
COM='6X1 FUEL TUBE STACK BETWEEN DISKS (-X)'
ARRAY 10 -11.7946 -77.3262 -2.4892
UNIT 18
COM='6X1 FUEL TUBE STACK BETWEEN DISKS (+X)'
ARRAY 11 -11.7946 -77.3262 -2.4892
UNIT 19
COM='2X1 FUEL TUBE STACK OF TUBES BETWEEN DISKS (-X)'
ARRAY 12 -11.7946 -25.4616 -2.4892
UNIT 20
COM='2X1 FUEL TUBE STACK OF TUBES BETWEEN DISKS (+X)'
ARRAY 13 -11.7946 -25.4616 -2.4892
UNIT 30
COM='TUBE CELL IN ST DISK (A)'
ARRAY  2 -10.7083 -10.7083 -0.6350
CUBOID 3 1 4P11.2141 2P0.6350
CUBOID 5 1 4P11.3355 2P0.6350
CUBOID 3 1 4P11.5260 2P0.6350
HOLE  7 0.0 +11.4308 0.0
HOLE  7 0.0 -11.4308 0.0
HOLE  8 +11.4308 0.0 0.0
HOLE  8 -11.4308 0.0 0.0
CUBOID 5 1 4P11.5715 2P0.6350
CUBOID 3 1 +12.0176 -11.5715 +12.0176 -11.5715 2P0.6350
UNIT 31
COM='TUBE CELL IN ST DISK (B)'
ARRAY  2 -10.7083 -10.7083 -0.6350
CUBOID 3 1 4P11.2141 2P0.6350
CUBOID 5 1 4P11.3355 2P0.6350
CUBOID 3 1 4P11.5260 2P0.6350
HOLE  7 0.0 +11.4308 0.0
HOLE  7 0.0 -11.4308 0.0
HOLE  8 +11.4308 0.0 0.0
HOLE  8 -11.4308 0.0 0.0
CUBOID 5 1 4P11.5715 2P0.6350
CUBOID 3 1 +11.5715 -12.0176 +12.0176 -11.5715 2P0.6350
UNIT 32
COM='TUBE CELL IN ST DISK (C)'
ARRAY  2 -10.7083 -10.7083 -0.6350
CUBOID 3 1 4P11.2141 2P0.6350
CUBOID 5 1 4P11.3355 2P0.6350
CUBOID 3 1 4P11.5260 2P0.6350
HOLE  7 0.0 +11.4308 0.0
HOLE  7 0.0 -11.4308 0.0
HOLE  8 +11.4308 0.0 0.0
HOLE  8 -11.4308 0.0 0.0
CUBOID 5 1 4P11.5715 2P0.6350
CUBOID 3 1 +11.5715 -12.0176 +11.5715 -12.0176 2P0.6350
UNIT 33
COM='TUBE CELL IN ST DISK (D)'
ARRAY  2 -10.7083 -10.7083 -0.6350
CUBOID 3 1 4P11.2141 2P0.6350
CUBOID 5 1 4P11.3355 2P0.6350
CUBOID 3 1 4P11.5260 2P0.6350
HOLE  7 0.0 +11.4308 0.0
HOLE  7 0.0 -11.4308 0.0
HOLE  8 +11.4308 0.0 0.0
HOLE  8 -11.4308 0.0 0.0
CUBOID 5 1 4P11.5715 2P0.6350
CUBOID 3 1 +12.0176 -11.5715 +11.5715 -12.0176 2P0.6350
UNIT 34
COM='WEB UNIT (1.5" WEB) - ST DISKS'
CUBOID 5 1  2P11.7946 2P1.8725 2P0.6350
```

Figure 6.8-1 (continued)

```
UNIT 35
COM='WEB UNIT (1.0" WEB) - ST DISKS'
CUBOID 5 1  2P11.7946 2P1.2510 2P0.6350
UNIT 36
COM='WEB UNIT (0.875" WEB) - ST DISKS'
CUBOID 5 1  2P11.7946 2P1.0923 2P0.6350
UNIT 37
COM='6x1 FUEL TUBE STACK ST DISK (-X)'
ARRAY 20 -11.7946 -77.3262 -0.6350
UNIT 38
COM='6x1 FUEL TUBE STACK ST DISK (+X)'
ARRAY 21 -11.7946 -77.3262 -0.6350
UNIT 39
COM='2X1 FUEL TUB STACK OF TUBES ST DISK (-X)'
ARRAY 22 -11.7946 -25.4616 -0.6350
UNIT 40
COM='2X1 FUEL TUB STACK OF TUBES ST DISK (+X)'
ARRAY 23 -11.7946 -25.4616 -0.6350
UNIT 50
COM='TUBE CELL IN AL DISK (A)'
ARRAY  2 -10.7083 -10.7083 -0.6350
CUBOID 3 1 4P11.2141 2P0.6350
CUBOID 5 1 4P11.3355 2P0.6350
CUBOID 3 1 4P11.5260 2P0.6350
HOLE  7 0.0 +11.4308 0.0
HOLE  7 0.0 -11.4308 0.0
HOLE  8 +11.4308 0.0 0.0
HOLE  8 -11.4308 0.0 0.0
CUBOID 5 1 4P11.5715 2P0.6350
CUBOID 3 1 +12.0176 -11.5715 +12.0176 -11.5715 2P0.6350
UNIT 51
COM='TUBE CELL IN AL DISK (B)'
ARRAY  2 -10.7083 -10.7083 -0.6350
CUBOID 3 1 4P11.2141 2P0.6350
CUBOID 5 1 4P11.3355 2P0.6350
CUBOID 3 1 4P11.5260 2P0.6350
HOLE  7 0.0 +11.4308 0.0
HOLE  7 0.0 -11.4308 0.0
HOLE  8 +11.4308 0.0 0.0
HOLE  8 -11.4308 0.0 0.0
CUBOID 5 1 4P11.5715 2P0.6350
CUBOID 3 1 +11.5715 -12.0176 +12.0176 -11.5715 2P0.6350
UNIT 52
COM='TUBE CELL IN AL DISK (C)'
ARRAY  2 -10.7083 -10.7083 -0.6350
CUBOID 3 1 4P11.2141 2P0.6350
CUBOID 5 1 4P11.3355 2P0.6350
CUBOID 3 1 4P11.5260 2P0.6350
HOLE  7 0.0 +11.4308 0.0
HOLE  7 0.0 -11.4308 0.0
HOLE  8 +11.4308 0.0 0.0
HOLE  8 -11.4308 0.0 0.0
CUBOID 5 1 4P11.5715 2P0.6350
CUBOID 3 1 +11.5715 -12.0176 +11.5715 -12.0176 2P0.6350
UNIT 53
COM='TUBE CELL IN AL DISK (D)'
ARRAY  2 -10.7083 -10.7083 -0.6350
CUBOID 3 1 4P11.2141 2P0.6350
CUBOID 5 1 4P11.3355 2P0.6350
CUBOID 3 1 4P11.5260 2P0.6350
HOLE  7 0.0 +11.4308 0.0
HOLE  7 0.0 -11.4308 0.0
HOLE  8 +11.4308 0.0 0.0
HOLE  8 -11.4308 0.0 0.0
CUBOID 5 1 4P11.5715 2P0.6350
CUBOID 3 1 +12.0176 -11.5715 +11.5715 -12.0176 2P0.6350
UNIT 54
COM='WEB UNIT (1.5" WEB) - AL DISKS'
CUBOID 4 1  2P11.7946 2P1.8725 2P0.6350
UNIT 55
COM='WEB UNIT (1.0" WEB) - AL DISKS'
CUBOID 4 1  2P11.7946 2P1.2510 2P0.6350
UNIT 56
COM='WEB UNIT (0.875" WEB) - AL DISKS'
CUBOID 4 1  2P11.7946 2P1.0923 2P0.6350
UNIT 57
COM='6X1 FUEL TUBE STACK AL DISK'
ARRAY 30 -11.7946 -77.3262 -0.6350
UNIT 58
COM='6X1 FUEL TUBE STACK AL DISK'
ARRAY 31 -11.7946 -77.3262 -0.6350
UNIT 59
COM='2X1 FUEL TUBE STACK OF TUBES AL DISK'
ARRAY 32 -11.7946 -25.4616 -0.6350
UNIT 60
COM='2X1 FUEL TUBE STACK OF TUBES AL DISK'
ARRAY 33 -11.7946 -25.4616 -0.6350
UNIT 70
COM='BASKET STRUCTURE IN TRANSFER CASK - WATER DISK'
CYLINDER 3 1 +83.5787 2P2.4892
HOLE 17  -13.6669 0.0 0.0
HOLE 18  +13.6669 0.0 0.0
HOLE 19  -39.7578 0.0 0.0
HOLE 20  +39.7578 0.0 0.0
HOLE 19  -65.5312 0.0 0.0
HOLE 20  +65.5312 0.0 0.0
HOLE 10  +40.8048 +40.8048 0.0
HOLE 11  -40.8048 +40.8048 0.0
```

Figure 6.8-1 (continued)

```
HOLE 12  -40.8048 -40.8048 0.0
HOLE 13  +40.8048 -40.8048 0.0
CYLINDER  5 1  +85.1662 2P2.4892
CYLINDER   9 1  +86.0425 2P2.4892
CYLINDER  11 1  +87.9475 2P2.4892
CYLINDER   7 1  +97.4725 2P2.4892
CYLINDER   8 1 +102.5525 2P2.4892
CYLINDER  11 1 +105.7275 2P2.4892
CUBOID     9 1 4P125.0   2P2.4892
UNIT 71
COM='BASKET STRUCTURE IN TRANSFER CASK - ST DISK'
CYLINDER  5 1 +83.1850 2P0.6350
HOLE 37  -13.6669 0.0 0.0
HOLE 38  +13.6669 0.0 0.0
HOLE 39  -39.7578 0.0 0.0
HOLE 40  +39.7578 0.0 0.0
HOLE 39  -65.5312 0.0 0.0
HOLE 40  +65.5312 0.0 0.0
HOLE 30  +40.8048 +40.8048 0.0
HOLE 31  -40.8048 +40.8048 0.0
HOLE 32  -40.8048 -40.8048 0.0
HOLE 33  +40.8048 -40.8048 0.0
CYLINDER  3 1  +83.5787 2P0.6350
CYLINDER  5 1  +85.1662 2P0.6350
CYLINDER   9 1  +86.0425 2P0.6350
CYLINDER  11 1  +87.9475 2P0.6350
CYLINDER   7 1  +97.4725 2P0.6350
CYLINDER   8 1 +102.5525 2P0.6350
CYLINDER  11 1 +105.7275 2P0.6350
CUBOID     9 1 4P125.0   2P0.6350
UNIT 72
COM='BASKET STRUCTURE IN TRANSFER CASK - AL DISK'
CYLINDER  4 1 +82.8675 2P0.6350
HOLE 57  -13.6669 0.0 0.0
HOLE 58  +13.6669 0.0 0.0
HOLE 59  -39.7578 0.0 0.0
HOLE 60  +39.7578 0.0 0.0
HOLE 59  -65.5312 0.0 0.0
HOLE 60  +65.5312 0.0 0.0
HOLE 50  +40.8048 +40.8048 0.0
HOLE 51  -40.8048 +40.8048 0.0
HOLE 52  -40.8048 -40.8048 0.0
HOLE 53  +40.8048 -40.8048 0.0
CYLINDER  3 1  +83.5787 2P0.6350
CYLINDER  5 1  +85.1662 2P0.6350
CYLINDER   9 1  +86.0425 2P0.6350
CYLINDER  11 1  +87.9475 2P0.6350
CYLINDER   7 1  +97.4725 2P0.6350
CYLINDER   8 1 +102.5525 2P0.6350
CYLINDER  11 1 +105.7275 2P0.6350
CUBOID     9 1 4P125.0   2P0.6350
GLOBAL UNIT 73
COM='DISK SLICE STACK'
ARRAY  40 -125.0 -125.0 0.0
END GEOM
READ ARRAY
ARA=1   NUX=17 NUY=17 NUZ=1  FILL
                         34R1
          5R1   2   2R1   2   2R1   2   5R1
               3R1   2   9R1   2   3R1
                         17R1
2R1   2   2R1   2   2R1   2   2R1   2   2R1   2   2R1
                         34R1
2R1   2   2R1   2   2R1   2   2R1   2   2R1   2   2R1
                         34R1
2R1   2   2R1   2   2R1   2   2R1   2   2R1   2   2R1
                         17R1
               3R1   2   9R1   2   3R1
          5R1   2   2R1   2   2R1   2   5R1
                         34R1
END FILL
ARA=2  NUX=17 NUY=17 NUZ=1  FILL
                         34R3
          5R3   4   2R3   4   2R3   4   5R3
               3R3   4   9R3   4   3R3
                         17R3
2R3   4   2R3   4   2R3   4   2R3   4   2R3   4   2R3
                         34R3
2R3   4   2R3   4   2R3   4   2R3   4   2R3   4   2R3
                         34R3
2R3   4   2R3   4   2R3   4   2R3   4   2R3   4   2R3
                         17R3
               3R3   4   9R3   4   3R3
          5R3   4   2R3   4   2R3   4   5R3
                         34R3
END FILL
ARA=10 NUX=1 NUY=11 NUZ=1 FILL 12 16 12 15 12 14 11 15 11 16 11 END FILL
ARA=11 NUX=1 NUY=11 NUZ=1 FILL 13 16 13 15 13 14 10 15 10 16 10 END FILL
ARA=12 NUX=1 NUY=3  NUZ=1 FILL 12 14 11 END FILL
ARA=13 NUX=1 NUY=3  NUZ=1 FILL 13 14 10 END FILL
ARA=20 NUX=1 NUY=11 NUZ=1 FILL 32 36 32 35 32 34 31 35 31 36 31 END FILL
ARA=21 NUX=1 NUY=11 NUZ=1 FILL 33 36 33 35 33 34 30 35 30 36 30 END FILL
ARA=22 NUX=1 NUY=3  NUZ=1 FILL 32 34 31 END FILL
ARA=23 NUX=1 NUY=3  NUZ=1 FILL 33 34 30 END FILL
ARA=30 NUX=1 NUY=11 NUZ=1 FILL 52 56 52 55 52 54 51 55 51 56 51 END FILL
ARA=31 NUX=1 NUY=11 NUZ=1 FILL 53 56 53 55 53 54 50 55 50 56 50 END FILL
ARA=32 NUX=1 NUY=3  NUZ=1 FILL 52 54 51 END FILL
ARA=33 NUX=1 NUY=3  NUZ=1 FILL 53 54 50 END FILL
```

Figure 6.8-1 (continued)

```
ARA=40 NUX=1 NUY=1 NUZ=4 FILL 70 71 70 72 END FILL
END ARRAY
READ BOUNDS ZFC=PER YXF=MIRROR END BOUNDS
END DATA
END

SECONDARY MODULE 000008    HAS BEEN CALLED.
```

Figure 6.8-2 CSAS Input Accident Conditions– Transfer Cask Containing PWR Fuel

```
=CSAS25
UMS PWR TFR; ACCIDENT; ARRAY; 1.0 GM/CC IN - 1.0 GM/CC EX; 250 CM PITCH
27GROUPNDF4 LATTICECELL
UO2  1  0.95 293.0 92235 4.20 92238 95.80 END
ZIRCALLOY   2  1.0  293.0  END
H2O  3  1.0  293.0  END
AL   4  1.0  293.0  END
SS304 5 1.0  293.0  END
AL     6 DEN=2.6000 0.4627 293.0 END
B-10   6 DEN=2.6000 0.0568 293.0 END
B-11   6 DEN=2.6000 0.3449 293.0 END
C      6 DEN=2.6000 0.1167 293.0 END
PB     7 1.0 293.0  END
B-10   8 0.0 8.553-5 293.0 END
B-11   8 0.0 3.422-4 293.0 END
AL     8 0.0 7.763-3 293.0 END
H      8 0.0 5.854-2 293.0 END
O      8 0.0 2.609-2 293.0 END
C      8 0.0 2.264-2 293.0 END
N      8 0.0 1.394-3 293.0 END
H2O    9 1.0 293.0 END
H2O   10 1.0 293.0 END
CARBONSTEEL 11 1.0 293.0 END
END COMP
SQUAREPITCH  1.2598 0.7844 1 3 0.9144 2 0.8001 10 END
UMS PWR TFR; ACCIDENT; ARRAY; 1.0 GM/CC IN - 1.0 GM/CC EX; 250 CM PITCH
READ PARAM RUN=YES PLT=NO TME=5000 GEN=803 NPG=1000 END PARAM
READ GEOM
UNIT  1
COM='FUEL PIN CELL - BETWEEN DISKS'
CYLINDER   1 1  0.3922    2P2.4892
CYLINDER  10 1  0.4001    2P2.4892
CYLINDER   2 1  0.4572    2P2.4892
CUBOID     3 1  4P0.6299 2P2.4892
UNIT  2
COM='WATER ROD CELL - BETWEEN DISKS'
CYLINDER  3 1  0.5715   2P2.4892
CYLINDER  2 1  0.6121   2P2.4892
CUBOID    3 1  4P0.6299 2P2.4892
UNIT  3
COM='FUEL PIN CELL - FOR DISK SLICE OF CASK'
CYLINDER   1 1  0.3922    2P0.6350
CYLINDER  10 1  0.4001    2P0.6350
CYLINDER   2 1  0.4572    2P0.6350
CUBOID     3 1  4P0.6299 2P0.6350
UNIT  4
COM='WATER ROD CELL - FOR DISK SLICE OF CASK'
CYLINDER  3 1  0.5715   2P0.6350
CYLINDER  2 1  0.6121   2P0.6350
CUBOID    3 1  4P0.6299 2P0.6350
UNIT 5
COM='X-X BORAL SHEET BETWEEN DISKS'
CUBOID 6 1 2P10.4140 2P0.0635 2P2.4892
CUBOID 4 1 2P10.4140 2P0.0951 2P2.4892
UNIT 6
COM='Y-Y BORAL SHEET BETWEEN DISKS'
CUBOID 6 1 2P0.0635 2P10.4140 2P2.4892
CUBOID 4 1 2P0.0951 2P10.4140 2P2.4892
UNIT 7
COM='X-X BORAL SHEET WITH DISKS'
CUBOID 6 1 2P10.4140 2P0.0635 2P0.6350
CUBOID 4 1 2P10.4140 2P0.0951 2P0.6350
UNIT 8
COM='Y-Y BORAL SHEET WITH DISKS'
CUBOID 6 1 2P0.0635 2P10.4140 2P0.6350
CUBOID 4 1 2P0.0951 2P10.4140 2P0.6350
UNIT 10
COM='TUBE CELL IN H2O BETWEEN DISKS (A)'
ARRAY  1  -10.7083 -10.7083 -2.4892
CUBOID 3 1 4P11.2141 2P2.4892
CUBOID 5 1 4P11.3355 2P2.4892
CUBOID 3 1 4P11.5260 2P2.4892
HOLE  5 0.0 +11.4308 0.0
HOLE  5 0.0 -11.4308 0.0
HOLE  6 +11.4308 0.0 0.0
HOLE  6 -11.4308 0.0 0.0
CUBOID 5 1 4P11.5715 2P2.4892
CUBOID 3 1 +12.0176 -11.5715 +12.0176 -11.5715 2P2.4892
UNIT 11
COM='TUBE CELL IN H2O BETWEEN DISKS (B)'
ARRAY  1  -10.7083 -10.7083 -2.4892
CUBOID 3 1 4P11.2141 2P2.4892
CUBOID 5 1 4P11.3355 2P2.4892
CUBOID 3 1 4P11.5260 2P2.4892
HOLE  5 0.0 +11.4308 0.0
HOLE  5 0.0 -11.4308 0.0
HOLE  6 +11.4308 0.0 0.0
HOLE  6 -11.4308 0.0 0.0
CUBOID 5 1 4P11.5715 2P2.4892
```

Figure 6.8-2 (continued)

```
CUBOID 3 1 +11.5715 -12.0176 +12.0176 -11.5715 2P2.4892
UNIT 12
COM='TUBE CELL IN H2O BETWEEN DISKS (C)'
ARRAY 1  -10.7083 -10.7083 -2.4892
CUBOID 3 1 4P11.2141 2P2.4892
CUBOID 5 1 4P11.3355 2P2.4892
CUBOID 3 1 4P11.5260 2P2.4892
HOLE  5 0.0 +11.4308 0.0
HOLE  5 0.0 -11.4308 0.0
HOLE  6 +11.4308 0.0 0.0
HOLE  6 -11.4308 0.0 0.0
CUBOID 5 1 4P11.5715 2P2.4892
CUBOID 3 1 +11.5715 -12.0176 +11.5715 -12.0176 2P2.4892
UNIT 13
COM='TUBE CELL IN H2O BETWEEN DISKS (D)'
ARRAY 1  -10.7083 -10.7083 -2.4892
CUBOID 3 1 4P11.2141 2P2.4892
CUBOID 5 1 4P11.3355 2P2.4892
CUBOID 3 1 4P11.5260 2P2.4892
HOLE  5 0.0 +11.4308 0.0
HOLE  5 0.0 -11.4308 0.0
HOLE  6 +11.4308 0.0 0.0
HOLE  6 -11.4308 0.0 0.0
CUBOID 5 1 4P11.5715 2P2.4892
CUBOID 3 1 +12.0176 -11.5715 +11.5715 -12.0176 2P2.4892
UNIT 14
COM='WEB UNIT (1.5" WEB) - BETWEEN DISKS'
CUBOID 3 1  2P11.7946 2P1.8725 2P2.4892
UNIT 15
COM='WEB UNIT (1.0" WEB) - BETWEEN DISKS'
CUBOID 3 1  2P11.7946 2P1.2510 2P2.4892
UNIT 16
COM='WEB UNIT (0.875" WEB) - BETWEEN DISKS'
CUBOID 3 1  2P11.7946 2P1.0923 2P2.4892
UNIT 17
COM='6X1 FUEL TUBE STACK BETWEEN DISKS (-X)'
ARRAY 10 -11.7946 -77.3262 -2.4892
UNIT 18
COM='6X1 FUEL TUBE STACK BETWEEN DISKS (+X)'
ARRAY 11 -11.7946 -77.3262 -2.4892
UNIT 19
COM='2X1 FUEL TUBE STACK OF TUBES BETWEEN DISKS (-X)'
ARRAY 12 -11.7946 -25.4616 -2.4892
UNIT 20
COM='2X1 FUEL TUBE STACK OF TUBES BETWEEN DISKS (+X)'
ARRAY 13 -11.7946 -25.4616 -2.4892
UNIT 30
COM='TUBE CELL IN ST DISK (A)'
ARRAY  2 -10.7083 -10.7083 -0.6350
CUBOID 3 1 4P11.2141 2P0.6350
CUBOID 5 1 4P11.3355 2P0.6350
CUBOID 3 1 4P11.5260 2P0.6350
HOLE  7 0.0 +11.4308 0.0
HOLE  7 0.0 -11.4308 0.0
HOLE  8 +11.4308 0.0 0.0
HOLE  8 -11.4308 0.0 0.0
CUBOID 5 1 4P11.5715 2P0.6350
CUBOID 3 1 +12.0176 -11.5715 +12.0176 -11.5715 2P0.6350
UNIT 31
COM='TUBE CELL IN ST DISK (B)'
ARRAY  2 -10.7083 -10.7083 -0.6350
CUBOID 3 1 4P11.2141 2P0.6350
CUBOID 5 1 4P11.3355 2P0.6350
CUBOID 3 1 4P11.5260 2P0.6350
HOLE  7 0.0 +11.4308 0.0
HOLE  7 0.0 -11.4308 0.0
HOLE  8 +11.4308 0.0 0.0
HOLE  8 -11.4308 0.0 0.0
CUBOID 5 1 4P11.5715 2P0.6350
CUBOID 3 1 +11.5715 -12.0176 +12.0176 -11.5715 2P0.6350
UNIT 32
COM='TUBE CELL IN ST DISK (C)'
ARRAY  2 -10.7083 -10.7083 -0.6350
CUBOID 3 1 4P11.2141 2P0.6350
CUBOID 5 1 4P11.3355 2P0.6350
CUBOID 3 1 4P11.5260 2P0.6350
HOLE  7 0.0 +11.4308 0.0
HOLE  7 0.0 -11.4308 0.0
HOLE  8 +11.4308 0.0 0.0
HOLE  8 -11.4308 0.0 0.0
CUBOID 5 1 4P11.5715 2P0.6350
CUBOID 3 1 +11.5715 -12.0176 +11.5715 -12.0176 2P0.6350
UNIT 33
COM='TUBE CELL IN ST DISK (D)'
ARRAY  2 -10.7083 -10.7083 -0.6350
CUBOID 3 1 4P11.2141 2P0.6350
CUBOID 5 1 4P11.3355 2P0.6350
CUBOID 3 1 4P11.5260 2P0.6350
HOLE  7 0.0 +11.4308 0.0
HOLE  7 0.0 -11.4308 0.0
HOLE  8 +11.4308 0.0 0.0
HOLE  8 -11.4308 0.0 0.0
CUBOID 5 1 4P11.5715 2P0.6350
CUBOID 3 1 +12.0176 -11.5715 +11.5715 -12.0176 2P0.6350
UNIT 34
COM='WEB UNIT (1.5" WEB) - ST DISKS'
CUBOID 5 1  2P11.7946 2P1.8725 2P0.6350
UNIT 35
```

Figure 6.8-2 (continued)

```
COM='WEB UNIT (1.0" WEB) - ST DISKS'
CUBOID 5 1  2P11.7946 2P1.2510 2P0.6350
UNIT 36
COM='WEB UNIT (0.875" WEB) - ST DISKS'
CUBOID 5 1  2P11.7946 2P1.0923 2P0.6350
UNIT 37
COM='6x1 FUEL TUBE STACK ST DISK (-X)'
ARRAY 20 -11.7946 -77.3262 -0.6350
UNIT 38
COM='6x1 FUEL TUBE STACK ST DISK (+X)'
ARRAY 21 -11.7946 -77.3262 -0.6350
UNIT 39
COM='2X1 FUEL TUB STACK OF TUBES ST DISK (-X)'
ARRAY 22 -11.7946 -25.4616 -0.6350
UNIT 40
COM='2X1 FUEL TUB STACK OF TUBES ST DISK (+X)'
ARRAY 23 -11.7946 -25.4616 -0.6350
UNIT 50
COM='TUBE CELL IN AL DISK (A)'
ARRAY  2 -10.7083 -10.7083 -0.6350
CUBOID 3 1 4P11.2141 2P0.6350
CUBOID 5 1 4P11.3355 2P0.6350
CUBOID 3 1 4P11.5260 2P0.6350
HOLE  7 0.0 +11.4308 0.0
HOLE  7 0.0 -11.4308 0.0
HOLE  8 +11.4308 0.0 0.0
HOLE  8 -11.4308 0.0 0.0
CUBOID 5 1 4P11.5715 2P0.6350
CUBOID 3 1 +12.0176 -11.5715 +12.0176 -11.5715 2P0.6350
UNIT 51
COM='TUBE CELL IN AL DISK (B)'
ARRAY  2 -10.7083 -10.7083 -0.6350
CUBOID 3 1 4P11.2141 2P0.6350
CUBOID 5 1 4P11.3355 2P0.6350
CUBOID 3 1 4P11.5260 2P0.6350
HOLE  7 0.0 +11.4308 0.0
HOLE  7 0.0 -11.4308 0.0
HOLE  8 +11.4308 0.0 0.0
HOLE  8 -11.4308 0.0 0.0
CUBOID 5 1 4P11.5715 2P0.6350
CUBOID 3 1 +11.5715 -12.0176 +12.0176 -11.5715 2P0.6350
UNIT 52
COM='TUBE CELL IN AL DISK (C)'
ARRAY  2 -10.7083 -10.7083 -0.6350
CUBOID 3 1 4P11.2141 2P0.6350
CUBOID 5 1 4P11.3355 2P0.6350
CUBOID 3 1 4P11.5260 2P0.6350
HOLE  7 0.0 +11.4308 0.0
HOLE  7 0.0 -11.4308 0.0
HOLE  8 +11.4308 0.0 0.0
HOLE  8 -11.4308 0.0 0.0
CUBOID 5 1 4P11.5715 2P0.6350
CUBOID 3 1 +11.5715 -12.0176 +11.5715 -12.0176 2P0.6350
UNIT 53
COM='TUBE CELL IN AL DISK (D)'
ARRAY  2 -10.7083 -10.7083 -0.6350
CUBOID 3 1 4P11.2141 2P0.6350
CUBOID 5 1 4P11.3355 2P0.6350
CUBOID 3 1 4P11.5260 2P0.6350
HOLE  7 0.0 +11.4308 0.0
HOLE  7 0.0 -11.4308 0.0
HOLE  8 +11.4308 0.0 0.0
HOLE  8 -11.4308 0.0 0.0
CUBOID 5 1 4P11.5715 2P0.6350
CUBOID 3 1 +12.0176 -11.5715 +11.5715 -12.0176 2P0.6350
UNIT 54
COM='WEB UNIT (1.5" WEB) - AL DISKS'
CUBOID 4 1  2P11.7946 2P1.8725 2P0.6350
UNIT 55
COM='WEB UNIT (1.0" WEB) - AL DISKS'
CUBOID 4 1  2P11.7946 2P1.2510 2P0.6350
UNIT 56
COM='WEB UNIT (0.875" WEB) - AL DISKS'
CUBOID 4 1  2P11.7946 2P1.0923 2P0.6350
UNIT 57
COM='6X1 FUEL TUBE STACK AL DISK'
ARRAY 30 -11.7946 -77.3262 -0.6350
UNIT 58
COM='6X1 FUEL TUBE STACK AL DISK'
ARRAY 31 -11.7946 -77.3262 -0.6350
UNIT 59
COM='2X1 FUEL TUBE STACK OF TUBES AL DISK'
ARRAY 32 -11.7946 -25.4616 -0.6350
UNIT 60
COM='2X1 FUEL TUBE STACK OF TUBES AL DISK'
ARRAY 33 -11.7946 -25.4616 -0.6350
UNIT 70
COM='BASKET STRUCTURE IN TRANSFER CASK - WATER DISK
CYLINDER 3 1 +83.5787 2P2.4892
HOLE 17  -13.6669 0.0 0.0
HOLE 18  +13.6669 0.0 0.0
HOLE 19  -39.7578 0.0 0.0
HOLE 20  +39.7578 0.0 0.0
HOLE 19  -65.5312 0.0 0.0
HOLE 20  +65.5312 0.0 0.0
HOLE 10  +40.8048 +40.8048 0.0
HOLE 11  -40.8048 +40.8048 0.0
HOLE 12  -40.8048 -40.8048 0.0
```

Figure 6.8-2 (continued)

```
HOLE 13  +40.8048 -40.8048 0.0
CYLINDER  5 1  +85.1662 2P2.4892
CYLINDER   9 1  +86.0425 2P2.4892
CYLINDER  11 1  +87.9475 2P2.4892
CYLINDER   7 1  +97.4725 2P2.4892
CYLINDER   8 1 +102.5525 2P2.4892
CYLINDER  11 1 +105.7275 2P2.4892
CUBOID     9 1 4P125.0   2P2.4892
UNIT 71
COM='BASKET STRUCTURE IN TRANSFER CASK - ST DISK'
CYLINDER  5 1 +83.1850 2P0.6350
HOLE 37  -13.6669 0.0 0.0
HOLE 38  +13.6669 0.0 0.0
HOLE 39  -39.7578 0.0 0.0
HOLE 40  +39.7578 0.0 0.0
HOLE 39  -65.5312 0.0 0.0
HOLE 40  +65.5312 0.0 0.0
HOLE 30  +40.8048 +40.8048 0.0
HOLE 31  -40.8048 +40.8048 0.0
HOLE 32  -40.8048 -40.8048 0.0
HOLE 33  +40.8048 -40.8048 0.0
CYLINDER  3 1  +83.5787 2P0.6350
CYLINDER  5 1  +85.1662 2P0.6350
CYLINDER   9 1  +86.0425 2P0.6350
CYLINDER  11 1  +87.9475 2P0.6350
CYLINDER   7 1  +97.4725 2P0.6350
CYLINDER   8 1 +102.5525 2P0.6350
CYLINDER  11 1 +105.7275 2P0.6350
CUBOID     9 1 4P125.0   2P0.6350
UNIT 72
COM='BASKET STRUCTURE IN TRANSFER CASK - AL DISK'
CYLINDER  4 1 +82.8675 2P0.6350
HOLE 57  -13.6669 0.0 0.0
HOLE 58  +13.6669 0.0 0.0
HOLE 59  -39.7578 0.0 0.0
HOLE 60  +39.7578 0.0 0.0
HOLE 59  -65.5312 0.0 0.0
HOLE 60  +65.5312 0.0 0.0
HOLE 50  +40.8048 +40.8048 0.0
HOLE 51  -40.8048 +40.8048 0.0
HOLE 52  -40.8048 -40.8048 0.0
HOLE 53  +40.8048 -40.8048 0.0
CYLINDER  3 1  +83.5787 2P0.6350
CYLINDER  5 1  +85.1662 2P0.6350
CYLINDER   9 1  +86.0425 2P0.6350
CYLINDER  11 1  +87.9475 2P0.6350
CYLINDER   7 1  +97.4725 2P0.6350
CYLINDER   8 1 +102.5525 2P0.6350
CYLINDER  11 1 +105.7275 2P0.6350
CUBOID     9 1 4P125.0   2P0.6350
GLOBAL UNIT 73
COM='DISK SLICE STACK'
ARRAY  40 -125.0 -125.0 0.0
END GEOM
READ ARRAY
ARA=1    NUX=17 NUY=17 NUZ=1  FILL
                        34R1
          5R1   2   2R1   2   2R1   2   5R1
               3R1   2   9R1   2   3R1
                        17R1
2R1   2   2R1   2   2R1   2   2R1   2   2R1   2   2R1
                        34R1
2R1   2   2R1   2   2R1   2   2R1   2   2R1   2   2R1
                        34R1
2R1   2   2R1   2   2R1   2   2R1   2   2R1   2   2R1
                        17R1
               3R1   2   9R1   2   3R1
          5R1   2   2R1   2   2R1   2   5R1
                        34R1
END FILL
ARA=2  NUX=17 NUY=17 NUZ=1  FILL
                        34R3
          5R3   4   2R3   4   2R3   4   5R3
               3R3   4   9R3   4   3R3
                        17R3
2R3   4   2R3   4   2R3   4   2R3   4   2R3   4   2R3
                        34R3
2R3   4   2R3   4   2R3   4   2R3   4   2R3   4   2R3
                        34R3
2R3   4   2R3   4   2R3   4   2R3   4   2R3   4   2R3
                        17R3
               3R3   4   9R3   4   3R3
          5R3   4   2R3   4   2R3   4   5R3
                        34R3
END FILL
ARA=10 NUX=1 NUY=11 NUZ=1 FILL 12 16 12 15 12 14 11 15 11 16 11 END FILL
ARA=11 NUX=1 NUY=11 NUZ=1 FILL 13 16 13 15 13 14 10 15 10 16 10 END FILL
ARA=12 NUX=1 NUY=3  NUZ=1 FILL 12 14 11 END FILL
ARA=13 NUX=1 NUY=3  NUZ=1 FILL 13 14 10 END FILL
ARA=20 NUX=1 NUY=11 NUZ=1 FILL 32 36 32 35 32 34 31 35 31 36 31 END FILL
ARA=21 NUX=1 NUY=11 NUZ=1 FILL 33 36 33 35 33 34 30 35 30 36 30 END FILL
ARA=22 NUX=1 NUY=3  NUZ=1 FILL 32 34 31 END FILL
ARA=23 NUX=1 NUY=3  NUZ=1 FILL 33 34 30 END FILL
ARA=30 NUX=1 NUY=11 NUZ=1 FILL 52 56 52 55 52 54 51 55 51 56 51 END FILL
ARA=31 NUX=1 NUY=11 NUZ=1 FILL 53 56 53 55 53 54 50 55 50 56 50 END FILL
ARA=32 NUX=1 NUY=3  NUZ=1 FILL 52 54 51 END FILL
ARA=33 NUX=1 NUY=3  NUZ=1 FILL 53 54 50 END FILL
ARA=40 NUX=1 NUY=1 NUZ=4 FILL 70 71 70 72 END FILL
```

Figure 6.8-2 (continued)

```
END ARRAY
READ BOUNDS ZFC=PER YXF=MIRROR END BOUNDS
END DATA
END
```

Figure 6.8-3 CSAS Input for Normal Conditions–Vertical Concrete Cask Containing PWR Fuel

```
=CSAS25
UMS PWR SC; NORMAL OP; ARRAY; 0.0001 GM/CC IN - 0.0001 GM/CC EX; 460 CM PITCH
27GROUPNDF4 LATTICECELL
UO2  1  0.95 293.0 92235 4.20 92238 95.80 END
ZIRCALLOY   2  1.0  293.0  END
H2O  3  0.0001  293.0  END
AL   4  1.0  293.0  END
SS304 5 1.0  293.0  END
AL     6 DEN=2.6000 0.4627 293.0 END
B-10   6 DEN=2.6000 0.0568 293.0 END
B-11   6 DEN=2.6000 0.3449 293.0 END
C      6 DEN=2.6000 0.1167 293.0 END
CARBONSTEEL  7 1.0     293.0  END
REG-CONCRETE 8 0.9750 293.0 END
H2O   9 0.0001 293.0 END
H2O  10 0.0001 293.0 END
END COMP
SQUAREPITCH  1.2598 0.7844 1 3 0.9144 2 0.8001 0 END
UMS PWR SC; NORMAL OP; ARRAY; 0.0001 GM/CC IN - 0.0001 GM/CC EX; 460 CM PITCH
READ PARAM RUN=YES PLT=NO TME=5000 GEN=203 NPG=1000 END PARAM
READ GEOM
UNIT  1
COM='FUEL PIN CELL - BETWEEN DISKS'
CYLINDER   1 1  0.3922    2P2.4892
CYLINDER   0 1  0.4001    2P2.4892
CYLINDER   2 1  0.4572    2P2.4892
CUBOID     3 1  4P0.6299 2P2.4892
UNIT  2
COM='WATER ROD CELL - BETWEEN DISKS'
CYLINDER  3 1  0.5715    2P2.4892
CYLINDER  2 1  0.6121    2P2.4892
CUBOID    3 1  4P0.6299 2P2.4892
UNIT  3
COM='FUEL PIN CELL - FOR DISK SLICE OF CASK'
CYLINDER   1 1  0.3922    2P0.6350
CYLINDER   0 1  0.4001    2P0.6350
CYLINDER   2 1  0.4572    2P0.6350
CUBOID     3 1  4P0.6299 2P0.6350
UNIT  4
COM='WATER ROD CELL - FOR DISK SLICE OF CASK'
CYLINDER  3 1  0.5715    2P0.6350
CYLINDER  2 1  0.6121    2P0.6350
CUBOID    3 1  4P0.6299 2P0.6350
UNIT 5
COM='X-X BORAL SHEET BETWEEN DISKS'
CUBOID 6 1 2P10.4140 2P0.0635 2P2.4892
CUBOID 4 1 2P10.4140 2P0.0951 2P2.4892
UNIT 6
COM='Y-Y BORAL SHEET BETWEEN DISKS'
CUBOID 6 1 2P0.0635 2P10.4140 2P2.4892
CUBOID 4 1 2P0.0951 2P10.4140 2P2.4892
UNIT 7
COM='X-X BORAL SHEET WITH DISKS'
CUBOID 6 1 2P10.4140 2P0.0635 2P0.6350
CUBOID 4 1 2P10.4140 2P0.0951 2P0.6350
UNIT 8
COM='Y-Y BORAL SHEET WITH DISKS'
CUBOID 6 1 2P0.0635 2P10.4140 2P0.6350
CUBOID 4 1 2P0.0951 2P10.4140 2P0.6350
UNIT 10
COM='TUBE CELL IN H2O BETWEEN DISKS (A)'
ARRAY  1  -10.7083 -10.7083 -2.4892
CUBOID 3 1 4P11.2141 2P2.4892
CUBOID 5 1 4P11.3355 2P2.4892
CUBOID 3 1 4P11.5260 2P2.4892
HOLE  5 0.0 +11.4308 0.0
HOLE  5 0.0 -11.4308 0.0
HOLE  6 +11.4308 0.0 0.0
HOLE  6 -11.4308 0.0 0.0
CUBOID 5 1 4P11.5715 2P2.4892
CUBOID 3 1 +12.0176 -11.5715 +12.0176 -11.5715 2P2.4892
UNIT 11
COM='TUBE CELL IN H2O BETWEEN DISKS (B)'
ARRAY  1  -10.7083 -10.7083 -2.4892
CUBOID 3 1 4P11.2141 2P2.4892
CUBOID 5 1 4P11.3355 2P2.4892
CUBOID 3 1 4P11.5260 2P2.4892
HOLE  5 0.0 +11.4308 0.0
HOLE  5 0.0 -11.4308 0.0
HOLE  6 +11.4308 0.0 0.0
HOLE  6 -11.4308 0.0 0.0
CUBOID 5 1 4P11.5715 2P2.4892
CUBOID 3 1 +11.5715 -12.0176 +12.0176 -11.5715 2P2.4892
UNIT 12
COM='TUBE CELL IN H2O BETWEEN DISKS (C)'
ARRAY  1  -10.7083 -10.7083 -2.4892
CUBOID 3 1 4P11.2141 2P2.4892
CUBOID 5 1 4P11.3355 2P2.4892
CUBOID 3 1 4P11.5260 2P2.4892
HOLE  5 0.0 +11.4308 0.0
HOLE  5 0.0 -11.4308 0.0
HOLE  6 +11.4308 0.0 0.0
HOLE  6 -11.4308 0.0 0.0
CUBOID 5 1 4P11.5715 2P2.4892
CUBOID 3 1 +11.5715 -12.0176 +11.5715 -12.0176 2P2.4892
```

Figure 6.8-3 (continued)

```
UNIT 13
COM='TUBE CELL IN H2O BETWEEN DISKS (D)'
ARRAY  1  -10.7083 -10.7083 -2.4892
CUBOID 3 1 4P11.2141 2P2.4892
CUBOID 5 1 4P11.3355 2P2.4892
CUBOID 3 1 4P11.5260 2P2.4892
HOLE  5 0.0 +11.4308 0.0
HOLE  5 0.0 -11.4308 0.0
HOLE  6 +11.4308 0.0 0.0
HOLE  6 -11.4308 0.0 0.0
CUBOID 5 1 4P11.5715 2P2.4892
CUBOID 3 1 +12.0176 -11.5715 +11.5715 -12.0176 2P2.4892
UNIT 14
COM='WEB UNIT (1.5" WEB) - BETWEEN DISKS'
CUBOID 3 1  2P11.7946 2P1.8725 2P2.4892
UNIT 15
COM='WEB UNIT (1.0" WEB) - BETWEEN DISKS'
CUBOID 3 1  2P11.7946 2P1.2510 2P2.4892
UNIT 16
COM='WEB UNIT (0.875" WEB) - BETWEEN DISKS'
CUBOID 3 1  2P11.7946 2P1.0923 2P2.4892
UNIT 17
COM='6X1 FUEL TUBE STACK BETWEEN DISKS (-X)'
ARRAY 10 -11.7946 -77.3262 -2.4892
UNIT 18
COM='6X1 FUEL TUBE STACK BETWEEN DISKS (+X)'
ARRAY 11 -11.7946 -77.3262 -2.4892
UNIT 19
COM='2X1 FUEL TUBE STACK OF TUBES BETWEEN DISKS (-X)'
ARRAY 12 -11.7946 -25.4616 -2.4892
UNIT 20
COM='2X1 FUEL TUBE STACK OF TUBES BETWEEN DISKS (+X)'
ARRAY 13 -11.7946 -25.4616 -2.4892
UNIT 30
COM='TUBE CELL IN ST DISK (A)'
ARRAY  2 -10.7083 -10.7083 -0.6350
CUBOID 3 1 4P11.2141 2P0.6350
CUBOID 5 1 4P11.3355 2P0.6350
CUBOID 3 1 4P11.5260 2P0.6350
HOLE  7 0.0 +11.4308 0.0
HOLE  7 0.0 -11.4308 0.0
HOLE  8 +11.4308 0.0 0.0
HOLE  8 -11.4308 0.0 0.0
CUBOID 5 1 4P11.5715 2P0.6350
CUBOID 3 1 +12.0176 -11.5715 +12.0176 -11.5715 2P0.6350
UNIT 31
COM='TUBE CELL IN ST DISK (B)'
ARRAY  2 -10.7083 -10.7083 -0.6350
CUBOID 3 1 4P11.2141 2P0.6350
CUBOID 5 1 4P11.3355 2P0.6350
CUBOID 3 1 4P11.5260 2P0.6350
HOLE  7 0.0 +11.4308 0.0
HOLE  7 0.0 -11.4308 0.0
HOLE  8 +11.4308 0.0 0.0
HOLE  8 -11.4308 0.0 0.0
CUBOID 5 1 4P11.5715 2P0.6350
CUBOID 3 1 +11.5715 -12.0176 +12.0176 -11.5715 2P0.6350
UNIT 32
COM='TUBE CELL IN ST DISK (C)'
ARRAY  2 -10.7083 -10.7083 -0.6350
CUBOID 3 1 4P11.2141 2P0.6350
CUBOID 5 1 4P11.3355 2P0.6350
CUBOID 3 1 4P11.5260 2P0.6350
HOLE  7 0.0 +11.4308 0.0
HOLE  7 0.0 -11.4308 0.0
HOLE  8 +11.4308 0.0 0.0
HOLE  8 -11.4308 0.0 0.0
CUBOID 5 1 4P11.5715 2P0.6350
CUBOID 3 1 +11.5715 -12.0176 +11.5715 -12.0176 2P0.6350
UNIT 33
COM='TUBE CELL IN ST DISK (D)'
ARRAY  2 -10.7083 -10.7083 -0.6350
CUBOID 3 1 4P11.2141 2P0.6350
CUBOID 5 1 4P11.3355 2P0.6350
CUBOID 3 1 4P11.5260 2P0.6350
HOLE  7 0.0 +11.4308 0.0
HOLE  7 0.0 -11.4308 0.0
HOLE  8 +11.4308 0.0 0.0
HOLE  8 -11.4308 0.0 0.0
CUBOID 5 1 4P11.5715 2P0.6350
CUBOID 3 1 +12.0176 -11.5715 +11.5715 -12.0176 2P0.6350
UNIT 34
COM='WEB UNIT (1.5" WEB) - ST DISKS'
CUBOID 5 1  2P11.7946 2P1.8725 2P0.6350
UNIT 35
COM='WEB UNIT (1.0" WEB) - ST DISKS'
CUBOID 5 1  2P11.7946 2P1.2510 2P0.6350
UNIT 36
COM='WEB UNIT (0.875" WEB) - ST DISKS'
CUBOID 5 1  2P11.7946 2P1.0923 2P0.6350
UNIT 37
COM='6x1 FUEL TUBE STACK ST DISK (-X)'
ARRAY 20 -11.7946 -77.3262 -0.6350
UNIT 38
COM='6x1 FUEL TUBE STACK ST DISK (+X)'
ARRAY 21 -11.7946 -77.3262 -0.6350
UNIT 39
```

Figure 6.8-3 (continued)

```
COM='2X1 FUEL TUB STACK OF TUBES ST DISK (-X)'
ARRAY 22 -11.7946 -25.4616 -0.6350
UNIT 40
COM='2X1 FUEL TUB STACK OF TUBES ST DISK (+X)'
ARRAY 23 -11.7946 -25.4616 -0.6350
UNIT 50
COM='TUBE CELL IN AL DISK (A)'
ARRAY  2 -10.7083 -10.7083 -0.6350
CUBOID 3 1 4P11.2141 2P0.6350
CUBOID 5 1 4P11.3355 2P0.6350
CUBOID 3 1 4P11.5260 2P0.6350
HOLE  7 0.0 +11.4308 0.0
HOLE  7 0.0 -11.4308 0.0
HOLE  8 +11.4308 0.0 0.0
HOLE  8 -11.4308 0.0 0.0
CUBOID 5 1 4P11.5715 2P0.6350
CUBOID 3 1 +12.0176 -11.5715 +12.0176 -11.5715 2P0.6350
UNIT 51
COM='TUBE CELL IN AL DISK (B)'
ARRAY  2 -10.7083 -10.7083 -0.6350
CUBOID 3 1 4P11.2141 2P0.6350
CUBOID 5 1 4P11.3355 2P0.6350
CUBOID 3 1 4P11.5260 2P0.6350
HOLE  7 0.0 +11.4308 0.0
HOLE  7 0.0 -11.4308 0.0
HOLE  8 +11.4308 0.0 0.0
HOLE  8 -11.4308 0.0 0.0
CUBOID 5 1 4P11.5715 2P0.6350
CUBOID 3 1 +11.5715 -12.0176 +12.0176 -11.5715 2P0.6350
UNIT 52
COM='TUBE CELL IN AL DISK (C)'
ARRAY  2 -10.7083 -10.7083 -0.6350
CUBOID 3 1 4P11.2141 2P0.6350
CUBOID 5 1 4P11.3355 2P0.6350
CUBOID 3 1 4P11.5260 2P0.6350
HOLE  7 0.0 +11.4308 0.0
HOLE  7 0.0 -11.4308 0.0
HOLE  8 +11.4308 0.0 0.0
HOLE  8 -11.4308 0.0 0.0
CUBOID 5 1 4P11.5715 2P0.6350
CUBOID 3 1 +11.5715 -12.0176 +11.5715 -12.0176 2P0.6350
UNIT 53
COM='TUBE CELL IN AL DISK (D)'
ARRAY  2 -10.7083 -10.7083 -0.6350
CUBOID 3 1 4P11.2141 2P0.6350
CUBOID 5 1 4P11.3355 2P0.6350
CUBOID 3 1 4P11.5260 2P0.6350
HOLE  7 0.0 +11.4308 0.0
HOLE  7 0.0 -11.4308 0.0
HOLE  8 +11.4308 0.0 0.0
HOLE  8 -11.4308 0.0 0.0
CUBOID 5 1 4P11.5715 2P0.6350
CUBOID 3 1 +12.0176 -11.5715 +11.5715 -12.0176 2P0.6350
UNIT 54
COM='WEB UNIT (1.5" WEB) - AL DISKS'
CUBOID 4 1  2P11.7946 2P1.8725 2P0.6350
UNIT 55
COM='WEB UNIT (1.0" WEB) - AL DISKS'
CUBOID 4 1  2P11.7946 2P1.2510 2P0.6350
UNIT 56
COM='WEB UNIT (0.875" WEB) - AL DISKS'
CUBOID 4 1  2P11.7946 2P1.0923 2P0.6350
UNIT 57
COM='6X1 FUEL TUBE STACK AL DISK'
ARRAY 30 -11.7946 -77.3262 -0.6350
UNIT 58
COM='6X1 FUEL TUBE STACK AL DISK'
ARRAY 31 -11.7946 -77.3262 -0.6350
UNIT 59
COM='2X1 FUEL TUBE STACK OF TUBES AL DISK'
ARRAY 32 -11.7946 -25.4616 -0.6350
UNIT 60
COM='2X1 FUEL TUBE STACK OF TUBES AL DISK'
ARRAY 33 -11.7946 -25.4616 -0.6350
UNIT 70
COM='BASKET STRUCTURE IN STORAGE CASK - WATER DISK'
CYLINDER 3 1 +83.5787 2P2.4892
HOLE 17  -13.6669 0.0 0.0
HOLE 18  +13.6669 0.0 0.0
HOLE 19  -39.7578 0.0 0.0
HOLE 20  +39.7578 0.0 0.0
HOLE 19  -65.5312 0.0 0.0
HOLE 20  +65.5312 0.0 0.0
HOLE 10  +40.8048 +40.8048 0.0
HOLE 11  -40.8048 +40.8048 0.0
HOLE 12  -40.8048 -40.8048 0.0
HOLE 13  +40.8048 -40.8048 0.0
CYLINDER  5 1  +85.1662 2P2.4892
CYLINDER  9 1  +94.615 2P2.4892
CYLINDER  7 1 +100.965 2P2.4892
CYLINDER  8 1 +172.72 2P2.4892
CUBOID    9 1 4P230.0 2P2.4892
UNIT 71
COM='BASKET STRUCTURE IN STORAGE CASK - ST DISK'
CYLINDER  5 1 +83.1850 2P0.6350
HOLE 37  -13.6669 0.0 0.0
HOLE 38  +13.6669 0.0 0.0
HOLE 39  -39.7578 0.0 0.0
```

Figure 6.8-3 (continued)

```
HOLE 40  +39.7578 0.0 0.0
HOLE 39  -65.5312 0.0 0.0
HOLE 40  +65.5312 0.0 0.0
HOLE 30  +40.8048 +40.8048 0.0
HOLE 31  -40.8048 +40.8048 0.0
HOLE 32  -40.8048 -40.8048 0.0
HOLE 33  +40.8048 -40.8048 0.0
CYLINDER  3 1  +83.5787 2P0.6350
CYLINDER  5 1  +85.1662 2P0.6350
CYLINDER  9 1  +94.615 2P0.6350
CYLINDER  7 1 +100.965 2P0.6350
CYLINDER  8 1 +172.72 2P0.6350
CUBOID    9 1 4P230.0 2P0.6350
UNIT 72
COM='BASKET STRUCTURE IN STORAGE CASK - AL DISK'
CYLINDER  4 1 +82.8675 2P0.6350
HOLE 57  -13.6669 0.0 0.0
HOLE 58  +13.6669 0.0 0.0
HOLE 59  -39.7578 0.0 0.0
HOLE 60  +39.7578 0.0 0.0
HOLE 59  -65.5312 0.0 0.0
HOLE 60  +65.5312 0.0 0.0
HOLE 50  +40.8048 +40.8048 0.0
HOLE 51  -40.8048 +40.8048 0.0
HOLE 52  -40.8048 -40.8048 0.0
HOLE 53  +40.8048 -40.8048 0.0
CYLINDER  3 1  +83.5787 2P0.6350
CYLINDER  5 1  +85.1662 2P0.6350
CYLINDER  9 1  +94.615 2P0.6350
CYLINDER  7 1 +100.965 2P0.6350
CYLINDER  8 1 +172.72 2P0.6350
CUBOID    9 1 4P230.0 2P0.6350
GLOBAL UNIT 73
COM='DISK SLICE STACK'
ARRAY  40 -230.0 -230.0 0.0
END GEOM
READ ARRAY
ARA=1    NUX=17 NUY=17 NUZ=1  FILL
                              34R1
          5R1   2   2R1   2   2R1   2   5R1
               3R1   2   9R1   2   3R1
                              17R1
2R1   2   2R1   2   2R1   2   2R1   2   2R1   2   2R1
                              34R1
2R1   2   2R1   2   2R1   2   2R1   2   2R1   2   2R1
                              34R1
2R1   2   2R1   2   2R1   2   2R1   2   2R1   2   2R1
                              17R1
               3R1   2   9R1   2   3R1
          5R1   2   2R1   2   2R1   2   5R1
                              34R1
END FILL
ARA=2  NUX=17 NUY=17 NUZ=1  FILL
                              34R3
          5R3   4   2R3   4   2R3   4   5R3
               3R3   4   9R3   4   3R3
                              17R3
2R3   4   2R3   4   2R3   4   2R3   4   2R3   4   2R3
                              34R3
2R3   4   2R3   4   2R3   4   2R3   4   2R3   4   2R3
                              34R3
2R3   4   2R3   4   2R3   4   2R3   4   2R3   4   2R3
                              17R3
               3R3   4   9R3   4   3R3
          5R3   4   2R3   4   2R3   4   5R3
                              34R3
END FILL
ARA=10 NUX=1 NUY=11 NUZ=1 FILL 12 16 12 15 12 14 11 15 11 16 11 END FILL
ARA=11 NUX=1 NUY=11 NUZ=1 FILL 13 16 13 15 13 14 10 15 10 16 10 END FILL
ARA=12 NUX=1 NUY=3  NUZ=1 FILL 12 14 11 END FILL
ARA=13 NUX=1 NUY=3  NUZ=1 FILL 13 14 10 END FILL
ARA=20 NUX=1 NUY=11 NUZ=1 FILL 32 36 32 35 32 34 31 35 31 36 31 END FILL
ARA=21 NUX=1 NUY=11 NUZ=1 FILL 33 36 33 35 33 34 30 35 30 36 30 END FILL
ARA=22 NUX=1 NUY=3  NUZ=1 FILL 32 34 31 END FILL
ARA=23 NUX=1 NUY=3  NUZ=1 FILL 33 34 30 END FILL
ARA=30 NUX=1 NUY=11 NUZ=1 FILL 52 56 52 55 52 54 51 55 51 56 51 END FILL
ARA=31 NUX=1 NUY=11 NUZ=1 FILL 53 56 53 55 53 54 50 55 50 56 50 END FILL
ARA=32 NUX=1 NUY=3  NUZ=1 FILL 52 54 51 END FILL
ARA=33 NUX=1 NUY=3  NUZ=1 FILL 53 54 50 END FILL
ARA=40 NUX=1 NUY=1 NUZ=4 FILL 70 71 70 72 END FILL
END ARRAY
READ BOUNDS ZFC=PER YXF=MIRROR END BOUNDS
END DATA
END
```

Figure 6.8-4 CSAS Input for Accident Conditions– Vertical Concrete Cask Containing PWR Fuel

```
=CSAS25
UMS PWR SC; ACCIDENT; ARRAY; 1.0 GM/CC IN - 1.0 GM/CC EX; 460 CM PITCH
27GROUPNDF4 LATTICECELL
UO2  1  0.95 293.0 92235 4.20 92238 95.80 END
ZIRCALLOY   2  1.0  293.0  END
H2O  3  1.0  293.0  END
AL   4  1.0  293.0  END
SS304 5 1.0  293.0  END
AL    6 DEN=2.6000 0.4627 293.0 END
B-10  6 DEN=2.6000 0.0568 293.0 END
B-11  6 DEN=2.6000 0.3449 293.0 END
C     6 DEN=2.6000 0.1167 293.0 END
CARBONSTEEL  7 1.0    293.0  END
REG-CONCRETE 8 0.9750 293.0 END
H2O   9 1.0 293.0 END
H2O  10 1.0 293.0 END
END COMP
SQUAREPITCH  1.2598 0.7844 1 3 0.9144 2 0.8001 10 END
UMS PWR SC; ACCIDENT; ARRAY; 1.0 GM/CC IN - 1.0 GM/CC EX; 460 CM PITCH
READ PARAM RUN=YES PLT=NO TME=5000 GEN=803 NPG=1000 END PARAM
READ GEOM
UNIT  1
COM='FUEL PIN CELL - BETWEEN DISKS'
CYLINDER   1 1  0.3922   2P2.4892
CYLINDER  10 1  0.4001   2P2.4892
CYLINDER   2 1  0.4572   2P2.4892
CUBOID     3 1  4P0.6299 2P2.4892
UNIT  2
COM='WATER ROD CELL - BETWEEN DISKS'
CYLINDER  3 1  0.5715   2P2.4892
CYLINDER  2 1  0.6121   2P2.4892
CUBOID    3 1  4P0.6299 2P2.4892
UNIT  3
COM='FUEL PIN CELL - FOR DISK SLICE OF CASK'
CYLINDER   1 1  0.3922   2P0.6350
CYLINDER  10 1  0.4001   2P0.6350
CYLINDER   2 1  0.4572   2P0.6350
CUBOID     3 1  4P0.6299 2P0.6350
UNIT  4
COM='WATER ROD CELL - FOR DISK SLICE OF CASK'
CYLINDER  3 1  0.5715   2P0.6350
CYLINDER  2 1  0.6121   2P0.6350
CUBOID    3 1  4P0.6299 2P0.6350
UNIT 5
COM='X-X BORAL SHEET BETWEEN DISKS'
CUBOID 6 1 2P10.4140 2P0.0635 2P2.4892
CUBOID 4 1 2P10.4140 2P0.0951 2P2.4892
UNIT 6
COM='Y-Y BORAL SHEET BETWEEN DISKS'
CUBOID 6 1 2P0.0635 2P10.4140 2P2.4892
CUBOID 4 1 2P0.0951 2P10.4140 2P2.4892
UNIT 7
COM='X-X BORAL SHEET WITH DISKS'
CUBOID 6 1 2P10.4140 2P0.0635 2P0.6350
CUBOID 4 1 2P10.4140 2P0.0951 2P0.6350
UNIT 8
COM='Y-Y BORAL SHEET WITH DISKS'
CUBOID 6 1 2P0.0635 2P10.4140 2P0.6350
CUBOID 4 1 2P0.0951 2P10.4140 2P0.6350
UNIT 10
COM='TUBE CELL IN H2O BETWEEN DISKS (A)'
ARRAY  1  -10.7083 -10.7083 -2.4892
CUBOID 3 1 4P11.2141 2P2.4892
CUBOID 5 1 4P11.3355 2P2.4892
CUBOID 3 1 4P11.5260 2P2.4892
HOLE  5 0.0 +11.4308 0.0
HOLE  5 0.0 -11.4308 0.0
HOLE  6 +11.4308 0.0 0.0
HOLE  6 -11.4308 0.0 0.0
CUBOID 5 1 4P11.5715 2P2.4892
CUBOID 3 1 +12.0176 -11.5715 +12.0176 -11.5715 2P2.4892
UNIT 11
COM='TUBE CELL IN H2O BETWEEN DISKS (B)'
ARRAY  1  -10.7083 -10.7083 -2.4892
CUBOID 3 1 4P11.2141 2P2.4892
CUBOID 5 1 4P11.3355 2P2.4892
CUBOID 3 1 4P11.5260 2P2.4892
HOLE  5 0.0 +11.4308 0.0
HOLE  5 0.0 -11.4308 0.0
HOLE  6 +11.4308 0.0 0.0
HOLE  6 -11.4308 0.0 0.0
CUBOID 5 1 4P11.5715 2P2.4892
CUBOID 3 1 +11.5715 -12.0176 +12.0176 -11.5715 2P2.4892
UNIT 12
COM='TUBE CELL IN H2O BETWEEN DISKS (C)'
ARRAY  1  -10.7083 -10.7083 -2.4892
CUBOID 3 1 4P11.2141 2P2.4892
CUBOID 5 1 4P11.3355 2P2.4892
CUBOID 3 1 4P11.5260 2P2.4892
```

Figure 6.8-4 (continued)

```
HOLE  5 0.0 +11.4308 0.0
HOLE  5 0.0 -11.4308 0.0
HOLE  6 +11.4308 0.0 0.0
HOLE  6 -11.4308 0.0 0.0
CUBOID 5 1 4P11.5715 2P2.4892
CUBOID 3 1 +11.5715 -12.0176 +11.5715 -12.0176 2P2.4892
UNIT 13
COM='TUBE CELL IN H2O BETWEEN DISKS (D)'
ARRAY  1  -10.7083 -10.7083 -2.4892
CUBOID 3 1 4P11.2141 2P2.4892
CUBOID 5 1 4P11.3355 2P2.4892
CUBOID 3 1 4P11.5260 2P2.4892
HOLE  5 0.0 +11.4308 0.0
HOLE  5 0.0 -11.4308 0.0
HOLE  6 +11.4308 0.0 0.0
HOLE  6 -11.4308 0.0 0.0
CUBOID 5 1 4P11.5715 2P2.4892
CUBOID 3 1 +12.0176 -11.5715 +11.5715 -12.0176 2P2.4892
UNIT 14
COM='WEB UNIT (1.5" WEB) - BETWEEN DISKS'
CUBOID 3 1  2P11.7946 2P1.8725 2P2.4892
UNIT 15
COM='WEB UNIT (1.0" WEB) - BETWEEN DISKS'
CUBOID 3 1  2P11.7946 2P1.2510 2P2.4892
UNIT 16
COM='WEB UNIT (0.875" WEB) - BETWEEN DISKS'
CUBOID 3 1  2P11.7946 2P1.0923 2P2.4892
UNIT 17
COM='6X1 FUEL TUBE STACK BETWEEN DISKS (-X)'
ARRAY 10 -11.7946 -77.3262 -2.4892
UNIT 18
COM='6X1 FUEL TUBE STACK BETWEEN DISKS (+X)'
ARRAY 11 -11.7946 -77.3262 -2.4892
UNIT 19
COM='2X1 FUEL TUBE STACK OF TUBES BETWEEN DISKS (-X)'
ARRAY 12 -11.7946 -25.4616 -2.4892
UNIT 20
COM='2X1 FUEL TUBE STACK OF TUBES BETWEEN DISKS (+X)'
ARRAY 13 -11.7946 -25.4616 -2.4892
UNIT 30
COM='TUBE CELL IN ST DISK (A)'
ARRAY  2 -10.7083 -10.7083 -0.6350
CUBOID 3 1 4P11.2141 2P0.6350
CUBOID 5 1 4P11.3355 2P0.6350
CUBOID 3 1 4P11.5260 2P0.6350
HOLE  7 0.0 +11.4308 0.0
HOLE  7 0.0 -11.4308 0.0
HOLE  8 +11.4308 0.0 0.0
HOLE  8 -11.4308 0.0 0.0
CUBOID 5 1 4P11.5715 2P0.6350
CUBOID 3 1 +12.0176 -11.5715 +12.0176 -11.5715 2P0.6350
UNIT 31
COM='TUBE CELL IN ST DISK (B)'
ARRAY  2 -10.7083 -10.7083 -0.6350
CUBOID 3 1 4P11.2141 2P0.6350
CUBOID 5 1 4P11.3355 2P0.6350
CUBOID 3 1 4P11.5260 2P0.6350
HOLE  7 0.0 +11.4308 0.0
HOLE  7 0.0 -11.4308 0.0
HOLE  8 +11.4308 0.0 0.0
HOLE  8 -11.4308 0.0 0.0
CUBOID 5 1 4P11.5715 2P0.6350
CUBOID 3 1 +11.5715 -12.0176 +12.0176 -11.5715 2P0.6350
UNIT 32
COM='TUBE CELL IN ST DISK (C)'
ARRAY  2 -10.7083 -10.7083 -0.6350
CUBOID 3 1 4P11.2141 2P0.6350
CUBOID 5 1 4P11.3355 2P0.6350
CUBOID 3 1 4P11.5260 2P0.6350
HOLE  7 0.0 +11.4308 0.0
HOLE  7 0.0 -11.4308 0.0
HOLE  8 +11.4308 0.0 0.0
HOLE  8 -11.4308 0.0 0.0
CUBOID 5 1 4P11.5715 2P0.6350
CUBOID 3 1 +11.5715 -12.0176 +11.5715 -12.0176 2P0.6350
UNIT 33
COM='TUBE CELL IN ST DISK (D)'
ARRAY  2 -10.7083 -10.7083 -0.6350
CUBOID 3 1 4P11.2141 2P0.6350
CUBOID 5 1 4P11.3355 2P0.6350
CUBOID 3 1 4P11.5260 2P0.6350
HOLE  7 0.0 +11.4308 0.0
HOLE  7 0.0 -11.4308 0.0
HOLE  8 +11.4308 0.0 0.0
HOLE  8 -11.4308 0.0 0.0
CUBOID 5 1 4P11.5715 2P0.6350
CUBOID 3 1 +12.0176 -11.5715 +11.5715 -12.0176 2P0.6350
UNIT 34
COM='WEB UNIT (1.5" WEB) - ST DISKS'
CUBOID 5 1  2P11.7946 2P1.8725 2P0.6350
UNIT 35
COM='WEB UNIT (1.0" WEB) - ST DISKS'
CUBOID 5 1  2P11.7946 2P1.2510 2P0.6350
UNIT 36
COM='WEB UNIT (0.875" WEB) - ST DISKS'
CUBOID 5 1  2P11.7946 2P1.0923 2P0.6350
UNIT 37
COM='6x1 FUEL TUBE STACK ST DISK (-X)'
ARRAY 20 -11.7946 -77.3262 -0.6350
```

Figure 6.8-4 (continued)

```
UNIT 38
COM='6x1 FUEL TUBE STACK ST DISK (+X)'
ARRAY 21 -11.7946 -77.3262 -0.6350
UNIT 39
COM='2X1 FUEL TUB STACK OF TUBES ST DISK (-X)'
ARRAY 22 -11.7946 -25.4616 -0.6350
UNIT 40
COM='2X1 FUEL TUB STACK OF TUBES ST DISK (+X)'
ARRAY 23 -11.7946 -25.4616 -0.6350
UNIT 50
COM='TUBE CELL IN AL DISK (A)'
ARRAY  2 -10.7083 -10.7083 -0.6350
CUBOID 3 1 4P11.2141 2P0.6350
CUBOID 5 1 4P11.3355 2P0.6350
CUBOID 3 1 4P11.5260 2P0.6350
HOLE  7 0.0 +11.4308 0.0
HOLE  7 0.0 -11.4308 0.0
HOLE  8 +11.4308 0.0 0.0
HOLE  8 -11.4308 0.0 0.0
CUBOID 5 1 4P11.5715 2P0.6350
CUBOID 3 1 +12.0176 -11.5715 +12.0176 -11.5715 2P0.6350
UNIT 51
COM='TUBE CELL IN AL DISK (B)'
ARRAY  2 -10.7083 -10.7083 -0.6350
CUBOID 3 1 4P11.2141 2P0.6350
CUBOID 5 1 4P11.3355 2P0.6350
CUBOID 3 1 4P11.5260 2P0.6350
HOLE  7 0.0 +11.4308 0.0
HOLE  7 0.0 -11.4308 0.0
HOLE  8 +11.4308 0.0 0.0
HOLE  8 -11.4308 0.0 0.0
CUBOID 5 1 4P11.5715 2P0.6350
CUBOID 3 1 +11.5715 -12.0176 +12.0176 -11.5715 2P0.6350
UNIT 52
COM='TUBE CELL IN AL DISK (C)'
ARRAY  2 -10.7083 -10.7083 -0.6350
CUBOID 3 1 4P11.2141 2P0.6350
CUBOID 5 1 4P11.3355 2P0.6350
CUBOID 3 1 4P11.5260 2P0.6350
HOLE  7 0.0 +11.4308 0.0
HOLE  7 0.0 -11.4308 0.0
HOLE  8 +11.4308 0.0 0.0
HOLE  8 -11.4308 0.0 0.0
CUBOID 5 1 4P11.5715 2P0.6350
CUBOID 3 1 +11.5715 -12.0176 +11.5715 -12.0176 2P0.6350
UNIT 53
COM='TUBE CELL IN AL DISK (D)'
ARRAY  2 -10.7083 -10.7083 -0.6350
CUBOID 3 1 4P11.2141 2P0.6350
CUBOID 5 1 4P11.3355 2P0.6350
CUBOID 3 1 4P11.5260 2P0.6350
HOLE  7 0.0 +11.4308 0.0
HOLE  7 0.0 -11.4308 0.0
HOLE  8 +11.4308 0.0 0.0
HOLE  8 -11.4308 0.0 0.0
CUBOID 5 1 4P11.5715 2P0.6350
CUBOID 3 1 +12.0176 -11.5715 +11.5715 -12.0176 2P0.6350
UNIT 54
COM='WEB UNIT (1.5" WEB) - AL DISKS'
CUBOID 4 1  2P11.7946 2P1.8725 2P0.6350
UNIT 55
COM='WEB UNIT (1.0" WEB) - AL DISKS'
CUBOID 4 1  2P11.7946 2P1.2510 2P0.6350
UNIT 56
COM='WEB UNIT (0.875" WEB) - AL DISKS'
CUBOID 4 1  2P11.7946 2P1.0923 2P0.6350
UNIT 57
COM='6X1 FUEL TUBE STACK AL DISK'
ARRAY 30 -11.7946 -77.3262 -0.6350
UNIT 58
COM='6X1 FUEL TUBE STACK AL DISK'
ARRAY 31 -11.7946 -77.3262 -0.6350
UNIT 59
COM='2X1 FUEL TUBE STACK OF TUBES AL DISK'
ARRAY 32 -11.7946 -25.4616 -0.6350
UNIT 60
COM='2X1 FUEL TUBE STACK OF TUBES AL DISK'
ARRAY 33 -11.7946 -25.4616 -0.6350
UNIT 70
COM='BASKET STRUCTURE IN STORAGE CASK - WATER DISK'
CYLINDER 3 1 +83.5787 2P2.4892
HOLE 17  -13.6669 0.0 0.0
HOLE 18  +13.6669 0.0 0.0
HOLE 19  -39.7578 0.0 0.0
HOLE 20  +39.7578 0.0 0.0
HOLE 19  -65.5312 0.0 0.0
HOLE 20  +65.5312 0.0 0.0
HOLE 10  +40.8048 +40.8048 0.0
HOLE 11  -40.8048 +40.8048 0.0
HOLE 12  -40.8048 -40.8048 0.0
HOLE 13  +40.8048 -40.8048 0.0
CYLINDER  5 1  +85.1662 2P2.4892
CYLINDER  9 1  +94.615 2P2.4892
CYLINDER  7 1 +100.965 2P2.4892
CYLINDER  8 1 +172.72 2P2.4892
CUBOID    9 1 4P230.0 2P2.4892
UNIT 71
COM='BASKET STRUCTURE IN STORAGE CASK - ST DISK'
CYLINDER  5 1 +83.1850 2P0.6350
```

Figure 6.8-4 (continued)

```
HOLE 37  -13.6669 0.0 0.0
HOLE 38  +13.6669 0.0 0.0
HOLE 39  -39.7578 0.0 0.0
HOLE 40  +39.7578 0.0 0.0
HOLE 39  -65.5312 0.0 0.0
HOLE 40  +65.5312 0.0 0.0
HOLE 30  +40.8048 +40.8048 0.0
HOLE 31  -40.8048 +40.8048 0.0
HOLE 32  -40.8048 -40.8048 0.0
HOLE 33  +40.8048 -40.8048 0.0
CYLINDER  3 1  +83.5787 2P0.6350
CYLINDER  5 1  +85.1662 2P0.6350
CYLINDER  9 1  +94.615 2P0.6350
CYLINDER  7 1 +100.965 2P0.6350
CYLINDER  8 1 +172.72 2P0.6350
CUBOID    9 1 4P230.0 2P0.6350
UNIT 72
COM='BASKET STRUCTURE IN STORAGE CASK - AL DISK'
CYLINDER  4 1 +82.8675 2P0.6350
HOLE 57  -13.6669 0.0 0.0
HOLE 58  +13.6669 0.0 0.0
HOLE 59  -39.7578 0.0 0.0
HOLE 60  +39.7578 0.0 0.0
HOLE 59  -65.5312 0.0 0.0
HOLE 60  +65.5312 0.0 0.0
HOLE 50  +40.8048 +40.8048 0.0
HOLE 51  -40.8048 +40.8048 0.0
HOLE 52  -40.8048 -40.8048 0.0
HOLE 53  +40.8048 -40.8048 0.0
CYLINDER  3 1  +83.5787 2P0.6350
CYLINDER  5 1  +85.1662 2P0.6350
CYLINDER  9 1  +94.615 2P0.6350
CYLINDER  7 1 +100.965 2P0.6350
CYLINDER  8 1 +172.72 2P0.6350
CUBOID    9 1 4P230.0 2P0.6350
GLOBAL UNIT 73
COM='DISK SLICE STACK'
ARRAY  40 -230.0 -230.0 0.0
END GEOM
READ ARRAY
ARA=1   NUX=17 NUY=17 NUZ=1  FILL
                        34R1
          5R1   2   2R1   2   2R1   2   5R1
                3R1   2   9R1   2   3R1
                        17R1
2R1   2   2R1   2   2R1   2   2R1   2   2R1   2   2R1
                        34R1
2R1   2   2R1   2   2R1   2   2R1   2   2R1   2   2R1
                        34R1
2R1   2   2R1   2   2R1   2   2R1   2   2R1   2   2R1
                        17R1
                3R1   2   9R1   2   3R1
          5R1   2   2R1   2   2R1   2   5R1
                        34R1
END FILL
ARA=2  NUX=17 NUY=17 NUZ=1  FILL
                        34R3
          5R3   4   2R3   4   2R3   4   5R3
                3R3   4   9R3   4   3R3
                        17R3
2R3   4   2R3   4   2R3   4   2R3   4   2R3   4   2R3
                        34R3
2R3   4   2R3   4   2R3   4   2R3   4   2R3   4   2R3
                        34R3
2R3   4   2R3   4   2R3   4   2R3   4   2R3   4   2R3
                        17R3
                3R3   4   9R3   4   3R3
          5R3   4   2R3   4   2R3   4   5R3
                        34R3
END FILL
ARA=10 NUX=1 NUY=11 NUZ=1 FILL 12 16 12 15 12 14 11 15 11 16 11 END FILL
ARA=11 NUX=1 NUY=11 NUZ=1 FILL 13 16 13 15 13 14 10 15 10 16 10 END FILL
ARA=12 NUX=1 NUY=3  NUZ=1 FILL 12 14 11 END FILL
ARA=13 NUX=1 NUY=3  NUZ=1 FILL 13 14 10 END FILL
ARA=20 NUX=1 NUY=11 NUZ=1 FILL 32 36 32 35 32 34 31 35 31 36 31 END FILL
ARA=21 NUX=1 NUY=11 NUZ=1 FILL 33 36 33 35 33 34 30 35 30 36 30 END FILL
ARA=22 NUX=1 NUY=3  NUZ=1 FILL 32 34 31 END FILL
ARA=23 NUX=1 NUY=3  NUZ=1 FILL 33 34 30 END FILL
ARA=30 NUX=1 NUY=11 NUZ=1 FILL 52 56 52 55 52 54 51 55 51 56 51 END FILL
ARA=31 NUX=1 NUY=11 NUZ=1 FILL 53 56 53 55 53 54 50 55 50 56 50 END FILL
ARA=32 NUX=1 NUY=3  NUZ=1 FILL 52 54 51 END FILL
ARA=33 NUX=1 NUY=3  NUZ=1 FILL 53 54 50 END FILL
ARA=40 NUX=1 NUY=1 NUZ=4 FILL 70 71 70 72 END FILL
END ARRAY
READ BOUNDS ZFC=PER YXF=MIRROR END BOUNDS
END DATA
END
```

Figure 6.8-5 CSAS Input for Normal Conditions – Transfer Cask Containing BWR Fuel

```
=CSAS25
UMS BWR TFR; NORMAL OP; CASK ARRAY; 1.0 GM/CC IN - 1.0 GM/CC EX; 75%B10
27GROUPNDF4 LATTICECELL
UO2    1 0.95 293.0 92235 4.00 92238 96.00 END
ZIRCALLOY  2 1.0  293.0  END
H2O    3 1.0  293.0  END
AL     4 1.0  293.0  END
SS304  5 1.0  293.0  END
AL     6 DEN=2.6849 0.8706 293.0 END
B-10   6 DEN=2.6849 0.0137 293.0 END
B-11   6 DEN=2.6849 0.0830 293.0 END
C      6 DEN=2.6849 0.0281 293.0 END
CARBONSTEEL 7 1.0 293.0 END
PB     8 1.0 293.0  END
B-10   9 0.0 8.553-5 END
B-11   9 0.0 3.422-4 END
AL     9 0.0 7.763-3 END
H      9 0.0 5.854-2 END
O      9 0.0 2.609-2 END
C      9 0.0 2.264-2 END
N      9 0.0 1.394-3 END
H2O   10 1.0 293.0 END
END COMP
SQUAREPITCH  1.4529 0.9055 1 3 1.0770 2 0.9246 0 END
UMS BWR TFR; NORMAL OP; CASK ARRAY; 1.0 GM/CC IN - 1.0 GM/CC EX; 75%B10
READ PARAM RUN=YES PLT=NO TME=5000 GEN=803 NPG=1000 END PARAM
READ GEOM
UNIT  1
COM='FUEL PIN CELL - WITH H2O'
CYLINDER  1 1  0.4528    2P1.7145
CYLINDER  0 1  0.4623    2P1.7145
CYLINDER  2 1  0.5385    2P1.7145
CUBOID    3 1  4P0.7264 2P1.7145
UNIT  2
COM='WATER ROD CELL - WITH H2O'
CYLINDER  3 1  0.4623    2P1.7145
CYLINDER  2 1  0.5385    2P1.7145
CUBOID    3 1  4P0.7264 2P1.7145
UNIT  3
COM='FUEL PIN CELL - WITH ST DISK'
CYLINDER  1 1  0.4528    2P0.7938
CYLINDER  0 1  0.4623    2P0.7938
CYLINDER  2 1  0.5385    2P0.7938
CUBOID    3 1  4P0.7264 2P0.7938
UNIT  4
COM='WATER ROD CELL - WITH ST DISK'
CYLINDER  3 1  0.4623    2P0.7938
CYLINDER  2 1  0.5385    2P0.7938
CUBOID    3 1  4P0.7264 2P0.7938
UNIT  5
COM='FUEL PIN CELL - WITH AL DISK'
CYLINDER  1 1  0.4528    2P0.6350
CYLINDER  0 1  0.4623    2P0.6350
CYLINDER  2 1  0.5385    2P0.6350
CUBOID    3 1  4P0.7264 2P0.6350
UNIT  6
COM='WATER ROD CELL - WITH AL DISK'
CYLINDER  3 1  0.4623    2P0.6350
CYLINDER  2 1  0.5385    2P0.6350
CUBOID    3 1  4P0.7264 2P0.6350
UNIT  7
COM='FUEL PIN ARRAY + CHANNEL - BETWEEN DISKS'
ARRAY  1    -6.5376 -6.5376 -1.7145
CUBOID 3 1 4P6.7031 2P1.7145
CUBOID 2 1 4P6.9063 2P1.7145
UNIT  8
COM='FUEL PIN ARRAY + CHANNEL - ST DISKS'
ARRAY  2    -6.5376 -6.5376 -0.7938
CUBOID 3 1 4P6.7031 2P0.7938
CUBOID 2 1 4P6.9063 2P0.7938
UNIT  9
COM='FUEL PIN ARRAY + CHANNEL - AL DISKS'
ARRAY  3    -6.5376 -6.5376 -0.6350
CUBOID 3 1 4P6.7031 2P0.6350
CUBOID 2 1 4P6.9063 2P0.6350
UNIT 10
COM='X-X BORAL + COVER SHEET BETWEEN DISKS'
CUBOID 6 1 2P6.7310 2P0.1124 2P1.7145
CUBOID 4 1 2P6.7310 2P0.1714 2P1.7145
CUBOID 5 1 2P6.7765 +0.2168 -0.1714 2P1.7145
UNIT 11
COM='Y-Y BORAL + COVER SHEET BETWEEN DISKS'
CUBOID 6 1 2P0.1124 2P6.7310 2P1.7145
CUBOID 4 1 2P0.1714 2P6.7310 2P1.7145
CUBOID 5 1 +0.2168 -0.1714 2P6.7765 2P1.7145
UNIT 12
COM='X-X BORAL + COVER.SHEET WITH ST DISKS'
CUBOID 6 1 2P6.7310 2P0.1124 2P0.7938
CUBOID 4 1 2P6.7310 2P0.1714 2P0.7938
```

Figure 6.8-5 (continued)

```
CUBOID 5 1 2P6.7765 +0.2168 -0.1714 2P0.7938
UNIT 13
COM='Y-Y BORAL + COVER SHEET WITH ST DISKS'
CUBOID 6 1 2P0.1124 2P6.7310 2P0.7938
CUBOID 4 1 2P0.1714 2P6.7310 2P0.7938
CUBOID 5 1 +0.2168 -0.1714 2P6.7765 2P0.7938
UNIT 14
COM='X-X BORAL + COVER SHEET WITH AL DISKS'
CUBOID 6 1 2P6.7310 2P0.1124 2P0.6350
CUBOID 4 1 2P6.7310 2P0.1714 2P0.6350
CUBOID 5 1 2P6.7765 +0.2168 -0.1714 2P0.6350
UNIT 15
COM='Y-Y BORAL + COVER SHEET WITH AL DISKS'
CUBOID 6 1 2P0.1124 2P6.7310 2P0.6350
CUBOID 4 1 2P0.1714 2P6.7310 2P0.6350
CUBOID 5 1 +0.2168 -0.1714 2P6.7765 2P0.6350
UNIT 20
COM='FUEL TUBE CELL 2 BORAL SHEETS - BETWEEN DISKS (TR)'
CUBOID 3 1 4P7.4930 2P1.7145
HOLE   7 +0.5867 +0.5867 0.0
CUBOID 5 1 4P7.6144 2P1.7145
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P1.7145
HOLE   10 0.0 +7.7859 0.0
HOLE   11 +7.7859 0.0 0.0
UNIT 21
COM='FUEL TUBE CELL 2 BORAL SHEETS - BETWEEN DISKS (TL)'
CUBOID 3 1 4P7.4930 2P1.7145
HOLE   7 -0.5867 +0.5867 0.0
CUBOID 5 1 4P7.6144 2P1.7145
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P1.7145
HOLE   10 0.0 +7.7859 0.0
HOLE   11 +7.7859 0.0 0.0
UNIT 22
COM='FUEL TUBE CELL 2 BORAL SHEETS - BETWEEN DISKS (BL)'
CUBOID 3 1 4P7.4930 2P1.7145
HOLE   7 -0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P1.7145
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P1.7145
HOLE   10 0.0 +7.7859 0.0
HOLE   11 +7.7859 0.0 0.0
UNIT 23
COM='FUEL TUBE CELL 2 BORAL SHEETS - BETWEEN DISKS (BR)'
CUBOID 3 1 4P7.4930 2P1.7145
HOLE   7 +0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P1.7145
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P1.7145
HOLE   10 0.0 +7.7859 0.0
HOLE   11 +7.7859 0.0 0.0
UNIT 24
COM='FUEL TUBE CELL 2 BORAL SHEETS - BETWEEN DISKS (T)'
CUBOID 3 1 4P7.4930 2P1.7145
HOLE   7 0.0 +0.5867 0.0
CUBOID 5 1 4P7.6144 2P1.7145
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P1.7145
HOLE   10 0.0 +7.7859 0.0
HOLE   11 +7.7859 0.0 0.0
UNIT 25
COM='FUEL TUBE CELL 2 BORAL SHEETS - BETWEEN DISKS (B)'
CUBOID 3 1 4P7.4930 2P1.7145
HOLE   7 0.0 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P1.7145
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P1.7145
HOLE   10 0.0 +7.7859 0.0
HOLE   11 +7.7859 0.0 0.0
UNIT 26
COM='FUEL TUBE CELL TOP BORAL SHEETS - BETWEEN DISKS (TL)'
CUBOID 3 1 4P7.4930 2P1.7145
HOLE   7 -0.5867 +0.5867 0.0
CUBOID 5 1 4P7.6144 2P1.7145
CUBOID 3 1 +7.6144 -7.6144 +8.0028 -7.6144 +2P1.7145
HOLE   10 0.0 +7.7859 0.0
UNIT 27
COM='FUEL TUBE CELL TOP BORAL SHEETS - BETWEEN DISKS (BL)'
CUBOID 3 1 4P7.4930 2P1.7145
HOLE   7 -0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P1.7145
CUBOID 3 1 +7.6144 -7.6144 +8.0028 -7.6144 +2P1.7145
HOLE   10 0.0 +7.7859 0.0
UNIT 28
COM='FUEL TUBE CELL RIGHT BORAL SHEETS - BETWEEN DISKS (BL)'
CUBOID 3 1 4P7.4930 2P1.7145
HOLE   7 -0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P1.7145
CUBOID 3 1 +8.0028 -7.6144 +7.6144 -7.6144 +2P1.7145
HOLE   11 +7.7859 0.0 0.0
UNIT 29
COM='FUEL TUBE CELL RIGHT BORAL SHEETS - BETWEEN DISKS (B)'
CUBOID 3 1 4P7.4930 2P1.7145
HOLE   7 0.0 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P1.7145
CUBOID 3 1 +8.0028 -7.6144 +7.6144 -7.6144 +2P1.7145
HOLE   11 +7.7859 0.0 0.0
UNIT 30
COM='FUEL TUBE CELL RIGHT BORAL SHEETS - BETWEEN DISKS (BR)'
CUBOID 3 1 4P7.4930 2P1.7145
HOLE   7 +0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P1.7145
CUBOID 3 1 +8.0028 -7.6144 +7.6144 -7.6144 +2P1.7145
HOLE   11 +7.7859 0.0 0.0
```

Figure 6.8-5 (continued)

```
UNIT 31
COM='FUEL TUBE CELL NO BORAL SHEETS - BETWEEN DISKS (BL)'
CUBOID 3 1 4P7.4930 2P1.7145
HOLE   7 -0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P1.7145
UNIT 40
COM='FUEL TUBE CELL 2 BORAL SHEETS - STEEL DISKS (TR)'
CUBOID 3 1 4P7.4930 2P0.7938
HOLE   8 +0.5867 +0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.7938
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P0.7938
HOLE   12 0.0 +7.7859 0.0
HOLE   13 +7.7859 0.0 0.0
UNIT 41
COM='FUEL TUBE CELL 2 BORAL SHEETS - STEEL DISKS (TL)'
CUBOID 3 1 4P7.4930 2P0.7938
HOLE   8 -0.5867 +0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.7938
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P0.7938
HOLE   12 0.0 +7.7859 0.0
HOLE   13 +7.7859 0.0 0.0
UNIT 42
COM='FUEL TUBE CELL 2 BORAL SHEETS - STEEL DISKS (BL)'
CUBOID 3 1 4P7.4930 2P0.7938
HOLE   8 -0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.7938
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P0.7938
HOLE   12 0.0 +7.7859 0.0
HOLE   13 +7.7859 0.0 0.0
UNIT 43
COM='FUEL TUBE CELL 2 BORAL SHEETS - STEEL DISKS (BR)'
CUBOID 3 1 4P7.4930 2P0.7938
HOLE   8 +0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.7938
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P0.7938
HOLE   12 0.0 +7.7859 0.0
HOLE   13 +7.7859 0.0 0.0
UNIT 44
COM='FUEL TUBE CELL 2 BORAL SHEETS - STEEL DISKS (T)'
CUBOID 3 1 4P7.4930 2P0.7938
HOLE   8 0.0 +0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.7938
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P0.7938
HOLE   12 0.0 +7.7859 0.0
HOLE   13 +7.7859 0.0 0.0
UNIT 45
COM='FUEL TUBE CELL 2 BORAL SHEETS - STEEL DISKS  B''
CUBOID 3 1 4P7.4930 2P0.7938
HOLE   8 0.0 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.7938
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P0.7938
HOLE   12 0.0 +7.7859 0.0
HOLE   13 +7.7859 0.0 0.0
UNIT 46
COM='FUEL TUBE CELL TOP BORAL SHEETS - STEEL DISKS (TL)'
CUBOID 3 1 4P7.4930 2P0.7938
HOLE   8 -0.5867 +0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.7938
CUBOID 3 1 +7.6144 -7.6144 +8.0028 -7.6144 +2P0.7938
HOLE   12 0.0 +7.7859 0.0
UNIT 47
COM='FUEL TUBE CELL TOP BORAL SHEETS - STEEL DISKS  BL '
CUBOID 3 1 4P7.4930 2P0.7938
HOLE   8 -0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.7938
CUBOID 3 1 +7.6144 -7.6144 +8.0028 -7.6144 +2P0.7938
HOLE   12 0.0 +7.7859 0.0
UNIT 48
COM='FUEL TUBE CELL RIGHT BORAL SHEETS - STEEL DISKS  BL
CUBOID 3 1 4P7.4930 2P0.7938
HOLE   8 -0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.7938
CUBOID 3 1 +8.0028 -7.6144 +7.6144 -7.6144 +2P0.7938
HOLE   13 +7.7859 0.0 0.0
UNIT 49
COM='FUEL TUBE CELL RIGHT BORAL SHEETS - STEEL DISKS  B
CUBOID 3 1 4P7.4930 2P0.7938
HOLE   8 0.0 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.7938
CUBOID 3 1 +8.0028 -7.6144 +7.6144 -7.6144 +2P0.7938
HOLE   13 +7.7859 0.0 0.0
UNIT 50
COM='FUEL TUBE CELL RIGHT BORAL SHEETS - STEEL DISKS  BR
CUBOID 3 1 4P7.4930 2P0.7938
HOLE   8 +0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.7938
CUBOID 3 1 +8.0028 -7.6144 +7.6144 -7.6144 +2P0.7938
HOLE   13 +7.7859 0.0 0.0
UNIT 51
COM='FUEL TUBE CELL NO BORAL SHEETS - STEEL DISKS  BL '
CUBOID 3 1 4P7.4930 2P0.7938
HOLE   8 -0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.7938
UNIT 60
COM='FUEL TUBE CELL 2 BORAL SHEETS - AL DISKS  TR '
CUBOID 3 1 4P7.4930 2P0.6350
HOLE   9 +0.5867 +0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.6350
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P0.6350
```

Figure 6.8-5 (continued)

```
HOLE   14 0.0 +7.7859 0.0
HOLE   15 +7.7859 0.0 0.0
UNIT 61
COM='FUEL TUBE CELL 2 BORAL SHEETS - AL DISKS (TL)'
CUBOID 3 1 4P7.4930 2P0.6350
HOLE   9 -0.5867 +0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.6350
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P0.6350
HOLE   14 0.0 +7.7859 0.0
HOLE   15 +7.7859 0.0 0.0
UNIT 62
COM='FUEL TUBE CELL 2 BORAL SHEETS - AL DISKS (BL)'
CUBOID 3 1 4P7.4930 2P0.6350
HOLE   9 -0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.6350
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P0.6350
HOLE   14 0.0 +7.7859 0.0
HOLE   15 +7.7859 0.0 0.0
UNIT 63
COM='FUEL TUBE CELL 2 BORAL SHEETS - AL DISKS (BR)'
CUBOID 3 1 4P7.4930 2P0.6350
HOLE   9 +0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.6350
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P0.6350
HOLE   14 0.0 +7.7859 0.0
HOLE   15 +7.7859 0.0 0.0
UNIT 64
COM='FUEL TUBE CELL 2 BORAL SHEETS - AL DISKS (T)'
CUBOID 3 1 4P7.4930 2P0.6350
HOLE   9 0.0 +0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.6350
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P0.6350
HOLE   14 0.0 +7.7859 0.0
HOLE   15 +7.7859 0.0 0.0
UNIT 65
COM='FUEL TUBE CELL 2 BORAL SHEETS - AL DISKS (B)'
CUBOID 3 1 4P7.4930 2P0.6350
HOLE   9 0.0 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.6350
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P0.6350
HOLE   14 0.0 +7.7859 0.0
HOLE   15 +7.7859 0.0 0.0
UNIT 66
COM='FUEL TUBE CELL TOP BORAL SHEETS - AL DISKS (TL)'
CUBOID 3 1 4P7.4930 2P0.6350
HOLE   9 -0.5867 +0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.6350
CUBOID 3 1 +7.6144 -7.6144 +8.0028 -7.6144 +2P0.6350
HOLE   14 0.0 +7.7859 0.0
UNIT 67
COM='FUEL TUBE CELL TOP BORAL SHEETS - AL DISKS (BL)'
CUBOID 3 1 4P7.4930 2P0.6350
HOLE   9 -0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.6350
CUBOID 3 1 +7.6144 -7.6144 +8.0028 -7.6144 +2P0.6350
HOLE   14 0.0 +7.7859 0.0
UNIT 68
COM='FUEL TUBE CELL RIGHT BORAL SHEETS - AL DISKS (BL)'
CUBOID 3 1 4P7.4930 2P0.6350
HOLE   9 -0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.6350
CUBOID 3 1 +8.0028 -7.6144 +7.6144 -7.6144 +2P0.6350
HOLE   15 +7.7859 0.0 0.0
UNIT 69
COM='FUEL TUBE CELL RIGHT BORAL SHEETS - AL DISKS (B)'
CUBOID 3 1 4P7.4930 2P0.6350
HOLE   9 0.0 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.6350
CUBOID 3 1 +8.0028 -7.6144 +7.6144 -7.6144 +2P0.6350
HOLE   15 +7.7859 0.0 0.0
UNIT 70
COM='FUEL TUBE CELL RIGHT BORAL SHEETS - AL DISKS (BR)'
CUBOID 3 1 4P7.4930 2P0.6350
HOLE   9 +0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.6350
CUBOID 3 1 +8.0028 -7.6144 +7.6144 -7.6144 +2P0.6350
HOLE   15 +7.7859 0.0 0.0
UNIT 71
COM='FUEL TUBE CELL NO BORAL SHEETS - AL DISKS (BL)'
CUBOID 3 1 4P7.4930 2P0.6350
HOLE   9 -0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.6350
UNIT 80
COM='DISK OPENING 2 BORAL SHEET TUBE - BETWEEN DISKS (TR)'
CUBOID 3 1 4P7.9731 2P1.7145
HOLE   20  -0.0297 -0.0297 0.0
UNIT 81
COM='DISK OPENING 2 BORAL SHEET TUBE - BETWEEN DISKS (TL)'
CUBOID 3 1 4P7.9731 2P1.7145
HOLE   21  -0.3586 -0.0297 0.0
UNIT 82
COM='DISK OPENING 2 BORAL SHEET TUBE - BETWEEN DISKS (BL)'
CUBOID 3 1 4P7.9731 2P1.7145
HOLE   22  -0.3586 -0.3586 0.0
UNIT 83
COM='DISK OPENING 2 BORAL SHEET TUBE - BETWEEN DISKS (BR)'
CUBOID 3 1 4P7.9731 2P1.7145
HOLE   23  -0.0297 -0.3586 0.0
UNIT 84
```

Figure 6.8-5 (continued)

```
COM='DISK OPENING 2 BORAL SHEET TUBE - BETWEEN DISKS (T)'
CUBOID 3 1 4P7.9731 2P1.7145
HOLE   24  -0.1942 -0.0297 0.0
UNIT 85
COM='DISK OPENING 2 BORAL SHEET TUBE - BETWEEN DISKS (B)'
CUBOID 3 1 4P7.9731 2P1.7145
HOLE   25  -0.1942 -0.3586 0.0
UNIT 86
COM='DISK OPENING TOP BORAL SHEET TUBE - BETWEEN DISKS (TL)'
CUBOID 3 1 4P7.9731 2P1.7145
HOLE   26  -0.3586 -0.0297 0.0
UNIT 87
COM='DISK OPENING TOP BORAL SHEET TUBE - BETWEEN DISKS (BL)'
CUBOID 3 1 4P7.9731 2P1.7145
HOLE   27  -0.3586 -0.3586 0.0
UNIT 88
COM='DISK OPENING RIGHT BORAL SHEET TUBE - BETWEEN DISKS (BL)'
CUBOID 3 1 4P7.9731 2P1.7145
HOLE   28  -0.3586 -0.3586 0.0
UNIT 89
COM='DISK OPENING RIGHT BORAL SHEET TUBE - BETWEEN DISKS (B)'
CUBOID 3 1 4P7.9731 2P1.7145
HOLE   29  -0.1942 -0.3586 0.0
UNIT 90
COM='DISK OPENING RIGHT BORAL SHEET TUBE - BETWEEN DISKS (BR)'
CUBOID 3 1 4P7.9731 2P1.7145
HOLE   30  -0.0297 -0.3586 0.0
UNIT 91
COM='DISK OPENING NO BORAL SHEET TUBE - BETWEEN DISKS (BL)'
CUBOID 3 1 4P7.9731 2P1.7145
HOLE   31  -0.3586 -0.3586 0.0
UNIT 100
COM='DISK OPENING 2 BORAL SHEET TUBE - STEEL DISKS (TR)'
CUBOID 3 1 4P7.9731 2P0.7938
HOLE   40  -0.0297 -0.0297 0.0
UNIT 101
COM='DISK OPENING 2 BORAL SHEET TUBE - STEEL DISKS (TL)'
CUBOID 3 1 4P7.9731 2P0.7938
HOLE   41  -0.3586 -0.0297 0.0
UNIT 102
COM='DISK OPENING 2 BORAL SHEET TUBE - STEEL DISKS (BL)'
CUBOID 3 1 4P7.9731 2P0.7938
HOLE   42  -0.3586 -0.3586 0.0
UNIT 103
COM='DISK OPENING 2 BORAL SHEET TUBE - STEEL DISKS (BR)'
CUBOID 3 1 4P7.9731 2P0.7938
HOLE   43  -0.0297 -0.3586 0.0
UNIT 104
COM='DISK OPENING 2 BORAL SHEET TUBE - STEEL DISKS (T)'
CUBOID 3 1 4P7.9731 2P0.7938
HOLE   44  -0.1942 -0.0297 0.0
UNIT 105
COM='DISK OPENING 2 BORAL SHEET TUBE - STEEL DISKS (B)'
CUBOID 3 1 4P7.9731 2P0.7938
HOLE   45  -0.1942 -0.3586 0.0
UNIT 106
COM='DISK OPENING TOP BORAL SHEET TUBE - STEEL DISKS (TL)'
CUBOID 3 1 4P7.9731 2P0.7938
HOLE   46  -0.3586 -0.0297 0.0
UNIT 107
COM='DISK OPENING TOP BORAL SHEET TUBE - STEEL DISKS (BL)'
CUBOID 3 1 4P7.9731 2P0.7938
HOLE   47  -0.3586 -0.3586 0.0
UNIT 108
COM='DISK OPENING RIGHT BORAL SHEET TUBE - STEEL DISKS (BL)'
CUBOID 3 1 4P7.9731 2P0.7938
HOLE   48  -0.3586 -0.3586 0.0
UNIT 109
COM='DISK OPENING RIGHT BORAL SHEET TUBE - STEEL DISKS (B)'
CUBOID 3 1 4P7.9731 2P0.7938
HOLE   49  -0.1942 -0.3586 0.0
UNIT 110
COM='DISK OPENING RIGHT BORAL SHEET TUBE - STEEL DISKS (BR)'
CUBOID 3 1 4P7.9731 2P0.7938
HOLE   50  -0.0297 -0.3586 0.0
UNIT 111
COM='DISK OPENING NO BORAL SHEET TUBE - STEEL DISKS (BL)'
CUBOID 3 1 4P7.9731 2P0.7938
HOLE   51  -0.3586 -0.3586 0.0
UNIT 120
COM='DISK OPENING 2 BORAL SHEET TUBE - AL DISKS (TR)'
CUBOID 3 1 4P7.9731 2P0.6350
HOLE   60  -0.0297 -0.0297 0.0
UNIT 121
COM='DISK OPENING 2 BORAL SHEET TUBE - AL DISKS (TL)'
CUBOID 3 1 4P7.9731 2P0.6350
HOLE   61  -0.3586 -0.0297 0.0
UNIT 122
COM='DISK OPENING 2 BORAL SHEET TUBE - AL DISKS (BL)'
CUBOID 3 1 4P7.9731 2P0.6350
HOLE   62  -0.3586 -0.3586 0.0
UNIT 123
COM='DISK OPENING 2 BORAL SHEET TUBE - AL DISKS (BR)'
CUBOID 3 1 4P7.9731 2P0.6350
HOLE   63  -0.0297 -0.3586 0.0
UNIT 124
COM='DISK OPENING 2 BORAL SHEET TUBE - AL DISKS (T)'
CUBOID 3 1 4P7.9731 2P0.6350
HOLE   64  -0.1942 -0.0297 0.0
```

Figure 6.8-5 (continued)

```
UNIT 125
COM='DISK OPENING 2 BORAL SHEET TUBE - AL DISKS (B)'
CUBOID 3 1 4P7.9731 2P0.6350
HOLE   65  -0.1942 -0.3586 0.0
UNIT 126
COM='DISK OPENING TOP BORAL SHEET TUBE - AL DISKS (TL)'
CUBOID 3 1 4P7.9731 2P0.6350
HOLE   66  -0.3586 -0.0297 0.0
UNIT 127
COM='DISK OPENING TOP BORAL SHEET TUBE - AL DISKS (BL)'
CUBOID 3 1 4P7.9731 2P0.6350
HOLE   67  -0.3586 -0.3586 0.0
UNIT 128
COM='DISK OPENING RIGHT BORAL SHEET TUBE - AL DISKS (BL)'
CUBOID 3 1 4P7.9731 2P0.6350
HOLE   68  -0.3586 -0.3586 0.0
UNIT 129
COM='DISK OPENING RIGHT BORAL SHEET TUBE - AL DISKS (B)'
CUBOID 3 1 4P7.9731 2P0.6350
HOLE   69  -0.1942 -0.3586 0.0
UNIT 130
COM='DISK OPENING RIGHT BORAL SHEET TUBE - AL DISKS (BR)'
CUBOID 3 1 4P7.9731 2P0.6350
HOLE   70  -0.0297 -0.3586 0.0
UNIT 131
COM='DISK OPENING NO BORAL SHEET TUBE - AL DISKS (BL)'
CUBOID 3 1 4P7.9731 2P0.6350
HOLE   71  -0.3586 -0.3586 0.0
UNIT 140
COM='BASKET STRUCTURE IN TRANPORT CASK - WATER DISK'
CYLINDER 3 1 +83.5787 2P1.7145
HOLE 90  -70.3885  +8.7986 0.0
HOLE 83  -52.7914  +8.7986 0.0
HOLE 83  -52.7914 +26.3957 0.0
HOLE 90  -52.7914 +43.9928 0.0
HOLE 83  -35.1942  +8.7986 0.0
HOLE 83  -35.1942 +26.3957 0.0
HOLE 83  -35.1942 +43.9928 0.0
HOLE 90  -35.1942 +61.5899 0.0
HOLE 83  -17.5971  +8.7986 0.0
HOLE 83  -17.5971 +26.3957 0.0
HOLE 83  -17.5971 +43.9928 0.0
HOLE 90  -17.5971 +61.5899 0.0
HOLE 85   0.0      +8.7986 0.0
HOLE 85   0.0     +26.3957 0.0
HOLE 85   0.0     +43.9928 0.0
HOLE 89   0.0     +61.5899 0.0
HOLE 82  +17.5971  +8.7986 0.0
HOLE 82  +17.5971 +26.3957 0.0
HOLE 82  +17.5971 +43.9928 0.0
HOLE 88  +17.5971 +61.5899 0.0
HOLE 82  +35.1942  +8.7986 0.0
HOLE 82  +35.1942 +26.3957 0.0
HOLE 82  +35.1942 +43.9928 0.0
HOLE 91  +35.1942 +61.5899 0.0
HOLE 82  +52.7914  +8.7986 0.0
HOLE 87  +52.7914 +26.3957 0.0
HOLE 91  +52.7914 +43.9928 0.0
HOLE 91  +70.3885  +8.7986 0.0
HOLE 80  -70.3885  -8.7986 0.0
HOLE 80  -52.7914  -8.7986 0.0
HOLE 80  -52.7914 -26.3957 0.0
HOLE 80  -52.7914 -43.9928 0.0
HOLE 80  -35.1942  -8.7986 0.0
HOLE 80  -35.1942 -26.3957 0.0
HOLE 80  -35.1942 -43.9928 0.0
HOLE 80  -35.1942 -61.5899 0.0
HOLE 80  -17.5971  -8.7986 0.0
HOLE 80  -17.5971 -26.3957 0.0
HOLE 80  -17.5971 -43.9928 0.0
HOLE 80  -17.5971 -61.5899 0.0
HOLE 84   0.0      -8.7986 0.0
HOLE 84   0.0     -26.3957 0.0
HOLE 84   0.0     -43.9928 0.0
HOLE 84   0.0     -61.5899 0.0
HOLE 81  +17.5971  -8.7986 0.0
HOLE 81  +17.5971 -26.3957 0.0
HOLE 81  +17.5971 -43.9928 0.0
HOLE 81  +17.5971 -61.5899 0.0
HOLE 81  +35.1942  -8.7986 0.0
HOLE 81  +35.1942 -26.3957 0.0
HOLE 81  +35.1942 -43.9928 0.0
HOLE 86  +35.1942 -61.5899 0.0
HOLE 81  +52.7914  -8.7986 0.0
HOLE 86  +52.7914 -26.3957 0.0
HOLE 86  +52.7914 -43.9928 0.0
HOLE 86  +70.3885  -8.7986 0.0
CYLINDER   5 1  +85.1662 2P1.7145
CYLINDER  10 1  +86.0425 2P1.7145
CYLINDER   7 1  +87.9475 2P1.7145
CYLINDER   8 1  +97.4725 2P1.7145
CYLINDER   9 1 +102.5525 2P1.7145
CYLINDER   7 1 +105.7275 2P1.7145
CUBOID    10 1 4P125.0   2P1.7145
UNIT 141
COM='BASKET STRUCTURE IN TRANPORT CASK - SS DISK'
CYLINDER 7 1  +83.1850 2P0.7938
HOLE 110  -70.3885  +8.7986 0.0
HOLE 103  -52.7914  +8.7986 0.0
```

Figure 6.8-5 (continued)

```
HOLE 103  -52.7914 +26.3957 0.0
HOLE 110  -52.7914 +43.9928 0.0
HOLE 103  -35.1942  +8.7986 0.0
HOLE 103  -35.1942 +26.3957 0.0
HOLE 103  -35.1942 +43.9928 0.0
HOLE 110  -35.1942 +61.5899 0.0
HOLE 103  -17.5971  +8.7986 0.0
HOLE 103  -17.5971 +26.3957 0.0
HOLE 103  -17.5971 +43.9928 0.0
HOLE 110  -17.5971 +61.5899 0.0
HOLE 105   0.0      +8.7986 0.0
HOLE 105   0.0     +26.3957 0.0
HOLE 105   0.0     +43.9928 0.0
HOLE 109   0.0     +61.5899 0.0
HOLE 102  +17.5971  +8.7986 0.0
HOLE 102  +17.5971 +26.3957 0.0
HOLE 102  +17.5971 +43.9928 0.0
HOLE 108  +17.5971 +61.5899 0.0
HOLE 102  +35.1942  +8.7986 0.0
HOLE 102  +35.1942 +26.3957 0.0
HOLE 102  +35.1942 +43.9928 0.0
HOLE 111  +35.1942 +61.5899 0.0
HOLE 102  +52.7914  +8.7986 0.0
HOLE 107  +52.7914 +26.3957 0.0
HOLE 111  +52.7914 +43.9928 0.0
HOLE 111  +70.3885  +8.7986 0.0
HOLE 100  -70.3885  -8.7986 0.0
HOLE 100  -52.7914  -8.7986 0.0
HOLE 100  -52.7914 -26.3957 0.0
HOLE 100  -52.7914 -43.9928 0.0
HOLE 100  -35.1942  -8.7986 0.0
HOLE 100  -35.1942 -26.3957 0.0
HOLE 100  -35.1942 -43.9928 0.0
HOLE 100  -35.1942 -61.5899 0.0
HOLE 100  -17.5971  -8.7986 0.0
HOLE 100  -17.5971 -26.3957 0.0
HOLE 100  -17.5971 -43.9928 0.0
HOLE 100  -17.5971 -61.5899 0.0
HOLE 104   0.0      -8.7986 0.0
HOLE 104   0.0     -26.3957 0.0
HOLE 104   0.0     -43.9928 0.0
HOLE 104   0.0     -61.5899 0.0
HOLE 101  +17.5971  -8.7986 0.0
HOLE 101  +17.5971 -26.3957 0.0
HOLE 101  +17.5971 -43.9928 0.0
HOLE 101  +17.5971 -61.5899 0.0
HOLE 101  +35.1942  -8.7986 0.0
HOLE 101  +35.1942 -26.3957 0.0
HOLE 101  +35.1942 -43.9928 0.0
HOLE 106  +35.1942 -61.5899 0.0
HOLE 101  +52.7914  -8.7986 0.0
HOLE 106  +52.7914 -26.3957 0.0
HOLE 106  +52.7914 -43.9928 0.0
HOLE 106  +70.3885  -8.7986 0.0
CYLINDER   3 1  +83.5787 2P0.7938
CYLINDER   5 1  +85.1662 2P0.7938
CYLINDER  10 1  +86.0425 2P0.7938
CYLINDER   7 1  +87.9475 2P0.7938
CYLINDER   8 1  +97.4725 2P0.7938
CYLINDER   9 1 +102.5525 2P0.7938
CYLINDER   7 1 +105.7275 2P0.7938
CUBOID    10 1 4P125.0   2P0.7938
UNIT 142
COM='BASKET STRUCTURE IN TRANPORT CASK - AL DISK'
CYLINDER 4 1  +82.8675 2P0.6350
HOLE 130  -70.3885  +8.7986 0.0
HOLE 123  -52.7914  +8.7986 0.0
HOLE 123  -52.7914 +26.3957 0.0
HOLE 130  -52.7914 +43.9928 0.0
HOLE 123  -35.1942  +8.7986 0.0
HOLE 123  -35.1942 +26.3957 0.0
HOLE 123  -35.1942 +43.9928 0.0
HOLE 130  -35.1942 +61.5899 0.0
HOLE 123  -17.5971  +8.7986 0.0
HOLE 123  -17.5971 +26.3957 0.0
HOLE 123  -17.5971 +43.9928 0.0
HOLE 130  -17.5971 +61.5899 0.0
HOLE 125   0.0      +8.7986 0.0
HOLE 125   0.0     +26.3957 0.0
HOLE 125   0.0     +43.9928 0.0
HOLE 129   0.0     +61.5899 0.0
HOLE 122  +17.5971  +8.7986 0.0
HOLE 122  +17.5971 +26.3957 0.0
HOLE 122  +17.5971 +43.9928 0.0
HOLE 128  +17.5971 +61.5899 0.0
HOLE 122  +35.1942  +8.7986 0.0
HOLE 122  +35.1942 +26.3957 0.0
HOLE 122  +35.1942 +43.9928 0.0
HOLE 131  +35.1942 +61.5899 0.0
HOLE 122  +52.7914  +8.7986 0.0
HOLE 127  +52.7914 +26.3957 0.0
HOLE 131  +52.7914 +43.9928 0.0
HOLE 131  +70.3885  +8.7986 0.0
HOLE 120  -70.3885  -8.7986 0.0
HOLE 120  -52.7914  -8.7986 0.0
HOLE 120  -52.7914 -26.3957 0.0
HOLE 120  -52.7914 -43.9928 0.0
HOLE 120  -35.1942  -8.7986 0.0
HOLE 120  -35.1942 -26.3957 0.0
```

Figure 6.8-5 (continued)

```
HOLE 120  -35.1942 -43.9928 0.0
HOLE 120  -35.1942 -61.5899 0.0
HOLE 120  -17.5971  -8.7986 0.0
HOLE 120  -17.5971 -26.3957 0.0
HOLE 120  -17.5971 -43.9928 0.0
HOLE 120  -17.5971 -61.5899 0.0
HOLE 124   0.0      -8.7986 0.0
HOLE 124   0.0     -26.3957 0.0
HOLE 124   0.0     -43.9928 0.0
HOLE 124   0.0     -61.5899 0.0
HOLE 121  +17.5971  -8.7986 0.0
HOLE 121  +17.5971 -26.3957 0.0
HOLE 121  +17.5971 -43.9928 0.0
HOLE 121  +17.5971 -61.5899 0.0
HOLE 121  +35.1942  -8.7986 0.0
HOLE 121  +35.1942 -26.3957 0.0
HOLE 121  +35.1942 -43.9928 0.0
HOLE 126  +35.1942 -61.5899 0.0
HOLE 121  +52.7914  -8.7986 0.0
HOLE 126  +52.7914 -26.3957 0.0
HOLE 126  +52.7914 -43.9928 0.0
HOLE 126  +70.3885  -8.7986 0.0
CYLINDER   3 1  +83.5787 2P0.6350
CYLINDER   5 1  +85.1662 2P0.6350
CYLINDER  10 1  +86.0425 2P0.6350
CYLINDER   7 1  +87.9475 2P0.6350
CYLINDER   8 1  +97.4725 2P0.6350
CYLINDER   9 1 +102.5525 2P0.6350
CYLINDER   7 1 +105.7275 2P0.6350
CUBOID    10 1 4P125.0    2P0.6350
GLOBAL UNIT 143
COM='CASK SLICES TOGETHER'
ARRAY  4 -125.00 -125.00 0.0
END GEOM
READ ARRAY
ARA=1    NUX=9 NUY=9 NUZ=1  FILL
    36R1
 4R1  2   4R1
 5R1  2   3R1
    27R1
END FILL
ARA=2    NUX=9 NUY=9 NUZ=1  FILL
    36R3
 4R3  4   4R3
 5R3  4   3R3
    27R3
END FILL
ARA=3    NUX=9 NUY=9 NUZ=1  FILL
    36R5
 4R5  6   4R5
 5R5  6   3R5
    27R5
END FILL
ARA=4 NUX=1 NUY=1 NUZ=4 FILL 140 141 140 142 END FILL
END ARRAY
READ BOUNDS ZFC=PER YXF=PER END BOUNDS
END DATA
END
```

Figure 6.8-6 CSAS Input for Accident Conditions - Transfer Cask Containing BWR Fuel

```
=CSAS25
UMS BWR TFR; ACCIDENT OP; CASK ARRAY; 1.0 GM/CC IN - 1.0 GM/CC EX; 75%B10
27GROUPNDF4 LATTICECELL
UO2    1 0.95 293.0 92235 4.00 92238 96.00 END
ZIRCALLOY  2 1.0  293.0  END
H2O    3 1.0  293.0  END
AL     4 1.0  293.0  END
SS304  5 1.0  293.0  END
AL     6 DEN=2.6849 0.8706 293.0 END
B-10   6 DEN=2.6849 0.0137 293.0 END
B-11   6 DEN=2.6849 0.0830 293.0 END
C      6 DEN=2.6849 0.0281 293.0 END
CARBONSTEEL 7 1.0 293.0 END
PB     8 1.0 293.0  END
B-10   9 0.0 8.553-5 END
B-11   9 0.0 3.422-4 END
AL     9 0.0 7.763-3 END
H      9 0.0 5.854-2 END
O      9 0.0 2.609-2 END
C      9 0.0 2.264-2 END
N      9 0.0 1.394-3 END
H2O   10 1.0 293.0 END
H2O   11 1.0 293.0 END
END COMP
SQUAREPITCH  1.4529 0.9055 1 3 1.0770 2 0.9246 11 END
UMS BWR TFR; ACCIDENT OP; CASK ARRAY; 1.0 GM/CC IN - 1.0 GM/CC EX; 75%B10
READ PARAM RUN=YES PLT=NO TME=5000 GEN=803 NPG=1000 END PARAM
READ GEOM
UNIT  1
COM='FUEL PIN CELL - WITH H2O'
CYLINDER  1 1  0.4528   2P1.7145
CYLINDER 11 1  0.4623   2P1.7145
CYLINDER  2 1  0.5385   2P1.7145
CUBOID    3 1  4P0.7264 2P1.7145
UNIT  2
COM='WATER ROD CELL - WITH H2O'
CYLINDER  3 1  0.4623   2P1.7145
CYLINDER  2 1  0.5385   2P1.7145
CUBOID    3 1  4P0.7264 2P1.7145
UNIT  3
COM='FUEL PIN CELL - WITH ST DISK'
CYLINDER  1 1  0.4528   2P0.7938
CYLINDER 11 1  0.4623   2P0.7938
CYLINDER  2 1  0.5385   2P0.7938
CUBOID    3 1  4P0.7264 2P0.7938
UNIT  4
COM='WATER ROD CELL - WITH ST DISK'
CYLINDER  3 1  0.4623   2P0.7938
CYLINDER  2 1  0.5385   2P0.7938
CUBOID    3 1  4P0.7264 2P0.7938
UNIT  5
COM='FUEL PIN CELL - WITH AL DISK'
CYLINDER  1 1  0.4528   2P0.6350
CYLINDER 11 1  0.4623   2P0.6350
CYLINDER  2 1  0.5385   2P0.6350
CUBOID    3 1  4P0.7264 2P0.6350
UNIT  6
COM='WATER ROD CELL - WITH AL DISK'
CYLINDER  3 1  0.4623   2P0.6350
CYLINDER  2 1  0.5385   2P0.6350
CUBOID    3 1  4P0.7264 2P0.6350
UNIT  7
COM='FUEL PIN ARRAY + CHANNEL - BETWEEN DISKS
ARRAY  1    -6.5376 -6.5376 -1.7145
CUBOID 3 1 4P6.7031 2P1.7145
CUBOID 2 1 4P6.9063 2P1.7145
UNIT  8
COM='FUEL PIN ARRAY + CHANNEL - ST DISKS'
ARRAY  2    -6.5376 -6.5376 -0.7938
CUBOID 3 1 4P6.7031 2P0.7938
CUBOID 2 1 4P6.9063 2P0.7938
UNIT  9
COM='FUEL PIN ARRAY + CHANNEL - AL DISKS'
ARRAY  3    -6.5376 -6.5376 -0.6350
CUBOID 3 1 4P6.7031 2P0.6350
CUBOID 2 1 4P6.9063 2P0.6350
UNIT 10
COM='X-X BORAL + COVER SHEET BETWEEN DISKS'
CUBOID 6 1 2P6.7310 2P0.1124 2P1.7145
CUBOID 4 1 2P6.7310 2P0.1714 2P1.7145
CUBOID 5 1 2P6.7765 +0.2168 -0.1714 2P1.7145
UNIT 11
COM='Y-Y BORAL + COVER SHEET BETWEEN DISKS'
CUBOID 6 1 2P0.1124 2P6.7310 2P1.7145
CUBOID 4 1 2P0.1714 2P6.7310 2P1.7145
CUBOID 5 1 +0.2168 -0.1714 2P6.7765 2P1.7145
UNIT 12
COM='X-X BORAL + COVER SHEET WITH ST DISKS'
CUBOID 6 1 2P6.7310 2P0.1124 2P0.7938
CUBOID 4 1 2P6.7310 2P0.1714 2P0.7938
CUBOID 5 1 2P6.7765 +0.2168 -0.1714 2P0.7938
UNIT 13
COM='Y-Y BORAL + COVER SHEET WITH ST DISKS'
CUBOID 6 1 2P0.1124 2P6.7310 2P0.7938
CUBOID 4 1 2P0.1714 2P6.7310 2P0.7938
CUBOID 5 1 +0.2168 -0.1714 2P6.7765 2P0.7938
```

Figure 6.8-6 (continued)

```
UNIT 14
COM='X-X BORAL + COVER SHEET WITH AL DISKS'
CUBOID 6 1 2P6.7310 2P0.1124 2P0.6350
CUBOID 4 1 2P6.7310 2P0.1714 2P0.6350
CUBOID 5 1 2P6.7765 +0.2168 -0.1714 2P0.6350
UNIT 15
COM='Y-Y BORAL + COVER SHEET WITH AL DISKS'
CUBOID 6 1 2P0.1124 2P6.7310 2P0.6350
CUBOID 4 1 2P0.1714 2P6.7310 2P0.6350
CUBOID 5 1 +0.2168 -0.1714 2P6.7765 2P0.6350
UNIT 20
COM='FUEL TUBE CELL 2 BORAL SHEETS - BETWEEN DISKS (TR)'
CUBOID 3 1 4P7.4930 2P1.7145
HOLE   7 +0.5867 +0.5867 0.0
CUBOID 5 1 4P7.6144 2P1.7145
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P1.7145
HOLE   10 0.0 +7.7859 0.0
HOLE   11 +7.7859 0.0 0.0
UNIT 21
COM='FUEL TUBE CELL 2 BORAL SHEETS - BETWEEN DISKS (TL)'
CUBOID 3 1 4P7.4930 2P1.7145
HOLE   7 -0.5867 +0.5867 0.0
CUBOID 5 1 4P7.6144 2P1.7145
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P1.7145
HOLE   10 0.0 +7.7859 0.0
HOLE   11 +7.7859 0.0 0.0
UNIT 22
COM='FUEL TUBE CELL 2 BORAL SHEETS - BETWEEN DISKS (BL)'
CUBOID 3 1 4P7.4930 2P1.7145
HOLE   7 -0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P1.7145
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P1.7145
HOLE   10 0.0 +7.7859 0.0
HOLE   11 +7.7859 0.0 0.0
UNIT 23
COM='FUEL TUBE CELL 2 BORAL SHEETS - BETWEEN DISKS (BR)'
CUBOID 3 1 4P7.4930 2P1.7145
HOLE   7 +0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P1.7145
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P1.7145
HOLE   10 0.0 +7.7859 0.0
HOLE   11 +7.7859 0.0 0.0
UNIT 24
COM='FUEL TUBE CELL 2 BORAL SHEETS - BETWEEN DISKS (T)'
CUBOID 3 1 4P7.4930 2P1.7145
HOLE   7 0.0 +0.5867 0.0
CUBOID 5 1 4P7.6144 2P1.7145
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P1.7145
HOLE   10 0.0 +7.7859 0.0
HOLE   11 +7.7859 0.0 0.0
UNIT 25
COM='FUEL TUBE CELL 2 BORAL SHEETS - BETWEEN DISKS (B)'
CUBOID 3 1 4P7.4930 2P1.7145
HOLE   7 0.0 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P1.7145
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P1.7145
HOLE   10 0.0 +7.7859 0.0
HOLE   11 +7.7859 0.0 0.0
UNIT 26
COM='FUEL TUBE CELL TOP BORAL SHEETS - BETWEEN DISKS (TL)'
CUBOID 3 1 4P7.4930 2P1.7145
HOLE   7 -0.5867 +0.5867 0.0
CUBOID 5 1 4P7.6144 2P1.7145
CUBOID 3 1 +7.6144 -7.6144 +8.0028 -7.6144 +2P1.7145
HOLE   10 0.0 +7.7859 0.0
UNIT 27
COM='FUEL TUBE CELL TOP BORAL SHEETS - BETWEEN DISKS (BL)'
CUBOID 3 1 4P7.4930 2P1.7145
HOLE   7 -0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P1.7145
CUBOID 3 1 +7.6144 -7.6144 +8.0028 -7.6144 +2P1.7145
HOLE   10 0.0 +7.7859 0.0
UNIT 28
COM='FUEL TUBE CELL RIGHT BORAL SHEETS - BETWEEN DISKS (BL)'
CUBOID 3 1 4P7.4930 2P1.7145
HOLE   7 -0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P1.7145
CUBOID 3 1 +8.0028 -7.6144 +7.6144 -7.6144 +2P1.7145
HOLE   11 +7.7859 0.0 0.0
UNIT 29
COM='FUEL TUBE CELL RIGHT BORAL SHEETS - BETWEEN DISKS (B)'
CUBOID 3 1 4P7.4930 2P1.7145
HOLE   7 0.0 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P1.7145
CUBOID 3 1 +8.0028 -7.6144 +7.6144 -7.6144 +2P1.7145
HOLE   11 +7.7859 0.0 0.0
UNIT 30
COM='FUEL TUBE CELL RIGHT BORAL SHEETS - BETWEEN DISKS (BR)'
CUBOID 3 1 4P7.4930 2P1.7145
HOLE   7 +0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P1.7145
CUBOID 3 1 +8.0028 -7.6144 +7.6144 -7.6144 +2P1.7145
HOLE   11 +7.7859 0.0 0.0
UNIT 31
COM='FUEL TUBE CELL NO BORAL SHEETS - BETWEEN DISKS (BL)'
CUBOID 3 1 4P7.4930 2P1.7145
```

Figure 6.8-6 (continued)

```
HOLE   7 -0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P1.7145
UNIT 40
COM='FUEL TUBE CELL 2 BORAL SHEETS - STEEL DISKS (TR)'
CUBOID 3 1 4P7.4930 2P0.7938
HOLE   8 +0.5867 +0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.7938
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P0.7938
HOLE   12 0.0 +7.7859 0.0
HOLE   13 +7.7859 0.0 0.0
UNIT 41
COM='FUEL TUBE CELL 2 BORAL SHEETS - STEEL DISKS (TL)'
CUBOID 3 1 4P7.4930 2P0.7938
HOLE   8 -0.5867 +0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.7938
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P0.7938
HOLE   12 0.0 +7.7859 0.0
HOLE   13 +7.7859 0.0 0.0
UNIT 42
COM='FUEL TUBE CELL 2 BORAL SHEETS - STEEL DISKS (BL)'
CUBOID 3 1 4P7.4930 2P0.7938
HOLE   8 -0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.7938
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P0.7938
HOLE   12 0.0 +7.7859 0.0
HOLE   13 +7.7859 0.0 0.0
UNIT 43
COM='FUEL TUBE CELL 2 BORAL SHEETS - STEEL DISKS (BR)'
CUBOID 3 1 4P7.4930 2P0.7938
HOLE   8 +0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.7938
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P0.7938
HOLE   12 0.0 +7.7859 0.0
HOLE   13 +7.7859 0.0 0.0
UNIT 44
COM='FUEL TUBE CELL 2 BORAL SHEETS - STEEL DISKS (T)'
CUBOID 3 1 4P7.4930 2P0.7938
HOLE   8 0.0 +0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.7938
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P0.7938
HOLE   12 0.0 +7.7859 0.0
HOLE   13 +7.7859 0.0 0.0
UNIT 45
COM='FUEL TUBE CELL 2 BORAL SHEETS - STEEL DISKS (B)'
CUBOID 3 1 4P7.4930 2P0.7938
HOLE   8 0.0 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.7938
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P0.7938
HOLE   12 0.0 +7.7859 0.0
HOLE   13 +7.7859 0.0 0.0
UNIT 46
COM='FUEL TUBE CELL TOP BORAL SHEETS - STEEL DISKS (TL)'
CUBOID 3 1 4P7.4930 2P0.7938
HOLE   8 -0.5867 +0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.7938
CUBOID 3 1 +7.6144 -7.6144 +8.0028 -7.6144 +2P0.7938
HOLE   12 0.0 +7.7859 0.0
UNIT 47
COM='FUEL TUBE CELL TOP BORAL SHEETS - STEEL DISKS (BL)'
CUBOID 3 1 4P7.4930 2P0.7938
HOLE   8 -0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.7938
CUBOID 3 1 +7.6144 -7.6144 +8.0028 -7.6144 +2P0.7938
HOLE   12 0.0 +7.7859 0.0
UNIT 48
COM='FUEL TUBE CELL RIGHT BORAL SHEETS - STEEL DISKS (BL)'
CUBOID 3 1 4P7.4930 2P0.7938
HOLE   8 -0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.7938
CUBOID 3 1 +8.0028 -7.6144 +7.6144 -7.6144 +2P0.7938
HOLE   13 +7.7859 0.0 0.0
UNIT 49
COM='FUEL TUBE CELL RIGHT BORAL SHEETS - STEEL DISKS (B)'
CUBOID 3 1 4P7.4930 2P0.7938
HOLE   8 0.0 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.7938
CUBOID 3 1 +8.0028 -7.6144 +7.6144 -7.6144 +2P0.7938
HOLE   13 +7.7859 0.0 0.0
UNIT 50
COM='FUEL TUBE CELL RIGHT BORAL SHEETS - STEEL DISKS (BR)'
CUBOID 3 1 4P7.4930 2P0.7938
HOLE   8 +0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.7938
CUBOID 3 1 +8.0028 -7.6144 +7.6144 -7.6144 +2P0.7938
HOLE   13 +7.7859 0.0 0.0
UNIT 51
COM='FUEL TUBE CELL NO BORAL SHEETS - STEEL DISKS (BL)'
CUBOID 3 1 4P7.4930 2P0.7938
HOLE   8 -0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.7938
UNIT 60
COM='FUEL TUBE CELL 2 BORAL SHEETS - AL DISKS (TR)'
CUBOID 3 1 4P7.4930 2P0.6350
HOLE   9 +0.5867 +0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.6350
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P0.6350
HOLE   14 0.0 +7.7859 0.0
```

Figure 6.8-6 (continued)

```
HOLE   15 +7.7859 0.0 0.0
UNIT 61
COM='FUEL TUBE CELL 2 BORAL SHEETS - AL DISKS (TL)'
CUBOID 3 1 4P7.4930 2P0.6350
HOLE   9 -0.5867 +0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.6350
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P0.6350
HOLE   14 0.0 +7.7859 0.0
HOLE   15 +7.7859 0.0 0.0
UNIT 62
COM='FUEL TUBE CELL 2 BORAL SHEETS - AL DISKS (BL)'
CUBOID 3 1 4P7.4930 2P0.6350
HOLE   9 -0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.6350
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P0.6350
HOLE   14 0.0 +7.7859 0.0
HOLE   15 +7.7859 0.0 0.0
UNIT 63
COM='FUEL TUBE CELL 2 BORAL SHEETS - AL DISKS (BR)'
CUBOID 3 1 4P7.4930 2P0.6350
HOLE   9 +0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.6350
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P0.6350
HOLE   14 0.0 +7.7859 0.0
HOLE   15 +7.7859 0.0 0.0
UNIT 64
COM='FUEL TUBE CELL 2 BORAL SHEETS - AL DISKS (T)'
CUBOID 3 1 4P7.4930 2P0.6350
HOLE   9 0.0 +0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.6350
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P0.6350
HOLE   14 0.0 +7.7859 0.0
HOLE   15 +7.7859 0.0 0.0
UNIT 65
COM='FUEL TUBE CELL 2 BORAL SHEETS - AL DISKS (B)'
CUBOID 3 1 4P7.4930 2P0.6350
HOLE   9 0.0 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.6350
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P0.6350
HOLE   14 0.0 +7.7859 0.0
HOLE   15 +7.7859 0.0 0.0
UNIT 66
COM='FUEL TUBE CELL TOP BORAL SHEETS - AL DISKS (TL)'
CUBOID 3 1 4P7.4930 2P0.6350
HOLE   9 -0.5867 +0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.6350
CUBOID 3 1 +7.6144 -7.6144 +8.0028 -7.6144 +2P0.6350
HOLE   14 0.0 +7.7859 0.0
UNIT 67
COM='FUEL TUBE CELL TOP BORAL SHEETS - AL DISKS (BL)'
CUBOID 3 1 4P7.4930 2P0.6350
HOLE   9 -0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.6350
CUBOID 3 1 +7.6144 -7.6144 +8.0028 -7.6144 +2P0.6350
HOLE   14 0.0 +7.7859 0.0
UNIT 68
COM='FUEL TUBE CELL RIGHT BORAL SHEETS - AL DISKS (BL)'
CUBOID 3 1 4P7.4930 2P0.6350
HOLE   9 -0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.6350
CUBOID 3 1 +8.0028 -7.6144 +7.6144 -7.6144 +2P0.6350
HOLE   15 +7.7859 0.0 0.0
UNIT 69
COM='FUEL TUBE CELL RIGHT BORAL SHEETS - AL DISKS (B)'
CUBOID 3 1 4P7.4930 2P0.6350
HOLE   9 0.0 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.6350
CUBOID 3 1 +8.0028 -7.6144 +7.6144 -7.6144 +2P0.6350
HOLE   15 +7.7859 0.0 0.0
UNIT 70
COM='FUEL TUBE CELL RIGHT BORAL SHEETS - AL DISKS (BR)'
CUBOID 3 1 4P7.4930 2P0.6350
HOLE   9 +0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.6350
CUBOID 3 1 +8.0028 -7.6144 +7.6144 -7.6144 +2P0.6350
HOLE   15 +7.7859 0.0 0.0
UNIT 71
COM='FUEL TUBE CELL NO BORAL SHEETS - AL DISKS (BL)'
CUBOID 3 1 4P7.4930 2P0.6350
HOLE   9 -0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.6350
UNIT 80
COM='DISK OPENING 2 BORAL SHEET TUBE - BETWEEN DISKS (TR)'
CUBOID 3 1 4P7.9731 2P1.7145
HOLE   20  -0.0297 -0.0297 0.0
UNIT 81
COM='DISK OPENING 2 BORAL SHEET TUBE - BETWEEN DISKS (TL)'
CUBOID 3 1 4P7.9731 2P1.7145
HOLE   21  -0.3586 -0.0297 0.0
UNIT 82
COM='DISK OPENING 2 BORAL SHEET TUBE - BETWEEN DISKS (BL)'
CUBOID 3 1 4P7.9731 2P1.7145
HOLE   22  -0.3586 -0.3586 0.0
UNIT 83
COM='DISK OPENING 2 BORAL SHEET TUBE - BETWEEN DISKS (BR)'
CUBOID 3 1 4P7.9731 2P1.7145
HOLE   23  -0.0297 -0.3586 0.0
```

Figure 6.8-6 (continued)

```
UNIT 84
COM='DISK OPENING 2 BORAL SHEET TUBE - BETWEEN DISKS (T)'
CUBOID 3 1 4P7.9731 2P1.7145
HOLE  24  -0.1942 -0.0297 0.0
UNIT 85
COM='DISK OPENING 2 BORAL SHEET TUBE - BETWEEN DISKS (B)'
CUBOID 3 1 4P7.9731 2P1.7145
HOLE  25  -0.1942 -0.3586 0.0
UNIT 86
COM='DISK OPENING TOP BORAL SHEET TUBE - BETWEEN DISKS (TL)'
CUBOID 3 1 4P7.9731 2P1.7145
HOLE  26  -0.3586 -0.0297 0.0
UNIT 87
COM='DISK OPENING TOP BORAL SHEET TUBE - BETWEEN DISKS (BL)'
CUBOID 3 1 4P7.9731 2P1.7145
HOLE  27  -0.3586 -0.3586 0.0
UNIT 88
COM='DISK OPENING RIGHT BORAL SHEET TUBE - BETWEEN DISKS (BL)'
CUBOID 3 1 4P7.9731 2P1.7145
HOLE  28  -0.3586 -0.3586 0.0
UNIT 89
COM='DISK OPENING RIGHT BORAL SHEET TUBE - BETWEEN DISKS (B)'
CUBOID 3 1 4P7.9731 2P1.7145
HOLE  29  -0.1942 -0.3586 0.0
UNIT 90
COM='DISK OPENING RIGHT BORAL SHEET TUBE - BETWEEN DISKS (BR)'
CUBOID 3 1 4P7.9731 2P1.7145
HOLE  30  -0.0297 -0.3586 0.0
UNIT 91
COM='DISK OPENING NO BORAL SHEET TUBE - BETWEEN DISKS (BL)'
CUBOID 3 1 4P7.9731 2P1.7145
HOLE  31  -0.3586 -0.3586 0.0
UNIT 100
COM='DISK OPENING 2 BORAL SHEET TUBE - STEEL DISKS (TR)'
CUBOID 3 1 4P7.9731 2P0.7938
HOLE  40  -0.0297 -0.0297 0.0
UNIT 101
COM='DISK OPENING 2 BORAL SHEET TUBE - STEEL DISKS (TL)'
CUBOID 3 1 4P7.9731 2P0.7938
HOLE  41  -0.3586 -0.0297 0.0
UNIT 102
COM='DISK OPENING 2 BORAL SHEET TUBE - STEEL DISKS (BL)'
CUBOID 3 1 4P7.9731 2P0.7938
HOLE  42  -0.3586 -0.3586 0.0
UNIT 103
COM='DISK OPENING 2 BORAL SHEET TUBE - STEEL DISKS (BR)'
CUBOID 3 1 4P7.9731 2P0.7938
HOLE  43  -0.0297 -0.3586 0.0
UNIT 104
COM='DISK OPENING 2 BORAL SHEET TUBE - STEEL DISKS (T)'
CUBOID 3 1 4P7.9731 2P0.7938
HOLE  44  -0.1942 -0.0297 0.0
UNIT 105
COM='DISK OPENING 2 BORAL SHEET TUBE - STEEL DISKS (B)'
CUBOID 3 1 4P7.9731 2P0.7938
HOLE  45  -0.1942 -0.3586 0.0
UNIT 106
COM='DISK OPENING TOP BORAL SHEET TUBE - STEEL DISKS (TL)'
CUBOID 3 1 4P7.9731 2P0.7938
HOLE  46  -0.3586 -0.0297 0.0
UNIT 107
COM='DISK OPENING TOP BORAL SHEET TUBE - STEEL DISKS (BL)'
CUBOID 3 1 4P7.9731 2P0.7938
HOLE  47  -0.3586 -0.3586 0.0
UNIT 108
COM='DISK OPENING RIGHT BORAL SHEET TUBE - STEEL DISKS (BL)'
CUBOID 3 1 4P7.9731 2P0.7938
HOLE  48  -0.3586 -0.3586 0.0
UNIT 109
COM='DISK OPENING RIGHT BORAL SHEET TUBE - STEEL DISKS (B)'
CUBOID 3 1 4P7.9731 2P0.7938
HOLE  49  -0.1942 -0.3586 0.0
UNIT 110
COM='DISK OPENING RIGHT BORAL SHEET TUBE - STEEL DISKS (BR)'
CUBOID 3 1 4P7.9731 2P0.7938
HOLE  50  -0.0297 -0.3586 0.0
UNIT 111
COM='DISK OPENING NO BORAL SHEET TUBE - STEEL DISKS (BL)'
CUBOID 3 1 4P7.9731 2P0.7938
HOLE  51  -0.3586 -0.3586 0.0
UNIT 120
COM='DISK OPENING 2 BORAL SHEET TUBE - AL DISKS (TR)'
CUBOID 3 1 4P7.9731 2P0.6350
HOLE  60  -0.0297 -0.0297 0.0
UNIT 121
COM='DISK OPENING 2 BORAL SHEET TUBE - AL DISKS (TL)'
CUBOID 3 1 4P7.9731 2P0.6350
HOLE  61  -0.3586 -0.0297 0.0
UNIT 122
COM='DISK OPENING 2 BORAL SHEET TUBE - AL DISKS (BL)'
CUBOID 3 1 4P7.9731 2P0.6350
HOLE  62  -0.3586 -0.3586 0.0
UNIT 123
COM='DISK OPENING 2 BORAL SHEET TUBE - AL DISKS (BR)'
CUBOID 3 1 4P7.9731 2P0.6350
HOLE  63  -0.0297 -0.3586 0.0
UNIT 124
```

Figure 6.8-6 (continued)

```
COM='DISK OPENING 2 BORAL SHEET TUBE - AL DISKS (T)'
CUBOID 3 1 4P7.9731 2P0.6350
HOLE   64  -0.1942 -0.0297 0.0
UNIT 125
COM='DISK OPENING 2 BORAL SHEET TUBE - AL DISKS (B)'
CUBOID 3 1 4P7.9731 2P0.6350
HOLE   65  -0.1942 -0.3586 0.0
UNIT 126
COM='DISK OPENING TOP BORAL SHEET TUBE - AL DISKS (TL)'
CUBOID 3 1 4P7.9731 2P0.6350
HOLE   66  -0.3586 -0.0297 0.0
UNIT 127
COM='DISK OPENING TOP BORAL SHEET TUBE - AL DISKS (BL)'
CUBOID 3 1 4P7.9731 2P0.6350
HOLE   67  -0.3586 -0.3586 0.0
UNIT 128
COM='DISK OPENING RIGHT BORAL SHEET TUBE - AL DISKS (BL)'
CUBOID 3 1 4P7.9731 2P0.6350
HOLE   68  -0.3586 -0.3586 0.0
UNIT 129
COM='DISK OPENING RIGHT BORAL SHEET TUBE - AL DISKS (B)'
CUBOID 3 1 4P7.9731 2P0.6350
HOLE   69  -0.1942 -0.3586 0.0
UNIT 130
COM='DISK OPENING RIGHT BORAL SHEET TUBE - AL DISKS (BR)'
CUBOID 3 1 4P7.9731 2P0.6350
HOLE   70  -0.0297 -0.3586 0.0
UNIT 131
COM='DISK OPENING NO BORAL SHEET TUBE - AL DISKS (BL)'
CUBOID 3 1 4P7.9731 2P0.6350
HOLE   71  -0.3586 -0.3586 0.0
UNIT 140
COM='BASKET STRUCTURE IN TRANPORT CASK - WATER DISK'
CYLINDER 3 1 +83.5787 2P1.7145
HOLE 90  -70.3885  +8.7986 0.0
HOLE 83  -52.7914  +8.7986 0.0
HOLE 83  -52.7914 +26.3957 0.0
HOLE 90  -52.7914 +43.9928 0.0
HOLE 83  -35.1942  +8.7986 0.0
HOLE 83  -35.1942 +26.3957 0.0
HOLE 83  -35.1942 +43.9928 0.0
HOLE 90  -35.1942 +61.5899 0.0
HOLE 83  -17.5971  +8.7986 0.0
HOLE 83  -17.5971 +26.3957 0.0
HOLE 83  -17.5971 +43.9928 0.0
HOLE 90  -17.5971 +61.5899 0.0
HOLE 85   0.0      +8.7986 0.0
HOLE 85   0.0     +26.3957 0.0
HOLE 85   0.0     +43.9928 0.0
HOLE 89   0.0     +61.5899 0.0
HOLE 82  +17.5971  +8.7986 0.0
HOLE 82  +17.5971 +26.3957 0.0
HOLE 82  +17.5971 +43.9928 0.0
HOLE 88  +17.5971 +61.5899 0.0
HOLE 82  +35.1942  +8.7986 0.0
HOLE 82  +35.1942 +26.3957 0.0
HOLE 82  +35.1942 +43.9928 0.0
HOLE 91  +35.1942 +61.5899 0.0
HOLE 82  +52.7914  +8.7986 0.0
HOLE 87  +52.7914 +26.3957 0.0
HOLE 91  +52.7914 +43.9928 0.0
HOLE 91  +70.3885  +8.7986 0.0
HOLE 80  -70.3885  -8.7986 0.0
HOLE 80  -52.7914  -8.7986 0.0
HOLE 80  -52.7914 -26.3957 0.0
HOLE 80  -52.7914 -43.9928 0.0
HOLE 80  -35.1942  -8.7986 0.0
HOLE 80  -35.1942 -26.3957 0.0
HOLE 80  -35.1942 -43.9928 0.0
HOLE 80  -35.1942 -61.5899 0.0
HOLE 80  -17.5971  -8.7986 0.0
HOLE 80  -17.5971 -26.3957 0.0
HOLE 80  -17.5971 -43.9928 0.0
HOLE 80  -17.5971 -61.5899 0.0
HOLE 84   0.0      -8.7986 0.0
HOLE 84   0.0     -26.3957 0.0
HOLE 84   0.0     -43.9928 0.0
HOLE 84   0.0     -61.5899 0.0
HOLE 81  +17.5971  -8.7986 0.0
HOLE 81  +17.5971 -26.3957 0.0
HOLE 81  +17.5971 -43.9928 0.0
HOLE 81  +17.5971 -61.5899 0.0
HOLE 81  +35.1942  -8.7986 0.0
HOLE 81  +35.1942 -26.3957 0.0
HOLE 81  +35.1942 -43.9928 0.0
HOLE 86  +35.1942 -61.5899 0.0
HOLE 81  +52.7914  -8.7986 0.0
HOLE 86  +52.7914 -26.3957 0.0
HOLE 86  +52.7914 -43.9928 0.0
HOLE 86  +70.3885  -8.7986 0.0
CYLINDER   5 1  +85.1662 2P1.7145
CYLINDER  10 1  +86.0425 2P1.7145
CYLINDER   7 1  +87.9475 2P1.7145
CYLINDER   8 1  +97.4725 2P1.7145
CYLINDER   9 1 +102.5525 2P1.7145
CYLINDER   7 1 +105.7275 2P1.7145
CUBOID    10 1 4P125.0   2P1.7145
```

Figure 6.8-6 (continued)

```
UNIT 141
COM='BASKET STRUCTURE IN TRANPORT CASK - SS DISK'
CYLINDER 7 1  +83.1850 2P0.7938
HOLE 110  -70.3885  +8.7986 0.0
HOLE 103  -52.7914  +8.7986 0.0
HOLE 103  -52.7914 +26.3957 0.0
HOLE 110  -52.7914 +43.9928 0.0
HOLE 103  -35.1942  +8.7986 0.0
HOLE 103  -35.1942 +26.3957 0.0
HOLE 103  -35.1942 +43.9928 0.0
HOLE 110  -35.1942 +61.5899 0.0
HOLE 103  -17.5971  +8.7986 0.0
HOLE 103  -17.5971 +26.3957 0.0
HOLE 103  -17.5971 +43.9928 0.0
HOLE 110  -17.5971 +61.5899 0.0
HOLE 105   0.0      +8.7986 0.0
HOLE 105   0.0     +26.3957 0.0
HOLE 105   0.0     +43.9928 0.0
HOLE 109   0.0     +61.5899 0.0
HOLE 102  +17.5971  +8.7986 0.0
HOLE 102  +17.5971 +26.3957 0.0
HOLE 102  +17.5971 +43.9928 0.0
HOLE 108  +17.5971 +61.5899 0.0
HOLE 102  +35.1942  +8.7986 0.0
HOLE 102  +35.1942 +26.3957 0.0
HOLE 102  +35.1942 +43.9928 0.0
HOLE 111  +35.1942 +61.5899 0.0
HOLE 102  +52.7914  +8.7986 0.0
HOLE 107  +52.7914 +26.3957 0.0
HOLE 111  +52.7914 +43.9928 0.0
HOLE 111  +70.3885  +8.7986 0.0
HOLE 100  -70.3885  -8.7986 0.0
HOLE 100  -52.7914  -8.7986 0.0
HOLE 100  -52.7914 -26.3957 0.0
HOLE 100  -52.7914 -43.9928 0.0
HOLE 100  -35.1942  -8.7986 0.0
HOLE 100  -35.1942 -26.3957 0.0
HOLE 100  -35.1942 -43.9928 0.0
HOLE 100  -35.1942 -61.5899 0.0
HOLE 100  -17.5971  -8.7986 0.0
HOLE 100  -17.5971 -26.3957 0.0
HOLE 100  -17.5971 -43.9928 0.0
HOLE 100  -17.5971 -61.5899 0.0
HOLE 104   0.0      -8.7986 0.0
HOLE 104   0.0     -26.3957 0.0
HOLE 104   0.0     -43.9928 0.0
HOLE 104   0.0     -61.5899 0.0
HOLE 101  +17.5971  -8.7986 0.0
HOLE 101  +17.5971 -26.3957 0.0
HOLE 101  +17.5971 -43.9928 0.0
HOLE 101  +17.5971 -61.5899 0.0
HOLE 101  +35.1942  -8.7986 0.0
HOLE 101  +35.1942 -26.3957 0.0
HOLE 101  +35.1942 -43.9928 0.0
HOLE 106  +35.1942 -61.5899 0.0
HOLE 101  +52.7914  -8.7986 0.0
HOLE 106  +52.7914 -26.3957 0.0
HOLE 106  +52.7914 -43.9928 0.0
HOLE 106  +70.3885  -8.7986 0.0
CYLINDER   3 1  +83.5787 2P0.7938
CYLINDER   5 1  +85.1662 2P0.7938
CYLINDER  10 1  +86.0425 2P0.7938
CYLINDER   7 1  +87.9475 2P0.7938
CYLINDER   8 1  +97.4725 2P0.7938
CYLINDER   9 1 +102.5525 2P0.7938
CYLINDER   7 1 +105.7275 2P0.7938
CUBOID    10 1 4P125.0   2P0.7938
UNIT 142
COM='BASKET STRUCTURE IN TRANPORT CASK - AL DISK'
CYLINDER 4 1  +82.8675 2P0.6350
HOLE 130  -70.3885  +8.7986 0.0
HOLE 123  -52.7914  +8.7986 0.0
HOLE 123  -52.7914 +26.3957 0.0
HOLE 130  -52.7914 +43.9928 0.0
HOLE 123  -35.1942  +8.7986 0.0
HOLE 123  -35.1942 +26.3957 0.0
HOLE 123  -35.1942 +43.9928 0.0
HOLE 130  -35.1942 +61.5899 0.0
HOLE 123  -17.5971  +8.7986 0.0
HOLE 123  -17.5971 +26.3957 0.0
HOLE 123  -17.5971 +43.9928 0.0
HOLE 130  -17.5971 +61.5899 0.0
HOLE 125   0.0      +8.7986 0.0
HOLE 125   0.0     +26.3957 0.0
HOLE 125   0.0     +43.9928 0.0
HOLE 129   0.0     +61.5899 0.0
HOLE 122  +17.5971  +8.7986 0.0
HOLE 122  +17.5971 +26.3957 0.0
HOLE 122  +17.5971 +43.9928 0.0
HOLE 128  +17.5971 +61.5899 0.0
HOLE 122  +35.1942  +8.7986 0.0
HOLE 122  +35.1942 +26.3957 0.0
HOLE 122  +35.1942 +43.9928 0.0
HOLE 131  +35.1942 +61.5899 0.0
HOLE 122  +52.7914  +8.7986 0.0
HOLE 127  +52.7914 +26.3957 0.0
HOLE 131  +52.7914 +43.9928 0.0
```

Figure 6.8-6 (continued)

```
HOLE 131  +70.3885   +8.7986 0.0
HOLE 120  -70.3885   -8.7986 0.0
HOLE 120  -52.7914   -8.7986 0.0
HOLE 120  -52.7914 -26.3957 0.0
HOLE 120  -52.7914 -43.9928 0.0
HOLE 120  -35.1942   -8.7986 0.0
HOLE 120  -35.1942 -26.3957 0.0
HOLE 120  -35.1942 -43.9928 0.0
HOLE 120  -35.1942 -61.5899 0.0
HOLE 120  -17.5971   -8.7986 0.0
HOLE 120  -17.5971 -26.3957 0.0
HOLE 120  -17.5971 -43.9928 0.0
HOLE 120  -17.5971 -61.5899 0.0
HOLE 124   0.0        -8.7986 0.0
HOLE 124   0.0       -26.3957 0.0
HOLE 124   0.0       -43.9928 0.0
HOLE 124   0.0       -61.5899 0.0
HOLE 121  +17.5971   -8.7986 0.0
HOLE 121  +17.5971 -26.3957 0.0
HOLE 121  +17.5971 -43.9928 0.0
HOLE 121  +17.5971 -61.5899 0.0
HOLE 121  +35.1942   -8.7986 0.0
HOLE 121  +35.1942 -26.3957 0.0
HOLE 121  +35.1942 -43.9928 0.0
HOLE 126  +35.1942 -61.5899 0.0
HOLE 121  +52.7914   -8.7986 0.0
HOLE 126  +52.7914 -26.3957 0.0
HOLE 126  +52.7914 -43.9928 0.0
HOLE 126  +70.3885   -8.7986 0.0
CYLINDER   3 1  +83.5787 2P0.6350
CYLINDER   5 1  +85.1662 2P0.6350
CYLINDER  10 1  +86.0425 2P0.6350
CYLINDER   7 1  +87.9475 2P0.6350
CYLINDER   8 1  +97.4725 2P0.6350
CYLINDER   9 1 +102.5525 2P0.6350
CYLINDER   7 1 +105.7275 2P0.6350
CUBOID    10 1 4P125.0    2P0.6350
GLOBAL UNIT 143
COM='CASK SLICES TOGETHER'
ARRAY  4 -125.00 -125.00 0.0
END GEOM
READ ARRAY
ARA=1   NUX=9 NUY=9 NUZ=1  FILL
     36R1
 4R1  2   4R1
 5R1  2   3R1
     27R1
END FILL
ARA=2   NUX=9 NUY=9 NUZ=1  FILL
     36R3
 4R3  4   4R3
 5R3  4   3R3
     27R3
END FILL
ARA=3   NUX=9 NUY=9 NUZ=1  FILL
     36R5
 4R5  6   4R5
 5R5  6   3R5
     27R5
END FILL
ARA=4 NUX=1 NUY=1 NUZ=4 FILL 140 141 140 142 END FILL
END ARRAY
READ BOUNDS ZFC=PER YXF=PER END BOUNDS
END DATA
END
```

Figure 6.8-7 CSAS Input for Normal Conditions–Vertical Concrete Cask Containing BWR Fuel

```
=CSAS25
UMS BWR VCC; NORMAL OP; CASK ARRAY; 0.0001 GM/CC IN - 0.0001 GM/CC EX; 75%B10
27GROUPNDF4 LATTICECELL
UO2   1 0.95 293.0 92235 4.00 92238 96.00 END
ZIRCALLOY  2 1.0  293.0  END
H2O   3 0.0001  293.0  END
AL    4 1.0  293.0  END
SS304 5 1.0  293.0  END
AL    6 DEN=2.6849 0.8706 293.0 END
B-10  6 DEN=2.6849 0.0137 293.0 END
B-11  6 DEN=2.6849 0.0830 293.0 END
C     6 DEN=2.6849 0.0281 293.0 END
CARBONSTEEL 7 1.0 293.0 END
REG-CONCRETE 8 0.9750 293.0 END
H2O   9 0.0001 293.0 END
END COMP
SQUAREPITCH  1.4529 0.9055 1 3 1.0770 2 0.9246 0 END
UMS BWR VCC; NORMAL OP; CASK ARRAY; 0.0001 GM/CC IN - 0.0001 GM/CC EX; 75%B10
READ PARAM RUN=YES PLT=NO TME=5000 GEN=203 NPG=1000 END PARAM
READ GEOM
UNIT  1
COM='FUEL PIN CELL - WITH H2O'
CYLINDER  1 1  0.4528   2P1.7145
CYLINDER  0 1  0.4623   2P1.7145
CYLINDER  2 1  0.5385   2P1.7145
CUBOID    3 1  4P0.7264 2P1.7145
UNIT  2
COM='WATER ROD CELL - WITH H2O'
CYLINDER  3 1  0.4623   2P1.7145
CYLINDER  2 1  0.5385   2P1.7145
CUBOID    3 1  4P0.7264 2P1.7145
UNIT  3
COM='FUEL PIN CELL - WITH ST DISK'
CYLINDER  1 1  0.4528   2P0.7938
CYLINDER  0 1  0.4623   2P0.7938
CYLINDER  2 1  0.5385   2P0.7938
CUBOID    3 1  4P0.7264 2P0.7938
UNIT  4
COM='WATER ROD CELL - WITH ST DISK'
CYLINDER  3 1  0.4623   2P0.7938
CYLINDER  2 1  0.5385   2P0.7938
CUBOID    3 1  4P0.7264 2P0.7938
UNIT  5
COM='FUEL PIN CELL - WITH AL DISK'
CYLINDER  1 1  0.4528   2P0.6350
CYLINDER  0 1  0.4623   2P0.6350
CYLINDER  2 1  0.5385   2P0.6350
CUBOID    3 1  4P0.7264 2P0.6350
UNIT  6
COM='WATER ROD CELL - WITH AL DISK'
CYLINDER  3 1  0.4623   2P0.6350
CYLINDER  2 1  0.5385   2P0.6350
CUBOID    3 1  4P0.7264 2P0.6350
UNIT  7
COM='FUEL PIN ARRAY + CHANNEL - BETWEEN DISKS'
ARRAY  1    -6.5376 -6.5376 -1.7145
CUBOID 3 1 4P6.7031 2P1.7145
CUBOID 2 1 4P6.9063 2P1.7145
UNIT  8
COM='FUEL PIN ARRAY + CHANNEL - ST DISKS'
ARRAY  2    -6.5376 -6.5376 -0.7938
CUBOID 3 1 4P6.7031 2P0.7938
CUBOID 2 1 4P6.9063 2P0.7938
UNIT  9
COM='FUEL PIN ARRAY + CHANNEL - AL DISKS'
ARRAY  3    -6.5376 -6.5376 -0.6350
CUBOID 3 1 4P6.7031 2P0.6350
CUBOID 2 1 4P6.9063 2P0.6350
UNIT 10
COM='X-X BORAL + COVER SHEET BETWEEN DISKS'
CUBOID 6 1 2P6.7310 2P0.1124 2P1.7145
CUBOID 4 1 2P6.7310 2P0.1714 2P1.7145
CUBOID 5 1 2P6.7765 +0.2168 -0.1714 2P1.7145
UNIT 11
COM='Y-Y BORAL + COVER SHEET BETWEEN DISKS'
CUBOID 6 1 2P0.1124 2P6.7310 2P1.7145
CUBOID 4 1 2P0.1714 2P6.7310 2P1.7145
CUBOID 5 1 +0.2168 -0.1714 2P6.7765 2P1.7145
UNIT 12
COM='X-X BORAL + COVER SHEET WITH ST DISKS'
CUBOID 6 1 2P6.7310 2P0.1124 2P0.7938
CUBOID 4 1 2P6.7310 2P0.1714 2P0.7938
CUBOID 5 1 2P6.7765 +0.2168 -0.1714 2P0.7938
UNIT 13
COM='Y-Y BORAL + COVER SHEET WITH ST DISKS'
CUBOID 6 1 2P0.1124 2P6.7310 2P0.7938
CUBOID 4 1 2P0.1714 2P6.7310 2P0.7938
CUBOID 5 1 +0.2168 -0.1714 2P6.7765 2P0.7938
```

Figure 6.8-7 (continued)

```
UNIT 14
COM='X-X BORAL + COVER SHEET WITH AL DISKS'
CUBOID 6 1 2P6.7310 2P0.1124 2P0.6350
CUBOID 4 1 2P6.7310 2P0.1714 2P0.6350
CUBOID 5 1 2P6.7765 +0.2168 -0.1714 2P0.6350
UNIT 15
COM='Y-Y BORAL + COVER SHEET WITH AL DISKS'
CUBOID 6 1 2P0.1124 2P6.7310 2P0.6350
CUBOID 4 1 2P0.1714 2P6.7310 2P0.6350
CUBOID 5 1 +0.2168 -0.1714 2P6.7765 2P0.6350
UNIT 20
COM='FUEL TUBE CELL 2 BORAL SHEETS - BETWEEN DISKS (TR)'
CUBOID 3 1 4P7.4930 2P1.7145
HOLE   7 +0.5867 +0.5867 0.0
CUBOID 5 1 4P7.6144 2P1.7145
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P1.7145
HOLE   10 0.0 +7.7859 0.0
HOLE   11 +7.7859 0.0 0.0
UNIT 21
COM='FUEL TUBE CELL 2 BORAL SHEETS - BETWEEN DISKS (TL)'
CUBOID 3 1 4P7.4930 2P1.7145
HOLE   7 -0.5867 +0.5867 0.0
CUBOID 5 1 4P7.6144 2P1.7145
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P1.7145
HOLE   10 0.0 +7.7859 0.0
HOLE   11 +7.7859 0.0 0.0
UNIT 22
COM='FUEL TUBE CELL 2 BORAL SHEETS - BETWEEN DISKS (BL)'
CUBOID 3 1 4P7.4930 2P1.7145
HOLE   7 -0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P1.7145
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P1.7145
HOLE   10 0.0 +7.7859 0.0
HOLE   11 +7.7859 0.0 0.0
UNIT 23
COM='FUEL TUBE CELL 2 BORAL SHEETS - BETWEEN DISKS (BR)'
CUBOID 3 1 4P7.4930 2P1.7145
HOLE   7 +0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P1.7145
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P1.7145
HOLE   10 0.0 +7.7859 0.0
HOLE   11 +7.7859 0.0 0.0
UNIT 24
COM='FUEL TUBE CELL 2 BORAL SHEETS - BETWEEN DISKS (T)'
CUBOID 3 1 4P7.4930 2P1.7145
HOLE   7 0.0 +0.5867 0.0
CUBOID 5 1 4P7.6144 2P1.7145
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P1.7145
HOLE   10 0.0 +7.7859 0.0
HOLE   11 +7.7859 0.0 0.0
UNIT 25
COM='FUEL TUBE CELL 2 BORAL SHEETS - BETWEEN DISKS (B)'
CUBOID 3 1 4P7.4930 2P1.7145
HOLE   7 0.0 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P1.7145
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P1.7145
HOLE   10 0.0 +7.7859 0.0
HOLE   11 +7.7859 0.0 0.0
UNIT 26
COM='FUEL TUBE CELL TOP BORAL SHEETS - BETWEEN DISKS (TL)'
CUBOID 3 1 4P7.4930 2P1.7145
HOLE   7 -0.5867 +0.5867 0.0
CUBOID 5 1 4P7.6144 2P1.7145
CUBOID 3 1 +7.6144 -7.6144 +8.0028 -7.6144 +2P1.7145
HOLE   10 0.0 +7.7859 0.0
UNIT 27
COM='FUEL TUBE CELL TOP BORAL SHEETS - BETWEEN DISKS (BL)'
CUBOID 3 1 4P7.4930 2P1.7145
HOLE   7 -0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P1.7145
CUBOID 3 1 +7.6144 -7.6144 +8.0028 -7.6144 +2P1.7145
HOLE   10 0.0 +7.7859 0.0
UNIT 28
COM='FUEL TUBE CELL RIGHT BORAL SHEETS - BETWEEN DISKS (BL)'
CUBOID 3 1 4P7.4930 2P1.7145
HOLE   7 -0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P1.7145
CUBOID 3 1 +8.0028 -7.6144 +7.6144 -7.6144 +2P1.7145
HOLE   11 +7.7859 0.0 0.0
UNIT 29
COM='FUEL TUBE CELL RIGHT BORAL SHEETS - BETWEEN DISKS (B)'
CUBOID 3 1 4P7.4930 2P1.7145
HOLE   7 0.0 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P1.7145
CUBOID 3 1 +8.0028 -7.6144 +7.6144 -7.6144 +2P1.7145
HOLE   11 +7.7859 0.0 0.0
UNIT 30
COM='FUEL TUBE CELL RIGHT BORAL SHEETS - BETWEEN DISKS (BR)'
CUBOID 3 1 4P7.4930 2P1.7145
HOLE   7 +0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P1.7145
CUBOID 3 1 +8.0028 -7.6144 +7.6144 -7.6144 +2P1.7145
HOLE   11 +7.7859 0.0 0.0
UNIT 31
COM='FUEL TUBE CELL NO BORAL SHEETS - BETWEEN DISKS (BL)'
CUBOID 3 1 4P7.4930 2P1.7145
HOLE   7 -0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P1.7145
```

Figure 6.8-7 (continued)

```
UNIT 40
COM='FUEL TUBE CELL 2 BORAL SHEETS - STEEL DISKS (TR)'
CUBOID 3 1 4P7.4930 2P0.7938
HOLE  8 +0.5867 +0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.7938
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P0.7938
HOLE  12 0.0 +7.7859 0.0
HOLE  13 +7.7859 0.0 0.0
UNIT 41
COM='FUEL TUBE CELL 2 BORAL SHEETS - STEEL DISKS (TL)'
CUBOID 3 1 4P7.4930 2P0.7938
HOLE  8 -0.5867 +0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.7938
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P0.7938
HOLE  12 0.0 +7.7859 0.0
HOLE  13 +7.7859 0.0 0.0
UNIT 42
COM='FUEL TUBE CELL 2 BORAL SHEETS - STEEL DISKS (BL)'
CUBOID 3 1 4P7.4930 2P0.7938
HOLE  8 -0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.7938
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P0.7938
HOLE  12 0.0 +7.7859 0.0
HOLE  13 +7.7859 0.0 0.0
UNIT 43
COM='FUEL TUBE CELL 2 BORAL SHEETS - STEEL DISKS (BR)'
CUBOID 3 1 4P7.4930 2P0.7938
HOLE  8 +0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.7938
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P0.7938
HOLE  12 0.0 +7.7859 0.0
HOLE  13 +7.7859 0.0 0.0
UNIT 44
COM='FUEL TUBE CELL 2 BORAL SHEETS - STEEL DISKS (T)'
CUBOID 3 1 4P7.4930 2P0.7938
HOLE  8 0.0 +0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.7938
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P0.7938
HOLE  12 0.0 +7.7859 0.0
HOLE  13 +7.7859 0.0 0.0
UNIT 45
COM='FUEL TUBE CELL 2 BORAL SHEETS - STEEL DISKS (B)'
CUBOID 3 1 4P7.4930 2P0.7938
HOLE  8 0.0 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.7938
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P0.7938
HOLE  12 0.0 +7.7859 0.0
HOLE  13 +7.7859 0.0 0.0
UNIT 46
COM='FUEL TUBE CELL TOP BORAL SHEETS - STEEL DISKS (TL)'
CUBOID 3 1 4P7.4930 2P0.7938
HOLE  8 -0.5867 +0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.7938
CUBOID 3 1 +7.6144 -7.6144 +8.0028 -7.6144 +2P0.7938
HOLE  12 0.0 +7.7859 0.0
UNIT 47
COM='FUEL TUBE CELL TOP BORAL SHEETS - STEEL DISKS (BL)'
CUBOID 3 1 4P7.4930 2P0.7938
HOLE  8 -0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.7938
CUBOID 3 1 +7.6144 -7.6144 +8.0028 -7.6144 +2P0.7938
HOLE  12 0.0 +7.7859 0.0
UNIT 48
COM='FUEL TUBE CELL RIGHT BORAL SHEETS - STEEL DISKS (BL)'
CUBOID 3 1 4P7.4930 2P0.7938
HOLE  8 -0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.7938
CUBOID 3 1 +8.0028 -7.6144 +7.6144 -7.6144 +2P0.7938
HOLE  13 +7.7859 0.0 0.0
UNIT 49
COM='FUEL TUBE CELL RIGHT BORAL SHEETS - STEEL DISKS (B)'
CUBOID 3 1 4P7.4930 2P0.7938
HOLE  8 0.0 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.7938
CUBOID 3 1 +8.0028 -7.6144 +7.6144 -7.6144 +2P0.7938
HOLE  13 +7.7859 0.0 0.0
UNIT 50
COM='FUEL TUBE CELL RIGHT BORAL SHEETS - STEEL DISKS (BR)'
CUBOID 3 1 4P7.4930 2P0.7938
HOLE  8 +0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.7938
CUBOID 3 1 +8.0028 -7.6144 +7.6144 -7.6144 +2P0.7938
HOLE  13 +7.7859 0.0 0.0
UNIT 51
COM='FUEL TUBE CELL NO BORAL SHEETS - STEEL DISKS (BL)'
CUBOID 3 1 4P7.4930 2P0.7938
HOLE  8 -0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.7938
UNIT 60
COM='FUEL TUBE CELL 2 BORAL SHEETS - AL DISKS (TR)'
CUBOID 3 1 4P7.4930 2P0.6350
HOLE  9 +0.5867 +0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.6350
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P0.6350
HOLE  14 0.0 +7.7859 0.0
HOLE  15 +7.7859 0.0 0.0
UNIT 61
COM='FUEL TUBE CELL 2 BORAL SHEETS - AL DISKS (TL)'
```

Figure 6.8-7 (continued)

```
CUBOID 3 1 4P7.4930 2P0.6350
HOLE   9 -0.5867 +0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.6350
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P0.6350
HOLE   14 0.0 +7.7859 0.0
HOLE   15 +7.7859 0.0 0.0
UNIT 62
COM='FUEL TUBE CELL 2 BORAL SHEETS - AL DISKS (BL)'
CUBOID 3 1 4P7.4930 2P0.6350
HOLE   9 -0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.6350
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P0.6350
HOLE   14 0.0 +7.7859 0.0
HOLE   15 +7.7859 0.0 0.0
UNIT 63
COM='FUEL TUBE CELL 2 BORAL SHEETS - AL DISKS (BR)'
CUBOID 3 1 4P7.4930 2P0.6350
HOLE   9 +0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.6350
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P0.6350
HOLE   14 0.0 +7.7859 0.0
HOLE   15 +7.7859 0.0 0.0
UNIT 64
COM='FUEL TUBE CELL 2 BORAL SHEETS - AL DISKS (T)'
CUBOID 3 1 4P7.4930 2P0.6350
HOLE   9 0.0 +0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.6350
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P0.6350
HOLE   14 0.0 +7.7859 0.0
HOLE   15 +7.7859 0.0 0.0
UNIT 65
COM='FUEL TUBE CELL 2 BORAL SHEETS - AL DISKS (B)'
CUBOID 3 1 4P7.4930 2P0.6350
HOLE   9 0.0 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.6350
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P0.6350
HOLE   14 0.0 +7.7859 0.0
HOLE   15 +7.7859 0.0 0.0
UNIT 66
COM='FUEL TUBE CELL TOP BORAL SHEETS - AL DISKS (TL)'
CUBOID 3 1 4P7.4930 2P0.6350
HOLE   9 -0.5867 +0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.6350
CUBOID 3 1 +7.6144 -7.6144 +8.0028 -7.6144 +2P0.6350
HOLE   14 0.0 +7.7859 0.0
UNIT 67
COM='FUEL TUBE CELL TOP BORAL SHEETS - AL DISKS (BL)'
CUBOID 3 1 4P7.4930 2P0.6350
HOLE   9 -0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.6350
CUBOID 3 1 +7.6144 -7.6144 +8.0028 -7.6144 +2P0.6350
HOLE   14 0.0 +7.7859 0.0
UNIT 68
COM='FUEL TUBE CELL RIGHT BORAL SHEETS - AL DISKS (BL)'
CUBOID 3 1 4P7.4930 2P0.6350
HOLE   9 -0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.6350
CUBOID 3 1 +8.0028 -7.6144 +7.6144 -7.6144 +2P0.6350
HOLE   15 +7.7859 0.0 0.0
UNIT 69
COM='FUEL TUBE CELL RIGHT BORAL SHEETS - AL DISKS (B)'
CUBOID 3 1 4P7.4930 2P0.6350
HOLE   9 0.0 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.6350
CUBOID 3 1 +8.0028 -7.6144 +7.6144 -7.6144 +2P0.6350
HOLE   15 +7.7859 0.0 0.0
UNIT 70
COM='FUEL TUBE CELL RIGHT BORAL SHEETS - AL DISKS (BR)'
CUBOID 3 1 4P7.4930 2P0.6350
HOLE   9 +0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.6350
CUBOID 3 1 +8.0028 -7.6144 +7.6144 -7.6144 +2P0.6350
HOLE   15 +7.7859 0.0 0.0
UNIT 71
COM='FUEL TUBE CELL NO BORAL SHEETS - AL DISKS (BL)'
CUBOID 3 1 4P7.4930 2P0.6350
HOLE   9 -0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.6350
UNIT 80
COM='DISK OPENING 2 BORAL SHEET TUBE - BETWEEN DISKS (TR)'
CUBOID 3 1 4P7.9731 2P1.7145
HOLE   20  -0.0297 -0.0297 0.0
UNIT 81
COM='DISK OPENING 2 BORAL SHEET TUBE - BETWEEN DISKS (TL)'
CUBOID 3 1 4P7.9731 2P1.7145
HOLE   21  -0.3586 -0.0297 0.0
UNIT 82
COM='DISK OPENING 2 BORAL SHEET TUBE - BETWEEN DISKS (BL)'
CUBOID 3 1 4P7.9731 2P1.7145
HOLE   22  -0.3586 -0.3586 0.0
UNIT 83
COM='DISK OPENING 2 BORAL SHEET TUBE - BETWEEN DISKS (BR)'
CUBOID 3 1 4P7.9731 2P1.7145
HOLE   23  -0.0297 -0.3586 0.0
UNIT 84
COM='DISK OPENING 2 BORAL SHEET TUBE - BETWEEN DISKS (T)'
CUBOID 3 1 4P7.9731 2P1.7145
HOLE   24  -0.1942 -0.0297 0.0
```

Figure 6.8-7 (continued)

```
UNIT 85
COM='DISK OPENING 2 BORAL SHEET TUBE - BETWEEN DISKS (B)'
CUBOID 3 1 4P7.9731 2P1.7145
HOLE   25  -0.1942 -0.3586 0.0
UNIT 86
COM='DISK OPENING TOP BORAL SHEET TUBE - BETWEEN DISKS (TL)'
CUBOID 3 1 4P7.9731 2P1.7145
HOLE   26  -0.3586 -0.0297 0.0
UNIT 87
COM='DISK OPENING TOP BORAL SHEET TUBE - BETWEEN DISKS (BL)'
CUBOID 3 1 4P7.9731 2P1.7145
HOLE   27  -0.3586 -0.3586 0.0
UNIT 88
COM='DISK OPENING RIGHT BORAL SHEET TUBE - BETWEEN DISKS (BL)'
CUBOID 3 1 4P7.9731 2P1.7145
HOLE   28  -0.3586 -0.3586 0.0
UNIT 89
COM='DISK OPENING RIGHT BORAL SHEET TUBE - BETWEEN DISKS (B)'
CUBOID 3 1 4P7.9731 2P1.7145
HOLE   29  -0.1942 -0.3586 0.0
UNIT 90
COM='DISK OPENING RIGHT BORAL SHEET TUBE - BETWEEN DISKS (BR)'
CUBOID 3 1 4P7.9731 2P1.7145
HOLE   30  -0.0297 -0.3586 0.0
UNIT 91
COM='DISK OPENING NO BORAL SHEET TUBE - BETWEEN DISKS (BL)'
CUBOID 3 1 4P7.9731 2P1.7145
HOLE   31  -0.3586 -0.3586 0.0
UNIT 100
COM='DISK OPENING 2 BORAL SHEET TUBE - STEEL DISKS (TR)'
CUBOID 3 1 4P7.9731 2P0.7938
HOLE   40  -0.0297 -0.0297 0.0
UNIT 101
COM='DISK OPENING 2 BORAL SHEET TUBE - STEEL DISKS (TL)'
CUBOID 3 1 4P7.9731 2P0.7938
HOLE   41  -0.3586 -0.0297 0.0
UNIT 102
COM='DISK OPENING 2 BORAL SHEET TUBE - STEEL DISKS (BL)'
CUBOID 3 1 4P7.9731 2P0.7938
HOLE   42  -0.3586 -0.3586 0.0
UNIT 103
COM='DISK OPENING 2 BORAL SHEET TUBE - STEEL DISKS (BR)'
CUBOID 3 1 4P7.9731 2P0.7938
HOLE   43  -0.0297 -0.3586 0.0
UNIT 104
COM='DISK OPENING 2 BORAL SHEET TUBE - STEEL DISKS (T)'
CUBOID 3 1 4P7.9731 2P0.7938
HOLE   44  -0.1942 -0.0297 0.0
UNIT 105
COM='DISK OPENING 2 BORAL SHEET TUBE - STEEL DISKS (B)'
CUBOID 3 1 4P7.9731 2P0.7938
HOLE   45  -0.1942 -0.3586 0.0
UNIT 106
COM='DISK OPENING TOP BORAL SHEET TUBE - STEEL DISKS (TL)'
CUBOID 3 1 4P7.9731 2P0.7938
HOLE   46  -0.3586 -0.0297 0.0
UNIT 107
COM='DISK OPENING TOP BORAL SHEET TUBE - STEEL DISKS (BL)'
CUBOID 3 1 4P7.9731 2P0.7938
HOLE   47  -0.3586 -0.3586 0.0
UNIT 108
COM='DISK OPENING RIGHT BORAL SHEET TUBE - STEEL DISKS (BL)'
CUBOID 3 1 4P7.9731 2P0.7938
HOLE   48  -0.3586 -0.3586 0.0
UNIT 109
COM='DISK OPENING RIGHT BORAL SHEET TUBE - STEEL DISKS (B)'
CUBOID 3 1 4P7.9731 2P0.7938
HOLE   49  -0.1942 -0.3586 0.0
UNIT 110
COM='DISK OPENING RIGHT BORAL SHEET TUBE - STEEL DISKS (BR)'
CUBOID 3 1 4P7.9731 2P0.7938
HOLE   50  -0.0297 -0.3586 0.0
UNIT 111
COM='DISK OPENING NO BORAL SHEET TUBE - STEEL DISKS (BL)'
CUBOID 3 1 4P7.9731 2P0.7938
HOLE   51  -0.3586 -0.3586 0.0
UNIT 120
COM='DISK OPENING 2 BORAL SHEET TUBE - AL DISKS (TR)'
CUBOID 3 1 4P7.9731 2P0.6350
HOLE   60  -0.0297 -0.0297 0.0
UNIT 121
COM='DISK OPENING 2 BORAL SHEET TUBE - AL DISKS (TL)'
CUBOID 3 1 4P7.9731 2P0.6350
HOLE   61  -0.3586 -0.0297 0.0
UNIT 122
COM='DISK OPENING 2 BORAL SHEET TUBE - AL DISKS (BL)'
CUBOID 3 1 4P7.9731 2P0.6350
HOLE   62  -0.3586 -0.3586 0.0
UNIT 123
COM='DISK OPENING 2 BORAL SHEET TUBE - AL DISKS (BR)'
CUBOID 3 1 4P7.9731 2P0.6350
HOLE   63  -0.0297 -0.3586 0.0
UNIT 124
COM='DISK OPENING 2 BORAL SHEET TUBE - AL DISKS (T)'
CUBOID 3 1 4P7.9731 2P0.6350
HOLE   64  -0.1942 -0.0297 0.0
UNIT 125
COM='DISK OPENING 2 BORAL SHEET TUBE - AL DISKS (B)'
```

Figure 6.8-7 (continued)

```
CUBOID 3 1 4P7.9731 2P0.6350
HOLE   65  -0.1942 -0.3586 0.0
UNIT 126
COM='DISK OPENING TOP BORAL SHEET TUBE - AL DISKS (TL)'
CUBOID 3 1 4P7.9731 2P0.6350
HOLE   66  -0.3586 -0.0297 0.0
UNIT 127
COM='DISK OPENING TOP BORAL SHEET TUBE - AL DISKS (BL)'
CUBOID 3 1 4P7.9731 2P0.6350
HOLE   67  -0.3586 -0.3586 0.0
UNIT 128
COM='DISK OPENING RIGHT BORAL SHEET TUBE - AL DISKS (BL)'
CUBOID 3 1 4P7.9731 2P0.6350
HOLE   68  -0.3586 -0.3586 0.0
UNIT 129
COM='DISK OPENING RIGHT BORAL SHEET TUBE - AL DISKS (B)'
CUBOID 3 1 4P7.9731 2P0.6350
HOLE   69  -0.1942 -0.3586 0.0
UNIT 130
COM='DISK OPENING RIGHT BORAL SHEET TUBE - AL DISKS (BR)'
CUBOID 3 1 4P7.9731 2P0.6350
HOLE   70  -0.0297 -0.3586 0.0
UNIT 131
COM='DISK OPENING NO BORAL SHEET TUBE - AL DISKS (BL)'
CUBOID 3 1 4P7.9731 2P0.6350
HOLE   71  -0.3586 -0.3586 0.0
UNIT 140
COM='BASKET STRUCTURE IN TRANPORT CASK - WATER DISK'
CYLINDER 3 1 +83.5787 2P1.7145
HOLE 90  -70.3885  +8.7986 0.0
HOLE 83  -52.7914  +8.7986 0.0
HOLE 83  -52.7914 +26.3957 0.0
HOLE 90  -52.7914 +43.9928 0.0
HOLE 83  -35.1942  +8.7986 0.0
HOLE 83  -35.1942 +26.3957 0.0
HOLE 83  -35.1942 +43.9928 0.0
HOLE 90  -35.1942 +61.5899 0.0
HOLE 83  -17.5971  +8.7986 0.0
HOLE 83  -17.5971 +26.3957 0.0
HOLE 83  -17.5971 +43.9928 0.0
HOLE 90  -17.5971 +61.5899 0.0
HOLE 85   0.0      +8.7986 0.0
HOLE 85   0.0     +26.3957 0.0
HOLE 85   0.0     +43.9928 0.0
HOLE 89   0.0     +61.5899 0.0
HOLE 82  +17.5971  +8.7986 0.0
HOLE 82  +17.5971 +26.3957 0.0
HOLE 82  +17.5971 +43.9928 0.0
HOLE 88  +17.5971 +61.5899 0.0
HOLE 82  +35.1942  +8.7986 0.0
HOLE 82  +35.1942 +26.3957 0.0
HOLE 82  +35.1942 +43.9928 0.0
HOLE 91  +35.1942 +61.5899 0.0
HOLE 82  +52.7914  +8.7986 0.0
HOLE 87  +52.7914 +26.3957 0.0
HOLE 91  +52.7914 +43.9928 0.0
HOLE 91  +70.3885  +8.7986 0.0
HOLE 80  -70.3885  -8.7986 0.0
HOLE 80  -52.7914  -8.7986 0.0
HOLE 80  -52.7914 -26.3957 0.0
HOLE 80  -52.7914 -43.9928 0.0
HOLE 80  -35.1942  -8.7986 0.0
HOLE 80  -35.1942 -26.3957 0.0
HOLE 80  -35.1942 -43.9928 0.0
HOLE 80  -35.1942 -61.5899 0.0
HOLE 80  -17.5971  -8.7986 0.0
HOLE 80  -17.5971 -26.3957 0.0
HOLE 80  -17.5971 -43.9928 0.0
HOLE 80  -17.5971 -61.5899 0.0
HOLE 84   0.0      -8.7986 0.0
HOLE 84   0.0     -26.3957 0.0
HOLE 84   0.0     -43.9928 0.0
HOLE 84   0.0     -61.5899 0.0
HOLE 81  +17.5971  -8.7986 0.0
HOLE 81  +17.5971 -26.3957 0.0
HOLE 81  +17.5971 -43.9928 0.0
HOLE 81  +17.5971 -61.5899 0.0
HOLE 81  +35.1942  -8.7986 0.0
HOLE 81  +35.1942 -26.3957 0.0
HOLE 81  +35.1942 -43.9928 0.0
HOLE 86  +35.1942 -61.5899 0.0
HOLE 81  +52.7914  -8.7986 0.0
HOLE 86  +52.7914 -26.3957 0.0
HOLE 86  +52.7914 -43.9928 0.0
HOLE 86  +70.3885  -8.7986 0.0
CYLINDER  5 1  +85.1662 2P1.7145
CYLINDER  9 1  +94.615 2P1.7145
CYLINDER  7 1 +100.965 2P1.7145
CYLINDER  8 1 +172.72  2P1.7145
CUBOID    9 1 4P230.0  2P1.7145
UNIT 141
COM='BASKET STRUCTURE IN TRANPORT CASK - SS DISK'
CYLINDER 7 1  +83.1850 2P0.7938
HOLE 110  -70.3885  +8.7986 0.0
HOLE 103  -52.7914  +8.7986 0.0
HOLE 103  -52.7914 +26.3957 0.0
HOLE 110  -52.7914 +43.9928 0.0
HOLE 103  -35.1942  +8.7986 0.0
```

Figure 6.8-7 (continued)

```
HOLE 103  -35.1942 +26.3957 0.0
HOLE 103  -35.1942 +43.9928 0.0
HOLE 110  -35.1942 +61.5899 0.0
HOLE 103  -17.5971  +8.7986 0.0
HOLE 103  -17.5971 +26.3957 0.0
HOLE 103  -17.5971 +43.9928 0.0
HOLE 110  -17.5971 +61.5899 0.0
HOLE 105   0.0      +8.7986 0.0
HOLE 105   0.0     +26.3957 0.0
HOLE 105   0.0     +43.9928 0.0
HOLE 109   0.0     +61.5899 0.0
HOLE 102  +17.5971  +8.7986 0.0
HOLE 102  +17.5971 +26.3957 0.0
HOLE 102  +17.5971 +43.9928 0.0
HOLE 108  +17.5971 +61.5899 0.0
HOLE 102  +35.1942  +8.7986 0.0
HOLE 102  +35.1942 +26.3957 0.0
HOLE 102  +35.1942 +43.9928 0.0
HOLE 111  +35.1942 +61.5899 0.0
HOLE 102  +52.7914  +8.7986 0.0
HOLE 107  +52.7914 +26.3957 0.0
HOLE 111  +52.7914 +43.9928 0.0
HOLE 111  +70.3885  +8.7986 0.0
HOLE 100  -70.3885  -8.7986 0.0
HOLE 100  -52.7914  -8.7986 0.0
HOLE 100  -52.7914 -26.3957 0.0
HOLE 100  -52.7914 -43.9928 0.0
HOLE 100  -35.1942  -8.7986 0.0
HOLE 100  -35.1942 -26.3957 0.0
HOLE 100  -35.1942 -43.9928 0.0
HOLE 100  -35.1942 -61.5899 0.0
HOLE 100  -17.5971  -8.7986 0.0
HOLE 100  -17.5971 -26.3957 0.0
HOLE 100  -17.5971 -43.9928 0.0
HOLE 100  -17.5971 -61.5899 0.0
HOLE 104   0.0      -8.7986 0.0
HOLE 104   0.0     -26.3957 0.0
HOLE 104   0.0     -43.9928 0.0
HOLE 104   0.0     -61.5899 0.0
HOLE 101  +17.5971  -8.7986 0.0
HOLE 101  +17.5971 -26.3957 0.0
HOLE 101  +17.5971 -43.9928 0.0
HOLE 101  +17.5971 -61.5899 0.0
HOLE 101  +35.1942  -8.7986 0.0
HOLE 101  +35.1942 -26.3957 0.0
HOLE 101  +35.1942 -43.9928 0.0
HOLE 106  +35.1942 -61.5899 0.0
HOLE 101  +52.7914  -8.7986 0.0
HOLE 106  +52.7914 -26.3957 0.0
HOLE 106  +52.7914 -43.9928 0.0
HOLE 106  +70.3885  -8.7986 0.0
CYLINDER  3 1  +83.5787 2P0.7938
CYLINDER  5 1  +85.1662 2P0.7938
CYLINDER  9 1  +94.615 2P0.7938
CYLINDER  7 1 +100.965 2P0.7938
CYLINDER  8 1 +172.72  2P0.7938
CUBOID    9 1 4P230.0  2P0.7938
UNIT 142
COM='BASKET STRUCTURE IN TRANPORT CASK - AL DISK'
CYLINDER 4 1  +82.8675 2P0.6350
HOLE 130  -70.3885  +8.7986 0.0
HOLE 123  -52.7914  +8.7986 0.0
HOLE 123  -52.7914 +26.3957 0.0
HOLE 130  -52.7914 +43.9928 0.0
HOLE 123  -35.1942  +8.7986 0.0
HOLE 123  -35.1942 +26.3957 0.0
HOLE 123  -35.1942 +43.9928 0.0
HOLE 130  -35.1942 +61.5899 0.0
HOLE 123  -17.5971  +8.7986 0.0
HOLE 123  -17.5971 +26.3957 0.0
HOLE 123  -17.5971 +43.9928 0.0
HOLE 130  -17.5971 +61.5899 0.0
HOLE 125   0.0      +8.7986 0.0
HOLE 125   0.0     +26.3957 0.0
HOLE 125   0.0     +43.9928 0.0
HOLE 129   0.0     +61.5899 0.0
HOLE 122  +17.5971  +8.7986 0.0
HOLE 122  +17.5971 +26.3957 0.0
HOLE 122  +17.5971 +43.9928 0.0
HOLE 128  +17.5971 +61.5899 0.0
HOLE 122  +35.1942  +8.7986 0.0
HOLE 122  +35.1942 +26.3957 0.0
HOLE 122  +35.1942 +43.9928 0.0
HOLE 131  +35.1942 +61.5899 0.0
HOLE 122  +52.7914  +8.7986 0.0
HOLE 127  +52.7914 +26.3957 0.0
HOLE 131  +52.7914 +43.9928 0.0
HOLE 131  +70.3885  +8.7986 0.0
HOLE 120  -70.3885  -8.7986 0.0
HOLE 120  -52.7914  -8.7986 0.0
HOLE 120  -52.7914 -26.3957 0.0
HOLE 120  -52.7914 -43.9928 0.0
HOLE 120  -35.1942  -8.7986 0.0
HOLE 120  -35.1942 -26.3957 0.0
HOLE 120  -35.1942 -43.9928 0.0
HOLE 120  -35.1942 -61.5899 0.0
HOLE 120  -17.5971  -8.7986 0.0
HOLE 120  -17.5971 -26.3957 0.0
```

Figure 6.8-7 (continued)

```
HOLE 120  -17.5971 -43.9928 0.0
HOLE 120  -17.5971 -61.5899 0.0
HOLE 124   0.0      -8.7986 0.0
HOLE 124   0.0     -26.3957 0.0
HOLE 124   0.0     -43.9928 0.0
HOLE 124   0.0     -61.5899 0.0
HOLE 121  +17.5971  -8.7986 0.0
HOLE 121  +17.5971 -26.3957 0.0
HOLE 121  +17.5971 -43.9928 0.0
HOLE 121  +17.5971 -61.5899 0.0
HOLE 121  +35.1942  -8.7986 0.0
HOLE 121  +35.1942 -26.3957 0.0
HOLE 121  +35.1942 -43.9928 0.0
HOLE 126  +35.1942 -61.5899 0.0
HOLE 121  +52.7914  -8.7986 0.0
HOLE 126  +52.7914 -26.3957 0.0
HOLE 126  +52.7914 -43.9928 0.0
HOLE 126  +70.3885  -8.7986 0.0
CYLINDER  3 1  +83.5787 2P0.6350
CYLINDER  5 1  +85.1662 2P0.6350
CYLINDER  9 1  +94.615  2P0.6350
CYLINDER  7 1 +100.965  2P0.6350
CYLINDER  8 1 +172.72   2P0.6350
CUBOID    9 1 4P230.0   2P0.6350
GLOBAL UNIT 143
COM='CASK SLICES TOGETHER'
ARRAY  4 -230.00 -230.00 0.0
END GEOM
READ ARRAY
ARA=1   NUX=9 NUY=9 NUZ=1  FILL
    36R1
 4R1  2    4R1
 5R1  2    3R1
    27R1
END FILL
ARA=2   NUX=9 NUY=9 NUZ=1  FILL
    36R3
 4R3  4    4R3
 5R3  4    3R3
    27R3
END FILL
ARA=3   NUX=9 NUY=9 NUZ=1  FILL
    36R5
 4R5  6    4R5
 5R5  6    3R5
    27R5
END FILL
ARA=4 NUX=1 NUY=1 NUZ=4 FILL 140 141 140 142 END FILL
END ARRAY
READ BOUNDS ZFC=PER YXF=PER END BOUNDS
END DATA
END
```

Figure 6.8-8 CSAS Input for Accident Conditions–Vertical Concrete Cask Containing BWR Fuel

```
=CSAS25
UMS BWR VCC; ACCIDENT; CASK ARRAY; 1.0 GM/CC IN - 1.0 GM/CC EX; 75%B10
27GROUPNDF4 LATTICECELL
UO2   1 0.95 293.0 92235 4.00 92238 96.00 END
ZIRCALLOY  2 1.0  293.0  END
H2O   3 1.0  293.0  END
AL    4 1.0  293.0  END
SS304 5 1.0  293.0  END
AL    6 DEN=2.6849 0.8706 293.0 END
B-10  6 DEN=2.6849 0.0137 293.0 END
B-11  6 DEN=2.6849 0.0830 293.0 END
C     6 DEN=2.6849 0.0281 293.0 END
CARBONSTEEL 7 1.0 293.0 END
REG-CONCRETE 8 0.9750 293.0 END
H2O   9 1.0 293.0 END
H2O  10 1.0 293.0 END
END COMP
SQUAREPITCH  1.4529 0.9055 1 3 1.0770 2 0.9246 10 END
UMS BWR VCC; ACCIDENT; CASK ARRAY; 1.0 GM/CC IN - 1.0 GM/CC EX; 75%B10
READ PARAM RUN=YES PLT=NO TME=5000 GEN=803 NPG=1000 END PARAM
READ GEOM
UNIT  1
COM='FUEL PIN CELL - WITH H2O'
CYLINDER  1 1  0.4528   2P1.7145
CYLINDER 10 1  0.4623   2P1.7145
CYLINDER  2 1  0.5385   2P1.7145
CUBOID    3 1  4P0.7264 2P1.7145
UNIT  2
COM='WATER ROD CELL - WITH H2O'
CYLINDER  3 1  0.4623   2P1.7145
CYLINDER  2 1  0.5385   2P1.7145
CUBOID    3 1  4P0.7264 2P1.7145
UNIT  3
COM='FUEL PIN CELL - WITH ST DISK'
CYLINDER  1 1  0.4528   2P0.7938
CYLINDER 10 1  0.4623   2P0.7938
CYLINDER  2 1  0.5385   2P0.7938
CUBOID    3 1  4P0.7264 2P0.7938
UNIT  4
COM='WATER ROD CELL - WITH ST DISK'
CYLINDER  3 1  0.4623   2P0.7938
CYLINDER  2 1  0.5385   2P0.7938
CUBOID    3 1  4P0.7264 2P0.7938
UNIT  5
COM='FUEL PIN CELL - WITH AL DISK'
CYLINDER  1 1  0.4528   2P0.6350
CYLINDER 10 1  0.4623   2P0.6350
CYLINDER  2 1  0.5385   2P0.6350
CUBOID    3 1  4P0.7264 2P0.6350
UNIT  6
COM='WATER ROD CELL - WITH AL DISK'
CYLINDER  3 1  0.4623   2P0.6350
CYLINDER  2 1  0.5385   2P0.6350
CUBOID    3 1  4P0.7264 2P0.6350
UNIT  7
COM='FUEL PIN ARRAY + CHANNEL - BETWEEN DISKS'
ARRAY  1    -6.5376 -6.5376 -1.7145
CUBOID 3 1 4P6.7031 2P1.7145
CUBOID 2 1 4P6.9063 2P1.7145
UNIT  8
COM='FUEL PIN ARRAY + CHANNEL - ST DISKS'
ARRAY  2    -6.5376 -6.5376 -0.7938
CUBOID 3 1 4P6.7031 2P0.7938
CUBOID 2 1 4P6.9063 2P0.7938
UNIT  9
COM='FUEL PIN ARRAY + CHANNEL - AL DISKS'
ARRAY  3    -6.5376 -6.5376 -0.6350
CUBOID 3 1 4P6.7031 2P0.6350
CUBOID 2 1 4P6.9063 2P0.6350
UNIT 10
COM='X-X BORAL + COVER SHEET BETWEEN DISKS'
CUBOID 6 1 2P6.7310 2P0.1124 2P1.7145
CUBOID 4 1 2P6.7310 2P0.1714 2P1.7145
CUBOID 5 1 2P6.7765 +0.2168 -0.1714 2P1.7145
UNIT 11
COM='Y-Y BORAL + COVER SHEET BETWEEN DISKS'
CUBOID 6 1 2P0.1124 2P6.7310 2P1.7145
CUBOID 4 1 2P0.1714 2P6.7310 2P1.7145
CUBOID 5 1 +0.2168 -0.1714 2P6.7765 2P1.7145
UNIT 12
COM='X-X BORAL + COVER SHEET WITH ST DISKS'
CUBOID 6 1 2P6.7310 2P0.1124 2P0.7938
CUBOID 4 1 2P6.7310 2P0.1714 2P0.7938
CUBOID 5 1 2P6.7765 +0.2168 -0.1714 2P0.7938
UNIT 13
COM='Y-Y BORAL + COVER SHEET WITH ST DISKS'
CUBOID 6 1 2P0.1124 2P6.7310 2P0.7938
CUBOID 4 1 2P0.1714 2P6.7310 2P0.7938
CUBOID 5 1 +0.2168 -0.1714 2P6.7765 2P0.7938
```

Figure 6.8-8 (continued)

```
UNIT 14
COM='X-X BORAL + COVER SHEET WITH AL DISKS'
CUBOID 6 1 2P6.7310 2P0.1124 2P0.6350
CUBOID 4 1 2P6.7310 2P0.1714 2P0.6350
CUBOID 5 1 2P6.7765 +0.2168 -0.1714 2P0.6350
UNIT 15
COM='Y-Y BORAL + COVER SHEET WITH AL DISKS'
CUBOID 6 1 2P0.1124 2P6.7310 2P0.6350
CUBOID 4 1 2P0.1714 2P6.7310 2P0.6350
CUBOID 5 1 +0.2168 -0.1714 2P6.7765 2P0.6350
UNIT 20
COM='FUEL TUBE CELL 2 BORAL SHEETS - BETWEEN DISKS (TR)'
CUBOID 3 1 4P7.4930 2P1.7145
HOLE   7 +0.5867 +0.5867 0.0
CUBOID 5 1 4P7.6144 2P1.7145
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P1.7145
HOLE   10 0.0 +7.7859 0.0
HOLE   11 +7.7859 0.0 0.0
UNIT 21
COM='FUEL TUBE CELL 2 BORAL SHEETS - BETWEEN DISKS (TL)'
CUBOID 3 1 4P7.4930 2P1.7145
HOLE   7 -0.5867 +0.5867 0.0
CUBOID 5 1 4P7.6144 2P1.7145
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P1.7145
HOLE   10 0.0 +7.7859 0.0
HOLE   11 +7.7859 0.0 0.0
UNIT 22
COM='FUEL TUBE CELL 2 BORAL SHEETS - BETWEEN DISKS (BL)'
CUBOID 3 1 4P7.4930 2P1.7145
HOLE   7 -0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P1.7145
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P1.7145
HOLE   10 0.0 +7.7859 0.0
HOLE   11 +7.7859 0.0 0.0
UNIT 23
COM='FUEL TUBE CELL 2 BORAL SHEETS - BETWEEN DISKS (BR)'
CUBOID 3 1 4P7.4930 2P1.7145
HOLE   7 +0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P1.7145
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P1.7145
HOLE   10 0.0 +7.7859 0.0
HOLE   11 +7.7859 0.0 0.0
UNIT 24
COM='FUEL TUBE CELL 2 BORAL SHEETS - BETWEEN DISKS (T)'
CUBOID 3 1 4P7.4930 2P1.7145
HOLE   7 0.0 +0.5867 0.0
CUBOID 5 1 4P7.6144 2P1.7145
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P1.7145
HOLE   10 0.0 +7.7859 0.0
HOLE   11 +7.7859 0.0 0.0
UNIT 25
COM='FUEL TUBE CELL 2 BORAL SHEETS - BETWEEN DISKS (B)'
CUBOID 3 1 4P7.4930 2P1.7145
HOLE   7 0.0 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P1.7145
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P1.7145
HOLE   10 0.0 +7.7859 0.0
HOLE   11 +7.7859 0.0 0.0
UNIT 26
COM='FUEL TUBE CELL TOP BORAL SHEETS - BETWEEN DISKS (TL)'
CUBOID 3 1 4P7.4930 2P1.7145
HOLE   7 -0.5867 +0.5867 0.0
CUBOID 5 1 4P7.6144 2P1.7145
CUBOID 3 1 +7.6144 -7.6144 +8.0028 -7.6144 +2P1.7145
HOLE   10 0.0 +7.7859 0.0
UNIT 27
COM='FUEL TUBE CELL TOP BORAL SHEETS - BETWEEN DISKS (BL)'
CUBOID 3 1 4P7.4930 2P1.7145
HOLE   7 -0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P1.7145
CUBOID 3 1 +7.6144 -7.6144 +8.0028 -7.6144 +2P1.7145
HOLE   10 0.0 +7.7859 0.0
UNIT 28
COM='FUEL TUBE CELL RIGHT BORAL SHEETS - BETWEEN DISKS (BL)'
CUBOID 3 1 4P7.4930 2P1.7145
HOLE   7 -0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P1.7145
CUBOID 3 1 +8.0028 -7.6144 +7.6144 -7.6144 +2P1.7145
HOLE   11 +7.7859 0.0 0.0
UNIT 29
COM='FUEL TUBE CELL RIGHT BORAL SHEETS - BETWEEN DISKS (B)'
CUBOID 3 1 4P7.4930 2P1.7145
HOLE   7 0.0 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P1.7145
CUBOID 3 1 +8.0028 -7.6144 +7.6144 -7.6144 +2P1.7145
HOLE   11 +7.7859 0.0 0.0
UNIT 30
COM='FUEL TUBE CELL RIGHT BORAL SHEETS - BETWEEN DISKS (BR)'
CUBOID 3 1 4P7.4930 2P1.7145
HOLE   7 +0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P1.7145
CUBOID 3 1 +8.0028 -7.6144 +7.6144 -7.6144 +2P1.7145
HOLE   11 +7.7859 0.0 0.0
UNIT 31
COM='FUEL TUBE CELL NO BORAL SHEETS - BETWEEN DISKS (BL)'
CUBOID 3 1 4P7.4930 2P1.7145
HOLE   7 -0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P1.7145
UNIT 40
```

Figure 6.8-8 (continued)

```
COM='FUEL TUBE CELL 2 BORAL SHEETS - STEEL DISKS (TR)'
CUBOID 3 1 4P7.4930 2P0.7938
HOLE   8 +0.5867 +0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.7938
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P0.7938
HOLE   12 0.0 +7.7859 0.0
HOLE   13 +7.7859 0.0 0.0
UNIT 41
COM='FUEL TUBE CELL 2 BORAL SHEETS - STEEL DISKS (TL)'
CUBOID 3 1 4P7.4930 2P0.7938
HOLE   8 -0.5867 +0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.7938
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P0.7938
HOLE   12 0.0 +7.7859 0.0
HOLE   13 +7.7859 0.0 0.0
UNIT 42
COM='FUEL TUBE CELL 2 BORAL SHEETS - STEEL DISKS (BL)'
CUBOID 3 1 4P7.4930 2P0.7938
HOLE   8 -0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.7938
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P0.7938
HOLE   12 0.0 +7.7859 0.0
HOLE   13 +7.7859 0.0 0.0
UNIT 43
COM='FUEL TUBE CELL 2 BORAL SHEETS - STEEL DISKS (BR)'
CUBOID 3 1 4P7.4930 2P0.7938
HOLE   8 +0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.7938
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P0.7938
HOLE   12 0.0 +7.7859 0.0
HOLE   13 +7.7859 0.0 0.0
UNIT 44
COM='FUEL TUBE CELL 2 BORAL SHEETS - STEEL DISKS (T)'
CUBOID 3 1 4P7.4930 2P0.7938
HOLE   8 0.0 +0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.7938
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P0.7938
HOLE   12 0.0 +7.7859 0.0
HOLE   13 +7.7859 0.0 0.0
UNIT 45
COM='FUEL TUBE CELL 2 BORAL SHEETS - STEEL DISKS (B)'
CUBOID 3 1 4P7.4930 2P0.7938
HOLE   8 0.0 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.7938
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P0.7938
HOLE   12 0.0 +7.7859 0.0
HOLE   13 +7.7859 0.0 0.0
UNIT 46
COM='FUEL TUBE CELL TOP BORAL SHEETS - STEEL DISKS (TL)'
CUBOID 3 1 4P7.4930 2P0.7938
HOLE   8 -0.5867 +0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.7938
CUBOID 3 1 +7.6144 -7.6144 +8.0028 -7.6144 +2P0.7938
HOLE   12 0.0 +7.7859 0.0
UNIT 47
COM='FUEL TUBE CELL TOP BORAL SHEETS - STEEL DISKS (BL)'
CUBOID 3 1 4P7.4930 2P0.7938
HOLE   8 -0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.7938
CUBOID 3 1 +7.6144 -7.6144 +8.0028 -7.6144 +2P0.7938
HOLE   12 0.0 +7.7859 0.0
UNIT 48
COM='FUEL TUBE CELL RIGHT BORAL SHEETS - STEEL DISKS (BL)'
CUBOID 3 1 4P7.4930 2P0.7938
HOLE   8 -0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.7938
CUBOID 3 1 +8.0028 -7.6144 +7.6144 -7.6144 +2P0.7938
HOLE   13 +7.7859 0.0 0.0
UNIT 49
COM='FUEL TUBE CELL RIGHT BORAL SHEETS - STEEL DISKS (B)'
CUBOID 3 1 4P7.4930 2P0.7938
HOLE   8 0.0 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.7938
CUBOID 3 1 +8.0028 -7.6144 +7.6144 -7.6144 +2P0.7938
HOLE   13 +7.7859 0.0 0.0
UNIT 50
COM='FUEL TUBE CELL RIGHT BORAL SHEETS - STEEL DISKS (BR)'
CUBOID 3 1 4P7.4930 2P0.7938
HOLE   8 +0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.7938
CUBOID 3 1 +8.0028 -7.6144 +7.6144 -7.6144 +2P0.7938
HOLE   13 +7.7859 0.0 0.0
UNIT 51
COM='FUEL TUBE CELL NO BORAL SHEETS - STEEL DISKS (BL)'
CUBOID 3 1 4P7.4930 2P0.7938
HOLE   8 -0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.7938
UNIT 60
COM='FUEL TUBE CELL 2 BORAL SHEETS - AL DISKS (TR)'
CUBOID 3 1 4P7.4930 2P0.6350
HOLE   9 +0.5867 +0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.6350
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P0.6350
HOLE   14 0.0 +7.7859 0.0
HOLE   15 +7.7859 0.0 0.0
UNIT 61
COM='FUEL TUBE CELL 2 BORAL SHEETS - AL DISKS (TL)'
CUBOID 3 1 4P7.4930 2P0.6350
HOLE   9 -0.5867 +0.5867 0.0
```

Figure 6.8-8 (continued)

```
CUBOID 5 1 4P7.6144 2P0.6350
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P0.6350
HOLE   14 0.0 +7.7859 0.0
HOLE   15 +7.7859 0.0 0.0
UNIT 62
COM='FUEL TUBE CELL 2 BORAL SHEETS - AL DISKS (BL)'
CUBOID 3 1 4P7.4930 2P0.6350
HOLE   9 -0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.6350
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P0.6350
HOLE   14 0.0 +7.7859 0.0
HOLE   15 +7.7859 0.0 0.0
UNIT 63
COM='FUEL TUBE CELL 2 BORAL SHEETS - AL DISKS (BR)'
CUBOID 3 1 4P7.4930 2P0.6350
HOLE   9 +0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.6350
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P0.6350
HOLE   14 0.0 +7.7859 0.0
HOLE   15 +7.7859 0.0 0.0
UNIT 64
COM='FUEL TUBE CELL 2 BORAL SHEETS - AL DISKS (T)'
CUBOID 3 1 4P7.4930 2P0.6350
HOLE   9 0.0 +0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.6350
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P0.6350
HOLE   14 0.0 +7.7859 0.0
HOLE   15 +7.7859 0.0 0.0
UNIT 65
COM='FUEL TUBE CELL 2 BORAL SHEETS - AL DISKS (B)'
CUBOID 3 1 4P7.4930 2P0.6350
HOLE   9 0.0 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.6350
CUBOID 3 1 +8.0028 -7.6144 +8.0028 -7.6144 +2P0.6350
HOLE   14 0.0 +7.7859 0.0
HOLE   15 +7.7859 0.0 0.0
UNIT 66
COM='FUEL TUBE CELL TOP BORAL SHEETS - AL DISKS (TL)'
CUBOID 3 1 4P7.4930 2P0.6350
HOLE   9 -0.5867 +0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.6350
CUBOID 3 1 +7.6144 -7.6144 +8.0028 -7.6144 +2P0.6350
HOLE   14 0.0 +7.7859 0.0
UNIT 67
COM='FUEL TUBE CELL TOP BORAL SHEETS - AL DISKS (BL)'
CUBOID 3 1 4P7.4930 2P0.6350
HOLE   9 -0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.6350
CUBOID 3 1 +7.6144 -7.6144 +8.0028 -7.6144 +2P0.6350
HOLE   14 0.0 +7.7859 0.0
UNIT 68
COM='FUEL TUBE CELL RIGHT BORAL SHEETS - AL DISKS (BL)'
CUBOID 3 1 4P7.4930 2P0.6350
HOLE   9 -0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.6350
CUBOID 3 1 +8.0028 -7.6144 +7.6144 -7.6144 +2P0.6350
HOLE   15 +7.7859 0.0 0.0
UNIT 69
COM='FUEL TUBE CELL RIGHT BORAL SHEETS - AL DISKS (B)'
CUBOID 3 1 4P7.4930 2P0.6350
HOLE   9 0.0 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.6350
CUBOID 3 1 +8.0028 -7.6144 +7.6144 -7.6144 +2P0.6350
HOLE   15 +7.7859 0.0 0.0
UNIT 70
COM='FUEL TUBE CELL RIGHT BORAL SHEETS - AL DISKS (BR)'
CUBOID 3 1 4P7.4930 2P0.6350
HOLE   9 +0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.6350
CUBOID 3 1 +8.0028 -7.6144 +7.6144 -7.6144 +2P0.6350
HOLE   15 +7.7859 0.0 0.0
UNIT 71
COM='FUEL TUBE CELL NO BORAL SHEETS - AL DISKS (BL)'
CUBOID 3 1 4P7.4930 2P0.6350
HOLE   9 -0.5867 -0.5867 0.0
CUBOID 5 1 4P7.6144 2P0.6350
UNIT 80
COM='DISK OPENING 2 BORAL SHEET TUBE - BETWEEN DISKS (TR)'
CUBOID 3 1 4P7.9731 2P1.7145
HOLE   20  -0.0297 -0.0297 0.0
UNIT 81
COM='DISK OPENING 2 BORAL SHEET TUBE - BETWEEN DISKS (TL)'
CUBOID 3 1 4P7.9731 2P1.7145
HOLE   21  -0.3586 -0.0297 0.0
UNIT 82
COM='DISK OPENING 2 BORAL SHEET TUBE - BETWEEN DISKS (BL)'
CUBOID 3 1 4P7.9731 2P1.7145
HOLE   22  -0.3586 -0.3586 0.0
UNIT 83
COM='DISK OPENING 2 BORAL SHEET TUBE - BETWEEN DISKS (BR)'
CUBOID 3 1 4P7.9731 2P1.7145
HOLE   23  -0.0297 -0.3586 0.0
UNIT 84
COM='DISK OPENING 2 BORAL SHEET TUBE - BETWEEN DISKS (T)'
CUBOID 3 1 4P7.9731 2P1.7145
HOLE   24  -0.1942 -0.0297 0.0
UNIT 85
COM='DISK OPENING 2 BORAL SHEET TUBE - BETWEEN DISKS (B)'
CUBOID 3 1 4P7.9731 2P1.7145
```

Figure 6.8-8 (continued)

```
HOLE   25  -0.1942 -0.3586 0.0
UNIT 86
COM='DISK OPENING TOP BORAL SHEET TUBE - BETWEEN DISKS (TL)'
CUBOID 3 1 4P7.9731 2P1.7145
HOLE   26  -0.3586 -0.0297 0.0
UNIT 87
COM='DISK OPENING TOP BORAL SHEET TUBE - BETWEEN DISKS (BL)'
CUBOID 3 1 4P7.9731 2P1.7145
HOLE   27  -0.3586 -0.3586 0.0
UNIT 88
COM='DISK OPENING RIGHT BORAL SHEET TUBE - BETWEEN DISKS (BL)'
CUBOID 3 1 4P7.9731 2P1.7145
HOLE   28  -0.3586 -0.3586 0.0
UNIT 89
COM='DISK OPENING RIGHT BORAL SHEET TUBE - BETWEEN DISKS (B)'
CUBOID 3 1 4P7.9731 2P1.7145
HOLE   29  -0.1942 -0.3586 0.0
UNIT 90
COM='DISK OPENING RIGHT BORAL SHEET TUBE - BETWEEN DISKS (BR)'
CUBOID 3 1 4P7.9731 2P1.7145
HOLE   30  -0.0297 -0.3586 0.0
UNIT 91
COM='DISK OPENING NO BORAL SHEET TUBE - BETWEEN DISKS (BL)'
CUBOID 3 1 4P7.9731 2P1.7145
HOLE   31  -0.3586 -0.3586 0.0
UNIT 100
COM='DISK OPENING 2 BORAL SHEET TUBE - STEEL DISKS (TR)'
CUBOID 3 1 4P7.9731 2P0.7938
HOLE   40  -0.0297 -0.0297 0.0
UNIT 101
COM='DISK OPENING 2 BORAL SHEET TUBE - STEEL DISKS (TL)'
CUBOID 3 1 4P7.9731 2P0.7938
HOLE   41  -0.3586 -0.0297 0.0
UNIT 102
COM='DISK OPENING 2 BORAL SHEET TUBE - STEEL DISKS (BL)'
CUBOID 3 1 4P7.9731 2P0.7938
HOLE   42  -0.3586 -0.3586 0.0
UNIT 103
COM='DISK OPENING 2 BORAL SHEET TUBE - STEEL DISKS (BR)'
CUBOID 3 1 4P7.9731 2P0.7938
HOLE   43  -0.0297 -0.3586 0.0
UNIT 104
COM='DISK OPENING 2 BORAL SHEET TUBE - STEEL DISKS (T)'
CUBOID 3 1 4P7.9731 2P0.7938
HOLE   44  -0.1942 -0.0297 0.0
UNIT 105
COM='DISK OPENING 2 BORAL SHEET TUBE - STEEL DISKS (B)'
CUBOID 3 1 4P7.9731 2P0.7938
HOLE   45  -0.1942 -0.3586 0.0
UNIT 106
COM='DISK OPENING TOP BORAL SHEET TUBE - STEEL DISKS (TL)'
CUBOID 3 1 4P7.9731 2P0.7938
HOLE   46  -0.3586 -0.0297 0.0
UNIT 107
COM='DISK OPENING TOP BORAL SHEET TUBE - STEEL DISKS (BL)'
CUBOID 3 1 4P7.9731 2P0.7938
HOLE   47  -0.3586 -0.3586 0.0
UNIT 108
COM='DISK OPENING RIGHT BORAL SHEET TUBE - STEEL DISKS (BL)'
CUBOID 3 1 4P7.9731 2P0.7938
HOLE   48  -0.3586 -0.3586 0.0
UNIT 109
COM='DISK OPENING RIGHT BORAL SHEET TUBE - STEEL DISKS (B)'
CUBOID 3 1 4P7.9731 2P0.7938
HOLE   49  -0.1942 -0.3586 0.0
UNIT 110
COM='DISK OPENING RIGHT BORAL SHEET TUBE - STEEL DISKS (BR)'
CUBOID 3 1 4P7.9731 2P0.7938
HOLE   50  -0.0297 -0.3586 0.0
UNIT 111
COM='DISK OPENING NO BORAL SHEET TUBE - STEEL DISKS (BL)'
CUBOID 3 1 4P7.9731 2P0.7938
HOLE   51  -0.3586 -0.3586 0.0
UNIT 120
COM='DISK OPENING 2 BORAL SHEET TUBE - AL DISKS (TR)'
CUBOID 3 1 4P7.9731 2P0.6350
HOLE   60  -0.0297 -0.0297 0.0
UNIT 121
COM='DISK OPENING 2 BORAL SHEET TUBE - AL DISKS (TL)'
CUBOID 3 1 4P7.9731 2P0.6350
HOLE   61  -0.3586 -0.0297 0.0
UNIT 122
COM='DISK OPENING 2 BORAL SHEET TUBE - AL DISKS (BL)'
CUBOID 3 1 4P7.9731 2P0.6350
HOLE   62  -0.3586 -0.3586 0.0
UNIT 123
COM='DISK OPENING 2 BORAL SHEET TUBE - AL DISKS (BR)'
CUBOID 3 1 4P7.9731 2P0.6350
HOLE   63  -0.0297 -0.3586 0.0
UNIT 124
COM='DISK OPENING 2 BORAL SHEET TUBE - AL DISKS (T)'
CUBOID 3 1 4P7.9731 2P0.6350
HOLE   64  -0.1942 -0.0297 0.0
UNIT 125
COM='DISK OPENING 2 BORAL SHEET TUBE - AL DISKS (B)'
CUBOID 3 1 4P7.9731 2P0.6350
HOLE   65  -0.1942 -0.3586 0.0
UNIT 126
COM='DISK OPENING TOP BORAL SHEET TUBE - AL DISKS (TL)'
```

Figure 6.8-8 (continued)

```
CUBOID 3 1 4P7.9731 2P0.6350
HOLE   66  -0.3586 -0.0297 0.0
UNIT 127
COM='DISK OPENING TOP BORAL SHEET TUBE - AL DISKS (BL)'
CUBOID 3 1 4P7.9731 2P0.6350
HOLE   67  -0.3586 -0.3586 0.0
UNIT 128
COM='DISK OPENING RIGHT BORAL SHEET TUBE - AL DISKS (BL)'
CUBOID 3 1 4P7.9731 2P0.6350
HOLE   68  -0.3586 -0.3586 0.0
UNIT 129
COM='DISK OPENING RIGHT BORAL SHEET TUBE - AL DISKS (B)'
CUBOID 3 1 4P7.9731 2P0.6350
HOLE   69  -0.1942 -0.3586 0.0
UNIT 130
COM='DISK OPENING RIGHT BORAL SHEET TUBE - AL DISKS (BR)'
CUBOID 3 1 4P7.9731 2P0.6350
HOLE   70  -0.0297 -0.3586 0.0
UNIT 131
COM='DISK OPENING NO BORAL SHEET TUBE - AL DISKS (BL)'
CUBOID 3 1 4P7.9731 2P0.6350
HOLE   71  -0.3586 -0.3586 0.0
UNIT 140
COM='BASKET STRUCTURE IN TRANPORT CASK - WATER DISK'
CYLINDER 3 1 +83.5787 2P1.7145
HOLE 90  -70.3885  +8.7986 0.0
HOLE 83  -52.7914  +8.7986 0.0
HOLE 83  -52.7914 +26.3957 0.0
HOLE 90  -52.7914 +43.9928 0.0
HOLE 83  -35.1942  +8.7986 0.0
HOLE 83  -35.1942 +26.3957 0.0
HOLE 83  -35.1942 +43.9928 0.0
HOLE 90  -35.1942 +61.5899 0.0
HOLE 83  -17.5971  +8.7986 0.0
HOLE 83  -17.5971 +26.3957 0.0
HOLE 83  -17.5971 +43.9928 0.0
HOLE 90  -17.5971 +61.5899 0.0
HOLE 85   0.0       +8.7986 0.0
HOLE 85   0.0      +26.3957 0.0
HOLE 85   0.0      +43.9928 0.0
HOLE 89   0.0      +61.5899 0.0
HOLE 82  +17.5971  +8.7986 0.0
HOLE 82  +17.5971 +26.3957 0.0
HOLE 82  +17.5971 +43.9928 0.0
HOLE 88  +17.5971 +61.5899 0.0
HOLE 82  +35.1942  +8.7986 0.0
HOLE 82  +35.1942 +26.3957 0.0
HOLE 82  +35.1942 +43.9928 0.0
HOLE 91  +35.1942 +61.5899 0.0
HOLE 82  +52.7914  +8.7986 0.0
HOLE 87  +52.7914 +26.3957 0.0
HOLE 91  +52.7914 +43.9928 0.0
HOLE 91  +70.3885  +8.7986 0.0
HOLE 80  -70.3885  -8.7986 0.0
HOLE 80  -52.7914  -8.7986 0.0
HOLE 80  -52.7914 -26.3957 0.0
HOLE 80  -52.7914 -43.9928 0.0
HOLE 80  -35.1942  -8.7986 0.0
HOLE 80  -35.1942 -26.3957 0.0
HOLE 80  -35.1942 -43.9928 0.0
HOLE 80  -35.1942 -61.5899 0.0
HOLE 80  -17.5971  -8.7986 0.0
HOLE 80  -17.5971 -26.3957 0.0
HOLE 80  -17.5971 -43.9928 0.0
HOLE 80  -17.5971 -61.5899 0.0
HOLE 84   0.0       -8.7986 0.0
HOLE 84   0.0      -26.3957 0.0
HOLE 84   0.0      -43.9928 0.0
HOLE 84   0.0      -61.5899 0.0
HOLE 81  +17.5971  -8.7986 0.0
HOLE 81  +17.5971 -26.3957 0.0
HOLE 81  +17.5971 -43.9928 0.0
HOLE 81  +17.5971 -61.5899 0.0
HOLE 81  +35.1942  -8.7986 0.0
HOLE 81  +35.1942 -26.3957 0.0
HOLE 81  +35.1942 -43.9928 0.0
HOLE 86  +35.1942 -61.5899 0.0
HOLE 81  +52.7914  -8.7986 0.0
HOLE 86  +52.7914 -26.3957 0.0
HOLE 86  +52.7914 -43.9928 0.0
HOLE 86  +70.3885  -8.7986 0.0
CYLINDER  5 1  +85.1662 2P1.7145
CYLINDER  9 1  +94.615 2P1.7145
CYLINDER  7 1 +100.965 2P1.7145
CYLINDER  8 1 +172.72  2P1.7145
CUBOID    9 1 4P230.0  2P1.7145
UNIT 141
COM='BASKET STRUCTURE IN TRANPORT CASK - SS DISK'
CYLINDER 7 1  +83.1850 2P0.7938
HOLE 110  -70.3885  +8.7986 0.0
HOLE 103  -52.7914  +8.7986 0.0
HOLE 103  -52.7914 +26.3957 0.0
HOLE 110  -52.7914 +43.9928 0.0
HOLE 103  -35.1942  +8.7986 0.0
HOLE 103  -35.1942 +26.3957 0.0
HOLE 103  -35.1942 +43.9928 0.0
HOLE 110  -35.1942 +61.5899 0.0
HOLE 103  -17.5971  +8.7986 0.0
HOLE 103  -17.5971 +26.3957 0.0
```

Figure 6.8-8 (continued)

```
HOLE 103  -17.5971 +43.9928 0.0
HOLE 110  -17.5971 +61.5899 0.0
HOLE 105   0.0      +8.7986 0.0
HOLE 105   0.0     +26.3957 0.0
HOLE 105   0.0     +43.9928 0.0
HOLE 109   0.0     +61.5899 0.0
HOLE 102  +17.5971  +8.7986 0.0
HOLE 102  +17.5971 +26.3957 0.0
HOLE 102  +17.5971 +43.9928 0.0
HOLE 108  +17.5971 +61.5899 0.0
HOLE 102  +35.1942  +8.7986 0.0
HOLE 102  +35.1942 +26.3957 0.0
HOLE 102  +35.1942 +43.9928 0.0
HOLE 111  +35.1942 +61.5899 0.0
HOLE 102  +52.7914  +8.7986 0.0
HOLE 107  +52.7914 +26.3957 0.0
HOLE 111  +52.7914 +43.9928 0.0
HOLE 111  +70.3885  +8.7986 0.0
HOLE 100  -70.3885  -8.7986 0.0
HOLE 100  -52.7914  -8.7986 0.0
HOLE 100  -52.7914 -26.3957 0.0
HOLE 100  -52.7914 -43.9928 0.0
HOLE 100  -35.1942  -8.7986 0.0
HOLE 100  -35.1942 -26.3957 0.0
HOLE 100  -35.1942 -43.9928 0.0
HOLE 100  -35.1942 -61.5899 0.0
HOLE 100  -17.5971  -8.7986 0.0
HOLE 100  -17.5971 -26.3957 0.0
HOLE 100  -17.5971 -43.9928 0.0
HOLE 100  -17.5971 -61.5899 0.0
HOLE 104   0.0      -8.7986 0.0
HOLE 104   0.0     -26.3957 0.0
HOLE 104   0.0     -43.9928 0.0
HOLE 104   0.0     -61.5899 0.0
HOLE 101  +17.5971  -8.7986 0.0
HOLE 101  +17.5971 -26.3957 0.0
HOLE 101  +17.5971 -43.9928 0.0
HOLE 101  +17.5971 -61.5899 0.0
HOLE 101  +35.1942  -8.7986 0.0
HOLE 101  +35.1942 -26.3957 0.0
HOLE 101  +35.1942 -43.9928 0.0
HOLE 106  +35.1942 -61.5899 0.0
HOLE 101  +52.7914  -8.7986 0.0
HOLE 106  +52.7914 -26.3957 0.0
HOLE 106  +52.7914 -43.9928 0.0
HOLE 106  +70.3885  -8.7986 0.0
CYLINDER  3 1  +83.5787 2P0.7938
CYLINDER  5 1  +85.1662 2P0.7938
CYLINDER  9 1  +94.615 2P0.7938
CYLINDER  7 1 +100.965 2P0.7938
CYLINDER  8 1 +172.72  2P0.7938
CUBOID    9 1 4P230.0  2P0.7938
UNIT 142
COM='BASKET STRUCTURE IN TRANPORT CASK - AL DISK'
CYLINDER 4 1  +82.8675 2P0.6350
HOLE 130  -70.3885  +8.7986 0.0
HOLE 123  -52.7914  +8.7986 0.0
HOLE 123  -52.7914 +26.3957 0.0
HOLE 130  -52.7914 +43.9928 0.0
HOLE 123  -35.1942  +8.7986 0.0
HOLE 123  -35.1942 +26.3957 0.0
HOLE 123  -35.1942 +43.9928 0.0
HOLE 130  -35.1942 +61.5899 0.0
HOLE 123  -17.5971  +8.7986 0.0
HOLE 123  -17.5971 +26.3957 0.0
HOLE 123  -17.5971 +43.9928 0.0
HOLE 130  -17.5971 +61.5899 0.0
HOLE 125   0.0      +8.7986 0.0
HOLE 125   0.0     +26.3957 0.0
HOLE 125   0.0     +43.9928 0.0
HOLE 129   0.0     +61.5899 0.0
HOLE 122  +17.5971  +8.7986 0.0
HOLE 122  +17.5971 +26.3957 0.0
HOLE 122  +17.5971 +43.9928 0.0
HOLE 128  +17.5971 +61.5899 0.0
HOLE 122  +35.1942  +8.7986 0.0
HOLE 122  +35.1942 +26.3957 0.0
HOLE 122  +35.1942 +43.9928 0.0
HOLE 131  +35.1942 +61.5899 0.0
HOLE 122  +52.7914  +8.7986 0.0
HOLE 127  +52.7914 +26.3957 0.0
HOLE 131  +52.7914 +43.9928 0.0
HOLE 131  +70.3885  +8.7986 0.0
HOLE 120  -70.3885  -8.7986 0.0
HOLE 120  -52.7914  -8.7986 0.0
HOLE 120  -52.7914 -26.3957 0.0
HOLE 120  -52.7914 -43.9928 0.0
HOLE 120  -35.1942  -8.7986 0.0
HOLE 120  -35.1942 -26.3957 0.0
HOLE 120  -35.1942 -43.9928 0.0
HOLE 120  -35.1942 -61.5899 0.0
HOLE 120  -17.5971  -8.7986 0.0
HOLE 120  -17.5971 -26.3957 0.0
HOLE 120  -17.5971 -43.9928 0.0
HOLE 120  -17.5971 -61.5899 0.0
HOLE 124   0.0      -8.7986 0.0
HOLE 124   0.0     -26.3957 0.0
HOLE 124   0.0     -43.9928 0.0
HOLE 124   0.0     -61.5899 0.0
```

Figure 6.8-8 (continued)

```
HOLE 121  +17.5971  -8.7986 0.0
HOLE 121  +17.5971 -26.3957 0.0
HOLE 121  +17.5971 -43.9928 0.0
HOLE 121  +17.5971 -61.5899 0.0
HOLE 121  +35.1942  -8.7986 0.0
HOLE 121  +35.1942 -26.3957 0.0
HOLE 121  +35.1942 -43.9928 0.0
HOLE 126  +35.1942 -61.5899 0.0
HOLE 121  +52.7914  -8.7986 0.0
HOLE 126  +52.7914 -26.3957 0.0
HOLE 126  +52.7914 -43.9928 0.0
HOLE 126  +70.3885  -8.7986 0.0
CYLINDER  3 1  +83.5787 2P0.6350
CYLINDER  5 1  +85.1662 2P0.6350
CYLINDER  9 1  +94.615 2P0.6350
CYLINDER  7 1 +100.965 2P0.6350
CYLINDER  8 1 +172.72  2P0.6350
CUBOID    9 1 4P230.0  2P0.6350
GLOBAL UNIT 143
COM='CASK SLICES TOGETHER'
ARRAY  4 -230.00 -230.00 0.0
END GEOM
READ ARRAY
ARA=1   NUX=9 NUY=9 NUZ=1  FILL
    36R1
 4R1  2   4R1
 5R1  2   3R1
    27R1
END FILL
ARA=2   NUX=9 NUY=9 NUZ=1  FILL
    36R3
 4R3  4   4R3
 5R3  4   3R3
    27R3
END FILL
ARA=3   NUX=9 NUY=9 NUZ=1  FILL
    36R5
 4R5  6   4R5
 5R5  6   3R5
    27R5
END FILL
ARA=4 NUX=1 NUY=1 NUZ=4 FILL 140 141 140 142 END FILL
END ARRAY
READ BOUNDS ZFC=PER YXF=PER END BOUNDS
END DATA
END
```

Figure 6.8-9 MONK8A Input for PWR Transfer Cask with Soluble Boron

```
columns 1 200
*
*   UMS Transfer Cask - we17b Standard
*
*   Cask Lid Configurations
*           Shield Lid - No Ports
*           Structural Lid - No Weld Shield
*
*   Neutron Poison Loading -  75 %
*   Exterior Water Density 0.0001
*   Cavity Water Density 0.9998
*   Fuel to Clad Gap Water Density 0.9998
*
*   Boron Content in Water - 1000 ppm
*
*   Model Revision v3.0
*
* Parameters
*
@randseed =  12345
*
*
* Unit 1 Control Data
*
begin control data
*READ   ! read and check each independently
*SEEK MULTIPLE DEFINITIONS

SEEDS  @randseed  @randseed
STAGES -15 810 4000 STDV 0.0008

end
*
* Unit 9 Material Specification
*
begin material specification
normalise
nmixtures  7
weight  mixture  1
      u235  4.4072E-02
      u238  8.3737E-01
      o16  1.1856E-01
atoms  mixture  2
      h  6.6667E-01
      o16  3.3333E-01
atoms  mixture  3
      h  6.6667E-01
      o16  3.3333E-01
atoms  mixture  4
      h  4.2857E-01
      b  1.4286E-01
      o16  4.2857E-01
weight  mixture  5
      al  4.6148E-01
      b10  7.5880E-02
      b11  3.4567E-01
      c  1.1697E-01
atoms  mixture  6
      c  2.8571E-01
      h  4.7619E-01
      o16  2.3810E-01
weight  mixture  7
      h  4.2152E-02
      o16  5.4785E-01
      fe  4.7900E-02
      c  9.3500E-02
      si  3.3600E-02
      ca  5.6100E-02
      al  1.7890E-01
*
* Materials List - v1.2 - Class 1 - we17b - WE17  OFA  Fuel
*
nmaterials  23
volume              ! UO2 at 5%
material  1
  mixture  1  density  10.4120  prop  1.00000
volume              ! Fuel pin cladding
material  2
  zircalloy    density  6.5500  prop  1.00000
volume              ! Water In Lattice and Tube
material  3
  mixture  4  density  1.0015  prop  0.00572  ! mixBoricAcid
  mixture  2  density  1.0015  prop  0.99428  ! mixH2O
volume              ! Water In Fuel Rod Clad Gap
material  4
  mixture  4  density  1.0015  prop  0.00572  ! mixBoricAcid
  mixture  2  density  1.0015  prop  0.99428  ! mixH2O
volume              ! Lower Nozzle Material
material  5
  stainless 304l steel    density  7.9200  prop  0.23669
  mixture  4  density  1.0015  prop  0.00437  ! mixBoricAcid
  mixture  2  density  1.0015  prop  0.75894  ! mixH2O
volume              ! Upper Nozzle Material
material  6
  stainless 304l steel    density  7.9200  prop  0.23180
  mixture  4  density  1.0015  prop  0.00439  ! mixBoricAcid
  mixture  2  density  1.0015  prop  0.76381  ! mixH2O
```

Figure 6.8-9 (continued)

```
*
* Materials List - Common Materials - v2.0
*
volume              ! Tube wall and cover sheet
material  7
  stainless 3041 steel    density  7.9300  prop  1.0000
volume              ! BORAL core
material  8
  mixture  5  density  1.9457  prop  1.0000  ! mixBORAL
volume              ! BORAL aluminum clad
material  9
  aluminium        prop  1.0000
volume              ! Structural Disk Material
material  10
  stainless 3041 steel    density  7.9300  prop  1.0000
volume              ! Weldment Material
material  11
  stainless 3041 steel    density  7.9300  prop  1.0000
volume              ! Heat Transfer Disk Material
material  12
  aluminium        prop  1.0000
volume              ! Canister Material
material  13
  stainless 3041 steel    density  7.9300  prop  1.0000
atoms               ! Transfer steel
material  14    density  0       !  (SCALE carbon steel)
    fe      prop  8.3498E-02
    c      prop  3.9250E-03
volume              ! Lead
material  15
  pb    density  11.0400  prop  1.0000
atoms               ! NS-4-FR
material  16    density  0       ! 0 means atom/b-cm
    b10      prop  8.5500E-05
    b11      prop  3.4200E-04
    al      prop  7.8000E-03
    h      prop  5.8500E-02
    o16      prop  2.6100E-02
    c      prop  2.2600E-02
    n      prop  1.3900E-03
volume              ! Stainless Steel 304
material  17
  stainless 3041 steel    density  7.9300  prop  1.0000
volume              ! Vent port middle cylinder
material  18
  stainless 3041 steel    density  7.9300  prop  0.5000
  void       prop  0.5000
atoms               ! SCALE Concrete
material  19    density  0
    h      prop  1.3401E-02
    o16      prop  4.4931E-02
    na      prop  1.7036E-03
    al      prop  1.7018E-03
    si      prop  1.6205E-02
    ca      prop  1.4826E-03
    fe      prop  3.3857E-04
volume              ! Heat fins for transport cask
material  20
  cu    density  8.9200  prop  0.4286
  stainless 3041 steel    density  7.9300  prop  0.5714
volume              ! Balsa
material  21
  mixture  6  density  0.1250  prop  1.0000
volume              ! Redwood
material  22
  mixture  6  density  0.3870  prop  1.0000
volume              ! NS3
material  23
  mixture  7  density  1.6507  prop  1.0000  ! Weight loss @ 200F of 2.90%
end

*
* Unit 2 Material Geometry
*
begin material geometry
* Fuel Rod - Class 1 - we17b - WE17 (OFA)
PART  1
ZROD  1     0.0000  0.0000  1.7399  0.3922  365.7600    ! Fuel pellet stack
ZROD  2     0.0000  0.0000  1.7399  0.4001  381.6604    ! Annulus + Plenum
ZROD  3     0.0000  0.0000  0.0000  0.4572  385.1402    ! Clad
ZROD  4     0.0000  0.0000  385.1402  0.0000  4.5720    ! Fuel rod to top nozzle
BOX  5    -0.6299  -0.6299  0.0000  1.2597  1.2597  389.7122  ! Pitch box
ZONES
/Fuel/     M1  +1
/Fuel to Clad Gap/    M4  +2  -1
/Clad & End Plugs/    M2  +3  -2
/Rod to Top Nozzle/    M2  +4
/Rod in Pitch/    M3  +5  -4  -3
* PWR Guide Tube - Class 1 - we17b - WE17 (OFA)
PART  2  NEST
ZROD  M3     0.0000  0.0000  0.0000  0.5740  365.7600    ! Guide tube interior
ZROD  M2     0.0000  0.0000  0.0000  0.6121  365.7600    ! Clad
BOX  M3    -0.6299  -0.6299  0.0000  1.2597  1.2597  389.7122  ! Pitch box
* PWR Instrument Tube - Class 1 - we17b - WE17 (OFA)
PART  3  NEST
ZROD  M3     0.0000  0.0000  0.0000  0.5740  365.7600    ! Inst. tube interior
ZROD  M2     0.0000  0.0000  0.0000  0.6121  365.7600    ! Clad
BOX  M3    -0.6299  -0.6299  0.0000  1.2597  1.2597  389.7122  ! Pitch box
* Array_17x17_264
```

Figure 6.8-9 (continued)

```
PART  4  ARRAY
17  17  1
1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
1  1  1  1  1  2  1  1  2  1  1  2  1  1  1  1  1
1  1  1  2  1  1  1  1  1  1  1  1  1  2  1  1  1
1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
1  1  2  1  1  2  1  1  2  1  1  2  1  1  2  1  1
1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
1  1  2  1  1  2  1  1  3  1  1  2  1  1  2  1  1
1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
1  1  2  1  1  2  1  1  2  1  1  2  1  1  2  1  1
1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
1  1  1  2  1  1  1  1  1  1  1  1  1  2  1  1  1
1  1  1  1  1  2  1  1  2  1  1  2  1  1  1  1  1
1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1  1
* Fuel Assembly Array Inserted Into Assembly - Class 1 - we17b - WE17 (OFA)
PART  5  NEST
BOX  P4  -10.7075  -10.7075  6.8580  21.4149  21.4149  389.7122   ! Array
BOX  M3  -10.7086  -10.7086  6.8580  21.4173  21.4173  389.7122   ! Fuel Width Envelope
BOX  M5  -10.7086  -10.7086  0.0000  21.4173  21.4173  396.5702   ! Lower Nozzle
BOX  M6  -10.7086  -10.7086  0.0000  21.4173  21.4173  405.8920   ! Upper Nozzle - Envelope
* PWR Neutron Poison and Cover Sheet          Configuration  R
PART  6
BOX  1  -9.9009  0.0318  0.0508  20.7467  0.1270  382.2700  ! BORAL Core
BOX  2  -9.9009  0.0000  0.0508  20.7467  0.1905  382.2700  ! BORAL Clad
BOX  3  -10.8458  0.0000  0.0508  21.6916  0.1905  384.2004  ! Space under Cover Sheet
BOX  4  -10.8915  0.0000  0.0051  21.7830  0.2362  384.2918  ! Cover Sheet (top/side)
BOX  5  -10.8966  0.0000  0.0000  21.7932  0.0457  384.3020  ! Remaining Cover Sheet
BOX  6  -10.8966  0.0000  0.0000  21.7932  0.2362  384.3020  ! Container
ZONES
/BORAL Core/    M8  +1
/BORAL Clad/    M9  +2  -1
/Space Under Cover/    H5  +3  -2
/Enclosing Cover/    M7  +4  -3
/Remaining Cover/    M7  +5  -4
/Container/    H5  +6  -5  -4
VOLUMES UNITY
* PWR Neutron Poison and Cover Sheet          Configuration  L
PART  7
BOX  1  -10.8458  0.0318  0.0508  20.7467  0.1270  382.2700  ! BORAL Core
BOX  2  -10.8458  0.0000  0.0508  20.7467  0.1905  382.2700  ! BORAL Clad
BOX  3  -10.8458  0.0000  0.0508  21.6916  0.1905  384.2004  ! Space under Cover Sheet
BOX  4  -10.8915  0.0000  0.0051  21.7830  0.2362  384.2918  ! Cover Sheet (top/side)
BOX  5  -10.8966  0.0000  0.0000  21.7932  0.0457  384.3020  ! Remaining Cover Sheet
BOX  6  -10.8966  0.0000  0.0000  21.7932  0.2362  384.3020  ! Container
ZONES
/BORAL Core/    M8  +1
/BORAL Clad/    M9  +2  -1
/Space Under Cover/    H5  +3  -2
/Enclosing Cover/    M7  +4  -3
/Remaining Cover/    M7  +5  -4
/Container/    H5  +6  -5  -4
VOLUMES UNITY
* Fuel Assembly in Tube v2.0          Configuration  Q1_4B
PART  8
BOX  1  -11.1684  -11.1684  0.0000  21.4173  21.4173  405.8920    ! Fuel assembly
BOX  2  -11.1684  -11.1684  0.0000  22.3368  22.3368  414.7820    ! Space inside tube from can lid to bottom
BOX  3  -11.2903  -11.2903  5.0800  22.5806  22.5806  388.1120    ! Fuel tube
BOX  4  -10.6807  11.2903  7.1120  21.7932  0.2362  384.3020    ! Boral plus cover sheet - Top (+Y)
BOX  5  11.1125  -11.2903  7.1120  21.7932  0.2362  384.3020  ZROT 180  ! Boral plus cover sheet - Bottom (-Y)
BOX  6  11.2903  11.1125  7.1120  21.7932  0.2362  384.3020  ZROT 90  ! Boral plus cover sheet - Right (+X)
BOX  7  -11.2903  -10.6807  7.1120  21.7932  0.2362  384.3020  ZROT 270  ! Boral plus cover sheet - Left (-X)
BOX  8  -11.5265  -11.5265  0.0000  23.0530  23.0530  414.7820    ! Complete tube with poison
BOX  9  -11.5265  -11.5265  0.0000  23.5890  23.5890  414.7820    ! Disk Opening
ZONES
/Fuel Assembly/  P5  +1
/Space in Tube/  H5  +2  -1
/Fuel Tube/  M7  +3  -2
/Boral plus Cover/  P6  +4
/Boral plus Cover/  P7  +5
/Boral plus Cover/  P7  +6
/Boral plus Cover/  P6  +7
/Fuel Tube+Poison/  H5  +8  -3  -2  -4  -6  -5  -7
/Disk Opening/  H5  +9  -8
VOLUMES UNITY
* Fuel Assembly in Tube v2.0          Configuration  Q2_4B
PART  9
BOX  1  -10.2489  -11.1684  0.0000  21.4173  21.4173  405.8920    ! Fuel assembly
BOX  2  -11.1684  -11.1684  0.0000  22.3368  22.3368  414.7820    ! Space inside tube from can lid to bottom
BOX  3  -11.2903  -11.2903  5.0800  22.5806  22.5806  388.1120    ! Fuel tube
BOX  4  -11.1125  11.2903  7.1120  21.7932  0.2362  384.3020    ! Boral plus cover sheet - Top (+Y)
BOX  5  10.6807  -11.2903  7.1120  21.7932  0.2362  384.3020  ZROT 180  ! Boral plus cover sheet - Bottom (-Y)
BOX  6  11.2903  11.1125  7.1120  21.7932  0.2362  384.3020  ZROT 90  ! Boral plus cover sheet - Right (+X)
BOX  7  -11.2903  -10.6807  7.1120  21.7932  0.2362  384.3020  ZROT 270  ! Boral plus cover sheet - Left (-X)
BOX  8  -11.5265  11.5265  0.0000  23.0530  23.0530  414.7820    ! Complete tube with poison
BOX  9  -12.0625  -11.5265  0.0000  23.5890  23.5890  414.7820    ! Disk Opening
ZONES
/Fuel Assembly/  P5  +1
/Space in Tube/  H5  +2  -1
/Fuel Tube/  M7  +3  -2
/Boral plus Cover/  P7  +4
/Boral plus Cover/  P6  +5
/Boral plus Cover/  P7  +6
/Boral plus Cover/  P6  +7
/Fuel Tube+Poison/  H5  +8  -3  -2  -4  -6  -5  -7
```

Figure 6.8-9 (continued)

```
/Disk Opening/  H5  +9  -8
VOLUMES UNITY
* Fuel Assembly in Tube v2.0          Configuration  Q3_4B
PART  10
BOX  1  -10.2489  -10.2489  0.0000  21.4173  21.4173  405.8920     ! Fuel assembly
BOX  2  -11.1684  -11.1684  0.0000  22.3368  22.3368  414.7820     ! Space inside tube from can lid to bottom
BOX  3  -11.2903  -11.2903  5.0800  22.5806  22.5806  388.1120     ! Fuel tube
BOX  4  -11.1125  11.2903  7.1120  21.7932  0.2362  384.3020    ! Boral plus cover sheet - Top (+Y)
BOX  5  10.6807  -11.2903  7.1120  21.7932  0.2362  384.3020  ZROT 180  ! Boral plus cover sheet - Bottom (-Y)
BOX  6  11.2903  10.6807  7.1120  21.7932  0.2362  384.3020  ZROT 90  ! Boral plus cover sheet - Right (+X)
BOX  7  -11.2903  -11.1125  7.1120  21.7932  0.2362  384.3020  ZROT 270  ! Boral plus cover sheet - Left (-X)
BOX  8  -11.5265  -11.5265  0.0000  23.0530  23.0530  414.7820     ! Complete tube with poison
BOX  9  -12.0625  -12.0625  0.0000  23.5890  23.5890  414.7820     ! Disk Opening
ZONES
/Fuel Assembly/  P5  +1
/Space in Tube/  H5  +2  -1
/Fuel Tube/  M7  +3  -2
/Boral plus Cover/  P7  +4
/Boral plus Cover/  P6  +5
/Boral plus Cover/  P6  +6
/Boral plus Cover/  P7  +7
/Fuel Tube+Poison/  H5  +8  -3  -2  -4  -6  -5  -7
/Disk Opening/  H5  +9  -8
VOLUMES UNITY
* Fuel Assembly in Tube v2.0          Configuration  Q4_4B
PART  11
BOX  1  -11.1684  -10.2489  0.0000  21.4173  21.4173  405.8920     ! Fuel assembly
BOX  2  -11.1684  -11.1684  0.0000  22.3368  22.3368  414.7820     ! Space inside tube from can lid to bottom
BOX  3  -11.2903  -11.2903  5.0800  22.5806  22.5806  388.1120     ! Fuel tube
BOX  4  -10.6807  11.2903  7.1120  21.7932  0.2362  384.3020    ! Boral plus cover sheet - Top (+Y)
BOX  5  11.1125  -11.2903  7.1120  21.7932  0.2362  384.3020  ZROT 180  ! Boral plus cover sheet - Bottom (-Y)
BOX  6  11.2903  10.6807  7.1120  21.7932  0.2362  384.3020  ZROT 90  ! Boral plus cover sheet - Right (+X)
BOX  7  -11.2903  -11.1125  7.1120  21.7932  0.2362  384.3020  ZROT 270  ! Boral plus cover sheet - Left (-X)
BOX  8  -11.5265  -11.5265  0.0000  23.0530  23.0530  414.7820     ! Complete tube with poison
BOX  9  -11.5265  -12.0625  0.0000  23.5890  23.5890  414.7820     ! Disk Opening
ZONES
/Fuel Assembly/  P5  +1
/Space in Tube/  H5  +2  -1
/Fuel Tube/  M7  +3  -2
/Boral plus Cover/  P6  +4
/Boral plus Cover/  P7  +5
/Boral plus Cover/  P6  +6
/Boral plus Cover/  P7  +7
/Fuel Tube+Poison/  H5  +8  -3  -2  -4  -6  -5  -7
/Disk Opening/  H5  +9  -8
VOLUMES UNITY
* PWR Canister Cavity - Basket Radius v2.0
PART  12
BOX  1  -77.3392  -25.4749  0.0000  23.5890  23.5890  414.7820  ! Basket Opening 1
BOX  2  -77.3392  1.8860  0.0000  23.5890  23.5890  414.7820  ! Basket Opening 2
BOX  3  -52.8358  -52.8358  0.0000  23.5890  23.5890  414.7820  ! Basket Opening 3
BOX  4  -51.5658  -25.4749  0.0000  23.5890  23.5890  414.7820  ! Basket Opening 4
BOX  5  -51.5658  1.8860  0.0000  23.5890  23.5890  414.7820  ! Basket Opening 5
BOX  6  -52.8358  29.2468  0.0000  23.5890  23.5890  414.7820  ! Basket Opening 6
BOX  7  -25.4749  -77.3392  0.0000  23.5890  23.5890  414.7820  ! Basket Opening 7
BOX  8  -25.4749  -51.5658  0.0000  23.5890  23.5890  414.7820  ! Basket Opening 8
BOX  9  -25.4749  -25.4749  0.0000  23.5890  23.5890  414.7820  ! Basket Opening 9
BOX  10  -25.4749  1.8860  0.0000  23.5890  23.5890  414.7820  ! Basket Opening 10
BOX  11  -25.4749  27.9768  0.0000  23.5890  23.5890  414.7820  ! Basket Opening 11
BOX  12  -25.4749  53.7502  0.0000  23.5890  23.5890  414.7820  ! Basket Opening 12
BOX  13  1.8860  -77.3392  0.0000  23.5890  23.5890  414.7820  ! Basket Opening 13
BOX  14  1.8860  -51.5658  0.0000  23.5890  23.5890  414.7820  ! Basket Opening 14
BOX  15  1.8860  -25.4749  0.0000  23.5890  23.5890  414.7820  ! Basket Opening 15
BOX  16  1.8860  1.8860  0.0000  23.5890  23.5890  414.7820  ! Basket Opening 16
BOX  17  1.8860  27.9768  0.0000  23.5890  23.5890  414.7820  ! Basket Opening 17
BOX  18  1.8860  53.7502  0.0000  23.5890  23.5890  414.7820  ! Basket Opening 18
BOX  19  29.2468  -52.8358  0.0000  23.5890  23.5890  414.7820  ! Basket Opening 19
BOX  20  27.9768  -25.4749  0.0000  23.5890  23.5890  414.7820  ! Basket Opening 20
BOX  21  27.9768  1.8860  0.0000  23.5890  23.5890  414.7820  ! Basket Opening 21
BOX  22  29.2468  29.2468  0.0000  23.5890  23.5890  414.7820  ! Basket Opening 22
BOX  23  53.7502  -25.4749  0.0000  23.5890  23.5890  414.7820  ! Basket Opening 23
BOX  24  53.7502  1.8860  0.0000  23.5890  23.5890  414.7820  ! Basket Opening 24
CONTAINER
ZROD  25  0.0000  0.0000  0.0000  82.9564  414.7820    ! Basket stack to cavity height
ZONES
/Opening01/  P10  +1
/Opening02/  P9  +2
/Opening03/  P10  +3            ! Corner position
/Opening04/  P10  +4
/Opening05/  P9  +5
/Opening06/  P9  +6            ! Corner position
/Opening07/  P10  +7
/Opening08/  P10  +8
/Opening09/  P10  +9
/Opening10/  P9  +10
/Opening11/  P9  +11
/Opening12/  P9  +12
/Opening13/  P11  +13
/Opening14/  P11  +14
/Opening15/  P11  +15
/Opening16/  P8  +16
/Opening17/  P8  +17
/Opening18/  P8  +18
/Opening19/  P11  +19            ! Corner position
/Opening20/  P11  +20
/Opening21/  P8  +21
/Opening22/  P8  +22            ! Corner position
/Opening23/  P11  +23
/Opening24/  P8  +24
```

Figure 6.8-9 (continued)

```
/Basket/  H1  +25  -1  -2  -3  -4  -5
    -6  -7  -8  -9  -10  -11
    -12  -13  -14  -15  -16  -17
    -18  -19  -20  -21  -22  -23
    -24

VOLUMES  UNITY
* Basket in Canister Cavity v2.0
PART  13  NEST
ZROD  P12  0.0000  0.0000  0.0000  82.9564  414.7820    ! Basket inserted - Includes gap to lid
ZROD  H5  0.0000  0.0000  0.0000  83.5787  414.7820    ! Inserts flood matl to canister shell
* Canister - Structural Lid - No Weld Shield v2.0
PART  14
ZROD  1  0.0000  0.0000  0.0000  83.5787  414.7820    ! Canister cavity contents
ZROD  2  0.0000  0.0000  -4.4450  85.1662  4.4450    ! Canister Bottom Plate
ZROD  3  0.0000  0.0000  414.7820  83.5787  17.7800    ! Shield Lid
ZROD  4  0.0000  0.0000  432.5620  83.5787  7.6200    ! Structural Lid
ZROD  5  0.0000  0.0000  0.0000  83.5787  440.1820    ! Canister Shell Inner
ZROD  6  0.0000  0.0000  0.0000  85.1662  440.1820    ! Canister Shell Outer
ZROD  7  0.0000  0.0000  -4.4450  85.1662  444.6270    ! Inner Detector Surface
ZONES
/Cavity/  P13  +1
/BottomPlate/  M13  +2
/ShieldLid/  P15  +3
/StructLid/  M13  +4
/Shell/  M13  +6  -5
/Canister/  M0  +7  -6  -4  -2
VOLUMES  UNITY
* Shield Lid - With Ports v2.0
PART  15  CLUSTER
ZROD  P16  -41.8271  59.7354  0.0000  7.6200  17.7800    ! Vent port
ZROD  P16  41.8271  -59.7354  0.0000  7.6200  17.7800    ! Drain port
ZROD  M13  0.0000  0.0000  0.0000  83.5787  17.7800    ! Shield Lid
* Vent Port Model - No Port v2.0
PART  16  CLUSTER
ZROD  M13  0.0000  0.0000  0.0000  1.3843  8.4328    ! Bottom Cylinder
ZROD  M13  0.0000  0.0000  8.4328  5.0800  7.9248    ! Middle Cyclinder
ZROD  M13  0.0000  0.0000  16.3576  7.6200  1.4224    ! Top Cylinder
ZROD  M13  0.0000  0.0000  0.0000  7.6200  17.7800    ! Shield lid material
* Transfer Cask Geometry - No Weld Shield - v2.0
PART  17
ZROD  1  0.0000  0.0000  0.0000  85.1662  444.6270    ! TSC
ZROD  2  0.0000  0.0000  0.0000  86.0425  450.3420    ! Cask cavity
ZROD  3  0.0000  0.0000  0.0000  108.2675  2.5400    ! Bottom plate
ZROD  4  0.0000  0.0000  2.5400  87.9475  442.7220    ! Inner shell
ZROD  5  0.0000  0.0000  2.5400  97.8535  436.6260    ! Lead shell
ZROD  6  0.0000  0.0000  2.5400  105.0925  442.7220    ! NS-4-FR shell
ZROD  7  0.0000  0.0000  2.5400  108.2675  442.7220    ! Outer shell
ZROD  8  0.0000  0.0000  445.2620  108.2675  5.0800    ! Top plate
ZROD  9  0.0000  0.0000  450.3420  82.2325  1.9050    ! Area inside retaining ring
ZROD  10  0.0000  0.0000  450.3420  97.8535  1.9050    ! Retaining ring
ZROD  11  0.0000  0.0000  -22.8600  108.2675  22.8600    ! Shield doors and rails
YP  12  102.5525                ! Y plane for shield door rail cutoff
YP  13  -102.5525               ! Y plane for shield door rail cutoff
XROD  14  -118.2675  0.0000  412.2420  12.7000  236.5350    ! Trunions (extended in x)
YROD  15  0.0000  -118.2675  412.2420  12.7000  236.5350    ! Trunions (extended in y)
ZROD  16  0.0000  0.0000  439.1660  97.8535  6.0960    ! Shielding ring
BOX  17  -2.5400  -86.8045  -5.0800  64.9732  173.6090  3.8100  ! Shield door B NS box
YXPRISM  18  62.4332  -86.8045  -5.0800            ! Shield door B NS trapezoid
    173.6090  39.4984  3.8100  36.9157  36.9157
BOX  19  -62.4332  -86.8045  -5.0800  54.8132  173.6090  3.8100  ! Shield door A NS box
YXPRISM  20  -101.9316  -34.2265  -5.0800          ! Shield door A NS trapezoid
    68.4530  39.4984  3.8100  143.0843  143.0843
YXPRISM  21  64.2620  -90.6780  -22.8600           ! Shield door B cut prism
    181.3560  41.4020  22.8600  36.9157  36.9157
XP  22  64.2620               ! Cut plane for NS boundary B
YXPRISM  23  -105.6640  -35.5600  -22.8600         ! Shield door A cut prism
    71.1200  41.4020  22.8600  143.0843  143.0843
XP  24  -64.2620              ! Cut plane for NS boundary A
ZROD  25  0.0000  0.0000  -22.8600  108.2675  475.1070    ! Container
ZONES
/TSC/  P14  +1              ! TSC
/CaskCavity/  M0  +2  -1            ! Cask cavity
/BottomPlate/  M14  +3  -2            ! Bottom plate
/InnerShell/  M14  +4  -2  -14  -15      ! Inner shell
/LeadShell/  M15  +5  -4  -14  -15      ! Lead shell
/NS-4-FRShell/  M16  +6  -5  -14  -15  -16    ! NS-4-FR shell
/ShieldRing/  M14  +16  -4  -14  -15      ! Shielding ring
/OuterShell/  M14  +7  -6  -14  -15      ! Outer shell
/TopPlate/  M14  +8  -2            ! Top plate
/RetRingInner/  M0  +9            ! Area inside retaining ring (null)
/RetRing/  M0  +10  -9           ! Retaining ring
/ShieldDoor1/  M14  +11  +13  -12  -17  -19    ! Shield doors and rails
    -18  -20  -22  +24
/ShieldDoor2/  M14  +11  +13  -12  -17  -19    ! Shield doors and rails
    -18  -20  +22  +21
/ShieldDoor3/  M14  +11  +13  -12  -17  -19    ! Shield doors and rails
    -18  -20  -24  +23
/ShieldDoorOuter1/  M0  +11  +12          ! Space outside of shield door
/ShieldDoorOuter2/  M0  +11  -13          ! Space outside of shield door
/ShieldDoorOuter3/  M0  +11  +22  -21        ! Space outside of shield door B
/ShieldDoorOuter4/  M0  +11  -24  -23        ! Space outside of shield door A
/XTrunions/  M14  +14  +7  -2         ! X Trunions
/YTrunions/  M14  +15  +7  -2         ! Y Trunions
/ShldDrBNSBox/  M16  +17            ! Shield door B NS box
/ShldDrANSBox/  M16  +19            ! Shield door A NS box
/ShldDrBNSTrap/  M16  +18            ! Shield door B NS trapezoid
/ShldDrANSTrap/  M16  +20            ! Shield door A NS trapezoid
/Container/  M0  +25  -11  -3  -7  -8  -10  ! Container
```

Figure 6.8-9 (continued)

```
VOLUMES UNITY
end

*
* Unit 5 - Source Geometry for
*
begin source geometry
ZONEMAT
ALL / MATERIAL    1
end

*
* Unit 3 Hole Data
*
begin hole data
* PWR Canister Hole Description v2.0
* Hole  1  General Basket Structure
PLATE
0  0  1
5
413.0040  0       ! Top of Basket
379.9840  -2       ! Top of Highest Support Disk
16.3068  -4       ! Bottom of Lowest Support Disk
0.0000  -3       ! Bottom of Basket
0.0000  3       ! Basket Offset
3

* Hole  2  Top Weldment Disk - no structure above the weldment disk
RZMESH
2         ! number of radial points
82.2198
83.1850
5         ! number of axial intervals
379.9840         ! Top of diskstack
394.4620         ! Bottom of weldment
397.6370         ! Top of weldment plate
406.1241         ! Ullage
411.7340         ! Flange
413.0040         ! Void to top of basket
3  3         ! Material below weldment
11  11        ! Plate Material
3  11        ! Ullage
3  11        ! Flange
3  3         ! Void to top of basket
3          ! Outside material

* Hole  3  Bottom Weldment Disk - no structure in the weldment disk support
RZMESH
1         ! number of radial points
83.1850
1         ! number of axial intervals
2.5400
5.0800           ! Coordinates inherited from PLATE Hole
11          ! Plate Material
3          ! Outside material

* Hole  4  Support disk and heat transfer disk stack
PLATE
origin  0  0  16.3068  ! Origin
0  0  1
4
cell  12.4968        ! Sets up a repeating lattice of cells
12.4968  3       ! flood matl
7.5184  3       ! water gap
6.2484  12       ! aluminium disk
1.2700  3       ! water gap
10         ! steel disk

* Hole  5  Flood material model
PLATE
0  0  1
1
406.1241  3       ! Above flooded region
3         ! Flooded region

end
```

Figure 6.8-10 MONK8A Input for BWR Transfer Cask

```
columns 1 200
*
*   UMS Transfer Cask - ex09c Standard
*
*   Cask Lid Configurations
*           Shield Lid - No Ports
*           Structural Lid - No Weld Shield
*
*   Neutron Poison Loading -  75 %
*   Exterior Water Density 0.0001
*   Cavity Water Density 0.9998
*   Fuel to Clad Gap Water Density 0.9998
*
*   Boron Content in Water - 0 ppm
*
*   Model Revision v3.0
*
* Parameters
*
@randseed =  12345
*
*
* Unit 1 Control Data
*
begin control data
*READ   ! read and check each independently
*SEEK MULTIPLE DEFINITIONS

SEEDS  @randseed  @randseed
STAGES -15 810 4000 STDV 0.0008

end
*
* Unit 9 Material Specification
*
begin material specification
normalise
nmixtures  7
weight  mixture  1
      u235  3.8784E-02
      u238  8.4267E-01
      o16  1.1855E-01
atoms  mixture  2
      h  6.6667E-01
      o16  3.3333E-01
atoms  mixture  3
      h  6.6667E-01
      o16  3.3333E-01
atoms  mixture  4
      h  4.2857E-01
      b  1.4286E-01
      o16  4.2857E-01
weight  mixture  5
      al  7.6834E-01
      b10  3.2642E-02
      b11  1.4870E-01
      c  5.0317E-02
atoms  mixture  6
      c  2.8571E-01
      h  4.7619E-01
      o16  2.3810E-01
weight  mixture  7
      h  4.2152E-02
      o16  5.4785E-01
      fe  4.7900E-02
      c  9.3500E-02
      si  3.3600E-02
      ca  5.6100E-02
      al  1.7890E-01
*
* Materials List - v1.2 - Class 5 - ex09c - Ex/ANF9  JP 4.5  Fuel
*
nmaterials  23
volume                ! UO2 at 4.4%
material  1
  mixture  1  density  10.4120  prop  1.00000
volume                ! Fuel pin cladding
material  2
  zircalloy    density  6.5500  prop  1.00000
volume                ! Water In Lattice and Tube
material  3
  mixture  2  density  0.9998  prop  1.00000  ' mixH2O
volume                ! Water In Fuel Rod Clad Gap
material  4
  mixture  2  density  0.9998  prop  1.00000  ' mixH2O
volume                ! Lower Nozzle Material
material  5
  stainless 304l steel    density  7.9200  prop  0.17007
  mixture  2  density  0.9998  prop  0.82993  ' mixH2O
volume                ! Upper Nozzle Material
material  6
  stainless 304l steel    density  7.9200  prop  0.06774
  mixture  2  density  0.9998  prop  0.93226  ' mixH2O
```

Figure 6.8-10 (continued)

```
*
* Materials List - Common Materials - v2.0
*
volume              ! Tube wall and cover sheet
material  7
  stainless 304l steel    density  7.9300  prop  1.0000
volume              ! BORAL core
material  8
  mixture  5  density  1.9901  prop  1.0000  ! mixBORAL
volume              ! BORAL aluminum clad
material  9
  aluminium       prop  1.0000
volume              ! Structural Disk Material
material  10
  stainless 304l steel    density  7.9300  prop  1.0000
volume              ! Weldment Material
material  11
  stainless 304l steel    density  7.9300  prop  1.0000
volume              ! Heat Transfer Disk Material
material  12
  aluminium       prop  1.0000
volume              ! Canister Material
material  13
  stainless 304l steel    density  7.9300  prop  1.0000
atoms              ! Transfer steel
material  14    density  0      !  (SCALE carbon steel)
    fe      prop  8.3498E-02
    c      prop  3.9250E-03
volume              ! Lead
material  15
  pb    density  11.0400  prop  1.0000
atoms              ! NS-4-FR
material  16    density  0      ! 0 means atom/b-cm
    b10       prop  8.5500E-05
    b11       prop  3.4200E-04
    al       prop  7.8000E-03
    h      prop  5.8500E-02
    o16       prop  2.6100E-02
    c      prop  2.2600E-02
    n      prop  1.3900E-03
volume              ! Stainless Steel 304
material  17
  stainless 304l steel    density  7.9300  prop  1.0000
volume              ! Vent port middle cylinder
material  18
  stainless 304l steel    density  7.9300  prop  0.5000
  void         prop  0.5000
atoms              ! SCALE Concrete
material  19    density  0
    h      prop  1.3401E-02
    o16       prop  4.4931E-02
    na       prop  1.7036E-03
    al       prop  1.7018E-03
    si       prop  1.6205E-02
    ca       prop  1.4826E-03
    fe       prop  3.3857E-04
volume              ! Heat fins for transport cask
material  20
  cu    density  8.9200  prop  0.4286
  stainless 304l steel    density  7.9300  prop  0.5714
volume              ! Balsa
material  21
  mixture  6  density  0.1250  prop  1.0000
volume              ! Redwood
material  22
  mixture  6  density  0.3870  prop  1.0000
volume              ! NS3
material  23
  mixture  7  density  1.6507  prop  1.0000  ! Weight loss @ 200F of 2.90%
end

*
* Unit 2 Material Geometry
*
begin material geometry
* Fuel Rod - Class 5 - ex09c - Ex/ANF9 (JP-4,5)
PART  1
ZROD  1    0.0000  0.0000  0.9017  0.4528  381.0000     ! Fuel pellet stack
ZROD  2    0.0000  0.0000  0.9017  0.4623  405.3281     ! Annulus + Plenum
ZROD  3    0.0000  0.0000  0.0000  0.5385  407.1315     ! Clad
ZROD  4    0.0000  0.0000  407.1315  0.2692  3.3782     ! Fuel rod to top nozzle
BOX  5    -0.7264  -0.7264  0.0000  1.4528  1.4528  410.5097  ! Pitch box
ZONES
/Fuel/    M1  +1
/Fuel to Clad Gap/    M4  +2  -1
/Clad & End Plugs/    M2  +3  -2
/Rod to Top Nozzle/    M2  +4
/Rod in Pitch/    M3  +5  -4  -3
* BWR Water Rod - Class 5 - ex09c - Ex/ANF9 (JP-4,5)
PART  2  NEST
ZROD  M3    0.0000  0.0000  0.0000  0.4623  381.0000     ! Water Rod Interior
ZROD  M2    0.0000  0.0000  0.0000  0.5385  381.0000     ! Clad
BOX  M3    -0.7264  -0.7264  0.0000  1.4528  1.4528  410.5097  ! Pitch box
* Array_9x9_79
PART  3  ARRAY
9  9  1
1  1  1  1  1  1  1  1  1
1  1  1  1  1  1  1  1  1
1  1  1  1  1  1  1  1  1
```

Figure 6.8-10 (continued)

```
1  1  1  1  1  1  1  1  1  1
1  1  1  1  2  1  1  1  1
1  1  1  1  1  2  1  1  1
1  1  1  1  1  1  1  1  1
1  1  1  1  1  1  1  1  1
1  1  1  1  1  1  1  1  1
* Fuel Assembly Array Inserted Into Assembly - Class 5 - ex09c - Ex/ANF9 (JP-4,5)
PART  4  NEST
BOX  P3  -6.5376  -6.5376  17.6276  13.0752  13.0752  410.5097    ! Array
BOX  M3  -6.7031  -6.7031  17.6276  13.4061  13.4061  410.5097    ! BWR Channel Interior
BOX  M2  -6.9063  -6.9063  17.6276  13.8125  13.8125  410.5097    ! BWR Channel
BOX  M3  -6.9063  -6.9063  17.6276  13.8125  13.8125  410.5097    ! Fuel Width Envelope
BOX  M5  -6.9063  -6.9063  0.0000  13.8125  13.8125  428.1373    ! Lower Nozzle
BOX  M6  -6.9063  -6.9063  0.0000  13.8125  13.8125  447.1873    ! Upper Nozzle - Envelope
* BWR Neutron Poison and Cover Sheet              Configuration  C
PART  5
BOX  1  -6.7031  0.1080  0.0508  13.4061  0.1270  396.4940  ! BORAL Core
BOX  2  -6.7031  0.0000  0.0508  13.4061  0.3429  396.4940  ! BORAL Clad
BOX  3  -7.1755  0.0000  0.0508  14.3510  0.3429  398.4244  ! Space under Cover Sheet
BOX  4  -7.2212  0.0000  0.0051  14.4424  0.3886  398.5158  ! Cover Sheet (top/side)
BOX  5  -7.2263  0.0000  0.0000  14.4526  0.0457  398.5260  ! Remaining Cover Sheet
BOX  6  -7.2263  0.0000  0.0000  14.4526  0.3886  398.5260  ! Container
ZONES
/BORAL Core/     M8  +1
/BORAL Clad/     M9  +2  -1
/Space Under Cover/     H5  +3  -2
/Enclosing Cover/     M7  +4  -3
/Remaining Cover/     M7  +5  -4
/Container/     H5  +6  -5  -4
VOLUMES UNITY
* BWR Neutron Poison and Cover Sheet              Configuration  R
PART  6
BOX  1  -6.2306  0.1080  0.0508  13.4061  0.1270  396.4940  ! BORAL Core
BOX  2  -6.2306  0.0000  0.0508  13.4061  0.3429  396.4940  ! BORAL Clad
BOX  3  -7.1755  0.0000  0.0508  14.3510  0.3429  398.4244  ! Space under Cover Sheet
BOX  4  -7.2212  0.0000  0.0051  14.4424  0.3886  398.5158  ! Cover Sheet (top/side)
BOX  5  -7.2263  0.0000  0.0000  14.4526  0.0457  398.5260  ! Remaining Cover Sheet
BOX  6  -7.2263  0.0000  0.0000  14.4526  0.3886  398.5260  ! Container
ZONES
/BORAL Core/     M8  +1
/BORAL Clad/     M9  +2  -1
/Space Under Cover/     H5  +3  -2
/Enclosing Cover/     M7  +4  -3
/Remaining Cover/     M7  +5  -4
/Container/     H5  +6  -5  -4
VOLUMES UNITY
* BWR Neutron Poison and Cover Sheet              Configuration  L
PART  7
BOX  1  -7.1755  0.1080  0.0508  13.4061  0.1270  396.4940  ! BORAL Core
BOX  2  -7.1755  0.0000  0.0508  13.4061  0.3429  396.4940  ! BORAL Clad
BOX  3  -7.1755  0.0000  0.0508  14.3510  0.3429  398.4244  ! Space under Cover Sheet
BOX  4  -7.2212  0.0000  0.0051  14.4424  0.3886  398.5158  ! Cover Sheet (top/side)
BOX  5  -7.2263  0.0000  0.0000  14.4526  0.0457  398.5260  ! Remaining Cover Sheet
BOX  6  -7.2263  0.0000  0.0000  14.4526  0.3886  398.5260  ! Container
ZONES
/BORAL Core/     M8  +1
/BORAL Clad/     M9  +2  -1
/Space Under Cover/     H5  +3  -2
/Enclosing Cover/     M7  +4  -3
/Remaining Cover/     M7  +5  -4
/Container/     H5  +6  -5  -4
VOLUMES UNITY
* Fuel Assembly in Tube v2.0          Configuration  C1_2B
PART  8
BOX  1  -7.4981  -7.4981  0.0000  13.8125  13.8125  447.1873    ! Fuel assembly
BOX  2  -7.4981  -7.4981  0.0000  14.9962  14.9962  453.6440    ! Space inside tube from can lid to bottom
BOX  3  -7.6200  -7.6200  12.7000  15.2400  15.2400  409.4480    ! Fuel tube
BOX  4  -7.1120  7.6200  14.7320  14.4526  0.3886  398.5260    ! Boral plus cover sheet - Top (+Y)
BOX  5  7.6200  7.3406  14.7320  14.4526  0.3886  398.5260  ZROT 90  ! Boral plus cover sheet - Right (+X)
BOX  6  -7.6200  -7.6200  0.0000  15.6286  15.6286  453.6440    ! Complete tube with poison
BOX  7  -7.6200  -7.6200  0.0000  15.9461  15.9461  453.6440    ! Disk Opening
ZONES
/Fuel Assembly/  P4  +1
/Space in Tube/  H5  +2  -1
/Fuel Tube/  M7  +3  -2
/Boral plus Cover/  P6  +4
/Boral plus Cover/  P7  +5
/Fuel Tube+Poison/  H5  +6  -3  -2  -4  -5
/Disk Opening/  H5  +7  -6
VOLUMES UNITY
* Fuel Assembly in Tube v2.0          Configuration  C2_2B
PART  9
BOX  1  -6.3144  -7.4981  0.0000  13.8125  13.8125  447.1873    ! Fuel assembly
BOX  2  -7.4981  7.4981  0.0000  14.9962  14.9962  453.6440    ! Space inside tube from can lid to bottom
BOX  3  -7.6200  -7.6200  12.7000  15.2400  15.2400  409.4480    ! Fuel tube
BOX  4  -7.3406  7.6200  14.7320  14.4526  0.3886  398.5260    ! Boral plus cover sheet - Top (+Y)
BOX  5  7.6200  7.3406  14.7320  14.4526  0.3886  398.5260  ZROT 90  ! Boral plus cover sheet - Right (+X)
BOX  6  -7.6200  -7.6200  0.0000  15.6286  15.6286  453.6440    ! Complete tube with poison
BOX  7  -7.9375  -7.6200  0.0000  15.9461  15.9461  453.6440    ! Disk Opening
ZONES
/Fuel Assembly/  P4  +1
/Space in Tube/  H5  +2  -1
/Fuel Tube/  M7  +3  -2
/Boral plus Cover/  P7  +4
/Boral plus Cover/  P7  +5
/Fuel Tube+Poison/  H5  +6  -3  -2  -4  -5
/Disk Opening/  H5  +7  -6
VOLUMES UNITY
* Fuel Assembly in Tube v2.0          Configuration  C3_2B
```

Figure 6.8-10 (continued)

```
PART  10
BOX  1  -6.3144  -6.3144  0.0000  13.8125  13.8125  447.1873    ! Fuel assembly
BOX  2  -7.4981  -7.4981  0.0000  14.9962  14.9962  453.6440    ! Space inside tube from can lid to bottom
BOX  3  -7.6200  -7.6200  12.7000  15.2400  15.2400  409.4480    ! Fuel tube
BOX  4  -7.3406  7.6200  14.7320  14.4526  0.3886  398.5260    ! Boral plus cover sheet - Top (+Y)
BOX  5  7.6200  7.1120  14.7320  14.4526  0.3886  398.5260  ZROT 90  ! Boral plus cover sheet - Right (+X)
BOX  6  -7.6200  -7.6200  0.0000  15.6286  15.6286  453.6440    ! Complete tube with poison
BOX  7  -7.9375  -7.9375  0.0000  15.9461  15.9461  453.6440    ! Disk Opening
ZONES
/Fuel Assembly/  P4  +1
/Space in Tube/  H5  +2  -1
/Fuel Tube/  M7  +3  -2
/Boral plus Cover/  P7  +4
/Boral plus Cover/  P6  +5
/Fuel Tube+Poison/  H5  +6  -3  -2  -4  -5
/Disk Opening/  H5  +7  -6
VOLUMES UNITY
* Fuel Assembly in Tube v2.0         Configuration  Q4_2B
PART  11
BOX  1  -7.4981  -6.3144  0.0000  13.8125  13.8125  447.1873    ! Fuel assembly
BOX  2  -7.4981  -7.4981  0.0000  14.9962  14.9962  453.6440    ! Space inside tube from can lid to bottom
BOX  3  -7.6200  -7.6200  12.7000  15.2400  15.2400  409.4480    ! Fuel tube
BOX  4  -7.1120  7.6200  14.7320  14.4526  0.3886  398.5260    ! Boral plus cover sheet - Top (+Y)
BOX  5  7.6200  7.1120  14.7320  14.4526  0.3886  398.5260  ZROT 90  ! Boral plus cover sheet - Right (+X)
BOX  6  -7.6200  -7.6200  0.0000  15.6286  15.6286  453.6440    ! Complete tube with poison
BOX  7  -7.6200  -7.9375  0.0000  15.9461  15.9461  453.6440    ! Disk Opening
ZONES
/Fuel Assembly/  P4  +1
/Space in Tube/  H5  +2  -1
/Fuel Tube/  M7  +3  -2
/Boral plus Cover/  P6  +4
/Boral plus Cover/  P6  +5
/Fuel Tube+Poison/  H5  +6  -3  -2  -4  -5
/Disk Opening/  H5  +7  -6
VOLUMES UNITY
* Fuel Assembly in Tube v2.0         Configuration  CT_2B
PART  12
BOX  1  -6.9063  -7.4981  0.0000  13.8125  13.8125  447.1873    ! Fuel assembly
BOX  2  -7.4981  -7.4981  0.0000  14.9962  14.9962  453.6440    ! Space inside tube from can lid to bottom
BOX  3  -7.6200  -7.6200  12.7000  15.2400  15.2400  409.4480    ! Fuel tube
BOX  4  -7.2263  7.6200  14.7320  14.4526  0.3886  398.5260    ! Boral plus cover sheet - Top (+Y)
BOX  5  7.6200  7.3406  14.7320  14.4526  0.3886  398.5260  ZROT 90  ! Boral plus cover sheet - Right (+X)
BOX  6  -7.6200  -7.6200  0.0000  15.6286  15.6286  453.6440    ! Complete tube with poison
BOX  7  -7.7788  -7.6200  0.0000  15.9461  15.9461  453.6440    ! Disk Opening
ZONES
/Fuel Assembly/  P4  +1
/Space in Tube/  H5  +2  -1
/Fuel Tube/  M7  +3  -2
/Boral plus Cover/  P5  +4
/Boral plus Cover/  P7  +5
/Fuel Tube+Poison/  H5  +6  -3  -2  -4  -5
/Disk Opening/  H5  +7  -6
VOLUMES UNITY
* Fuel Assembly in Tube v2.0         Configuration  CB_2B
PART  13
BOX  1  -6.9063  -6.3144  0.0000  13.8125  13.8125  447.1873    ! Fuel assembly
BOX  2  -7.4981  -7.4981  0.0000  14.9962  14.9962  453.6440    ! Space inside tube from can lid to bottom
BOX  3  -7.6200  -7.6200  12.7000  15.2400  15.2400  409.4480    ! Fuel tube
BOX  4  -7.2263  7.6200  14.7320  14.4526  0.3886  398.5260    ! Boral plus cover sheet - Top (+Y)
BOX  5  7.6200  7.1120  14.7320  14.4526  0.3886  398.5260  ZROT 90  ! Boral plus cover sheet - Right (+X)
BOX  6  -7.6200  -7.6200  0.0000  15.6286  15.6286  453.6440    ! Complete tube with poison
BOX  7  -7.7788  -7.9375  0.0000  15.9461  15.9461  453.6440    ! Disk Opening
ZONES
/Fuel Assembly/  P4  +1
/Space in Tube/  H5  +2  -1
/Fuel Tube/  M7  +3  -2
/Boral plus Cover/  P5  +4
/Boral plus Cover/  P6  +5
/Fuel Tube+Poison/  H5  +6  -3  -2  -4  -5
/Disk Opening/  H5  +7  -6
VOLUMES UNITY
* Fuel Assembly in Tube v2.0         Configuration  Q1_RB
PART  14
BOX  1  -7.4981  -7.4981  0.0000  13.8125  13.8125  447.1873    ! Fuel assembly
BOX  2  -7.4981  -7.4981  0.0000  14.9962  14.9962  453.6440    ! Space inside tube from can lid to bottom
BOX  3  -7.6200  -7.6200  12.7000  15.2400  15.2400  409.4480    ! Fuel tube
BOX  4  7.6200  7.3406  14.7320  14.4526  0.3886  398.5260  ZROT 90  ! Boral plus cover sheet - Right (+X)
BOX  5  -7.6200  -7.6200  0.0000  15.6286  15.2400  453.6440    ! Complete tube with poison
BOX  6  -7.6200  -7.6200  0.0000  15.9461  15.9461  453.6440    ! Disk Opening
ZONES
/Fuel Assembly/  P4  +1
/Space in Tube/  H5  +2  -1
/Fuel Tube/  M7  +3  -2
/Boral plus Cover/  P7  +4
/Fuel Tube+Poison/  H5  +5  -3  -2    -4
/Disk Opening/  H5  +6  -5
VOLUMES UNITY
* Fuel Assembly in Tube v2.0         Configuration  Q2_RB
PART  15
BOX  1  -6.3144  -7.4981  0.0000  13.8125  13.8125  447.1873    ! Fuel assembly
BOX  2  -7.4981  -7.4981  0.0000  14.9962  14.9962  453.6440    ! Space inside tube from can lid to bottom
BOX  3  -7.6200  -7.6200  12.7000  15.2400  15.2400  409.4480    ! Fuel tube
BOX  4  7.6200  7.3406  14.7320  14.4526  0.3886  398.5260  ZROT 90  ! Boral plus cover sheet - Right (+X)
BOX  5  -7.6200  -7.6200  0.0000  15.6286  15.2400  453.6440    ! Complete tube with poison
BOX  6  -7.9375  -7.6200  0.0000  15.9461  15.9461  453.6440    ! Disk Opening
ZONES
/Fuel Assembly/  P4  +1
/Space in Tube/  H5  +2  -1
/Fuel Tube/  M7  +3  -2
```

Figure 6.8-10 (continued)

```
/Boral plus Cover/  P7  +4
/Fuel Tube+Poison/  H5  +5  -3  -2    -4
/Disk Opening/  H5  +6  -5
VOLUMES UNITY
* Fuel Assembly in Tube v2.0          Configuration  CT_RB
PART  16
BOX  1  -6.9063  -7.4981  0.0000  13.8125  13.8125  447.1873    ! Fuel assembly
BOX  2  -7.4981  -7.4981  0.0000  14.9962  14.9962  453.6440    ! Space inside tube from can lid to bottom
BOX  3  -7.6200  -7.6200  12.7000  15.2400  15.2400  409.4480    ! Fuel tube
BOX  4  7.6200  7.3406  14.7320  14.4526  0.3886  398.5260  ZROT 90  ! Boral plus cover sheet - Right (+X)
BOX  5  -7.6200  -7.6200  0.0000  15.6286  15.2400  453.6440    ! Complete tube with poison
BOX  6  -7.7788  -7.6200  0.0000  15.9461  15.9461  453.6440    ! Disk Opening
ZONES
/Fuel Assembly/  P4  +1
/Space in Tube/  H5  +2  -1
/Fuel Tube/  M7  +3  -2
/Boral plus Cover/  P7  +4
/Fuel Tube+Poison/  H5  +5  -3  -2    -4
/Disk Opening/  H5  +6  -5
VOLUMES UNITY
* Fuel Assembly in Tube v2.0          Configuration  Q1_TB
PART  17
BOX  1  -7.4981  -7.4981  0.0000  13.8125  13.8125  447.1873    ! Fuel assembly
BOX  2  -7.4981  -7.4981  0.0000  14.9962  14.9962  453.6440    ! Space inside tube from can lid to bottom
BOX  3  -7.6200  -7.6200  12.7000  15.2400  15.2400  409.4480    ! Fuel tube
BOX  4  -7.1120  7.6200  14.7320  14.4526  0.3886  398.5260    ! Boral plus cover sheet - Top (+Y)
BOX  5  -7.6200  -7.6200  0.0000  15.2400  15.6286  453.6440    ! Complete tube with poison
BOX  6  -7.6200  -7.6200  0.0000  15.9461  15.9461  453.6440    ! Disk Opening
ZONES
/Fuel Assembly/  P4  +1
/Space in Tube/  H5  +2  -1
/Fuel Tube/  M7  +3  -2
/Boral plus Cover/  P6  +4
/Fuel Tube+Poison/  H5  +5  -3  -2  -4
/Disk Opening/  H5  +6  -5
VOLUMES UNITY
* Fuel Assembly in Tube v2.0          Configuration  Q4_TB
PART  18
BOX  1  -7.4981  -6.3144  0.0000  13.8125  13.8125  447.1873    ! Fuel assembly
BOX  2  -7.4981  -7.4981  0.0000  14.9962  14.9962  453.6440    ! Space inside tube from can lid to bottom
BOX  3  -7.6200  -7.6200  12.7000  15.2400  15.2400  409.4480    ! Fuel tube
BOX  4  -7.1120  7.6200  14.7320  14.4526  0.3886  398.5260    ! Boral plus cover sheet - Top (+Y)
BOX  5  -7.6200  -7.6200  0.0000  15.2400  15.6286  453.6440    ! Complete tube with poison
BOX  6  -7.6200  -7.9375  0.0000  15.9461  15.9461  453.6440    ! Disk Opening
ZONES
/Fuel Assembly/  P4  +1
/Space in Tube/  H5  +2  -1
/Fuel Tube/  M7  +3  -2
/Boral plus Cover/  P6  +4
/Fuel Tube+Poison/  H5  +5  -3  -2  -4
/Disk Opening/  H5  +6  -5
VOLUMES UNITY
* Fuel Assembly in Tube v2.0          Configuration  Q1_NB
PART  19
BOX  1  -7.4981  -7.4981  0.0000  13.8125  13.8125  447.1873    ! Fuel assembly
BOX  2  -7.4981  -7.4981  0.0000  14.9962  14.9962  453.6440    ! Space inside tube from can lid to bottom
BOX  3  -7.6200  -7.6200  12.7000  15.2400  15.2400  409.4480    ! Fuel tube
BOX  4  -7.6200  -7.6200  0.0000  15.2400  15.2400  453.6440    ! Complete tube with poison
BOX  5  -7.6200  -7.6200  0.0000  15.9461  15.9461  453.6440    ! Disk Opening
ZONES
/Fuel Assembly/  P4  +1
/Space in Tube/  H5  +2  -1
/Fuel Tube/  M7  +3  -2
/Fuel Tube+Poison/  H5  +4  -3  -2
/Disk Opening/  H5  +5  -4
VOLUMES UNITY
* Fuel Assembly in Tube v2.0          Configuration  Q10_NB
PART  20
BOX  1  -7.6759  -7.6759  0.0000  13.8125  13.8125  447.1873    ! Fuel assembly
BOX  2  -7.6759  -7.6759  0.0000  15.3518  15.3518  453.6440    ! Space inside tube from can lid to bottom
BOX  3  -7.7978  -7.7978  12.7000  15.5956  15.5956  409.4480    ! Fuel tube
BOX  4  -7.7978  -7.7978  0.0000  15.5956  15.5956  453.6440    ! Complete tube with poison
BOX  5  -7.7978  -7.7978  0.0000  16.3271  16.3271  453.6440    ! Disk Opening
ZONES
/Fuel Assembly/  P4  +1
/Space in Tube/  H5  +2  -1
/Fuel Tube/  M7  +3  -2
/Fuel Tube+Poison/  H5  +4  -3  -2
/Disk Opening/  H5  +5  -4
VOLUMES UNITY
* Fuel Assembly in Tube v2.0          Configuration  Q20_RB
PART  21
BOX  1  -6.1366  -7.6759  0.0000  13.8125  13.8125  447.1873    ! Fuel assembly
BOX  2  -7.6759  -7.6759  0.0000  15.3518  15.3518  453.6440    ! Space inside tube from can lid to bottom
BOX  3  -7.7978  -7.7978  12.7000  15.5956  15.5956  409.4480    ! Fuel tube
BOX  4  7.7978  7.5184  14.7320  14.4526  0.3886  398.5260  ZROT 90  ! Boral plus cover sheet - Right (+X)
BOX  5  -7.7978  -7.7978  0.0000  15.9842  15.5956  453.6440    ! Complete tube with poison
BOX  6  -8.1407  -7.7978  0.0000  16.3271  16.3271  453.6440    ! Disk Opening
ZONES
/Fuel Assembly/  P4  +1
/Space in Tube/  H5  +2  -1
/Fuel Tube/  M7  +3  -2
/Boral plus Cover/  P7  +4
/Fuel Tube+Poison/  H5  +5  -3  -2    -4
/Disk Opening/  H5  +6  -5
VOLUMES UNITY
* Fuel Assembly in Tube v2.0          Configuration  Q30_2B
PART  22
BOX  1  -6.1366  -6.1366  0.0000  13.8125  13.8125  447.1873    ! Fuel assembly
```

Figure 6.8-10 (continued)

```
BOX  2  -7.6759  -7.6759  0.0000  15.3518  15.3518  453.6440   ! Space inside tube from can lid to bottom
BOX  3  -7.7978  -7.7978  12.7000  15.5956  15.5956  409.4480   ! Fuel tube
BOX  4  -7.5184  7.7978  14.7320  14.4526  0.3886  398.5260   ! Boral plus cover sheet - Top (+Y)
BOX  5  7.7978  6.9342  14.7320  14.4526  0.3886  398.5260  ZROT 90  ! Boral plus cover sheet - Right (+X)
BOX  6  -7.7978  -7.7978  0.0000  15.9842  15.9842  453.6440   ! Complete tube with poison
BOX  7  -8.1407  -8.1407  0.0000  16.3271  16.3271  453.6440   ! Disk Opening
ZONES
/Fuel Assembly/  P4  +1
/Space in Tube/  H5  +2  -1
/Fuel Tube/  M7  +3  -2
/Boral plus Cover/  P7  +4
/Boral plus Cover/  P6  +5
/Fuel Tube+Poison/  H5  +6  -3  -2  -4  -5
/Disk Opening/  H5  +7  -6
VOLUMES UNITY
* Fuel Assembly in Tube v2.0          Configuration  Q40_TB
PART  23
BOX  1  -7.6759  -6.1366  0.0000  13.8125  13.8125  447.1873   ! Fuel assembly
BOX  2  -7.6759  -7.6759  0.0000  15.3518  15.3518  453.6440   ! Space inside tube from can lid to bottom
BOX  3  -7.7978  -7.7978  12.7000  15.5956  15.5956  409.4480   ! Fuel tube
BOX  4  -6.9342  7.7978  14.7320  14.4526  0.3886  398.5260   ! Boral plus cover sheet - Top (+Y)
BOX  5  -7.7978  -7.7978  0.0000  15.5956  15.9842  453.6440   ! Complete tube with poison
BOX  6  -7.7978  -8.1407  0.0000  16.3271  16.3271  453.6440   ! Disk Opening
ZONES
/Fuel Assembly/  P4  +1
/Space in Tube/  H5  +2  -1
/Fuel Tube/  M7  +3  -2
/Boral plus Cover/  P6  +4
/Fuel Tube+Poison/  H5  +5  -3  -2  -4
/Disk Opening/  H5  +6  -5
VOLUMES UNITY
* BWR Canister Cavity - Basket Radius v2.0
PART  24
BOX  1  -78.3615  -16.7716  0.0000  15.9461  15.9461  453.6440  ! Basket Opening 1
BOX  2  -78.3615  0.8255  0.0000  15.9461  15.9461  453.6440  ! Basket Opening 2
BOX  3  -60.9549  -52.1564  0.0000  16.3271  16.3271  453.6440  ! Basket Opening 3 - Oversize
BOX  4  -60.7644  -34.3687  0.0000  15.9461  15.9461  453.6440  ! Basket Opening 4
BOX  5  -60.7644  -16.7716  0.0000  15.9461  15.9461  453.6440  ! Basket Opening 5
BOX  6  -60.7644  0.8255  0.0000  15.9461  15.9461  453.6440  ! Basket Opening 6
BOX  7  -60.7644  18.4226  0.0000  15.9461  15.9461  453.6440  ! Basket Opening 7
BOX  8  -60.9549  35.8292  0.0000  16.3271  16.3271  453.6440  ! Basket Opening 8 - Oversize
BOX  9  -43.1673  -69.5630  0.0000  15.9461  15.9461  453.6440  ! Basket Opening 9
BOX  10  -43.1673  -51.9659  0.0000  15.9461  15.9461  453.6440  ! Basket Opening 10
BOX  11  -43.1673  -34.3687  0.0000  15.9461  15.9461  453.6440  ! Basket Opening 11
BOX  12  -43.1673  -16.7716  0.0000  15.9461  15.9461  453.6440  ! Basket Opening 12
BOX  13  -43.1673  0.8255  0.0000  15.9461  15.9461  453.6440  ! Basket Opening 13
BOX  14  -43.1673  18.4226  0.0000  15.9461  15.9461  453.6440  ! Basket Opening 14
BOX  15  -43.1673  36.0197  0.0000  15.9461  15.9461  453.6440  ! Basket Opening 15
BOX  16  -43.1673  53.6169  0.0000  15.9461  15.9461  453.6440  ! Basket Opening 16
BOX  17  -25.5702  -69.5630  0.0000  15.9461  15.9461  453.6440  ! Basket Opening 17
BOX  18  -25.5702  -51.9659  0.0000  15.9461  15.9461  453.6440  ! Basket Opening 18
BOX  19  -25.5702  -34.3687  0.0000  15.9461  15.9461  453.6440  ! Basket Opening 19
BOX  20  -25.5702  -16.7716  0.0000  15.9461  15.9461  453.6440  ! Basket Opening 20
BOX  21  -25.5702  0.8255  0.0000  15.9461  15.9461  453.6440  ! Basket Opening 21
BOX  22  -25.5702  18.4226  0.0000  15.9461  15.9461  453.6440  ! Basket Opening 22
BOX  23  -25.5702  36.0197  0.0000  15.9461  15.9461  453.6440  ! Basket Opening 23
BOX  24  -25.5702  53.6169  0.0000  15.9461  15.9461  453.6440  ! Basket Opening 24
BOX  25  -7.9731  -69.5630  0.0000  15.9461  15.9461  453.6440  ! Basket Opening 25
BOX  26  -7.9731  -51.9659  0.0000  15.9461  15.9461  453.6440  ! Basket Opening 26
BOX  27  -7.9731  -34.3687  0.0000  15.9461  15.9461  453.6440  ! Basket Opening 27
BOX  28  -7.9731  -16.7716  0.0000  15.9461  15.9461  453.6440  ! Basket Opening 28
BOX  29  -7.9731  0.8255  0.0000  15.9461  15.9461  453.6440  ! Basket Opening 29
BOX  30  -7.9731  18.4226  0.0000  15.9461  15.9461  453.6440  ! Basket Opening 30
BOX  31  -7.9731  36.0197  0.0000  15.9461  15.9461  453.6440  ! Basket Opening 31
BOX  32  -7.9731  53.6169  0.0000  15.9461  15.9461  453.6440  ! Basket Opening 32
BOX  33  9.6241  -69.5630  0.0000  15.9461  15.9461  453.6440  ! Basket Opening 33
BOX  34  9.6241  -51.9659  0.0000  15.9461  15.9461  453.6440  ! Basket Opening 34
BOX  35  9.6241  -34.3687  0.0000  15.9461  15.9461  453.6440  ! Basket Opening 35
BOX  36  9.6241  -16.7716  0.0000  15.9461  15.9461  453.6440  ! Basket Opening 36
BOX  37  9.6241  0.8255  0.0000  15.9461  15.9461  453.6440  ! Basket Opening 37
BOX  38  9.6241  18.4226  0.0000  15.9461  15.9461  453.6440  ! Basket Opening 38
BOX  39  9.6241  36.0197  0.0000  15.9461  15.9461  453.6440  ! Basket Opening 39
BOX  40  9.6241  53.6169  0.0000  15.9461  15.9461  453.6440  ! Basket Opening 40
BOX  41  27.2212  -69.5630  0.0000  15.9461  15.9461  453.6440  ! Basket Opening 41
BOX  42  27.2212  -51.9659  0.0000  15.9461  15.9461  453.6440  ! Basket Opening 42
BOX  43  27.2212  -34.3687  0.0000  15.9461  15.9461  453.6440  ! Basket Opening 43
BOX  44  27.2212  -16.7716  0.0000  15.9461  15.9461  453.6440  ! Basket Opening 44
BOX  45  27.2212  0.8255  0.0000  15.9461  15.9461  453.6440  ! Basket Opening 45
BOX  46  27.2212  18.4226  0.0000  15.9461  15.9461  453.6440  ! Basket Opening 46
BOX  47  27.2212  36.0197  0.0000  15.9461  15.9461  453.6440  ! Basket Opening 47
BOX  48  27.2212  53.6169  0.0000  15.9461  15.9461  453.6440  ! Basket Opening 48
BOX  49  44.6278  -52.1564  0.0000  16.3271  16.3271  453.6440  ! Basket Opening 49 - Oversize
BOX  50  44.8183  -34.3687  0.0000  15.9461  15.9461  453.6440  ! Basket Opening 50
BOX  51  44.8183  -16.7716  0.0000  15.9461  15.9461  453.6440  ! Basket Opening 51
BOX  52  44.8183  0.8255  0.0000  15.9461  15.9461  453.6440  ! Basket Opening 52
BOX  53  44.8183  18.4226  0.0000  15.9461  15.9461  453.6440  ! Basket Opening 53
BOX  54  44.6278  35.8292  0.0000  16.3271  16.3271  453.6440  ! Basket Opening 54 - Oversize
BOX  55  62.4154  -16.7716  0.0000  15.9461  15.9461  453.6440  ! Basket Opening 55
BOX  56  62.4154  0.8255  0.0000  15.9461  15.9461  453.6440  ! Basket Opening 56
CONTAINER
ZROD  57  0.0000  0.0000  0.0000  82.8675  453.6440     ! Basket stack to cavity height
ZONES
/Opening1/  P10  +1
/Opening2/  P15  +2
/Opening3/  P22  +3              ! Oversized opening
/Opening4/  P10  +4
/Opening5/  P10  +5
/Opening6/  P9  +6
/Opening7/  P9  +7
```

Figure 6.8-10 (continued)

```
/Opening8/  P21  +8              ! Oversized opening
/Opening9/  P10  +9
/Opening10/  P10  +10
/Opening11/  P10  +11
/Opening12/  P10  +12
/Opening13/  P9  +13
/Opening14/  P9  +14
/Opening15/  P9  +15
/Opening16/  P15  +16
/Opening17/  P10  +17
/Opening18/  P10  +18
/Opening19/  P10  +19
/Opening20/  P10  +20
/Opening21/  P9  +21
/Opening22/  P9  +22
/Opening23/  P9  +23
/Opening24/  P15  +24
/Opening25/  P13  +25
/Opening26/  P13  +26
/Opening27/  P13  +27
/Opening28/  P13  +28
/Opening29/  P12  +29
/Opening30/  P12  +30
/Opening31/  P12  +31
/Opening32/  P16  +32
/Opening33/  P11  +33
/Opening34/  P11  +34
/Opening35/  P11  +35
/Opening36/  P11  +36
/Opening37/  P8  +37
/Opening38/  P8  +38
/Opening39/  P8  +39
/Opening40/  P14  +40
/Opening41/  P18  +41
/Opening42/  P11  +42
/Opening43/  P11  +43
/Opening44/  P11  +44
/Opening45/  P8  +45
/Opening46/  P8  +46
/Opening47/  P8  +47
/Opening48/  P19  +48
/Opening49/  P23  +49              ! Oversized opening
/Opening50/  P18  +50
/Opening51/  P11  +51
/Opening52/  P8  +52
/Opening53/  P17  +53
/Opening54/  P20  +54              ! Oversized opening
/Opening55/  P18  +55
/Opening56/  P19  +56
/Basket/  H1  +57  -1  -2  -3  -4  -5
    -6  -7  -8  -9  -10  -11
    -12  -13  -14  -15  -16  -17
    -18  -19  -20  -21  -22  -23
    -24  -25  -26  -27  -28  -29
    -30  -31  -32  -33  -34  -35
    -36  -37  -38  -39  -40  -41
    -42  -43  -44  -45  -46  -47
    -48  -49  -50  -51  -52  -53
    -54  -55  -56

VOLUMES  UNITY
* Basket in Canister Cavity v2.0
PART  25  NEST
ZROD  P24  0.0000  0.0000  0.0000  82.8675  453.6440    ' Basket inserted - Includes gap to lid
ZROD  H5  0.0000  0.0000  0.0000  83.5787  453.6440    ' Inserts flood matl to canister shell
* Canister - Structural Lid - No Weld Shield v2.0
PART  26
ZROD  1  0.0000  0.0000  0.0000  83.5787  453.6440    ' Canister cavity contents
ZROD  2  0.0000  0.0000  -4.4450  85.1662  4.4450    ' Canister Bottom Plate
ZROD  3  0.0000  0.0000  453.6440  83.5787  17.7800    ' Shield Lid
ZROD  4  0.0000  0.0000  471.4240  83.5787  7.6200    ' Structural Lid
ZROD  5  0.0000  0.0000  0.0000  83.5787  479.0440    ' Canister Shell Inner
ZROD  6  0.0000  0.0000  0.0000  85.1662  479.0440    ' Canister Shell Outer
ZROD  7  0.0000  0.0000  -4.4450  85.1662  483.4890    ' Inner Detector Surface
ZONES
/Cavity/  P25  +1
/BottomPlate/  M13  +2
/ShieldLid/  P27  +3
/StructLid/  M13  +4
/Shell/  M13  +6  -5
/Canister/  M0  +7  -6  -4  -2
VOLUMES  UNITY
* Shield Lid - With Ports v2.0
PART  27  CLUSTER
ZROD  P28  -46.8743  55.8626  0.0000  7.6200  17.7800    ' Vent port
ZROD  P28  46.8743  -55.8626  0.0000  7.6200  17.7800    ' Drain port
ZROD  M13  0.0000  0.0000  0.0000  83.5787  17.7800    ' Shield Lid
* Vent Port Model - No Port v2.0
PART  28  CLUSTER
ZROD  M13  0.0000  0.0000  0.0000  1.3843  8.4328    ' Bottom Cylinder
ZROD  M13  0.0000  0.0000  8.4328  5.0800  7.9248    ' Middle Cyclinder
ZROD  M13  0.0000  0.0000  16.3576  7.6200  1.4224    ' Top Cylinder
ZROD  M13  0.0000  0.0000  0.0000  7.6200  17.7800    ' Shield lid material
* Transfer Cask Geometry - No Weld Shield  v2.0
PART  29
ZROD  1  0.0000  0.0000  0.0000  85.1662  483.4890    ' TSC
ZROD  2  0.0000  0.0000  0.0000  86.0425  489.2040    ' Cask cavity
ZROD  3  0.0000  0.0000  0.0000  108.2675  2.5400    ' Bottom plate
ZROD  4  0.0000  0.0000  2.5400  87.9475  481.5840    ' Inner shell
```

Figure 6.8-10 (continued)

```
ZROD  5  0.0000  0.0000  2.5400  97.8535  475.4880    ! Lead shell
ZROD  6  0.0000  0.0000  2.5400  105.0925  481.5840    ! NS-4-FR shell
ZROD  7  0.0000  0.0000  2.5400  108.2675  481.5840    ! Outer shell
ZROD  8  0.0000  0.0000  484.1240  108.2675  5.0800    ! Top plate
ZROD  9  0.0000  0.0000  489.2040  82.2325  1.9050    ! Area inside retaining ring
ZROD  10  0.0000  0.0000  489.2040  97.8535  1.9050    ! Retaining ring
ZROD  11  0.0000  0.0000  -22.8600  108.2675  22.8600    ! Shield doors and rails
YP  12  102.5525             ! Y plane for shield door rail cutoff
YP  13  -102.5525             ! Y plane for shield door rail cutoff
XROD  14  -118.2675  0.0000  451.1040  12.7000  236.5350    ! Trunions (extended in x)
YROD  15  0.0000  -118.2675  451.1040  12.7000  236.5350    ! Trunions (extended in y)
ZROD  16  0.0000  0.0000  478.0280  97.8535  6.0960    ! Shielding ring
BOX  17  -2.5400  -86.8045  -5.0800  64.9732  173.6090  3.8100  ! Shield door B NS box
YXPRISM  18  62.4332  -86.8045  -5.0800         ! Shield door B NS trapezoid
    173.6090  39.4984  3.8100  36.9157  36.9157
BOX  19  -62.4332  -86.8045  -5.0800  54.8132  173.6090  3.8100  ! Shield door A NS box
YXPRISM  20  -101.9316  -34.2265  -5.0800         ! Shield door A NS trapezoid
    68.4530  39.4984  3.8100  143.0843  143.0843
YXPRISM  21  64.2620  -90.6780  -22.8600         ! Shield door B cut prism
    181.3560  41.4020  22.8600  36.9157  36.9157
XP  22  64.2620            ! Cut plane for NS boundary B
YXPRISM  23  -105.6640  -35.5600  -22.8600         ! Shield door A cut prism
    71.1200  41.4020  22.8600  143.0843  143.0843
XP  24  -64.2620            ! Cut plane for NS boundary A
ZROD  25  0.0000  0.0000  -22.8600  108.2675  513.9690    ! Container
ZONES
/TSC/  P26  +1            ! TSC
/CaskCavity/  M0  +2  -1          ! Cask cavity
/BottomPlate/  M14  +3  -2          ! Bottom plate
/InnerShell/  M14  +4  -2  -14  -15       ! Inner shell
/LeadShell/  M15  +5  -4  -14  -15       ! Lead shell
/NS-4-FRShell/  M16  +6  -5  -14  -15  -16     ! NS-4-FR shell
/ShieldRing/  M14  +16  -4  -14  -15       ! Shielding ring
/OuterShell/  M14  +7  -6  -14  -15       ! Outer shell
/TopPlate/  M14  +8  -2          ! Top plate
/RetRingInner/  M0  +9           ! Area inside retaining ring (null)
/RetRing/  M0  +10  -9          ! Retaining ring
/ShieldDoor1/  M14  +11  +13  -12  -17  -19    ! Shield doors and rails
    -18  -20  -22  +24
/ShieldDoor2/  M14  +11  +13  -12  -17  -19    ! Shield doors and rails
    -18  -20  +22  +21
/ShieldDoor3/  M14  +11  +13  -12  -17  -19    ! Shield doors and rails
    -18  -20  -24  +23
/ShieldDoorOuter1/  M0  +11  +12          ! Space outside of shield door
/ShieldDoorOuter2/  M0  +11  -13          ! Space outside of shield door
/ShieldDoorOuter3/  M0  +11  +22  -21        ! Space outside of shield door B
/ShieldDoorOuter4/  M0  +11  -24  -23        ! Space outside of shield door A
/XTrunions/  M14  +14  +7  -2        ! X Trunions
/YTrunions/  M14  +15  +7  -2        ! Y Trunions
/ShldDrBNSBox/  M16  +17           ! Shield door B NS box
/ShldDrANSBox/  M16  +19           ! Shield door A NS box
/ShldDrBNSTrap/  M16  +18           ! Shield door B NS trapezoid
/ShldDrANSTrap/  M16  +20           ! Shield door A NS trapezoid
/Container/  M0  +25  -11  -3  -7  -8  -10  ! Container
VOLUMES UNITY
end

*
* Unit 5 - Source Geometry for
*
begin source geometry
ZONEMAT
ALL / MATERIAL    1
end

*
* Unit 3 Hole Data
*
begin hole data
* BWR Canister Hole Description v2.0
* Hole  1  General Basket Structure
PLATE
0  0  1
7
451.8660  0      ! Top of Basket
413.1056  -2      ! Top of Highest Support Disk
275.3233  -7      ! Resume support disk only
110.1598  -4      ! Start of support+heat disk region
22.6060  -6      ! Bottom of Lowest Support Disk
0.0000  -3      ! Bottom of Basket
0.0000  3      ! Basket Offset
3

* Hole  2  Top Weldment Disk - no structure above the weldment disk
RZMESH
2        ! number of radial points
82.2198
83.1850
5        ! number of axial intervals
413.1056        ! Top of diskstack
423.1640        ! Bottom of weldment
425.7040        ! Top of weldment plate
444.9861        ! Ullage
450.4690        ! Flange
451.8660        ! Void to top of basket
3  3       ! Material below weldment
11  11       ! Plate Material
3  11       ! Ullage
3  11       ! Flange
```

Figure 6.8-10 (continued)

```
3  3      ! Void to top of basket
3        ! Outside material

* Hole  3  Bottom Weldment Disk - no structure in the weldment disk support
RZMESH
1        ! number of radial points
83.1850
1        ! number of axial intervals
10.1600
12.7000        ! Coordinates inherited from PLATE Hole
11        ! Plate Material
3        ! Outside material

* Hole  4  Support disk and heat transfer disk stack
PLATE
origin  0  0  110.1598  ! Origin
0  0  1
4
cell  9.7155      ! Sets up a repeating lattice of cells
9.7155  3      ! flood matl
6.2865  3      ! water gap
5.0165  12      ! aluminium disk
1.5875  3      ! water gap
10        ! steel disk

* Hole  5  Flood material model
PLATE
0  0  1
1
444.9861  3      ! Above flooded region
3        ! Flooded region

* Hole  6  Support disk stack lower
PLATE
origin  0  0  22.6060  ! Origin
0  0  1
2
cell  9.7282      ! Sets up a repeating lattice of cells
9.7282  3      ! flood matl
1.5875  3      ! water gap
10        ! steel disk

* Hole  7  Support disk stack upper
PLATE
origin  0  0  275.3233  ! Origin
0  0  1
2
cell  9.7282      ! Sets up a repeating lattice of cells
9.7282  3      ! flood matl
1.5875  3      ! water gap
10        ! steel disk

end
```

Chapter 7

Table of Contents

List of Figures

List of Tables

7.0 CONFINEMENT

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

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

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

7.1 Confinement Boundary

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

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

7.1.1 Confinement Vessel

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

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

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

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

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

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

7.1.1.1 Design Documents, Codes and Standards

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

7.1.1.2 Technical Requirements for the Canister

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

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

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

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

7.1.1.3 Release Rate

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

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

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

7.1.2 Confinement Penetrations

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

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

7.1.3 Seals and Welds

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

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

7.1.3.1 Fabrication

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

7.1.3.2 Welding Specifications

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

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

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

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

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

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

7.1.3.3 Testing, Inspection, and Examination

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

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

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

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

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

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

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

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

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

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

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

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

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

7.1.4 Closure

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

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

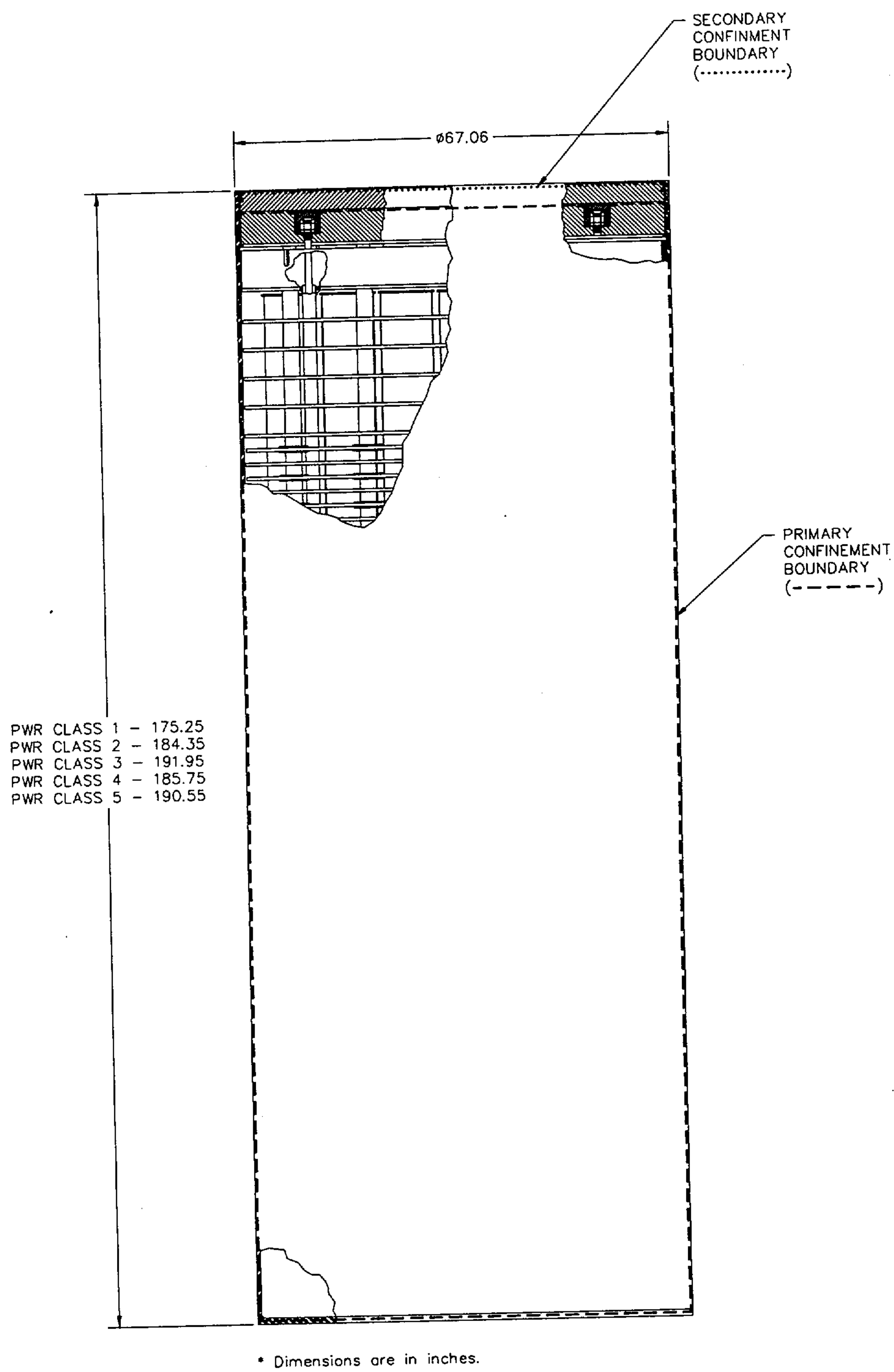


Figure 7.1-2 Confinement Boundary Detail at Shield Lid Penetration

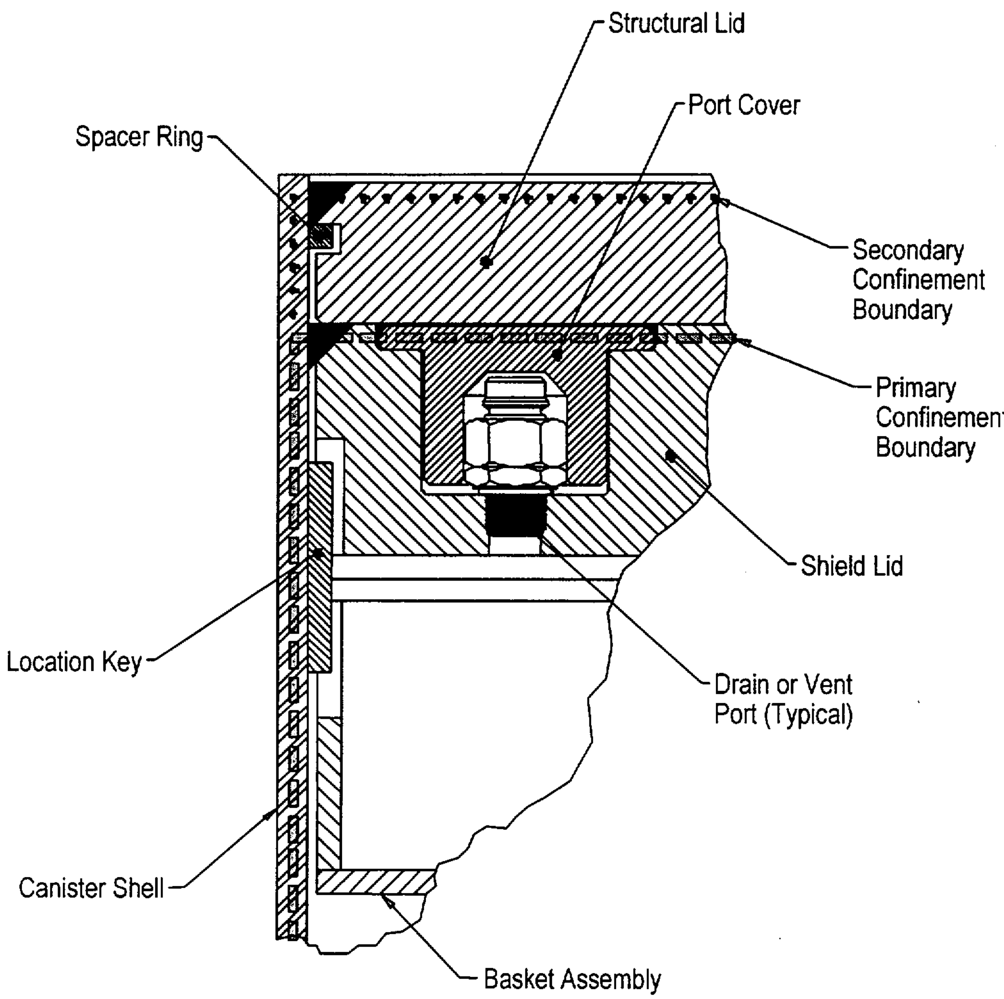


Table 7.1-1 Canister Confinement Boundary Welds

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

THIS PAGE INTENTIONALLY LEFT BLANK

7.2 Requirements for Normal Conditions of Storage

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

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

7.2.1 Release of Radioactive Material

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

7.2.2 Pressurization of the Confinement Vessel

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

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

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

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

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

7.3 Confinement Requirements for Hypothetical Accident Conditions

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

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

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

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

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

THIS PAGE INTENTIONALLY LEFT BLANK

7.4 Confinement Evaluation for Site Specific Spent Fuel

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

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

7.4.1 Confinement Evaluation for Maine Yankee Site Specific Spent Fuel

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

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

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

THIS PAGE INTENTIONALLY LEFT BLANK

7.5 References

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

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

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

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

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

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

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

THIS PAGE INTENTIONALLY LEFT BLANK

Chapter 8

Table of Contents

List of Figures

List of Tables

8.0 OPERATING PROCEDURES

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

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

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

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

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

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

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

8.1 Procedures For Loading the Universal Storage System

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

The transfer cask is provided in the following configurations: A standard and advanced configuration standard transfer cask, weighing approximately 121,500 pounds, and a 100-ton transfer cask weighing approximately 100,000 pounds. The 100-ton transfer cask is designed to accommodate sites having a 100-ton cask handling crane weight limit. It has two trunnions for handling in the vertical orientation, but it may also be moved in a horizontal orientation using a wheeled cradle. Horizontal movement can only be used when the transfer cask is empty, when it holds a canister without fuel, or when it holds a canister that is loaded and closed. Canister handling, fuel loading and canister closing are operationally identical for either transfer cask configuration, except that the standard transfer cask can accommodate an extension fixture to allow the use of the next longer length canister.

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

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

Note: Certain steps of the procedures in this section may be completed out of sequence to allow for operational efficiency. Changing the order of these steps, within the intent of the procedures, has no effect on the safety of the canister loading process and does not violate any requirements stated in the Technical Specifications or the NAC-UMS® Storage FSAR. These steps include the following:

- Placement and installation of air pads
- Sequence and use of an annulus fill system including optional seals and/or foreign material exclusion devices.

8.1.1 Loading and Closing the Transportable Storage Canister

1. Visually inspect the basket fuel tubes to ensure that they are unobstructed and free of debris. Ensure that the welding zones on the canister, shield, and structural lids, and the port covers are prepared for welding. Ensure transfer cask door lock bolts/lock pins are installed and secure.
2. Fill the canister with clean or filtered pool water until the water is about 4 inches from the top of the canister.

   Note: Do not fill the canister completely in order to avoid spilling water during the transfer to the spent fuel pool.

   Note: If fuel loading requires boron credit, the minimum boron concentration of the water in the canister must be at least 1,000 ppm (boron), in accordance with Chapter 12, Section A5.3.
3. Install the annulus fill system to transfer cask including the clean or filtered pool water lines.
4. If it is not already attached, attach the transfer cask lifting yoke to the cask handling crane, and engage the transfer cask lifting trunnions.

   Note: The minimum temperature of the transfer cask (i.e., surrounding air temperature) must be verified to be higher than 0°F prior to lifting, in accordance with Appendix 12B, Section B3.4 (8).
5. Raise the transfer cask and move it over the pool, following the prescribed travel path.
6. Lower the transfer cask to the pool surface and turn on the clean or filtered pool water line to fill the canister and the annulus between the transfer cask and canister.
7. Lower the transfer cask as the annulus fills with clean or filtered pool water until the trunnions are at the surface, and hold that position until the clean or filtered pool water overflows through the upper fill lines or annulus of the transfer cask. Then lower the transfer cask to the bottom of the pool cask loading area.

   Note: If an intermediate shelf is used to avoid wetting the cask handling crane hook, follow the plant procedure for use of the crane lift extension piece.
8. Disengage the transfer cask lifting yoke to provide clear access to the canister.
9. Load the previously designated fuel assemblies into the canister.

   Note: Contents must be in accordance with the Approved Contents provisions of Appendix 12B, Section B2.0.

   Note: Contents shall be administratively controlled to ensure that fuel assemblies with certain characteristics are preferentially loaded in specified positions in the basket. Preferential loading requirements are presented in Appendix 12B, Section B2.1.2 and B2.1.3.

10. Attach a three-legged sling to the shield lid using the swivel hoist rings. Torque hoist rings in accordance with Table 8.1-2. Attach the suction pump fitting to the vent port.
    Caution: Verify that the hoist rings are fully seated against the shield lid.
    Note: Ensure that the shield lid key slot aligns with the key welded to the canister shell.
11. Using the cask handling crane, or auxiliary hook, lower the shield lid until it rests in the top of the canister.
12. Raise the transfer cask until its top just clears the pool surface. Hold at that position, and using a suction pump, drain the pool water from above the shield lid. After the water is removed, continue to raise the cask. Note the time that the transfer cask is removed from the pool. Operations through Step 28 must be completed in accordance with the time limits presented in Table 8.1.1-3.
    Note: Alternately, the temperature of the water in the canister may be used to establish the time for completion through Step 28. Those operations must be completed within 2 hours of the time that the canister water temperature is 200°F. For this alternative, the water temperature must be determined every 2 hours beginning 17 hours after the time the transfer cask is removed from the pool.
    Note: As an alternative, some sites may choose to perform welding operations for closure of the canister in a cask loading pit with water around the canister (below the trunnions) and in the annulus. This alternative provides additional shielding during the closure operation.
13. As the cask is raised, spray the transfer cask outer surface with clean or filtered pool water to wash off any gross contamination.
14. When the transfer cask is clear of the pool surface, but still over the pool, turn off the clean or filtered pool water flow to the annulus, remove hoses and allow the annulus water to drain to the pool. Move the transfer cask to the decontamination area or other suitable work station.
    Note: Access to the top of the transfer cask is required. A suitable work platform may need to be erected.
    Caution: If the 100-ton transfer cask is used, the neutron shield tank must be filled with water to provide neutron shielding for the remaining operations.
15. Verify that the shield lid is level and centered.
16. Attach the suction pump to the suction pump fitting on the vent port. Operate the suction pump to remove free water from the shield lid surface. Disconnect the suction pump and suction pump fitting. Remove any free standing water from the shield lid surface and from the vent and drain ports.
17. Decontaminate the top of the transfer cask and shield lid as required to allow welding and inspection activities.
    Note: Supplemental shielding may be used for activities around the shield lid.

18. Insert the drain tube assembly with a female quick-disconnect attached through the drain port of the shield lid into the basket drain tube sleeve. Remove the female quick-disconnect. Torque the drain tube assembly to 125 ± 5 ft-lbs. Install a quick-disconnect to open the valve in the vent port.
19. Connect the suction pump to the drain port. Verify that the vent port is open. Remove approximately 50 gallons of water from the canister. Disconnect and remove the pump.
    Caution: Radiation level may increase as water is removed from the canister.
20. Install the automatic welding equipment, including the supplemental shield plate.
21. Attach the hydrogen gas detector to the vent port. Verify that the concentration of any detectable hydrogen gas is below 2.4%.
    Note: If the concentration exceeds 2.4%, connect and operate the vacuum system to remove gases from the underside of the shield lid and re-verify the hydrogen gas concentration. Disconnect and remove vacuum system.
22. Operate the welding equipment to complete the root weld joining the shield lid to the canister shell following approved procedures. Remove the hydrogen detector from the vent tube. Leave the connector and vent tube installed to vent the canister.
23. Examine the root weld using liquid penetrant and record the results.
24. Complete welding of the shield lid to the canister shell.
25. Liquid penetrant examine the final weld surface and record the results.
26. Attach a regulated air or nitrogen supply line to the vent port. Install a valved fitting on the drain port and ensure the valve is closed. Pressurize the canister to 35 psia and hold the pressure. There must be no loss of pressure for a minimum of 60 minutes.
27. Release the pressure.
    Note: As an option, an informational helium leak test may be conducted at this point using the following steps (the record leak test is performed at Step 49).
    27a. Evacuate and backfill the canister with helium having a minimum purity of 99.9% to a pressure of 18.0 psia.
    27b. Using a helium leak detector ("sniffer" detector) with a test sensitivity of 5×10^{-5} cm^3/sec (helium), survey the weld joining the shield lid and canister shell.
    27c. At the completion of the survey, vent the canister helium pressure to one atmosphere (0 psig).
28. Drain the canister.
    28a. Attach the suction pump to the drain line. Ensure that the vent line is open. Using the pump, remove the remaining free water from the canister cavity.
    28b. Remove the suction pump from the drain line and close the drain line.
    28c. Using the vent port, pressurize the canister with nitrogen to 15 (+3, -0) psig.

28d. Open the drain line to blow any remaining free water from the canister.

28e. When free water is no longer present at the drain line, stop the flow of nitrogen, vent the remaining pressure and remove the nitrogen supply line. Note the time that the last free water is removed from the canister cavity.

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

Note: The time duration from completion of draining through the completion of helium backfill (Step 34) shall be monitored in accordance with LCO 3.1.1.

29. Attach the vacuum equipment to the vent and drain ports. Dry any free standing water in the vent and drain port recesses.
30. Operate the vacuum equipment until a vacuum of 3 mm of mercury exists in the canister.
    Note: Vacuum drying pressure must conform to the requirements of LCO 3.1.2.
31. Verify that no water remains in the canister by holding the vacuum for 30 minutes. If water is present in the cavity, the pressure will rise as the water vaporizes. Continue the vacuum/hold cycle until the conditions of LCO 3.1.2 are met.
32. Backfill the canister cavity with helium having a minimum purity of 99.9% to a pressure of one atmosphere (0 psig).
33. Restart the vacuum equipment and operate until a vacuum of 3 mm of mercury exists in the canister.
34. Backfill the canister with helium having a minimum purity of 99.9% to a pressure of one atmosphere (0 psig).
    Note: Canister helium backfill pressure must conform to the requirements of LCO 3.1.3.
    Note: Monitor the time from this step (completion of helium backfill) until completion of canister transfer to the concrete cask in accordance with LCO 3.1.4.
35. Disconnect the vacuum and helium supply lines from the vent and drain ports. Dry any residual water that may be present in the vent and drain port cavities.
36. Install the vent and drain port covers.
37. Complete the root pass weld of the drain port cover to the shield lid.
    Note: If the drain port cover weld is completed in a single pass, the weld final surface is liquid penetrant inspected in accordance with Step 40.
38. Prepare the weld and perform a liquid penetrant examination of the root pass. Record the results.
39. Complete welding of the drain port cover to the shield lid.
40. Prepare the weld and perform a liquid penetrant examination of the drain port cover weld final pass. Record the results.

41. Complete the root pass weld of the vent port cover to the shield lid.

    Note: If the drain port cover weld is completed in a single pass, the weld final surface is liquid penetrant inspected in accordance with Step 44.

42. Prepare the weld and perform a liquid penetrant examination of the root pass. Record the results.

43. Complete welding of the vent port cover to the shield lid.

44. Prepare the weld and perform a liquid penetrant examination of the weld final surface. Record the results.

45. Remove the welding machine and any supplemental shielding used during shield lid closure activities.

46. Install the helium leak test fixture.

47. Attach the vacuum line and leak detector to the leak test fixture fitting.

48. Operate the vacuum system to establish a vacuum in the leak test fixture.

49. Operate the helium leak detector to verify that there is no indication of a helium leak exceeding 2×10^{-7} cm^3/second, at a minimum test sensitivity of 1×10^{-7} cm^3/second helium, in accordance with the requirements of LCO 3.1.5.

50. Release the vacuum and disconnect the vacuum and leak detector lines from the fixture.

51. Remove the leak test fixture.

52. Attach a three-legged sling to the structural lid using the swivel hoist rings.

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

    Note: Verify that the structural lid is stamped or otherwise marked to provide traceability of the canister contents.

53. Using the cask handling crane or the auxiliary hook, install the structural lid in the top of the canister. Verify that the structural lid is flush with, or protrudes slightly above, the canister shell. Verify that the gap in the spacer ring is not aligned with the shield lid alignment key. Remove the hoist rings.

54. Install the automatic welding equipment on the structural lid including the supplemental shield plate.

55. Operate the welding equipment to complete the root weld joining the structural lid to the canister shell.

56. Prepare the weld and perform a liquid penetrant examination of the weld root pass. Record the results.

57. Continue with the welding procedure, examining the weld at 3/8-inch intervals using liquid penetrant. Record the results of each intermediate and the final examination.

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

Figure 8.1.1-1 Vent and Drain Port Locations

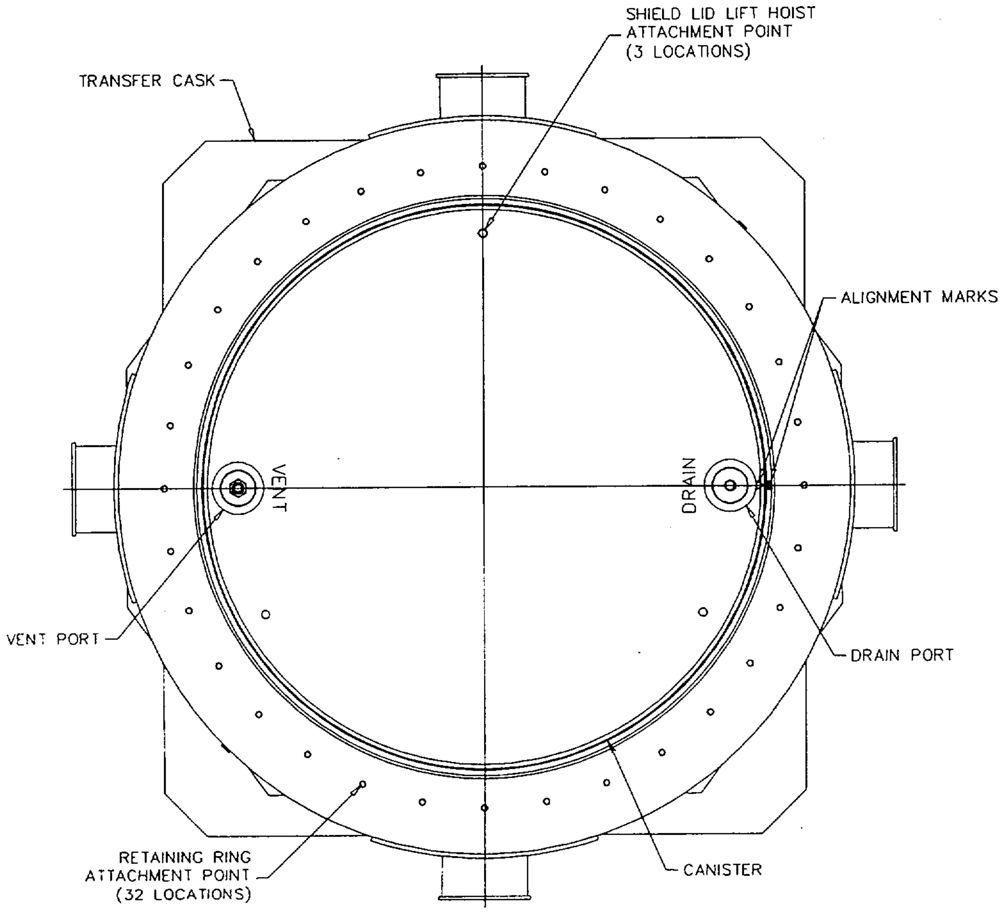


Table 8.1.1-1 List of Principal Ancillary Equipment

Item	**Description**
Transfer Cask Lifting Yoke	Required for lifting and moving the transfer cask.
Heavy-Haul Transporter (Optional)	Heavy-haul (double drop frame) trailer required for moving the loaded and empty vertical concrete cask to and from the ISFSI pad.
Mobile Lifting Frame (Optional)	A self-propelled or towed A-frame lifting device for the concrete cask. Mobile Lifting Frame is used to lift the cask and move it using two lifting lugs in the top of the concrete cask.
Horizontal Transfer Cradle	A wheeled cradle for the movement of the 100-ton transfer cask in the horizontal orientation.
Helium Supply System	Supplies helium to the canister for helium backfill and purging operations.
Vacuum Drying System	Used for evacuating the canister. Used to remove residual water, air and initial helium backfill.
Automated Welding System	Used for welding the shield lid and structural lid to the canister shell.
Self-Priming Pump	Used to remove water from the canister.
Shield Lid Sling	A three-legged sling used for lifting the shield lid. It is also used to lift the concrete cask shield plug and lid.
Canister Sling	A set of 2 three-legged slings used for lifting the structural lid by itself, or for lifting the canister when the structural lid is welded to it. The slings are configured to provide for simultaneous loading during the canister lift.
Transfer Adapter	Used to align the transfer cask to the vertical concrete cask or the Universal Transport Cask. Provides the platform for the operation of the transfer cask shield doors.
Transfer Cask Extension	A carbon steel ring used to extend the height of the standard transfer cask when using the next longer size canister.
Hydraulic Unit	Operates the shield doors of the transfer cask.
Lift Pump Unit	Jacking system for raising and lowering the concrete cask.
Air Pad Rig Set	Air cushion system used for moving the concrete cask.
Supplemental Shielding Fixture	An optional carbon steel fixture inserted in the Vertical Concrete Cask air inlets to reduce radiation dose rates at the inlets.

Table 8.1.1-2 Torque Values

Fastener	Torque Value (ft-lbs)	Torque Pattern
Transfer Adapter Bolts (Optional)	40 ± 5	None
Transfer Cask Retaining Ring	155 ±10	0°, 180°, 270° and 90° in two passes
Transfer Cask Extension	155 ±10	None
Vertical Concrete Cask Lid	40 ± 5	None
Lifting Hoist Rings (Loaded Canister) Canister Structural Lid	800 +80, -0	None
Canister Lid Plug Bolts Shield Lid Plug Bolts	Hand Tight Hand Tight	None None
Transfer Cask Door Lock Bolts	Hand Tight	None
Canister Drain Tube	125 ± 5	None

Table 8.1.1-3 Handling Time Limits Based on Decay Heat Load with Canister Full of Water

Total Heat Load (L) (kW)	**PWR Time Limit (Hours)**	**BWR Time Limit (Hours)**
$20.0 < L \leq 23.0$	17	17
$17.6 < L \leq 20.0$	18	17
$14.0 < L \leq 17.6$	20	17
$11.0 < L \leq 14.0$	22	17
$8.0 < L \leq 11.0$	24	17
$L \leq 8.0$	26	17

8.1.2 Loading the Vertical Concrete Cask

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

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

11. Return the cask handling crane hook to the top of the transfer cask and engage the two (2) three-legged slings attached to the canister.

    Caution: The top connection of the three-legged slings must be at least 75 inches above the top of the canister.

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

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

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

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

8.1.3 Transport and Placement of the Vertical Concrete Cask

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

The vertical concrete cask lift height limit is 24-inches when the cask is moved using the air pad set or the mobile lifting frame in accordance with the requirements of Appendix 12A, Section A5.6. Because of lift fixture configuration, the maximum lift height of the concrete cask using the jacking arrangement is approximately 4 inches.

The concrete cask surface dose rates must be verified in accordance with the requirements of LCO 3.2.2. These measurements may be made prior to movement of the cask, at a location along the transport path, or at the ISFSI. An optional supplemental shielding fixture, shown in Drawing 790-613, may be installed in the concrete cask air inlets to reduce the radiation dose rate at the inlets.

1. Using a suitable towing vehicle, tow the heavy-haul transporter to the dry storage pad (ISFSI). Verify that the bed of the transporter is approximately at the same height as the pad surface. Install four (4) hydraulic jacks at the four (4) designated jacking points at the air inlets in the bottom of the vertical concrete cask.
2. Raise the concrete cask approximately 4 inches using the hydraulic jacks.
   Caution: Do not exceed a maximum lift height of 24 inches, in accordance with the requirements of Administrative Control A5.6.
3. Move the air-bearing rig set under the cask.
   Note: A hydraulic skid may also be used to move the concrete cask. The height the concrete cask is raised depends upon the height of the skid or air pad set used, but may not exceed 20 inches.
4. Inflate the air-bearing rig set. Remove the four (4) hydraulic jacks.
5. Using a suitable towing vehicle, move the concrete cask from the bed of the transporter to the designated location on the storage pad.
   Note: Spacing between concrete casks must not be less than 15 feet (center-to-center).
6. Turn off the air-bearing rig set, allowing it to deflate.

7. Reinstall the four (4) hydraulic jacks and raise the concrete cask approximately 4 inches.

   Caution: Do not exceed a maximum lift height of 24 inches, in accordance with the requirements of Administrative Control A5.6.

8. Remove the air-bearing rig set pads. Ensure that the surface of the dry storage pad under the concrete cask is free of foreign objects.

9. Lower the concrete cask to the surface and remove the four (4) hydraulic jacks.

10. Install the screens in the inlets and outlets.

11. Install/connect temperature monitoring equipment and verify operation in accordance with LCO 3.1.6.

12. Scribe/stamp concrete cask name plate to indicate loading information.

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

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

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

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

Certain steps of the procedures in this section may be completed out of sequence to allow for operational efficiency. Changing the order of these steps, within the intent of the procedures, has no effect on the safety of the canister loading process and does not violate any requirements stated in the Technical Specifications or the NAC-UMS® FSAR. This includes the placement and installation of the air pads.

1. Remove the screens and instrumentation.
2. Using the hydraulic jacking system and the air pad set, move the concrete cask from the ISFSI pad to the heavy-haul transporter. The bed of the transporter must be approximately level with the surface of the pad and sheet metal plates are placed across the gap between the pad and the transporter bed.

   Caution: Do not exceed a maximum lift height of 24 inches when raising the concrete cask.
3. Tow the transporter to the cask receiving area or other designated work area or facility.

4. Remove the concrete cask shield plug and lid. Install the hoist rings in the canister structural lid and torque to the value specified in Table 8.1.1-2. Verify that the hoist rings are fully seated against the structural lid and attach the lift slings. Install the transfer adapter on the top of the concrete cask.
5. Retrieve the transfer cask with the retaining ring installed, and position it on the transfer adapter. Attach the shield door hydraulic cylinders.

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

   Caution: The attachment point of the two three-legged slings must be at least 75 inches above the top of the canister.
7. Raise the canister into the transfer cask.

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

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

8.3 Unloading the Transportable Storage Canister

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

Certain steps of the procedures in this section may be completed out of sequence to allow for operational efficiency. Changing the order of these steps, within the intent of the procedures, has no effect on the safety of the canister loading process and does not violate any requirements stated in the Technical Specifications of the NAC-UMS® Storage FSAR. This includes the sequence and use of an annulus fill system including optional seals and/or foreign material exclusion devices.

1. Remove the transfer cask retaining ring.
2. Survey the top of the canister to establish the radiation level and contamination level at the structural lid.
3. Set up the weld cutting equipment to cut the structural lid weld (Abrasive grinding, hydrolaser, or similar cutting equipment).
4. Enclose the top of the transfer cask in a radioactive material retention tent, as required.
   Caution: Monitor for any out-gassing. Wear respiratory protection as required.
5. Operate the cutting equipment to cut the structural lid weld.
6. After proper monitoring, remove the retention tent. Remove the cutting equipment and attach a three-legged sling to the structural lid.
7. Using the auxiliary crane, lift the structural lid from the canister and out of the transfer cask.
8. Survey the top of the shield lid to determine radiation and contamination levels. Use supplemental shielding as necessary. Decontaminate the top of the shield lid, if necessary.
9. Reinstall the retention tent. Using an abrasive grinder or hydrolaser, and wearing suitable respiratory protection, cut the welds joining the vent and drain port covers to the shield lid.
   Caution: The canister could be pressurized.

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

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

    Note: Any significant radiation level in the discharge gas indicates the presence of fission gas products. The temperature of the gas indicates the thermal conditions in the canister.
12. Start the flow of nitrogen through the line until there is no evidence of fission gas activity in the discharge line. Continue to monitor the gas discharge temperature. When there is no additional evidence of fission gas, stop the nitrogen flow and disconnect the drain and vent port line connections. The nitrogen gas flush must be maintained for at least 10 minutes.

    Note: See Figure 8.3-1 for Canister Reflood Piping and Control Schematic.
13. Perform canister refill and fuel cooldown operations. Attach a source of clean or filtered pool water with a minimum temperature of 70°F and a maximum supply pressure of 25 (+10, -0) psig to the drain port quick-disconnect. Attach a steam rated discharge line to the vent port quick-disconnect and route it to a fuel pool cooler or an in-pool steam condensing unit. Slowly start the flow of clean or filtered pool water to establish a flow rate at 5 (+3, -0) gpm. Monitor the discharge line pressure gauge during canister flooding. Stop filling the canister if the canister vent line pressure exceeds 45 psig. Re-establish water flow when the canister pressure is below 35 psig. The discharge line will initially discharge hot gas, but after the canister fills, it will discharge hot water.

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

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

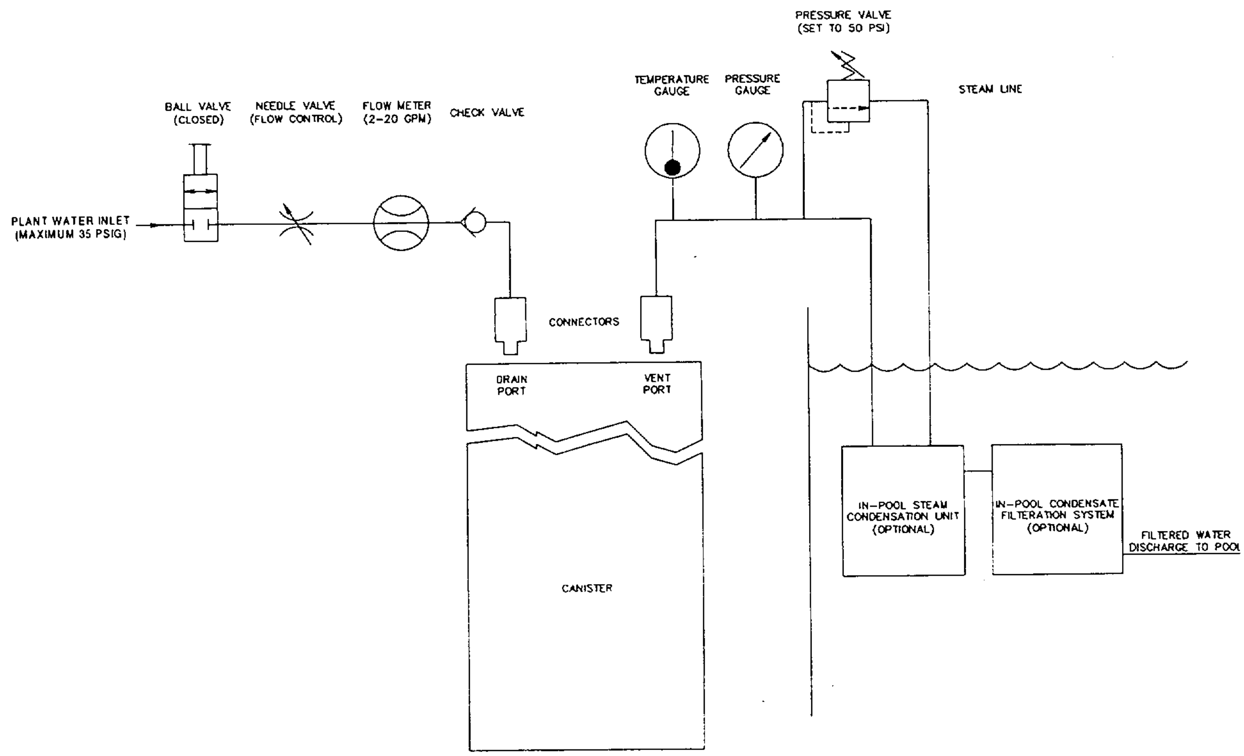
    Caution: Reflooding requires the use of borated water (water with not less than 1,000 parts per million of soluble boron) if borated water was required for the initial fuel loading.
14. Monitor water flow through the canister until the water discharge temperature is below 200°F. Stop the flow of water and remove the connection to the drain line.

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

15. Connect a suction pump to the drain port and a vent line to the vent port. Operate the pump and remove approximately 50 gallons of water. Disconnect and remove the pump.
16. Set up the weld cutting equipment to cut the shield lid weld (Abrasive grinding, hydrolaser, or similar cutting equipment.). Route the vent line to avoid interference with the weld cutting operation.
17. Tent the top of the transfer cask and wear respiratory protection equipment as required. Attach a hydrogen gas detector to the vent port line. Verify that the concentration of hydrogen gas is less than 2.4%.
18. Operate the cutting equipment to cut the shield lid weld.
    Note: Stop the cutting operation if the hydrogen gas detector indicates a concentration of hydrogen gas above 2.4%. Connect the vacuum drying system and evacuate gas before proceeding with the cutting operation.
19. Remove the cutting equipment. Remove supplemental shielding if used. Install the shield lid lifting hoist rings, verifying that the hoist rings are fully seated against the shield lid, and attach a three-legged sling. Attach a tag line to the sling set to aid in attaching the sling to the crane hook (at Step 24).
20. Install the annulus fill system to the transfer cask, including the clean or demineralized water lines.
21. Retrieve the transfer cask lifting yoke and engage the transfer cask lifting trunnions.
22. Move the transfer cask over the pool and lower the bottom of the transfer cask to the surface. Start the flow of clean or filtered pool water to the transfer cask annulus. Continue to lower the transfer cask, as the annulus fills with water, until the top of the transfer cask is about 4 inches above the pool surface. Hold this position until clean or filtered pool water fills to the top of the transfer cask.
23. Lower the transfer cask to the bottom of the cask loading area and remove the lifting yoke.
24. Attach the shield lid lifting sling to the crane hook.
    Caution: The drain line tube is suspended from the under side of the shield lid. The lid should be raised as straight as possible until the drain tube clears the canister basket. The under side of the shield lid could be highly contaminated.
25. Slowly lift the shield lid. Move the shield lid to one side after it is raised clear of the transfer cask.
26. Visually inspect the fuel for damage.

At this point, the spent fuel could be transferred from the canister to the fuel racks. If the fuel is damaged, special handling equipment may be required to remove the fuel. In addition, the bottom of the canister could be highly contaminated. Care must be exercised in the handling of the transfer cask when it is removed from the pool.

Figure 8.3-1 Canister Reflood Piping and Controls Schematic



8.4 References

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

THIS PAGE INTENTIONALLY LEFT BLANK

Chapter 9

Table of Contents

THIS PAGE INTENTIONALLY LEFT BLANK

9.0 ACCEPTANCE CRITERIA AND MAINTENANCE PROGRAM

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

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

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

9.1 Acceptance Criteria

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

9.1.1 Visual and Nondestructive Examination Inspection

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

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

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

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

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

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

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

9.1.1.1 Nondestructive Weld Examination

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

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

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

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

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

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

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

9.1.1.2 Fabrication Inspections

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

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

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

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

9.1.1.3 Construction Inspections

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

9.1.2 Structural and Pressure Test

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

9.1.2.1 Transfer Casks

The transfer cask is provided in three configurations – the standard, the advanced configuration, and the 100-ton. The standard transfer cask is restricted to handling the standard weight canister. The advanced configuration transfer cask incorporates a reinforced trunnion design that allows it to handle either the standard weight, or a heavier weight, canister. The 100-ton transfer cask is designed for horizontal handling. Consequently, the three configurations have different load test requirements.

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

Standard Transfer Cask

The standard transfer cask lifting trunnion load test shall consist of applying a vertical load of 660,000 pounds, which is greater than 300% of the maximum service load for the transfer cask and loaded canister with the shield lid and full of water. The bottom shield door and rail load test shall consist of applying a vertical load of 266,000 pounds, which is over 300% of the maximum service load for the loaded canister with the shield lid and full of water. These maximum service loads are selected based on the heaviest configuration and, thus, bound all of the other configurations.

Advanced Configuration Standard Transfer Cask

The advanced configuration standard transfer cask lifting trunnion load test shall consist of applying a vertical load of 660,000 pounds, which is greater than 300% of the maximum service load (214,300 pounds) for the transfer cask and loaded canister with the shield lid and full of water. The bottom shield door and rail load test shall consist of applying a vertical load of 266,000 pounds, which is over 300% of the maximum service load (88,000 pounds) for the loaded canister with the shield lid and full of water. These maximum service loads are based on the heaviest configuration and, thus, bounds all the other configurations.

100-Ton Transfer Cask

The 100-ton transfer cask shall be load tested in both the vertical and horizontal orientations. The 100-ton transfer cask lifting trunnion load test shall consist of applying a vertical load of 580,000 pounds, which is greater than 300% of the maximum service load (191,900 pounds) for the loaded canister with the shield lid and full of water. The bottom shield door and rail load test shall consist of applying a vertical load of 266,000 pounds, which is over 300% of the maximum service load (88,000 pounds) for the loaded canister with the shield lid and full of water. These maximum service loads are based on the heaviest configuration and, thus, bound all of the other configurations.

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

Following completion of the lifting trunnion load tests, all trunnion welds and all load bearing surfaces shall be visually inspected for permanent deformation, galling or cracking. Magnetic particle or liquid penetrant examinations shall be performed 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. Similarly, following completion of the bottom shield door and rail load tests, all door rail welds and all load bearing surfaces shall be visually inspected for permanent deformation, galling or cracking.

Any evidence of permanent deformation, cracking or galling of the load bearing surfaces or unacceptable liquid penetrant examination results, shall be cause for evaluation, rejection, or rework of the affected component. Liquid penetrant or magnetic particle examinations of all load bearing welds shall be performed in accordance with ASME Code Section V, Articles 1, 6 and/or

7, with acceptance in accordance with ASME Code Section III, NF-5350 or NF-5340, as applicable.

9.1.2.2 Concrete Cask

The concrete cask, at the option of the user/licensee, may be provided with lifting lugs to allow for the vertical handling and movement of the concrete cask. The lifting lugs are provided as two sets of two lugs each, through which a lifting pin is inserted and connected to a specially designed mobile lifting frame. The concrete cask lifting lug system and mobile lifting frame and pins are designed, analyzed, and load tested in accordance with ANSI N14.6. The concrete cask lifting lug load test shall consist of applying a vertical load of 520,000 pounds, which is greater than 150 percent of the maximum concrete cask weight of 313,900 pounds plus a 10 percent dynamic load factor.

The test load shall be applied for a minimum of 10 minutes in accordance with approved, written procedures. Following completion of the load test, all load bearing surfaces of the lifting lugs shall be visually inspected for permanent deformation, galling, or cracking. Liquid penetrant or magnetic particle examinations of load bearing surfaces shall be performed in accordance with ASME Code, Section V, Articles 1, 6 and/or 7, with acceptance criteria in accordance with ASME Code, Section III, Subsection NF, NF-5350 or NF-5340, as applicable.

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

9.1.2.3 Transportable Storage Canister

The transportable storage canister shell may be hydrostatically or pneumatically pressure tested during fabrication in accordance with Section NB-6200 or NB-6300 of the ASME Code, respectively. Hydrostatic testing will be performed in accordance with NB-6221 using 1.25 times the design pressure of 15 psig. The test pressure shall be held a minimum of 10 minutes in accordance with NB-6223. Examination after the pressure test shall be in accordance with NB-6224. Alternately, a pneumatic pressure test may be performed in accordance with NB-6321 using 1.2 times the design pressure of 15 psig. The test pressure shall be held a minimum of 10 minutes in accordance with NB-6323. Examination after the pressure test shall be in accordance with NB-6224.

The canister shell shall consist of the completed Shell Weldment as shown on Drawing 790-582.

If the pressure test is not performed during fabrication, a pressure test must be performed upon closure of the canister with the shield lid as described in Section 8.1.1 of the operating procedures.

9.1.3 Leak Tests

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

9.1.4 Component Tests

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

9.1.4.1 Valves, Rupture Disks and Fluid Transport Devices

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

9.1.4.2 Gaskets

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

9.1.5 Shielding Tests

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

9.1.6 Neutron-Absorber Tests

A neutron absorbing material is used for criticality control in the PWR, BWR and oversize BWR fuel tubes. The placement and dimensions of the neutron absorber are as shown on the License Drawings for these components. The neutron absorbing material is an aluminum matrix material formed from aluminum and boron carbide, available from a number of qualified vendors. The mixing of the aluminum and boron carbide powder forming the neutron absorber material is controlled to assure the required ^{10}B areal density, as specified on the component License Drawings. The constituents of the neutron absorber material shall be verified by chemical testing and spectroscopy and by physical property measurement to ensure the quality of the finished plate or sheet. The results of all neutron absorber material tests and inspections, including the results of wet chemistry coupon testing, are documented and become part of the quality records documentation package for the fuel tube and basket assembly.

Aluminum/boron carbide neutron absorbing material is available under trade names such as BORAL® and METAMIC®.

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

METAMIC is similarly manufactured by California Consolidated Technology, Inc. (CCT). CCT uses patented and proprietary processes to control the weight and blend of the powders used to meet the ^{10}B content specification and also uses a computer-aided manufacturing process to form the neutron absorber plates.

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

9.1.6.1 Neutron Absorber Material Sampling Plan

The neutron absorber sampling plan is selected to demonstrate a 95/95 statistical confidence level in the neutron absorber sheet material in 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 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 of the first 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. 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 Neutron Absorber Wet Chemistry Testing

Wet chemistry testing of the test coupons obtained from the sampling plan is used to verify the ^{10}B content of the neutron absorber material. Wet chemistry testing is applied because it is considered to be the most accurate and practical direct measurement method for determining ^{10}B, boron and B_4C content of metal materials and is considered by the Electric Power Research Institute (EPRI) to be the method of choice for this determination.
An approved facility with chemical analysis capability, which could include the neutron absorber vendor's facility, shall be selected to perform the wet chemistry tests. Personnel performing the testing shall be trained and qualified in the process and in the test procedure.

Wet chemistry testing is performed by dissolving the aluminum in the matrix, including the powder and cladding, in a strong acid, leaving the B_4C material. A comparison of the amount of B_4C material remaining to the amount required to meet the ^{10}B content specification is made using a mass-balance calculation based on sample size.

A statistical conclusion about the neutron absorber sheet from which the sample was taken and that batch of neutron absorber sheets may then be drawn based on the test results and the controlled manufacturing processes.

The adequacy of the wet chemistry method is based on its use to qualify the standards employed in neutron blackness testing. The neutron absorption performance of a test material is validated based on its performance compared to a standard. The material properties of the standard are demonstrated by wet chemistry testing. Consequently, the specified test regimen provides adequate assurance that the neutron absorber sheet thus qualified is acceptable.

9.1.6.3 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 License Drawings. Failure of any coupon wet chemistry test shall result in 100% sampling, as described in the sampling plan, until compliance with the acceptance criteria is demonstrated.

9.1.7 Thermal Tests

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

9.1.8 Cask Identification

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

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

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

9.2 Maintenance Program

This section presents the maintenance requirements for the UMS® Universal Storage System and for the transfer cask.

9.2.1 UMS® Storage System Maintenance

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

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

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

The ambient air temperature and air outlet temperature of each Vertical Concrete Cask must be recorded upon placement in service. Thereafter, the temperatures shall be recorded on a daily basis to verify the continuing thermal performance of the system.

In the event of a decline in thermal performance, the heat removal system must be restored to acceptable operation. The user should perform a visual inspection of air inlets and outlets for evidence of blockage and verify that the inlet and outlet screens are whole, secure and in place.

The user must also visually inspect the Vertical Concrete Cask within 4 hours of any off-normal, accident or natural phenomena event, such as an earthquake.

An annual inspection of the Vertical Concrete Cask exterior is required, to include:

- Visual inspection of concrete surfaces for chipping, spalling or other surface defects. Any defects larger than one inch in diameter (or width) and deeper than one inch shall be regrouted, according to the grout manufacturer's recommendations.
- Reapplication of corrosion-inhibiting (external) coatings on accessible corroded surfaces, including concrete cask lifting lugs, if present.

9.2.2 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, the lifting trunnions, shield doors and shield door rails shall be either dye penetrant or magnetic particle examined, using the examination method appropriate to the material. The examination method shall be in accordance with Section V of the ASME Code. The acceptance criteria shall be in accordance with Section III, Subsection NF, Article NF-5350 or NF-5340 as appropriate to the examination method, as required by ANSI N14.6.

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

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

9.2.3 Required Surveillance of First Storage System Placed in Service

For the first Universal Storage System placed in service with a heat load equal to or greater than 10 kW, the canister is loaded with spent fuel assemblies and the decay heat load calculated for that canister. The canister is then loaded into the vertical concrete cask, and the cask's thermal performance is evaluated by measuring the ambient and air outlet temperatures for normal air flow. The purpose of the surveillance is to measure the heat removal performance of the Universal Storage System and to establish baseline data. In accordance with 10 CFR 72.4, a letter report summarizing the results of the surveillance and evaluation will be submitted to the NRC within 30 days of placing the loaded cask on the ISFSI pad. The report will include a comparison of the calculated temperatures of the NAC-UMS® system heat load to the measured temperatures. A report is not required to be submitted for the NAC-UMS® systems that are subsequently loaded, provided that the performance of the first system placed in service with a heat load $\geq$ 10 kW, is demonstrated by the comparison of the calculated and measured temperatures.

9.3 References

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

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

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

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

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

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

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

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

THIS PAGE INTENTIONALLY LEFT BLANK

Chapter 10

Table of Contents

List of Figures

List of Tables

10.0 RADIATION PROTECTION

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

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

10.1.1 Policy Considerations

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

10.1.2 Design Considerations

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

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

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

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

10.1.3 Operational Considerations

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

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

- Use of automatic equipment for weld inspections.

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

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

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

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

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

10.2 Radiation Protection Design Features

The radiation shielding design description is provided in Sections 5.3.1 and 5.3.2. The design criteria radiation exposure rates are summarized in Table 2-1. The principal radiation protection design features are the shielding necessary to meet the design objectives, the placement of penetrations near the edge of the canister shield lid to reduce operator exposure and handling time, and the use of shaped supplemental shielding for work on and around the shield lid, as necessary. This supplemental shielding reduces operator dose rates during the welding, inspection, draining, drying and backfilling operations that seal the canister. An optional supplemental shielding fixture, shown in Drawing 790-613, may be installed in the air inlets to reduce the radiation dose rate at the base of the vertical concrete cask.

Radiation exposure rates at various work locations are determined for the principal Universal Storage System operational steps using a combination of the SAS4 [3], MCBEND [6] and SKYSHINE III [4] computer codes. The use of SAS4 and MCBEND is described in Section 5.1.2. The SKYSHINE-III code is discussed in Section 10.4. The calculated dose rates decrease with time.

10.2.1 Design Basis for Normal Storage Conditions

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

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

The calculated dose rates at these, and at other dose points, are reported in Sections 5.1.3 and 5.4.1.3. The dose rates presented are for the design basis 40,000 MWD/MTU, 5-year cooled, fuel. These dose rates bound those of the higher burnup, but longer cooled, fuel described in Section 2.1.

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

10.2.2 Design Basis for Accident Conditions

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

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

10.3 Estimated On-Site Collective Dose Assessment

Occupational radiation exposures (person-mrem) resulting from the use of the Universal Storage System are calculated using the estimated exposure rates presented in Sections 5.1.3, 5.4.1.3, 5.4.2.3 and 10.2.1. Exposure is evaluated by identifying the tasks and estimating the duration and number of personnel performing those tasks based on industry experience. The tasks identified are based on the design basis operating procedures, as presented in Chapter 8.

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

As described in Section 5.1, there are no single PWR or BWR design basis assemblies for the 100-ton transfer cask. Instead, the seven bounding fuel assembly types listed in Section 5.5 are employed to calculate the 100-ton transfer cask bounding dose rates using the minimum allowable cool time tables.

10.3.1 Estimated Collective Dose for Loading a Single Universal Storage System

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

Table 10.3-1 summarizes the estimated total exposure by task, attributable to the loading, transfer, sealing and placement of a design basis Universal Storage System based on the use of the standard transfer cask. Table 10.3-2 summarizes total exposure based on the use of the 100-ton transfer cask.

Exposures associated with shield lid operations are based on the presence of a temporary 5-inch thick steel shield.

This estimated dose is considered to be conservative as it assumes the loading of a cask with design basis fuel (or the limiting fuel from the 100-ton transfer cask analysis) and does not account for efficiencies in the loading process that occur with experience.

10.3.2 Estimated Annual Dose Due to Routine Operations

Once in place, the ISFSI requires limited ongoing inspection and surveillance throughout its service life. The annual dose evaluations presented in Tables 10.3-4 through 10.3-7 estimate the exposure due to a combination of inspection and surveillance activities and other tasks that are anticipated to be representative of an operational facility. The visual inspection exposure, based on a daily inspection of the storage cask or storage cask array, is provided for information only since a daily inspection is not required as long as the temperature monitoring system is operational. Other than an inspection of the Vertical Concrete Cask surface, no annual maintenance of the storage system is required. Collective dose due to design basis off-normal conditions and accident events, such as clearing the blockage of air vents, is accounted for in Chapter 11.0, and is not included in this evaluation.

Routine operations are expected to include:

- Daily electronic measurement of air outlet temperatures. The outlet temperature monitoring station is located away from the cask array. Remote temperature measurement is not assumed to contribute to operator dose.
- A daily security inspection of the fence and equipment surrounding the storage area. The security inspection is assumed to make no significant additional contribution to operator dose.
- Grounds maintenance performed every other week by 1 maintenance technician. Grounds maintenance is assumed to require 0.5 hour.
- Quarterly radiological surveillance. The surveillance consists of a radiological survey comprised of a surface radiation measurement on each cask, the determination and/or verification of general area exposure rates and radiological postings. This surveillance is assumed to require 1 hour and 1 person.

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

Calculation of the dose due to annual operation and surveillance requirements is estimated based on a single cask containing design basis fuel, and on an ISFSI array of 20 casks that are assumed to be loaded at the rate of 2 casks per year over a ten year period. Consequently, the casks in the array are assumed to have the cool times as shown in Table 10.3-3. To account for the reduction in source term with cool time, weighting factors are applied to the neutron and gamma radiation spectra as shown in Table 10.3-4.

The annual operation and surveillance requirements result in an estimated annual collective exposure of 26.4 person-mrem for a single PWR cask containing design basis fuel and 17.0 person-mrem for a single design basis BWR cask. The annual operation and surveillance requirements for the assumed single cask and total estimated dose is shown in Table 10.3-5 for the single PWR cask and in Table 10.3-7 for the BWR cask. The annual operation and surveillance requirements for the assumed 20-cask ISFSI are shown in Tables 10.3-6 and 10.3-8 for PWR and BWR configurations, respectively. These tables show an estimated annual collective exposure of 377.6 person-mrem for the PWR cask configuration and 239.4 person-mrem for the BWR cask configuration for operation and maintenance of a 20-cask array.

Figure 10.3-1 Typical ISFSI 20 Cask Array Layout

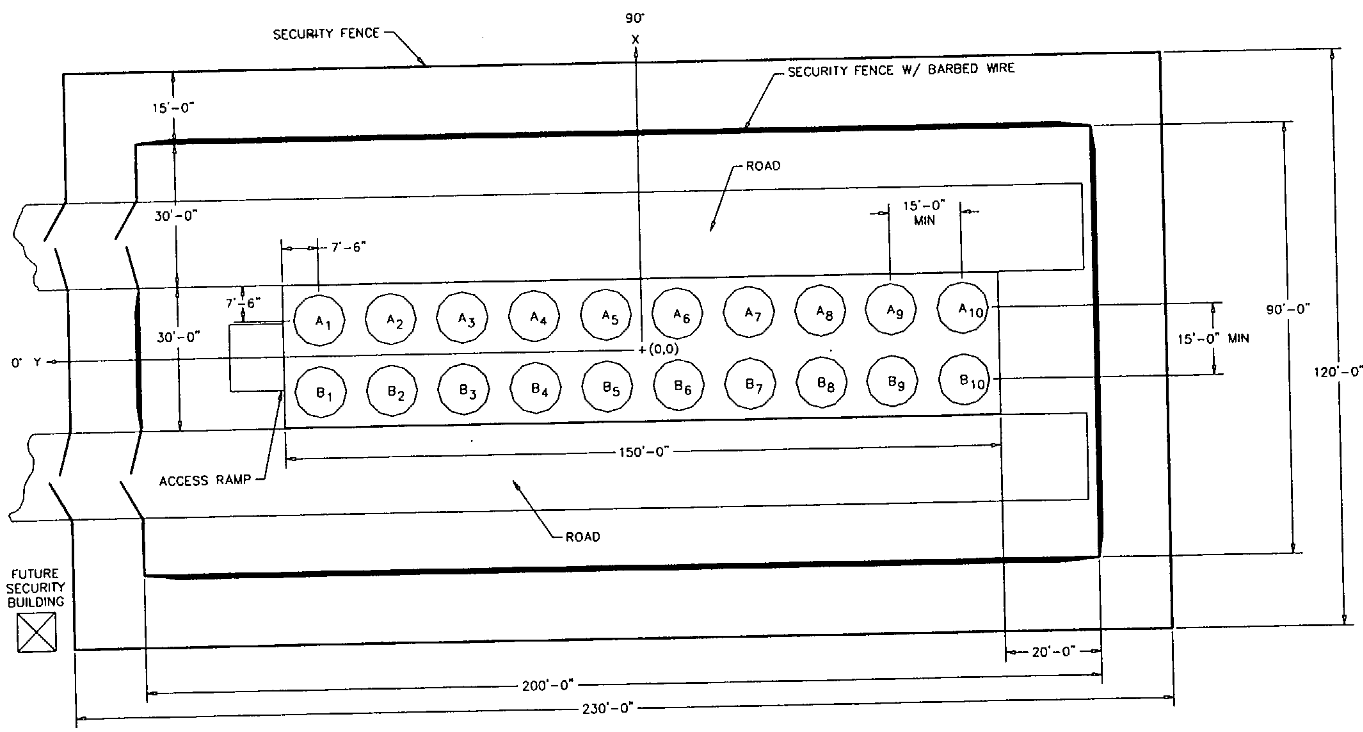


Table 10.3-1 Estimated Exposure for Operations Using the Standard Transfer Cask

Design Basis Fuel Assemblies Loading and Handling Activity	Estimated Number of Personnel[6]	Exposure Duration (hr)	Average Dose Rate (mrem/hr)		Exposure (person-mrem)	
			PWR	BWR	PWR	BWR
Load Canister[1]	2	9.9/21.9	2.1	2.0	42	88
Move to Decon Area/Prep for Weld	2	0.6	29.1	19.4	33	22
Setup Shield Lid Weld[3]	2	0.5	39.6	25.7	37	24
Welding Operation (Automated)	1	0.3	BDR[2]	BDR[2]	0	0
Weld Inspections[3,4]	1	7.5	10.4	6.6	78	50
Drain/ Vacuum Dry/Backfill and Leak Test[3,5]	2	0.4	30.0	20.4	25	17
Weld and Inspect Port Covers[3,4]	2	2.2	35.1	22.8	151	98
Setup Structural Lid Weld[3]	2	0.3	25.3	15.8	16	10
Welding Operation (Automated)	1	0.3	BDR[2]	BDR[2]	0	0
Weld Inspections[3,4]	1	7.7	6.8	4.0	52	31
Transfer to Vertical Concrete Cask	4	2.8	22.0	13.4	249	152
Position on ISFSI Pad	2	0.8	16.3	11.3	26	18
Total					709	510

1. Assumes 22.5 minutes for the loading of each PWR or BWR fuel assembly with additional time for installation of drain tube and shield lid prior to move to decontamination area.
2. Background Dose Rate (BDR). No exposure is estimated due to the canister contents.
3. Dose rates associated with the presence of a temporary shield on top of the shield lid.
4. Includes root, progressive, and final weld surface inspections.
5. Includes fixturing, connection and monitoring time. Operators not present during routine draining and drying process.
6. Number of personnel shown is a representative number. Personnel vary for the different operation stages, with total exposure divided over a larger number of personnel than the number shown.

Table 10.3-2 Estimated Exposure for Operations Using the 100-Ton Transfer Cask

Design Basis/100-ton Fuel Assemblies Loading and Handling Activity	Estimated Number of Personnel[6]	Exposure Duration (hr)	Average Dose Rate (mrem/hr)		Exposure (person-mrem)	
			PWR	BWR	PWR	BWR
Load Canister[1]	2	9.9/21.9	3.1	2.4	61	107
Move to Decon Area/Prep for Weld	2	0.6	29.1	19.4	33	22
Setup Shield Lid Weld[3]	2	0.5	39.6	25.7	37	24
Welding Operation (Automated)	1	0.3	BDR[2]	BDR[2]	0	0
Weld Inspections[3,4]	1	7.5	10.4	6.6	78	50
Drain/ Vacuum Dry/Backfill and Leak Test[3,5]	2	0.4	30.0	20.4	25	17
Weld and Inspect Port Covers[3,4]	2	2.2	35.1	22.8	151	98
Setup Structural Lid Weld[3]	2	0.3	25.3	15.8	16	10
Welding Operation (Automated)	1	0.3	BDR[2]	BDR[2]	0	0
Weld Inspections[3,4]	1	7.7	6.8	4.0	52	31
Transfer to Vertical Concrete Cask	4	2.8	37.9	28.6	429	324
Position on ISFSI Pad	2	0.8	16.3	11.3	26	18
Total					908	701

1. Assumes 22.5 minutes for the loading of each PWR or BWR fuel assembly with additional time for installation of drain tube and shield lid prior to move to decontamination area.
2. Background Dose Rate (BDR). No exposure is estimated due to the canister contents.
3. Dose rates associated with the presence of a temporary shield on top of the shield lid.
4. Includes root, progressive, and final weld surface inspections.
5. Includes fixturing, connection and monitoring time. Operators not present during routine draining and drying process.
6. Number of personnel shown is a representative number. Personnel vary for the different operation stages, with total exposure divided over a larger number of personnel than the number shown.

Table 10.3-3 Assumed Contents Cooling Time of the Vertical Concrete Casks Depicted in the Typical ISFSI Array

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

Table 10.3-4 Vertical Concrete Cask Radiation Spectra Weighting Factors

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

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

Activity	Dose Rate Distance (meters)	Frequency (days)	Time (min)	Dose Rate (mrem/hr)	Personnel Required	Total Exposure (Pers-mrem)
Radiological surveillance	4	4	15	7.40	1	7.4
Annual inspection						
Operations	1	1	15	25.30	1	6.3
Radiological Support	1	1	3	25.30	1	1.3
Grounds maintenance	10	26	15	1.76	1	11.4
Total Person-mrem						26.4

Table 10.3-6 Estimate of Annual Exposure for the Operation and Surveillance of a 20-Cask Array of PWR Casks

Activity	Dose Rate Distance (meters)	Frequency (days)	Time (min)	Dose Rate (mrem/hr)	Personnel Required	Total Exposure (Pers-mrem)
Radiological surveillance	4	4	60	5.96	1	23.8
Annual inspection						
Operations	1	1	15(1)	47.91	1	239.6
Radiological Support	1	1	3(1)	47.91	1	47.9
Grounds maintenance	10	26	60	2.55	1	66.3
Total Person-mrem for the 20-Cask Array						377.6
Total Person-mrem for a Single Cask in the Array						18.6

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

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

Activity	Dose Rate Distance (meters)	Frequency (days)	Time (min)	Dose Rate (mrem/hr)	Personnel Required	Total Exposure (mrem)
Radiological surveillance	4	4	15	4.9	1	4.9
Annual inspection						
Operations	1	1	15	15.2	1	3.8
Radiological Support	1	1	3	15.2	1	0.8
Grounds maintenance	10	26	15	1.16	1	7.5
Total Person - mrem						17.0

Table 10.3-8 Estimate of Annual Exposure for the Operation and Surveillance of a 20-Cask Array of BWR Casks

Activity	Dose Rate Distance (meters)	Frequency (days)	Time (min)	Dose Rate (mrem/hr)	Personnel Required	Total Exposure (mrem)
Radiological surveillance	4	4	60	4.2	1	16.8
Annual inspection						
Operations	1	1	15(1)	29.9	1	149.5
Radiological Support	1	1	3(1)	29.9	1	29.9
Grounds maintenance	10	26	60	1.7	1	43.2
Total Person - mrem for the 20-Cask Array						239.4
Total Person - mrem for a Single Cask in the Array						12.0

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

10.4 Exposure to the Public

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

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

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

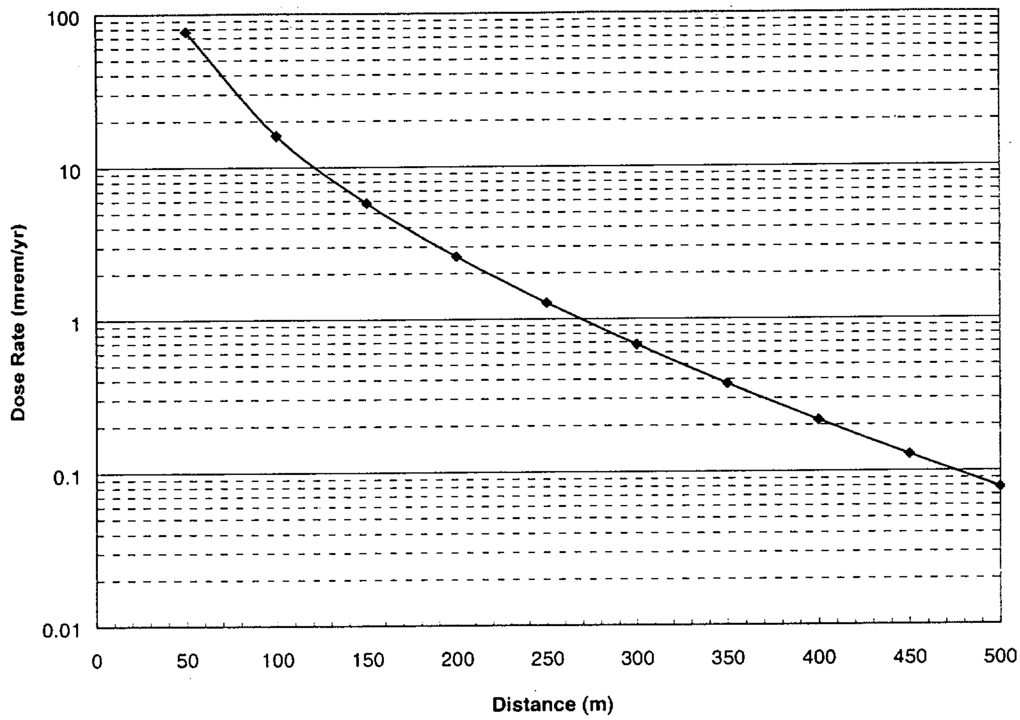
The storage cask array is explicitly modeled in the code, with the source term from each cask represented as top and side surface sources. Surface source emission fluxes are provided from one-dimensional SAS1 shielding evaluations. The top and side source energy distributions for both neutron and gamma radiation are taken from the design basis cask shielding evaluation. As stated in Section 10.3, the array cask source strengths are multiplied by weighting factors to correct for the differences in cooling times resulting from the assumption of a loading rate of 2 casks per year. The SKYSHINE cask surface fluxes (sources) are adjusted to reflect the higher cask surface fluxes calculated by the SAS4 three-dimensional shielding evaluation. Surface gamma-ray fluxes are also adjusted for dose peaks associated with fuel assembly end-fitting hardware and radiation streaming through the cask vents and canister-to-cask annulus. The 2×10 ISFSI storage cask array layout is presented in Figure 10.3-1. For this analysis the cask-to-cask pitch is conservatively taken at 16 feet, as opposed to the minimum 15 feet, to minimize cask-to-cask shadowing. These results are conservative for the minimum 15-foot cask center-to-center-spacing specified in Section 4.5.2, Appendix 12A.

Exposures are determined at distances ranging from 50 to 500 meters surrounding a single PWR and BWR storage cask containing design basis fuel. The results are presented graphically in Figures 10.4-1 and 10.4-2, for the PWR or BWR single cask, respectively. The storage casks in the 2×10 array are assumed to be loaded at the rate of 2 per year with design basis PWR and BWR spent fuel, with credit taken for the cool time that occurs during the 10-year period that the ISFSI array is completed. For both the single cask and 2×10 array calculations, the controlled area boundary is based on the 25 mrem/year limit. Occupancy at the controlled area boundary is assumed at 2,080 hours per year. While higher occupancy may be required at certain sites, the increased exposure time will likely be offset by increased cool time or decreased burnup.

Table 10.4-1 presents a summary of the dose rates versus distance for a single PWR and BWR storage cask containing design basis fuel. Linear interpolation of these results shows that minimum distances from a single cask to the site boundary of 93 meters and 84 meters for the design basis PWR and BWR fuels, respectively, are required for compliance with the requirements of 10 CFR 72.104(a), i.e., a dose rate of 25 mrem/year. Table 10.4-2 results show that a minimum site boundary of ≈195 meters is required for a 2×10 PWR cask array to meet the 10 CFR 72.104(a) 25 mrem/year requirement. The 2×10 BWR cask array requires a minimum site boundary of ≈186 meters to meet 10 CFR 72.104(a).

The distances used in Tables 10.4-1 and 10.4-2 are measured from the center of the 2×10 cask array along a line perpendicular to the center of the 10-cask face of the array.

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

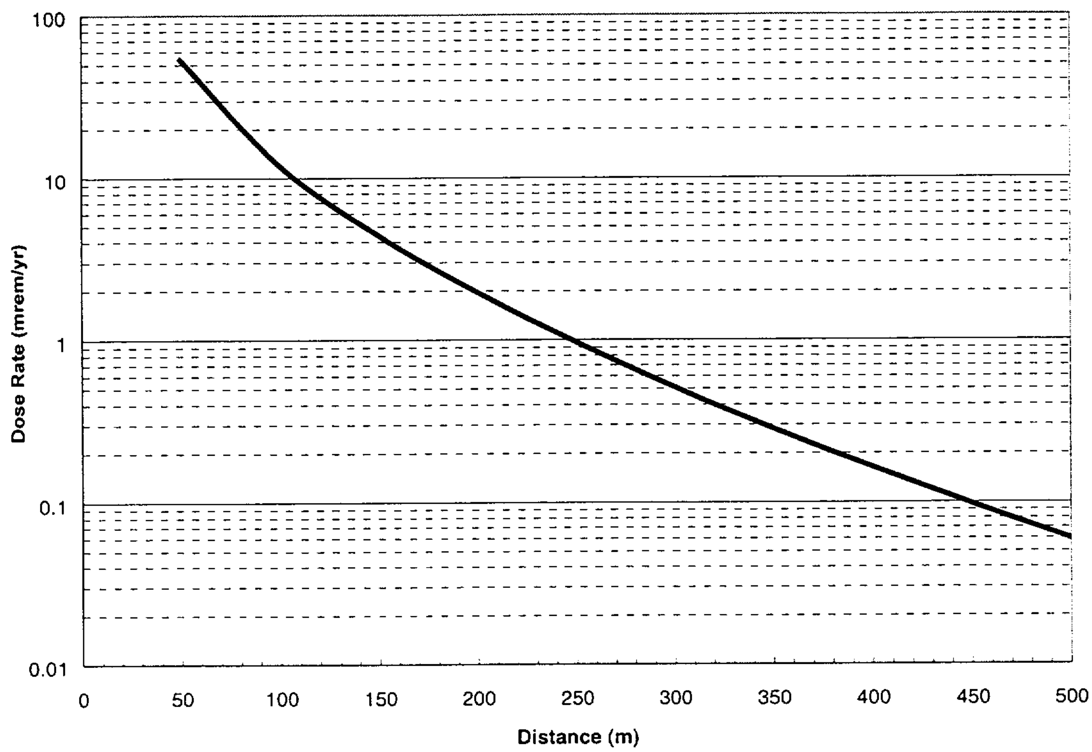


Distance from Center of Cask(m)	Dose Rate (mrem/year)			
	Gamma Dose	Neutron Dose	N-Gamma Dose	Total Dose
50	7.28E+01	3.85E+00	7.93E-04	77
100	1.47E+01	1.34E+00	8.07E-04	16
150	5.25E+00	5.56E-01	8.14E-04	5.8
200	2.32E+00	2.54E-01	7.86E-04	2.6
250	1.15E+00	1.24E-01	7.26E-04	1.3
300	6.12E-01	6.29E-02	6.43E-04	0.68
350	3.40E-01	3.34E-02	5.50E-04	0.37
400	1.97E-01	1.83E-02	4.58E-04	0.22
450	1.18E-01	1.03E-02	3.71E-04	0.13
500	7.19E-02	5.97E-03	2.95E-04	0.08

General Notes:

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

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



Distance from Center of Cask(m)	Dose Rate (mrem/year)			
	Gamma Dose	Neutron Dose	N-Gamma Dose	Total Dose
50	4.81E+01	5.80E+00	1.47E-03	54
100	9.86E+00	2.02E+00	1.27E-03	12
150	3.53E+00	8.40E-01	1.25E-03	4.4
200	1.57E+00	3.84E-01	1.20E-03	2.0
250	7.78E-01	1.86E-01	1.10E-03	0.97
300	4.15E-01	9.49E-02	9.78E-04	0.51
350	2.33E-01	5.03E-02	8.37E-04	0.28
400	1.35E-01	2.76E-02	6.96E-04	0.16
450	8.12E-02	1.56E-02	5.64E-04	0.10
500	5.00E-02	9.00E-03	4.48E-04	0.06

General Notes:

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

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

Distance from Center of Cask (m)	PWR Cask Total Dose Rate (mrem/y)[1]	BWR Cask Total Dose Rate (mrem/y)[1]
50	77	54
100	16	12
150	5.8	4.4
200	2.6	2.0
250	1.3	0.97
300	0.68	0.51
350	0.37	0.28
400	0.22	0.16
450	0.13	0.10
500	0.08	0.06

1. 2,080-hour exposure.

Table 10.4-2 Annual Exposures from a 2×10 Cask Array Containing Design Basis PWR or BWR Fuel

Distance from Center of Array (m)	PWR Cask Total Dose Rate (mrem/y)[1]	BWR Cask Total Dose Rate (mrem/y)[1]
50	600	466
100	135	111
150	49	41
200	22	19
250	11	9.2
300	5.8	4.9
350	3.2	2.7
400	1.9	1.5
450	1.1	0.90
500	0.67	0.55

1. 2,080-hour exposure.

THIS PAGE INTENTIONALLY LEFT BLANK

10.5 Radiation Protection Evaluation for Site Specific Spent Fuel

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

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

10.5.1 Radiation Protection Evaluation for Maine Yankee Site Specific Spent Fuel

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

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

THIS PAGE INTENTIONALLY LEFT BLANK

10.6 References

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

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

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

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

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

6. Serco Assurance, "MCBEND, A Monte Carlo Program for General Radiation Transport Solutions, User Guide for Version 9," ANSWERS/MCBEND (94) 15, June 2000.

THIS PAGE INTENTIONALLY LEFT BLANK