11.2.14 Canister Closure Weld Evaluation

The closure weld for the canister is a groove weld with a thickness of 0.9 inches. The evaluation of this weld, in accordance with NRC guidance, is to incorporate a 0.8 stress reduction factor. Applying a factor of 0.8 to the weld stress allowable incorporates the stress reduction factor.

The stresses for the canister are evaluated using sectional stresses as permitted by Subsection NB of the ASME Code. Canister stresses resulting from the concrete cask tip-over accident (Section 11.2.12.4) are used for evaluation. The location of the section for the canister weld evaluation is shown in Figure 11.2.12.4.1-6 and corresponds to Section 11. The governing P_m and $P_m + P_b$ stress intensities for Section 11 and the associated allowables are listed in Tables 11.2.12.4.1-1 and Table 11.2.12.4.1-2, respectively. The factored allowables, incorporating a 0.8 stress reduction factor, and the resulting controlling Margins of Safety are:

Stress Category	Analysis Stress (ksi)	0.8 × Allowable Stress (ksi)	Margin of Safety
P_m	22.81	32.06	0.41
$P_m + P_b$	25.03	48.09	0.92

This confirms that the canister closure weld is acceptable for accident conditions.

Critical Flaw Size for the Canister Closure Weld

The closure weld for the canister is comprised of multiple weld beads using a compatible weld material for Type 304L stainless steel. An allowable (critical) flaw evaluation has been performed to determine the critical flaw size in the weld region. The result of the flaw evaluation is used to define the minimum flaw size, which must be identifiable in the nondestructive examination of the weld. Due to the inherent toughness associated with Type 304L stainless steel, a limit load analysis is used in conjunction with a J-integral/tearing modulus approach. The safety margins used in this evaluation correspond to the stress limits contained in Section XI of the ASME Code.

One of the stress components used in the evaluation for the critical flaw size is the radial stress component in the weld region of the structural lid. For an accident (Level D) event, in accordance with ASME Code Section XI, a safety factor of $\sqrt{2}$ is required. For the purpose of identifying the stress for the flaw evaluation, the weld region corresponds to Section 11 in Figure 11.2.12.4.1-6 is considered.

The maximum tensile radial stress at Section 11 is 6.9 ksi, based on the analysis results of the tip-over accident (Section 11.2.12.4). To perform the flaw evaluation, a 10 ksi stress is conservatively used, resulting in a significantly larger safety factor than the required safety factor of $\sqrt{2}$. Using 10 ksi as the basis for the evaluation, the minimum detectable flaw size is 0.52 inch for a flaw that extends 360 degrees around the circumference of the canister. Stress components for the circumferential and axial directions are also reported in the concrete cask tip-over analysis, which would be associated with flaws oriented in the radial or horizontal directions respectively. The maximum stress for these components is 2.5 ksi, which is also enveloped by the value of 10 ksi used in the critical flaw evaluation for stresses in the radial direction. The 360-degree flaw employed for the circumferential direction is considered to be bounding with respect to any partial flaw in the weld, which could occur in the radial and horizontal directions. Therefore, using a minimum detectable flaw size of 0.375 inch is acceptable, since it is less than the very conservatively determined 0.52-inch critical flaw size.

11.2.15 Accident and Natural Phenomena Events Evaluation for Site Specific Spent Fuel

This section presents the accident and natural phenomena events evaluation of spent fuel assemblies or configurations, which are unique to specific reactor sites. These site specific 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 blankets and variable enrichment assemblies, fuel with burnup that exceeds the design basis, and fuel that is classified as damaged. Damaged fuel includes fuel rods with cladding that exhibits defects greater than pinhole leaks or hairline cracks.

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

11.2.15.1 Accident and Natural Phenomena Events Evaluation for Maine Yankee Site Specific Fuel

Maine Yankee site specific fuels are described in Section 1.3.2.1. A thermal evaluation has been performed for Maine Yankee site specific fuels that exceed the design basis burnup, as shown in Section 4.5.1.2. As shown in that section, loading of fuel with a burnup between 45,000 and 50,000 MWD/MTU is subject to preferential loading in designated basket positions in the Transportable Storage Canister, and certain high burnup fuel may require loading in the Maine Yankee fuel can.

With preferential loading, the design basis total heat load of the canister is not changed. Consequently, the thermal performance for the Maine Yankee site specific fuels is bounded by the design basis PWR fuels. Therefore, no further evaluation is required for the thermal accident events, as presented in Sections 11.2.6, 11.2.7, and 11.2.13.

As shown in Section 3.6.1.1, the total weight of the contents of the Transportable Storage Canister for Maine Yankee fuels is bounded by the total weight for the PWR design basis fuels. However, some design parameters for the Maine Yankee site ISFSI pad are different from those for the design basis ISFSI pad. Therefore, the hypothetical accident (non-mechanistic) tip-over event is evaluated to ensure that the maximum tip-over g-load remains below the bounding g-load (40g) used in the evaluation of the PWR canister and basket in Section 11.2.12.4. The evaluation of the UMS®

Vertical Concrete Cask tip-over event on the Maine Yankee site ISFSI pad is presented in Section 11.2.15.1.1. The methodology used is similar to that used in Section 11.2.12.3.1.

Although the total weight, and the maximum g-load, for the Maine Yankee fuel is bounded by the PWR design basis fuels, the maximum weight of the consolidated fuel lattices (2,100 lbs) is larger than that of a single PWR Class 1 design basis fuel assembly (1,567 lbs). This additional weight need only be considered in the support disk evaluation for a side impact condition, similar to the analysis presented in Section 11.2.12.4.1. A parametric study is presented in Section 11.2.15.1.2 to demonstrate that the maximum stress in the support disk due to the consolidated fuel lattice remains bounded by the maximum stress for the support disk for the PWR design basis fuels for a side impact condition.

Section 11.2.15.1.3 provides the structural evaluation for the Maine Yankee fuel can for the 24-inch drop (Section 11.2.4) and the tip-over (Section 11.2.12) accident events.

A Maine Yankee site earthquake evaluation is presented in Section 11.2.15.1.4 to demonstrate the stability of the Vertical Concrete Cask on the Maine Yankee site ISFSI pad.

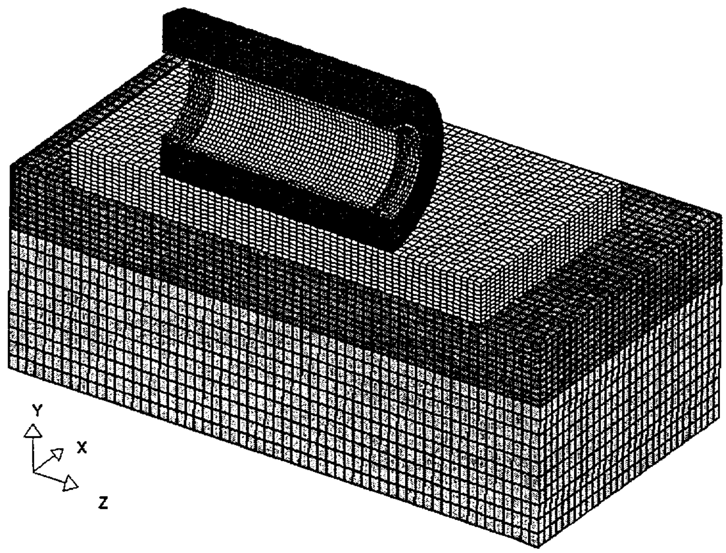
11.2.15.1.1 Maine Yankee Vertical Concrete Cask Tip-Over Analysis

This section evaluates the maximum acceleration of the Transportable Storage Canister and basket during the Vertical Concrete Cask tip-over event on the Maine Yankee site ISFSI pad. This evaluation applies the methodology of Section 11.2.12 for the design basis cask tip-over evaluation.

A finite element model is generated using the LS-DYNA program to determine the acceleration of the vertical concrete cask during the tip-over event.

The concrete pad in the model corresponds to a pad 31-feet by 31-feet square and 3-feet thick, supporting one concrete cask in the center of the pad. The soil under the concrete pad is considered to be 40-feet by 40-feet square and made up of two layers: a 4.5-foot thick upper layer and a 10-foot thick lower layer. Only one-half of the concrete cask, pad and soil configuration is modeled due to symmetry. Both the Class 1 and Class 2 UMS® configurations are evaluated.

The model includes a half section of the concrete cask, the concrete ISFSI pad and soil subgrade, as shown:



Concrete Pad Properties

Vertical concrete cask tip-over analyses are performed for ISFSI pad concrete compressive strengths of 3,000 and 4,000 psi. The Poisson's Ratio (ν_c) is 0.22. The concrete dry density is considered to be between 135 pcf and 145 pcf. To account for the weight of reinforcing bar in the pad, three values of Density (ρ) are used in the model:

ρ (lbs/ft^3)	E_c (psi)	K_c (psi)
140	2.994×10^6	1.782×10^6
145	3.156×10^6	1.879×10^6
152	3.387×10^6	2.016×10^6

The corresponding values of Modulus of Elasticity (E_c) and Bulk Modulus (K_c) are also provided, where:

Modulus of Elasticity (E_c) $= 33\rho_c^{1.5}\sqrt{f_c'}$ (ACI 318-95)

Bulk Modulus (K_c) $= \dfrac{E_c}{3(1-2\nu_c)}$ (Blevins [19])

Soil Properties

The soil properties used in the model are based on three soil sets. The vertical concrete cask tip-over analyses are performed for three different combinations of soil densities: (1) 4.5-foot thick upper layer density of 135 pcf (Modulus of Elasticity, E = 162,070 psi), with a 10-foot thick lower layer density of 127 pcf (E = 31,900 psi); (2) 4.5-foot thick upper layer density of 130 pcf, with a 10-foot thick lower layer density of 127 pcf; and (3) 15-foot depth with density of 145 pcf ($E \leq$ 60,000 psi). The Poisson's Ratio (ν_s) of the soil is 0.45.

Summary of Design Basis ISFSI Pad Parameters

The ISFSI pads and foundation shall include the following characteristics as applicable to the end drop and tip-over analyses:

Concrete thickness	36 inches maximum
Pad subsoil thickness	15 feet minimum
Specified concrete compressive strength	≤ 4,000 psi at 28 days
Soil in place density (ρ)	$\rho \leq 145$ lbs/ft^3 (upper layer)
Concrete dry density (ρ)	$135 \leq \rho \leq 145$ lbs/ft^3
Soil Modulus of Elasticity	≤ 60,000 psi

The concrete pad maximum thickness excludes the ISFSI pad footer. The compressive strength of the concrete is determined in accordance with Section 5.6 of ACI-318 with concrete acceptance in accordance with the same section. Steel reinforcement is used in the pad and footer. The soil modulus of elasticity is determined according to the test method described in ASTM D4719.

Vertical Concrete Cask Properties

The material properties used in the model for the Vertical Concrete Cask are the same as the properties used in the PWR models in Section 11.2.12.3. The tip-over impact is simulated by applying an initial angular velocity of 1.485 rad/sec (PWR Class 1) and 1.483 rad/sec (PWR Class 2), respectively, to the entire cask. The angular velocity values are determined by the method used in Section 11.2.12 based on the weight of the loaded concrete cask with Maine Yankee fuel (285,513 pounds and 297,509 pounds for PWR Class 1 and PWR Class 2, respectively).

A cut-off frequency of 210 Hz (PWR Class 1) and 190 Hz (PWR Class 2) is applied to filter the analysis results from the LS-DYNA models and determine the peak accelerations. The resulting calculated accelerations on the canister at the location of the top support disk and of the top of the structural lid are tabulated for all of the analysis cases that were run. The maximum accelerations at the two key locations on the canister for the PWR Class 1 and Class 2 configurations are:

Component Location	Position Measured from the Bottom of the Concrete Cask (inches)		Acceleration (g)	
	Class 1	Class 2	Class 1	Class 2
Top Support Disk	176.7	185.2	32.3	34.2
Top of the Canister Structural Lid	197.9	207.0	35.3	37.6

The impact accelerations for the vertical concrete cask tip-over on the Maine Yankee ISFSI pad site are observed to be slightly higher than those reported in Section 11.2.12.3.1 for the design-basis ISFSI pad. Therefore, peak accelerations are calculated for the top support disk and are evaluated with respect to the analysis presented in Section 11.2.12.4.1.

To determine the effect of the rapid application of the inertia loading for the support disk, a dynamic load factor (DLF) is computed using the method presented in Section 11.2.12.4. The DLF is computed to be 1.07 and 1.02 for PWR Class 1 and Class 2, respectively. Applying the DLFs to the 32.3g and 35.4g results in peak accelerations of 34.6g and 36.1g for the top support disk PWR Class 1 and Class 2, respectively. The DLFs for the canister lids are considered to be unity since the lids have significant in-plane stiffness and are considered to be rigid. Additional sensitivity evaluations considering varying values of the ISFSI concrete pad density have been performed. The results of those evaluations demonstrate that the maximum acceleration for the canister and basket are below 40g. Therefore, the maximum acceleration for the canister and basket for the cask tipover accident on the Maine Yankee site ISFSI pad is bounded by the 40g used in Section 11.2.12.4.1 (analysis of canister and basket for PWR configurations for tip-over event).

11.2.15.1.2 Parametric Study of Support Disk Evaluation for Maine Yankee Consolidated Fuel

A parametric study is performed to show that the PWR basket loaded with a Maine Yankee consolidated fuel lattice is bounded by the PWR basket design basis loading for a side impact condition. Only one consolidated fuel lattice, in a Maine Yankee Fuel Can, will be loaded in any single Transportable Storage Canister. However, Maine Yankee Fuel Cans holding other intact or damaged fuel can be loaded in the other three corner positions of the basket. (Maine Yankee Fuel

Cans may be loaded only in the four corner positions of the basket. See Figure 11.2.15.1.2-2 for corner positions. Therefore, the bounding case for Maine Yankee is the basket configuration with twenty (20) Maine Yankee fuel assemblies, three (3) fuel cans containing spent fuel, and one (1) fuel can containing consolidated fuel.

A two-dimensional ANSYS model is employed for the parametric study as shown in Figure 11.2.15.1.2-1. The load from a PWR fuel assembly is modeled as a pressure load at the inner surface of each support disk slot opening. The design basis fuel pressure loading (1g) is 12.26 psi. Based on the same design parameters (slot size = 9.272 in., disk thickness = 0.5 inch, and the number of disks = 30), the pressure load corresponding to a Maine Yankee standard CE 14 × 14 fuel assembly is 10.3 psi. The pressure load is 11.3 psi for a Maine Yankee fuel can holding an intact or damaged fuel assembly. For a Maine Yankee fuel can holding consolidated fuel the pressure load is 17.0 psi.

This study considers a 60g side impact condition for four different basket orientations: 0°, 18.22°, 26.28° and 45°, as shown in Figure 11.2.15.1.2-2. The 60g bounds the g-load for the PWR support disks (40g) due to the Vertical Concrete Cask tip-over accident as shown in Section 11.2.12.

A total of five cases are considered in the study. Inertial loads are applied to the support disk in all cases. The base case considers that all 24 fuel positions hold design basis PWR fuel assemblies. The other four cases (Cases 1 through 4) represent four possible load combinations for the placement of four Maine Yankee fuel cans in the corner positions, one of which holds consolidated fuel. The remaining twenty basket positions hold Maine Yankee standard 14 × 14 fuel assemblies. The basket loading positions are shown in Figure 11.2.15.1.2-2. The load combinations evaluated in the four Maine Yankee fuel can loading cases are:

Case	Basket Position 1	Basket Position 2	Basket Position 3	Basket Position 4
1	Consolidated	Damaged	Damaged	Damaged
2	Damaged	Consolidated	Damaged	Damaged
3	Damaged	Damaged	Damaged	Consolidated
4	Damaged	Damaged	Consolidated	Damaged

Table 11.2.15.1.2-1 provides a parametric comparison between the Base Case and the four cases evaluated, based on the maximum sectional stress in the support disk. As shown in the table, the maximum stress in the PWR basket support disk loaded with 20 standard fuel assemblies and four Maine Yankee fuel cans, including one holding consolidated fuel, is bounded by that for the support disk loaded with the design basis PWR fuel.

Additionally, a three-dimensional analysis was performed for Case 4 with a 26.28° drop orientation using the three-dimensional canister/basket model presented in Section 11.2.12.4.1. Results of the analysis for the top support disk, where maximum stress occurs, are presented in Tables 11.2.15.1.2-2 and 11.2.15.1.2-3. The minimum margin of safety is +1.12 and +0.11 for P_m stresses and $P_m + P_b$ stresses, respectively. The minimum margin of safety for the corresponding analysis for the design basis PWR configuration is +0.97 and +0.05 for P_m and $P_m + P_b$ stresses, respectively (see Table 11.2.12.4.1-4). Therefore, it is further demonstrated that the maximum stress in the PWR support disk loaded with Maine Yankee fuel with consolidated fuel is bounded by the stress for the PWR support disk loaded with the design basis PWR fuel.

Since no credit is taken for the structural integrity of the consolidated fuel or damaged fuel inside the fuel can, it is assumed that 100% of the fuel rods fail during an accident. For a Maine Yankee standard 14×14 fuel assembly, the volume of 176 fuel rods (100%) and 5 guide tubes will fill up the lower 103.6 inches (about at the elevation of the 21st support disk) assuming a 50% volume compaction factor. For the consolidated fuel, the volume of 283 rods (100%) and 4 connector rods will fill up the lower 109.6 inches (about at the elevation of the 22nd support disk) assuming a 75% compaction factor. The compaction factor of 75% for the consolidated fuel considers that the number of rods in the consolidated fuel is approximately 1.5 times of the number of rods in the standard Maine Yankee fuel and these rods are initially more closely spaced.

During a tip-over accident of the vertical concrete cask, the maximum total load on the support disk (top/30th disk) for the design basis PWR basket is 54.6 kips (12.26 psi × 9.272-inch × 0.5-inch × 24 × 40g), considering the design deceleration of 40g (Section 11.2.12.4). With the assumption of 100% rod failure for the damaged fuel and consolidated fuel in the Maine Yankee fuel can, the 21st disk is subjected to the maximum total load (including weight from 20 standard fuel assemblies, 3 damaged fuel assemblies and the consolidated fuel). The pressure load (1g) on the support disk corner slot corresponding to 100% failed damaged fuel is 15.3 psi (load distributed to 21 support disks) and the pressure load corresponding to the 100% failed consolidated fuel is 22.6 psi (load distributed on 22 support disks). In the tip-over accident, the g-load at the 21st disk is 30g, based on the design deceleration of 40g at the top (30th) disk. The total load (W_{21}) on the 21st support disk is:

$$W_{21} = (10.3\times20+15.3\times3+22.6\times1) \times 9.272 \times 0.5 \times 30 = 38{,}200 \text{ pounds} = 38.2 \text{ kips}$$

The support disk load is only 70% (38.2/54.6 = 0.7) of the maximum total load on the support disk due to the design basis PWR fuel load. Consequently, the maximum stress in the support disk, assuming 100% rod failure of the damaged and consolidated fuel in Maine Yankee fuel cans, is bounded by the maximum stress in the support disk calculated for the design basis fuel.

Figure 11.2.15.1.2-1 Two-Dimensional Support Disk Model

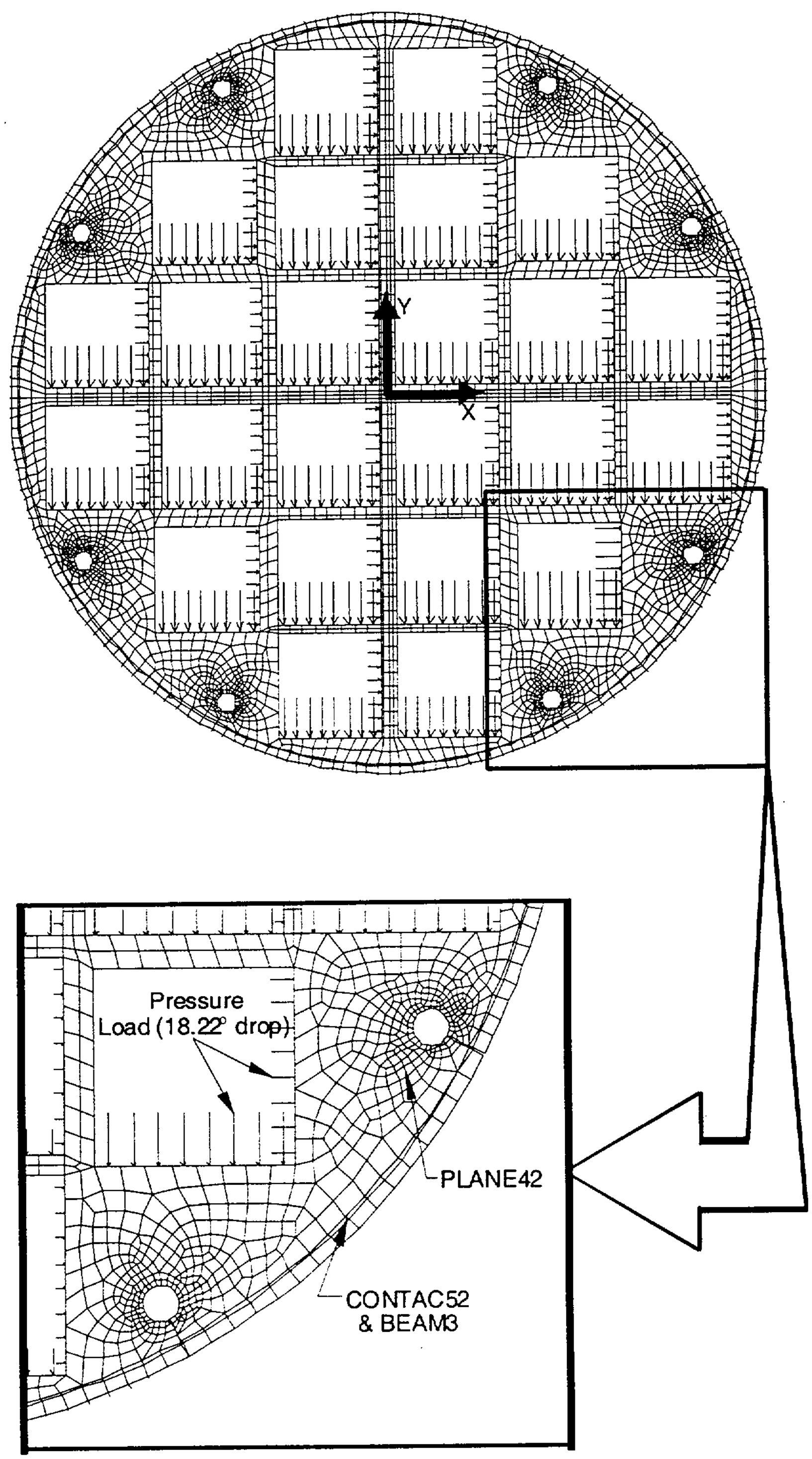


Figure 11.2.15.1.2-2 PWR Basket Impact Orientations and Case Study Loading Positions for Maine Yankee Consolidated Fuel

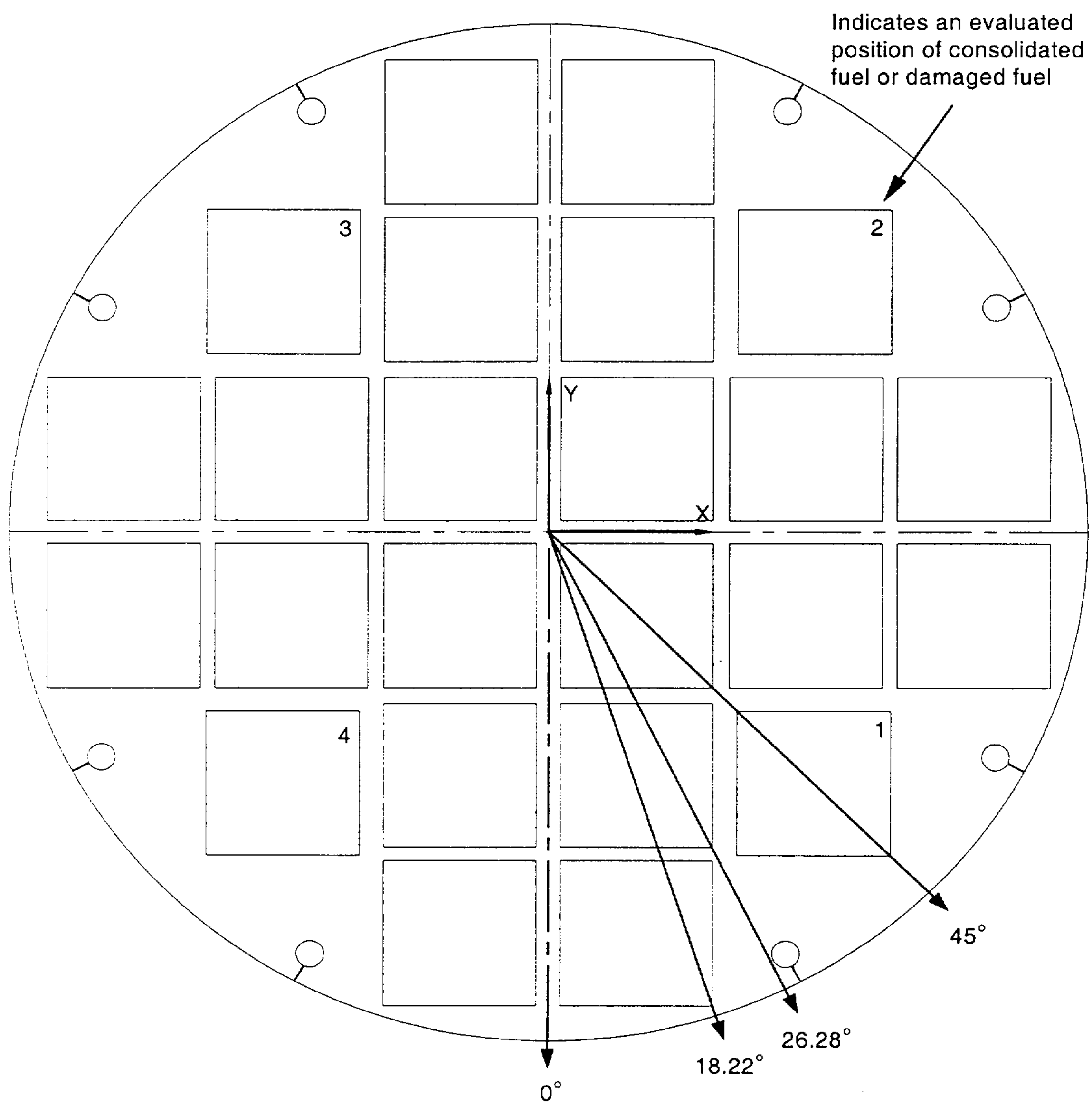


Table 11.2.15.1.2-1 Normalized Stress Ratios – PWR Basket Support Disk Maximum Stresses

Orientation[1]	Membrane Stress Ratio[2]				Membrane + Bending Stress Ratio[2]			
	0°	18.22°	26.28°	45°	0°	18.22°	26.28°	45°
Base Case	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Case 1	0.91	0.94	0.94	0.94	0.96	0.94	0.94	0.94
Case 2	0.91	0.94	0.94	0.95	0.95	0.95	0.95	0.95
Case 3	0.91	0.95	0.95	0.95	0.96	0.95	0.95	0.95
Case 4	0.91	0.95	0.95	0.96	0.96	0.98	0.98	0.97

1. Orientations correspond to those shown in Figure 11.2.15.1.2-2.
2. Stress ratios are based on the maximum sectional stresses of the support disk.

Table 11.2.15.1.2-2 Support Disk Primary Membrane (P_m) Stresses for Case 4, 26.28° Drop Orientation (ksi)

Section Number	Sx	Sy	Sxy	Stress Intensity	Allowable Stress	Margin of Safety
18	19.3	-22.9	2.8	42.6	90.4	1.12
3	27.1	-12.2	2.4	39.6	89.3	1.26
16	37.1	-22.8	1	37.2	89.3	1.4
1	32.3	-12.1	0.6	32.3	90.4	1.8
94	26.8	-19	2.7	27.6	90.5	2.28
17	-0.1	-22.8	1.9	23.1	89.8	2.9
88	18.3	-5.6	-7.3	21.6	91.5	3.23
96	6.7	-13.8	-3.2	21.4	91.5	3.27
95	-0.1	-19.9	1.5	20	91.1	3.55
90	15.3	-3.5	0.8	18.9	90.5	3.8
84	15.6	-18.5	-0.4	18.6	91.5	3.93
61	15.7	-10.5	4.7	18.5	91.5	3.96
60	10.2	-17.5	1.3	17.7	89.3	4.03
82	15.7	-7.8	3.8	17.2	90.8	4.27
37	11.9	-4.3	0.6	16.3	89.3	4.49
58	10.3	-12.1	5	16.3	90.4	4.54
62	15.7	-0.2	2.6	16.3	91.2	4.59
83	15.7	-0.2	1.7	15.8	91.2	4.75
91	-7.4	-15.4	-1.5	15.7	90.5	4.78
63	15.6	-9.9	0.5	15.7	90.8	4.8
30	14.1	-9.3	3.1	15.6	91.9	4.89
33	14.6	-4.7	2.3	15.1	89.3	4.93
108	13.5	-5.6	-3.9	15.1	91.5	5.07
24	-2	-14.3	1.7	14.5	91.5	5.31
79	-5.3	6.3	4.1	14.2	89.3	5.31
23	-0.1	-14.2	0.7	14.2	91.2	5.41
22	-7.3	-14.1	-0.4	14.2	90.8	5.42
28	13.2	-9.1	1.8	13.9	90.9	5.56
7	13.6	-11.9	-0.7	13.8	91.5	5.62
46	-2.4	-10.8	5.1	13.2	89.3	5.74

Note: See Figure 11.2.12.4.1-7 for Section locations.

Table 11.2.15.1.2-3 Support Disk Primary Membrane + Primary Bending ($P_m + P_b$) Stresses for Case 4, 26.28° Drop Orientation (ksi)

Section Number	Sx	Sy	Sxy	Stress Intensity	Allowable Stress	Margin of Safety
61	-116.4	-39.3	10.1	117.7	130.8	0.11
58	-109.5	-43.9	8.7	110.6	129.1	0.17
43	-92.6	-32.4	6.2	93.2	129.1	0.39
82	-87.8	-27.9	7	88.6	129.8	0.46
60	-81.6	-39.9	7.7	83	127.6	0.54
79	-82	-18.9	2	82	127.6	0.56
55	-83.5	-29.3	4.6	83.9	130.8	0.56
16	-52.5	-71.9	15	80.1	127.6	0.59
46	-77.1	-49.3	9.5	80	127.6	0.59
64	-76.2	-31.8	7	77.2	127.6	0.65
30	-34.4	-75.2	13.1	79.1	131.3	0.66
18	-2.8	-77.6	-2.9	77.8	129.1	0.66
3	10.1	-65.4	-6	76.5	127.6	0.67
63	-75.4	-26	4.3	75.8	129.8	0.71
76	69	21	4.7	69.5	129.8	0.87
48	-66	-42.7	4	66.7	125.7	0.89
19	-38.2	-65.3	2.6	65.5	125.7	0.92
6	-43.2	-62	5.4	63.4	125.7	0.98
45	-63.2	-15.3	-0.2	63.2	127.6	1.02
94	-56.3	-40.8	10.4	61.5	129.3	1.1
21	-47.1	-57.5	5.3	59.7	127.6	1.14
67	-54.5	-42.3	5.3	56.5	125.7	1.22
1	-47.7	-40.7	12.7	57.3	129.1	1.25
33	-29.7	-52.9	7.4	55	127.6	1.32
51	26.7	-27.3	3.9	54.5	127.7	1.34
39	-29	-49.8	6.3	51.6	129.1	1.5
81	-49.9	-29.5	5.3	51.2	129.1	1.52
84	-48	-26.1	6.2	49.7	130.8	1.63
4	-41.7	-43.6	5.3	48	127.6	1.66
28	-44.6	-29.6	8.3	48.2	129.9	1.69

Note: See Figure 11.2.12.4.1-7 for Section locations.

11.2.15.1.3 Structural Evaluation for the Maine Yankee Fuel Can

Twenty-Four Inch Drop of the Vertical Concrete Cask

The 24-inch drop of the Vertical Concrete Cask onto an unyielding surface (Section 11.2.4) results in accelerations that are bounded by the 60g acceleration used in this structural evaluation for the Maine Yankee fuel can. The compressive load (P) on the tube is the combined weight of the lid, side plates and tube body.

The compressive load (P) is:

$$P = (17.89 + 6.57 + 78.77) \times 60 = 6{,}193.8 \text{ lbs, use } 8{,}500 \text{ lbs.}$$

The compressive stress (S_c) in the tube body is:

$$S_c = \frac{P}{A} = \frac{8{,}500}{1.714} = 4{,}959 \text{ psi}$$

The margin of safety (MS) is determined based on the accident condition allowable primary membrane stress (0.7 S_u) at a bounding temperature of 600°F for Type 304 stainless steel:

$$MS = \frac{0.7S_u}{S_c} - 1 = \frac{0.7(63{,}300)}{4{,}959} - 1 = +7.9$$

The potential buckling of the tube is evaluated, using the Euler formula, to determine the critical buckling load (P_{cr}):

$$P_{cr} = \frac{\pi^2 EI}{L_e^2} = \frac{\pi^2 (25.2 \times 10^6)(20.98)}{2(157.8)} = 16.5 \times 10^6 \text{ lbs}$$

where:

$E = 25.2 \times 10^6$ psi

$$I = \frac{8.62^4 - 8.52^4}{12} = 20.98 \text{ in.}^4$$

L_e = 2L (worst case condition)

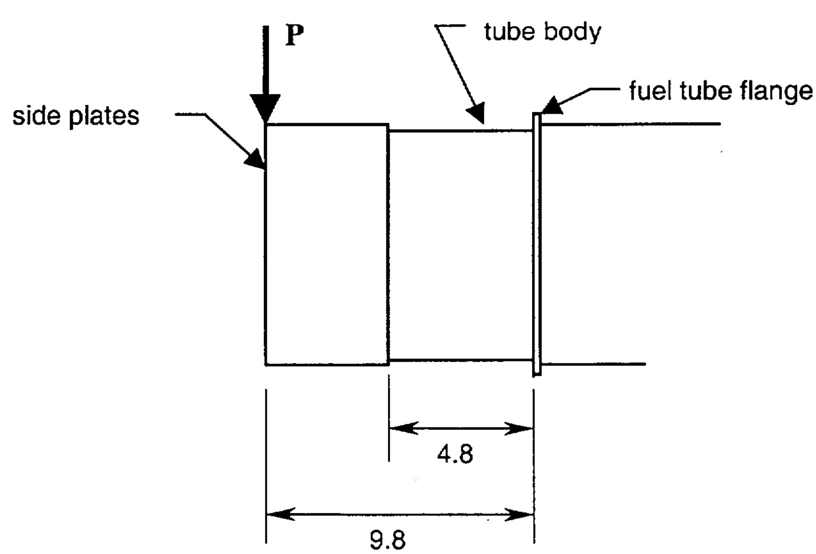
L = tube body length (157.8 in.)

Because the maximum compressive load (8,500 lbs under the accident condition) is much less than the critical buckling load (16.5×10^6 psi) the tube has adequate resistance to buckling.

Tip–Over of the Vertical Concrete Cask

The majority of the fuel can tube body is contained within the fuel tube in the basket assembly. Because both the tube body of the fuel can and the fuel tube have square cross sections, they are effectively in full contact (for 153.0 in. longitudinally) during a side impact and no significant bending stress is introduced into the tube body. The last 4.8 inches of the tube body and the 5.0 inches length of the side plates are unsupported past the fuel tube flange in the side impact orientation.

The tube body is evaluated as a cantilevered beam with the combined weight (P) of the overhanging tube body and side plates and conservatively, concentrated at the top end of the side plates multiplied by a deceleration factor of 60g. Note that the maximum g-load for the PWR basket is 40g for the tip-over accident (Section 11.2.12).



The maximum bending moment (M) is:

$$M = Pg \times L = 25(60)(9.8) = 14{,}700 \text{ lbs}\cdot\text{in.}$$

where:

P = 25 lbs (weight of the overhung tube and side plates)

g = 60 (conservative g-load that bounds the tip over condition)

L = 9.8 in. (the total overhung length of the tube body and side plates)

The maximum bending stress, f_b, is:

$$f_b = \frac{Mc}{I} = \frac{14{,}700(4.31)}{20.98} = 3{,}020 \text{ psi}$$

where:

c = half of the outer dimension of the tube

I = the moment of inertia

The shear stress (τ) is:

$$\tau = \frac{Pg}{A} = \frac{25(60)}{1.714} = 875 \text{ psi}$$

where:

A = the cross-sectional area of the tube = 1.714 in^2

The principal stresses are calculated to be 3,255 psi and -470 psi, and the corresponding stress intensity is determined to be 3,725 psi.

The margin of safety (MS) is calculated based on the allowable primary membrane plus bending stress (1.0 S_u) at a bounding temperature of 600°F for Type 304 stainless steel:

$$MS = \frac{1.0S_u}{\sigma_{max}} - 1 = \frac{63,300 \text{ psi}}{3,725 \text{ psi}} - 1 = +16$$

As discussed in Section 11.2.15.1.2, the Maine Yankee fuel can may hold a 100% failed damaged fuel lattice or consolidated fuel lattice. An evaluation is performed to demonstrate that the fuel can maintains its integrity during a tip-over accident for this condition. The fuel can is evaluated using the methodology presented in Section 11.2.12.4.1 for the PWR Fuel Tube Analysis for a 60-g side impact condition. This g-load bounds the maximum g-load (40g) for the PWR basket in the concrete cask tip-over event. Similar to the finite element model used for the PWR fuel tube analysis for the uniform pressure case (see Section 11.2.12.4.1), an ANSYS finite element model is generated to represent a section of the damage fuel can with a length of three spans, i.e., the model is supported at four locations by the support disks. The fuel tube, the neutron absorber plate, and its stainless steel cover plate are conservatively ignored in the model. A bounding uniform pressure is applied to the lower inside surface of the fuel can wall. The pressure is determined based on the weight of the 100% failed consolidated fuel (2,100 lbs × 60g) occupying a length of 109.6 inches (see Section 11.2.15.1.2) as shown below. The inside dimension of the fuel can is 8.52-inches.

$$P = \frac{2,100}{109.6(8.52)} \times 60 = 135 \text{ psi}$$

The finite element analysis results show that the maximum stress in the fuel can is 25.4 ksi, which is local to the sections of the tube resting on the support disks. At 750°F the ultimate strength for Type 304 stainless steel is 63.1 ksi. The Margin of Safety is:

$$MS = \frac{63.1}{25.4} - 1 = +1.48$$

The analysis shows that the maximum total strain is 0.05 inch/inch. Defining the acceptable elastic-plastic response of the stainless steel as one half of the material failure strain of 0.40 in./in. at 750°F, the resulting Margin of Safety is:

$$MS = \frac{0.40/2}{0.05} - 1 = +3.0$$

Similarly, the Margin of Safety for elastic-plastic stress is:

$$MS = \frac{63.1 - 17.3}{25.4 - 17.3} - 1 = +4.65$$

where the yield strength of Type 304 stainless steel is 17.3 ksi at 750°F.

Therefore the Maine Yankee fuel can maintains its integrity for the accident conditions.

11.2.15.1.4 Maine Yankee Site Specific Earthquake Evaluation of the Vertical Concrete Cask

This section provides an evaluation of the response of the vertical concrete cask to an earthquake imparting a horizontal acceleration of 0.38g at the top surface of the concrete pad. The evaluation shows that the loaded or empty vertical concrete cask does not tip over or slide in the earthquake event. The methodology used in this evaluation is identical to that presented in Section 11.2.8.

Tip-Over Evaluation of the Vertical Concrete Cask

To maintain the concrete cask in equilibrium, the restoring moment, M_R must be greater than, or equal to, the overturning moment, M_o (i.e. $M_R \geq M_o$). Based on this premise, the following derivation shows that a 0.38g acceleration of the design basis earthquake at the surface of the concrete pad is well below the acceleration required to tip-over the cask.

The combination of horizontal and vertical acceleration components is based on the 100-40-40 approach of ASCE 4-86 [36], which considers that when the maximum response from one component occurs, the response from the other two components are 40% of the maximum. The vertical component of acceleration is obtained by scaling the corresponding ordinates of the horizontal components by two-thirds.

Using this method, two cases are evaluated where:

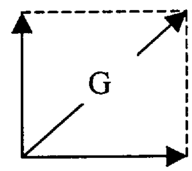
$a_x = a_z = a$ = horizontal acceleration components
$a_y = (2/3)\ a$ = vertical acceleration component
G_h = Vector sum of two horizontal acceleration components
G_v = Vertical acceleration component

In the first case, the horizontal acceleration is at its maximum. In the second, one horizontal acceleration is at its maximum.

Case 1) The vertical acceleration, a_y, is at its peak: ($a_y = 2/3a$, $a_x = 0.4a$, $a_z = 0.4a$)

$$G_h = \sqrt{a_x^2 + a_z^2}$$

$$G_h = \sqrt{(0.4 \times a)^2 + (0.4 \times a)^2} = 0.566 \times a$$

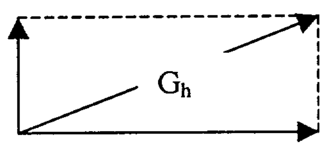


$$G_v = 1.0 \times a_y = 1.0 \times \left(a \times \frac{2}{3}\right) = 0.667 \times a$$

Case 2) One horizonal acceleration, a_x, is at its peak: ($a_y = 0.4 \times 2/3a$, $a_x = a$, $a_z = 0.4a$)

$$G_h = \sqrt{a_x^2 + a_z^2}$$

$$G_h = \sqrt{(1.0 \times a)^2 + (0.4 \times a)^2} = 1.077 \times a$$



$$G_v = 0.4 \times a_y = 0.4 \times \left(a \times \frac{2}{3}\right) = 0.267 \times a$$

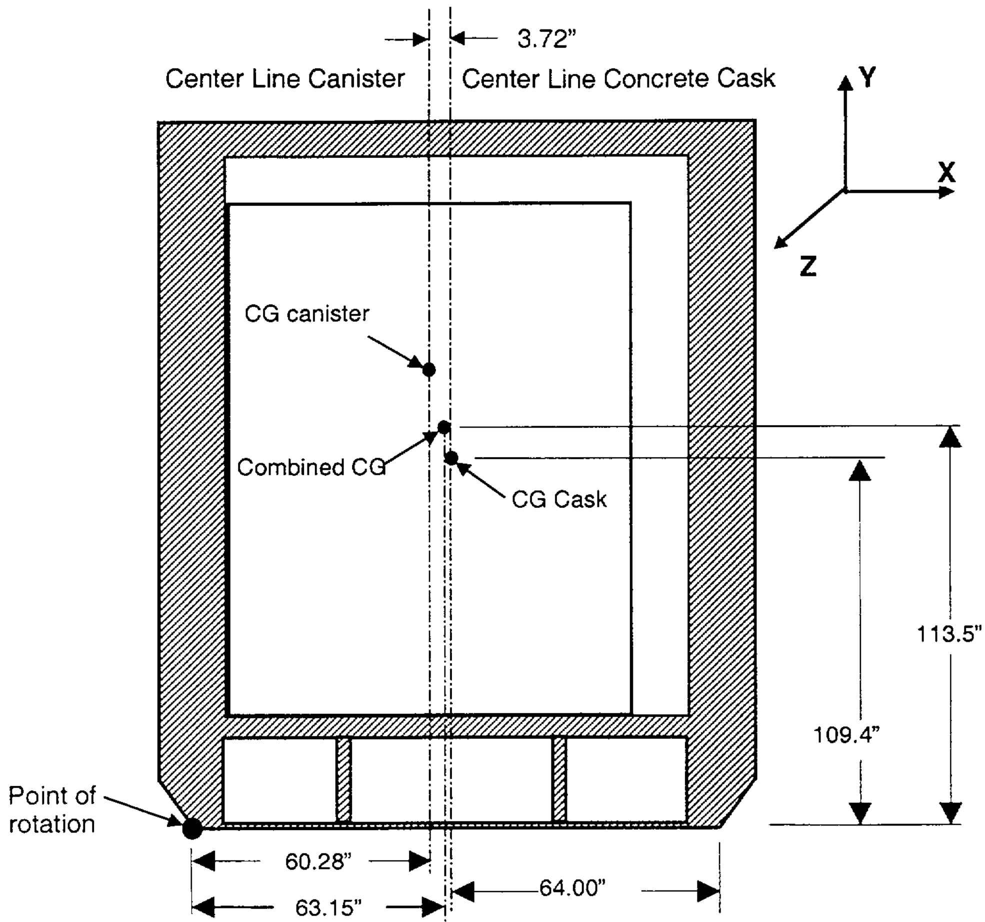
In order for the cask to resist overturning, the restoring moment, M_R, about the point of rotation, must be greater than the overturning moment, M_o, that:

$$M_R \geq M_o \text{, or}$$

$$F_r \times b \geq F_o \times d \Rightarrow (W \times 1 - W \times G_v) \times b \geq (W \times G_h) \times d$$

where:

- d = vertical distance measured from the base of the Vertical Concrete Cask to the center of gravity
- b = horizontal distance measured from the point of rotation to the C.G.
- W = the weight of the Vertical Concrete Cask
- F_o = overturning force
- F_r = restoring force



Substituting for G_h and G_v gives:

Case 1

$$(1 - 0.667a)\ \frac{b}{d} \geq 0.566 \times a$$

$$a \leq \frac{b/d}{0.566 + 0.667\ (b/d)}$$

Case 2

$$(1 - 0.267a)\frac{b}{d} \geq 1.077a$$

$$a \leq \frac{b/d}{1.077 + 0.267(b/d)}$$

Because the canister is not attached to the concrete cask, the combined center of gravity for the concrete cask, with the canister in its maximum off-center position, must be calculated. The point of rotation is established at the outside lower edge of the concrete cask.

The inside diameter of the concrete cask is 74.5 inches and the outside diameter of the canister is 67.06 inches; therefore, the maximum eccentricity between the two is:

$$e \quad = \quad \frac{74.50\,\text{in} - 67.06\,\text{in}}{2} = 3.72 \text{ in.}$$

The horizontal displacement, x, of the combined C.G. due to eccentric placement of the canister is

$$x = \frac{70{,}783(3.72)}{308{,}432} = 0.85 \text{ in}$$

Therefore,

$$b \quad = \quad 64 - 0.85 = 63.15 \text{ in.}$$

and

$$d \quad = \quad 113.5 \text{ in.}$$

The C.G. of the loaded Maine Yankee Vertical Concrete Cask is conservatively assumed to be 113.5 inches, which bounds all of the Maine Yankee UMS® Storage System configurations.

1) $$a \le \frac{63.15/113.5}{0.566 + 0.667 \times \left(63.15/113.5\right)}$$

$$a \le 0.59\text{g}$$

2) $$a \le \frac{63.15/113.5}{1.077 + 0.267 \times \left(63.15/113.5\right)}$$

$$a \le 0.45\text{g}$$

Therefore, the minimum ground acceleration that may cause a tip-over of a loaded concrete cask is 0.45g. Since the 0.38g design basis earthquake ground acceleration for the UMS® System at the Maine Yankee site is less than 0.45g, the storage cask will not tip-over.

The factor of safety is 0.45 / 0.38 = 1.18, which is greater than the required factor of safety of 1.1 in accordance with ANSI/ANS-57.9.

Since an empty vertical concrete cask has a lower C.G. as compared to a loaded concrete cask, the tip-over evaluation for the empty concrete cask is bounded by that for the loaded concrete cask.

Sliding Evaluation of the Vertical Concrete Cask

To keep the cask from sliding on the concrete pad, the force holding the cask (F_s) has to be greater than or equal to the force trying to move the cask.

Based on the equation for static friction:

$$F_s = \mu N \geq G_h W$$

$$\mu (1 - G_v) W \geq G_h W$$

Where:

μ = coefficient of friction
N = the normal force
W = the weight of the concrete cask
G_v = vertical acceleration component
G_h = resultant of horizontal acceleration component

Substituting G_h and G_v for the two cases:

Case 1) $\mu(1 - 0.667a) \geq 0.566\,a$

$$\mu \geq \frac{0.566a}{1 - 0.667a}$$

Case 2) $\mu(1 - 0.267a) \geq 1.077\,a$

$$\mu \geq \frac{1.077a}{1 - 0.267a}$$

For a = 0.38g

Case 1) $\mu \geq 0.29$

Case 2) $\mu \geq 0.45$

The analysis shows that the minimum coefficient of friction, μ, required to prevent sliding of the concrete cask is 0.45. The coefficient of friction between the steel bottom plate of the concrete cask and the concrete surface (broom finish) of the storage pad, 0.50, is greater than the coefficient of friction required to prevent sliding of the concrete cask [45,46]. Therefore, the concrete cask will not slide under design-basis earthquake conditions. The factor of safety is 0.50 / 0.45 =1.11 which is greater than the required factor of safety of 1.1 in accordance with ANSI/ANS-57.9 [1].

11.2.15.1.5 Buckling Evaluation for Maine Yankee High Burnup Fuel Rods

This section presents the buckling evaluation for Maine Yankee high burnup fuel (burnup between 45,000 and 50,000 MWD/MTU) having cladding oxide layers that are 80 and 120 microns thick. A similar evaluation is presented in Section 11.2.15.1.6 for Maine Yankee high burnup fuel with an oxide layer thickness of 80 microns that is also mechanically damaged. These analyses show that the high burnup fuel and the damaged high burnup fuel do not buckle in the design basis accident events. An end drop orientation is considered with an acceleration of 60 g, which subjects the fuel rod to axial loading. A reduced clad thickness is assumed, due to the cladding oxide layer.

In the end drop orientation, the fuel rods are laterally restrained by the grids and may come into contact with the fuel assembly base. The only vertical constraint for the fuel rod is the base of the assembly. The weight of the fuel pellets is included in this evaluation, as the pellets are considered to be vertically supported by the cladding. A two-dimensional model comprised of ANSYS BEAM3 elements, shown in Figure 11.2.15.1.5-1, is used for the evaluation. This evaluation is considered to be the bounding condition (as opposed to an evaluation, which considers the cladding only).

80 Micron Oxide Layer Thickness Evaluation

During the end drop, the fuel rod impacts the fuel assembly base. The fuel rod itself will respond as an elastic bar under a sudden compression load at its bottom end. The duration of this impact is bounded by the first extentional mode shape of the fuel rod. Contribution of higher frequency extentional modes of the rod would tend to shorten the duration of impact of the fuel rod with the fuel assembly base. The fuel rod, upon initiation of impact, corresponds to an undeformed state. In the process of the impact, the compression of the fuel rod will increase to a maximum and then return to a near uncompressed state, at which point the time of impact has been completed. This actually represents half of a cycle of the lowest frequency mode shape of the fuel rod. The shape of the time dependence of the deformation is sinusoidal. The single extentional mode shape can also be considered to be a single degree of freedom with a corresponding mass and stiffness. In viewing such an event as a spring mass system, the time variation of the deformation during the impact is expected to be sinusoidal.

The buckling mode for the fuel rod is governed by the boundary conditions. For this configuration, the grids provide a lateral support, but no vertical support. The only vertical restraint is considered to be at the point of contact of the fuel rod and the base of the assembly. The weight of the fuel rod pellets and cladding is assumed to be uniformly distributed along the length of the fuel rod. In the end drop, this results in the maximum compressive load occurring at the base of the fuel rod. The first buckling mode shape corresponding to these conditions is computed as shown in Figure 11.2.15.1.5-2.

Typically eigenvalue buckling is applied for static environments. For dynamic loading, it is assumed that the duration of the loading is sufficiently long to allow the system to experience the complete load, even as the deformation associated with the buckling is commenced. For dynamic loading, the lateral motion, which would correspond to the buckled shape, will correspond to the lowest mode shape. This lowest frequency mode shape is shown in Figure 11.2.15.1.5-2 and corresponds to a frequency of 25.9 Hz. The similarity of the two shapes shown in Figure 11.2.15.1.5-2 is expected, since both have the same displacement boundary conditions, the same stiffness matrix, and the same governing finite element equations, i.e.,

$$[K]\{\phi_i\} = \lambda_i \, [A]\{\phi_i\}$$

where:

- $[K]$ = structure stiffness matrix
- $\{\phi_i\}$ = eigenvector
- λ_i = eigenvalue
- $[A]$ = mass matrix for the mode shape calculation or stress stiffening matrix for the buckling evaluation

Based on the time duration of the impact and the inherent inability of the fuel rod to rapidly displace in the lateral direction, the effect of the actual lateral motion of buckling can be computed with a dynamic load factor (DLF) [47]. The expression for the DLF for a half-sine loading for a single degree of freedom is given by

$$DLF = \frac{2\beta \cos(\pi/2\beta)}{1 - \beta^2}$$

where:

β = ratio of the first extentional mode frequency to the first lateral mode frequency

These values, computed in this section, are $\beta = 8.32$ and DLF = 0.244.

This DLF is applied to the end drop acceleration of 60g, which is the bounding load to potentially result in the buckling of the fuel rod. The product of 60g × DLF (= 14.6g) is well below the vertical acceleration corresponding to the first buckling mode shape, 37.9g as computed in this section. This indicates that the time duration of the impact of the fuel onto the fuel assembly base is of sufficiently short nature that buckling of the fuel rod cannot occur.

An effective cross-sectional property is used in the model to consider the properties of the fuel pellet and the fuel cladding. The modulus of elasticity (EX) for the fuel pellet has a nominal value of 26.0×10^6 psi [48]. To be conservative, only 50 percent of this value is used in the evaluation. The EX for the fuel pellet was, therefore, taken to be 13.0×10^6 psi. The value of EX (10.47×10^6 psi) was used for the irradiated Zircaloy cladding (ISG-12). Reference information shows that there is no additional reduction of the ductility of the cladding due to extended burnup into the 45,000 – 50,000 MWD/MTU range [49].

The bounding dimensions and physical data (minimum clad thickness, maximum rod length and minimum number of support grids) for the Maine Yankee fuel rod used in the model are:

Outer diameter of cladding (inches)	0.434
Cladding thickness (inches)	0.023
Cladding density (lb/in^3)	0.237
Fuel pellet density (lb/in^3)	0.396

The cladding is reduced from its nominal value of 0.026 inches by the assumed 80 micron oxidation layer (0.003 inches) to 0.023 inches. Similarly, the fuel rod outer diameter is reduced from the nominal value of 0.44 inches to 0.434 inches.

The elevation of the grids, measured from the bottom of the fuel assembly are: 2.3, 33.0, 51.85, 70.7, 89.6, 108.4, 127.3 and 144.9 (inches).

The effective cross-sectional properties (EI_{eff}) for the beam are computed by adding the value of EI for the cladding and the pellet, where:

E = modulus of elasticity (lb/in^2)
I = cross-sectional moment of inertia (in^4)

The lowest frequency for the extentional mode shape was computed to be 219.0 Hz. The first mode shape corresponds to a frequency of 25.9 Hz. Using the expression for the DLF previously discussed, the DLF is computed to be 0.240 ($\beta = 8.44$).

120 Micron Oxide Layer Thickness Evaluation

The buckling calculation used the same model employed for the mode shape calculation. The load that would potentially buckle the fuel rod in the end drop is due to the deceleration of the rod. This loading was implemented by applying a 1g acceleration in the direction that would result in compressive loading of the fuel rod. The acceleration required to buckle the fuel rod is computed to be 37.3g.

Using the same fuel rod model, the acceleration required to buckle the fuel rods is found to be 37.3g, which is much higher than the calculated effective g-load (14.3g) due to the 60g end drop. Therefore, the fuel rods with a 120 micron cladding oxide layer do not buckle in the 60g end drop event.

Figure 11.2.15.1.5-1 Two-Dimensional Beam Finite Element Model for Maine Yankee Fuel Rod

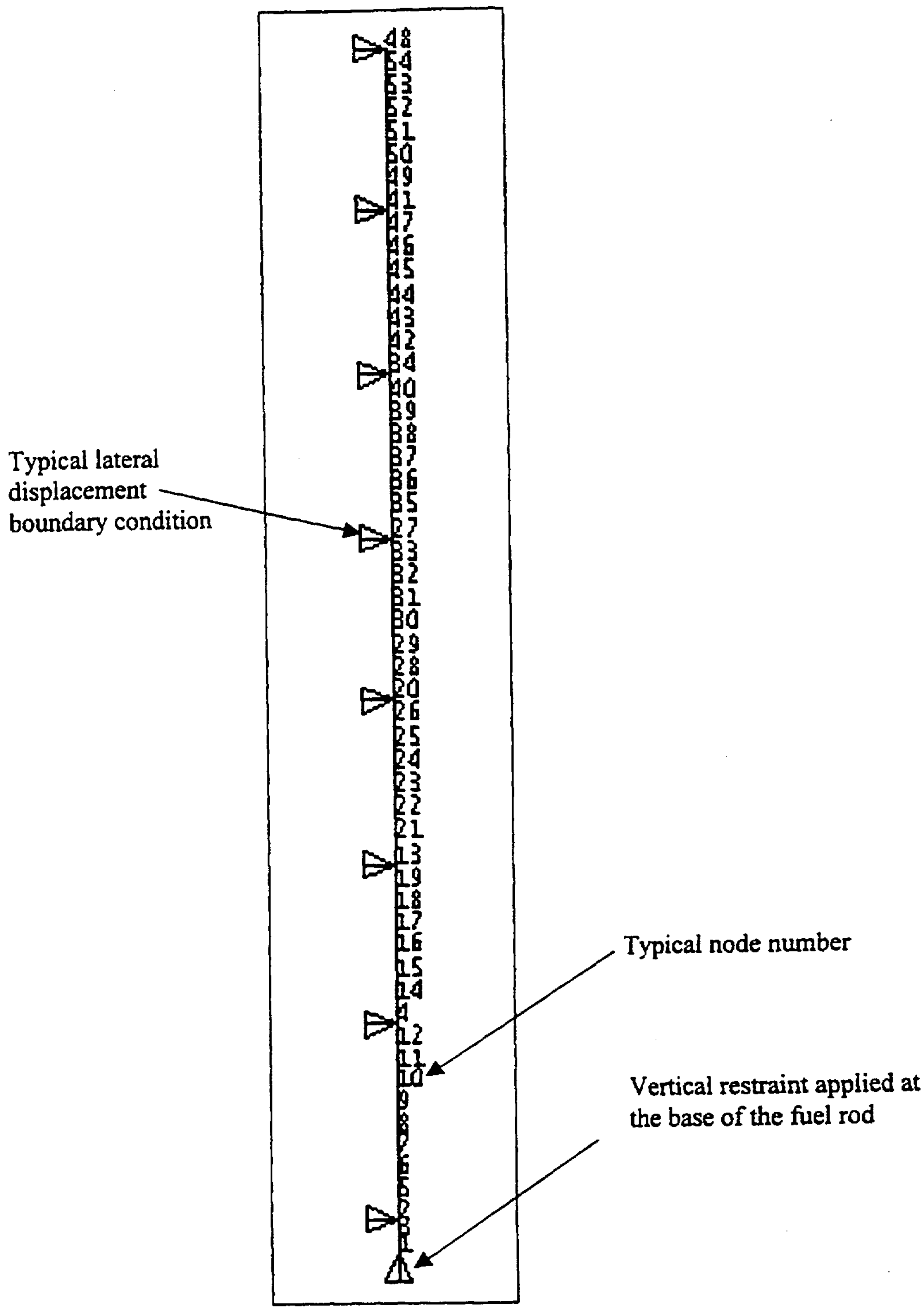
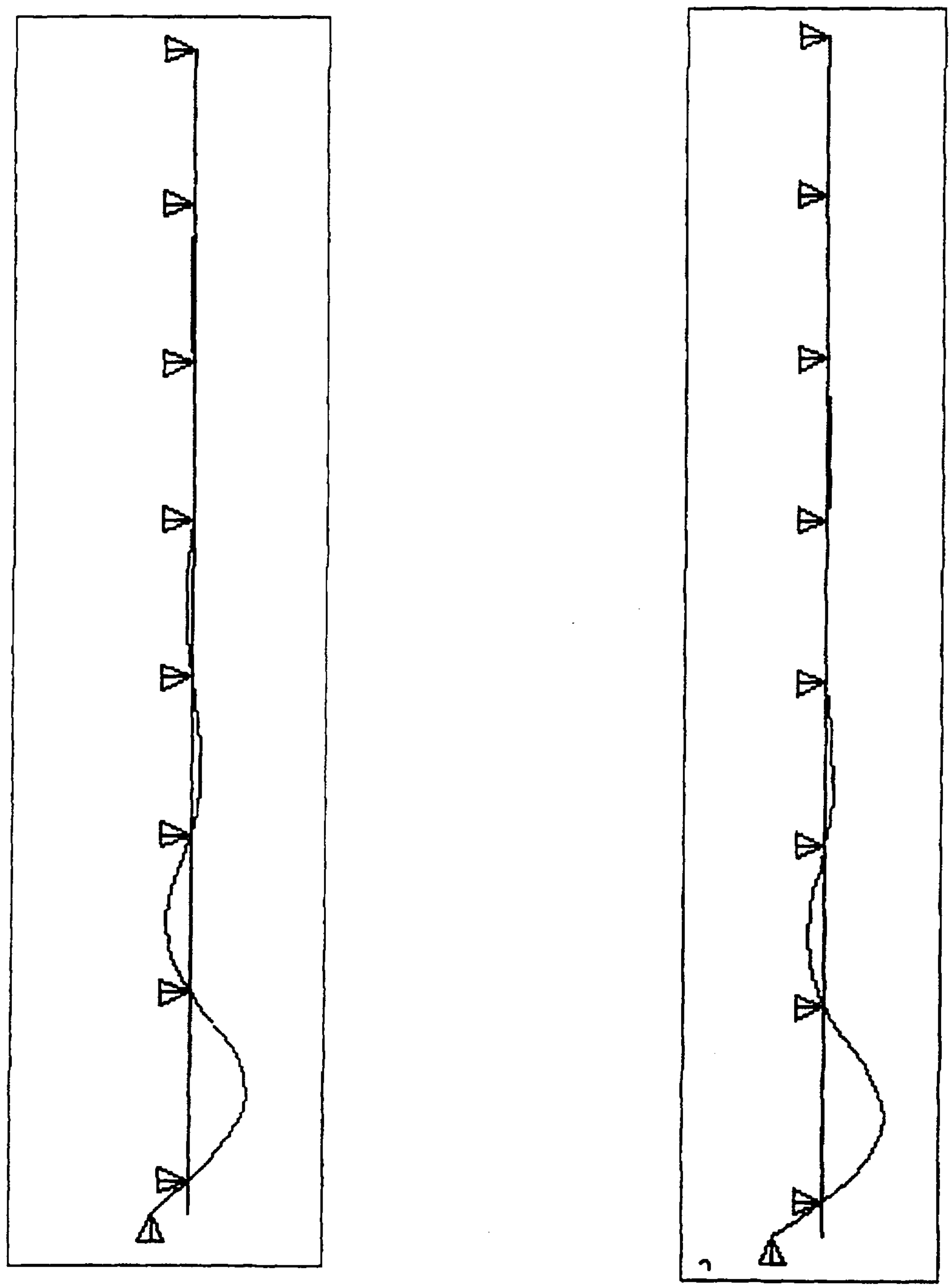


Figure 11.2.15.1.5-2 Mode Shape and First Buckling Shape for the Maine Yankee Fuel Rod

First Lateral Dynamic
Mode Shape at 25.9 Hz

First Buckling
Shape at 37.9g



11.2.15.1.6 Buckling Evaluation for High Burnup Fuel with Mechanical Damage

This section presents the buckling evaluation for high burnup fuel having an 80 micron cladding oxide layer thickness and with mechanical damage consisting of one or more missing support grids up to an unsupported fuel rod length of 60 inches.

End Drop Evaluation

The buckling load is maximized at the bottom of the fuel assembly. The bounding evaluation is the removal of the grid strap that maximizes the spacing at the lowest vertical elevation. The elevations of the grids in the model, measured from the bottom of the fuel assembly are: 2.3, 51.85, 70.7, 89.6, 108.4, 127.3 and 144.9 inches (Figure 11.2.15.1.6-1). The grid at the 33.0-inch elevation is removed, resulting in a grid spacing of approximately 50.0 inches. The grid located at 51.85 inches is conservatively assumed to be located at 62.3 inches, resulting in an unsupported rod length of 60.0 inches.

The case of the missing grid is evaluated using the methodology presented in Section 11.2.15.1.5 for the fuel assembly with the grids being present. The dimensions and physical data for the Maine Yankee fuel rod used in the model are:

Outer diameter of cladding (inches)	0.434
Cladding thickness (inches)	0.023
Cladding density (lb/in^3)	0.237
Fuel pellet density (lb/in^3)	0.396
Fuel pellet Modulus of Elasticity (psi)	13.0×10^6
Zircaloy cladding Modulus of Elasticity (psi)	10.47×10^6

The cladding is reduced from its nominal value of 0.026 inches by the assumed 80 micron oxidation layer thickness (0.003 inches) to 0.023 inches. Similarly, the fuel rod outer diameter is reduced from the nominal value of 0.44 inches to 0.434 inches. The fuel pellet modulus of elasticity is conservatively reduced 50%. The modulus of elasticity of the Zircaloy cladding is taken from ISG-12 [50].

With the grid missing, the frequency of the fundamental lateral mode shape is 7.8 Hz. The natural frequency of the fundamental extensional mode was determined to be 218.9 Hz. The DLF is computed to be 0.072, resulting in an effective acceleration of $0.072 \times 60 = 4.3$ g. Using the same method to compute the acceleration at which buckling occurs, the lowest buckling acceleration is 14.4 g, which is significantly greater than 4.3 g. Therefore, the fuel rod does not buckle during an end drop. Figures 11.2.16-1 and 11.2.16-2 show the finite element model and buckling results and mode shape.

Side Drop Evaluation

The Maine Yankee fuel rod is evaluated for a 60 g side drop with a missing support grid in the fuel assembly. Using the same assumptions as for the end drop evaluation, the span between support grids is assumed to be 60.0 inches.

For this analysis, the dimensions and physical data used are:

Fuel rod OD	0.434 in. (80 micron oxidation layer)
Clad ID	0.388 in.
E_{clad}	10.47E6 psi
E_{fuel}	13.0E6 psi
Clad density	0.237 lb/in^3
Fuel density	0.396 lb/in^3
A_{clad}	0.030 in^2 (cross-sectional area)
A_{fuel}	0.118 in^2 (cross-sectional area)

The mass of the fuel rod per unit length is:

$$m = \frac{0.396(0.122) + 0.237(0.030)}{386.4} = 0.000143 \text{ lb-s}^2/\text{in}^2$$

For the fuel rod, the product of the Modulus of Elasticity (E) and Moment of Inertia (I), is:

$$EI_{clad} = 10.47E6 \frac{\pi(0.217^4 - 0.194^4)}{4} = 6{,}586 \text{ lb-in}^2$$

$$EI_{fuel} = 13.0E6 \frac{\pi(0.194^4)}{4} = 14{,}462 \text{ lb-in}^2$$

$$EI = 6{,}586 + 14{,}462 = 21{,}048 \text{ lb-in}^2$$

During a side drop, the maximum deflection of a fuel rod is based on the fuel rod spacing of the fuel assembly. The pitch (center-to-center spacing) of fuel rods is 0.58 inches [51]. The maximum pitch is across the diagonal of the fuel assembly. The maximum pitch is:

$$dp = \frac{0.58}{\sin 45} = 0.82\,\text{in.}$$

The maximum deflection of a fuel rod is at the top of the fuel assembly and the minimum deflection is at the bottom of the fuel assembly.

Assuming a 17 × 17 array (which envelops the Maine Yankee 14 × 14 array), the maximum fuel rod deflection is:

$$(17\text{-}1) \times (0.82\text{-}0.43) = 6.18\ \text{in.}$$

The deflection of a simply supported beam with a distributed load is given by the equation:

$$\Delta = \frac{5\omega l^4}{384EI} = \frac{5(g\omega)l^4}{384\,(EI_{total})} \qquad [52]$$

$$g = \frac{384\Delta(EI_{total})}{5\omega l^4}$$

The cladding bending stress is given by the equation:

$$S = \frac{Mc}{I} = \frac{\left(\left(g\omega l^2\right)/8\right)c}{I_{clad}}\left(\frac{EI_{clad}}{EI_{total}}\right)$$

Inserting the equation for ‘g’:

$$S = \frac{384\Delta cE_{clad}}{40 \times L^2}$$

where:

$c = 0.217$ inch distance from center of fuel rod to extreme outer fiber

$L = 60$ inches (the unsupported fuel rod length)

$\Delta = 6.18$ inches (the maximum deflection)

The bending stress in the fuel rod is:

$$S = \frac{384 \times 6.18 \times 0.217 \times 10.47E6}{40(60)^2} = 37.4 \text{ ksi}$$

The maximum hoop stress due to the fuel rod internal pressure is determined to be 19.1 ksi (131.4 MPa per Tables 4.4.7-3 and 4.5.1.2-1). Therefore, the maximum axial stress is 9.6 ksi (one half of the hoop stress [53]).

The bearing stress between two fuel rods under a 60 g load is:

$$S_{brg} = 0.591\sqrt{\frac{\omega E}{K_D}} = 0.591\sqrt{\frac{(0.000143 \times 386.4) \times 60 \times 10.47E6}{0.22}} = 7.4 \text{ ksi} \quad [53]$$

where:

$$K_D = \frac{D_1 D_2}{D_1 + D_2} = \frac{0.434 \times 0.434}{0.434 + 0.434} = 0.22$$

The total stress is:

$$S = 37.4 + 9.6 + 7.4 = 54.4 \text{ ksi}$$

The ultimate strength allowable for irradiated Zircaloy–4 is 83.4 ksi (Figure 3-2 [54]). Therefore, the margin of safety for ultimate strength is:

$$MS = \frac{83.4}{54.4} - 1 = 0.53$$

The yield strength allowable for irradiated Zircaloy–4 is 78.3 ksi (Figure 3-2 [54]). Therefore, the margin of safety for yield strength is:

$$MS = \frac{78.3}{54.4} - 1 = 0.44$$

The maximum bearing stress occurs between the bottom fuel rod and the fuel tube. The bearing stress is:

$$S_{brg} = 0.591\sqrt{\frac{17 \times 0.000143 \times 386.4 \times 60 \times 10.47E6}{0.44}} = 21.6 \text{ ksi}$$

The bending stress is negligible because the maximum deflection is equal to the spacing of the fuel rods established by the grid. Therefore, the top fuel rod is bounding.

Consequently, the fuel rods are demonstrated to be structurally adequate for the 60g side drop loading condition.

Figure 11.2.15.1.6-1 Two-Dimensional Beam Finite Element Model for a Fuel Rod with a Missing Grid

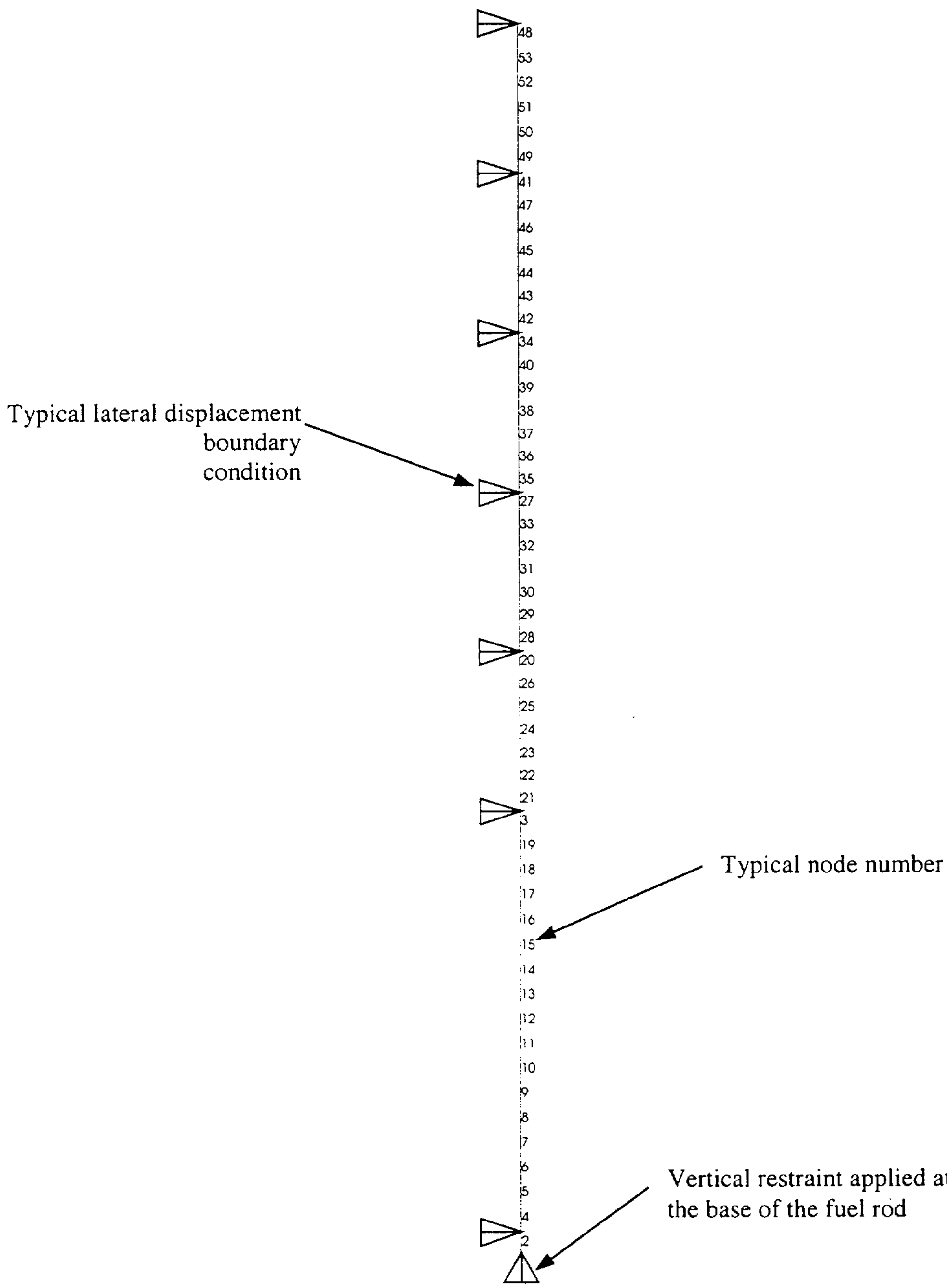
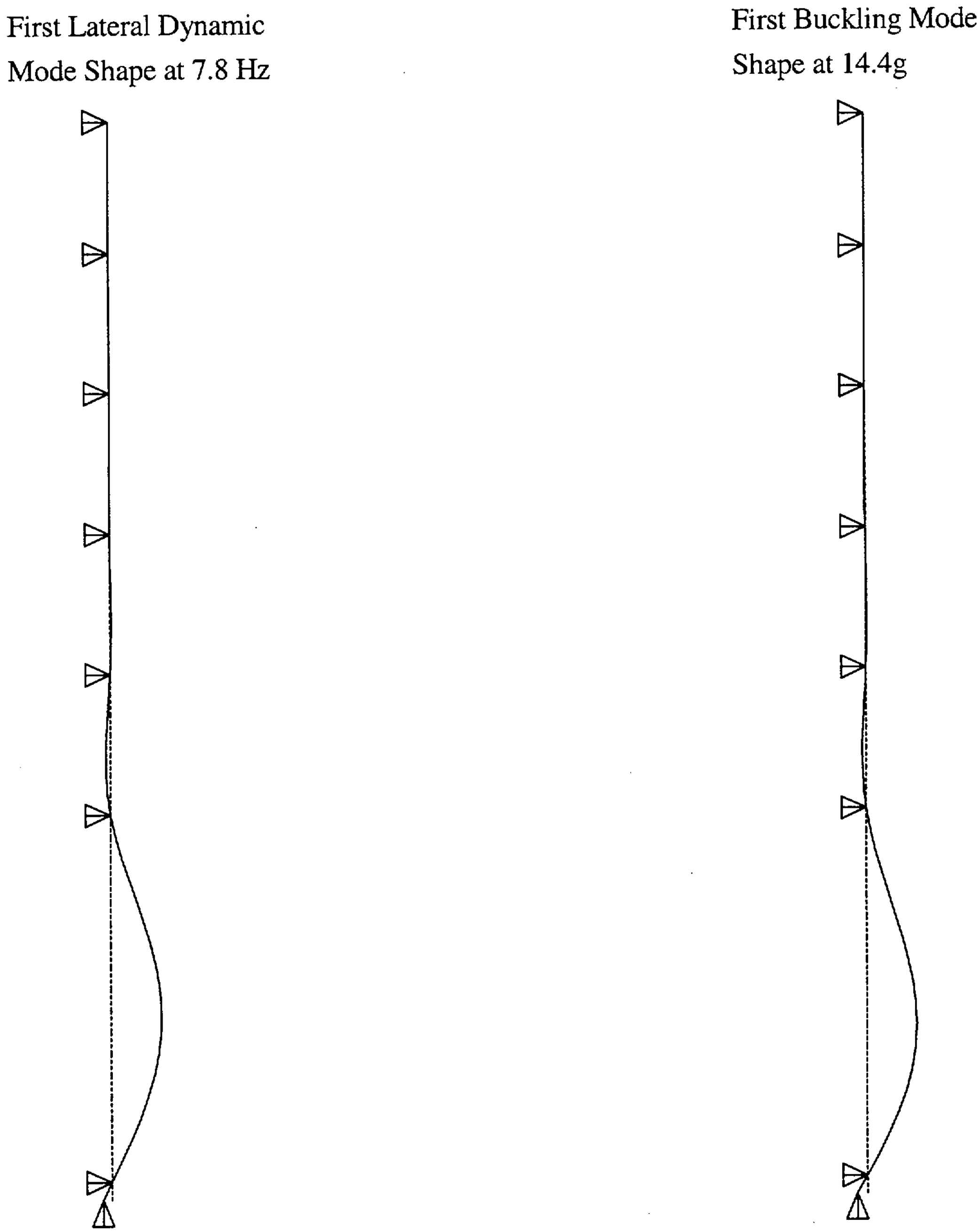


Figure 11.2.15.1.6-2 Modal Shape and First Buckling Mode Shape for a Fuel Rod with a Missing Grid



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11.2.16 100-Ton Transfer Cask Side Drop

During transfer conditions, the 100-ton transfer cask is postulated to roll off the transfer cradle. Because the properties affect the final impact acceleration of the 100-ton transfer cask, the bounding side drop is considered to occur on the ISFSI pad that was used to evaluate the vertical concrete cask during the tip-over accident in Section 11.2.12. The non-linear structural dynamic analysis program, LS-DYNA, is used to predict the acceleration response of the 100-ton transfer cask, during an on-site transfer side-drop accident. The analysis simulates the transfer cask's drop onto a horizontal concrete pad (30-ft × 30-ft × 3-ft) supported by a subsoil mat (35-ft × 35-ft × 10-ft). Two side drop impact analyses are performed on the 100-ton transfer cask, each corresponding to the soil properties associated with the ISFSI pads contained in Section 11.2.12.3.

11.2.16.1 Cause of 100-Ton Transfer Cask Side Drop

During transfer conditions, the 100-ton transfer cask is fastened in a horizontal position to a transfer cradle. The postulated accident scenario predicts that the transfer cask breaks away and rolls off from the transfer cradle and drops onto the ISFSI pad.

11.2.16.2 Detection of Cask Tip-Over

The damaged configuration of the 100-Ton transfer cask will be obvious during inspection following the initiating event.

11.2.16.3 Analysis of the 100-Ton Transfer Cask Side Drop

The non-linear structural dynamic analysis program, LS-DYNA, is used to predict the acceleration response of the 100-ton transfer cask, during an on-site transfer side-drop accident. The assumed effective drop height of the 100-ton transfer cask is 53 inches, i.e., from the transfer cradle to the ground. Since the 53-inch drop represents the dynamic force input, the initial velocity is 202.38 in/sec, which is the vertical velocity of a rigid body after a free fall of 53-in under 1g gravitational force ($v = \sqrt{2gh}$).

The 100-ton transfer cask model consists of the fuel canister, inner shell, lead shell, divider shell, and outer shell (water jacket). The finite element model of the 100-ton transfer cask and canister is shown in Figures 11.2.16-1 and 11.2.16-2. The overall length of the transfer cask model is 189.25

inches. The outside diameter of the transfer cask model at the water jacket is 83.25 inches. A 8-inch diameter trunnion is located 9 inches from the top plate. The bottom plate of the 100-ton transfer cask provides the attachment for the shield door rails. The center of the transfer cask is open so that the fuel canister can be transferred in and out of the cask. The fuel canister does not share nodes with the transfer cask, i.e., it is not connected in the model with the transfer cask. The weight of the fuel is distributed along a rigid strip inside the canister model. Water in the water jacket is not modeled. The fuel canister in the transfer cask model is shown in Figure 11.2.16-3. The ISFSI concrete pad upon which the cask impacts has dimensions of 30-ft × 30-ft × 3-ft. The subsoil mat under the concrete pad has dimensions of 35-ft × 35-ft × 10-ft. The transfer cask, canister, concrete pad and soil are modeled using 8-node solid brick elements and 4-node shell elements. Figure 11.2.16-2 shows the complete loaded 100-ton transfer cask model on the concrete and subsoil model.

11.2.16.3.1 Analysis of the 100-Ton Transfer Cask Side Drop for the PWR Fuel Canister

The side drop of the 100-ton transfer cask with the PWR fuel canister was evaluated using the finite model described above and the concrete pad material model in Section 11.2.12.3.1. To account for large deformation and buckling, the mechanical property of Type 304 stainless steel is represented by an elastic-plastic material formula with LS-DYNA material type 24 (Piecewise_Linear_Plasticity). The detailed stress-strain curve for Type 304 stainless steel at room temperature beyond yield is presented in Figure 11.2.16-4 ("Impact Dynamics" J.A. Zukas, T. Nicholas, H.F. Swift, L.B. Greszczuk, and D.R. Curran, John Wiley & Sons).

Boundary and Initial Condition

The assumed effective drop height of the 100-ton transfer cask is 53 inches. Since the 53-inch drop represents the dynamic force input, the initial velocity is 202.38 in/sec, i.e., the vertical velocity of a rigid body after a free fall of 53-in under 1g gravitational force ($v = \sqrt{2gh}$). The kinetic energy is checked to ensure that the total initial energy is correct.

The symmetry condition is at the XZ-plane (Y=0), at which all displacements in the Y-direction are constrained. The soil mat is constrained at the boundaries (X_{max}, X_{min}, Y_{max}, Z_{min}) with a roller condition. The body force is included as an acceleration in the vertical direction (386.4 inches/sec^2).

Filter Frequency

A modal analysis was performed using the ANSYS program on the 100-ton transfer cask model to determine the frequency to be used in filtering the acceleration time history data generated by the LS-DYNA program. The 100-ton transfer cask modal analysis finite element model is shown in Figure 11.2.16-5. The x-z plane is the plane of symmetry (at Y=0, Uy=0). The vibration modes of interest for the side-drop are primarily in the lateral direction to the cask body, i.e., the global z-direction. To find the primary vibration mode in the lateral direction, the nodes at the two extreme ends of the cask on the plane of symmetry are pinned in the z-direction (Uz=0 at X_{max}, Y_{min} and X_{min}, Y_{min}). The modal frequency and modal participation factor for the primary mode in the lateral direction is presented in the following table and Figure 11.2.16-6.

Description of Primary Mode of Excitation	Global Direction	Frequency, Hz	Effective Mass, slugs	Sum of Effective Mass, slugs	Percent Mass Participation Factor
Lateral	Z	38.3	82.2	90.7	90.6%

The vibration mode presented is based on the highest percent mass participation factor and is, therefore, called the primary mode of vibration since more than 50% of the mass participates in this mode. As the table shows, the cut-off frequency of the 100-ton transfer cask is 38 Hz. The predicted accelerations are, therefore, obtained by filtering the LS-DYNA acceleration outputs using a filter frequency of 50 Hz.

100-Ton Transfer Cask Side Drop Analysis Results (PWR Canister)

The analysis results are obtained by using the LS-DYNA postprocessor, LS-POST, to display the nodal acceleration time-histories. From the modal analysis, a filter frequency of 50 Hz is used in conjunction with the LS-POST Butterworth filter. For the PWR basket/canister, the maximum filtered acceleration of 24.9g occurs near the bottom of fuel canister.

11.2.16.3.2 Analysis of the 100-Ton Transfer Cask Side Drop for the BWR Fuel Canister

The side drop of the 100-ton transfer cask with the BWR fuel canister was evaluated using the finite model described above and the concrete pad material model in Section 11.2.12.3.2. To account for large deformation and buckling, the mechanical property of Type 304 stainless steel is represented by an elastic-plastic material formula with LS-DYNA material type 24 (Piecewise_Linear_Plasticity). The detailed stress-strain curve for Type 304 stainless steel at room temperature beyond yield is presented in Figure 11.2.16-4 ("Impact Dynamics" J.A. Zukas, T. Nicholas, H.F. Swift, L.B. Greszczuk, and D.R. Curran, John Wiley & Sons).

Boundary and Initial Condition

The assumed effective drop height of the 100-ton transfer cask is 53 inches. Since the 53-inch drop represents the dynamic force input, the initial velocity is 202.38 in/sec, i.e., the vertical velocity of a rigid body after a free fall of 53-in under 1-g gravitational force ($v = \sqrt{2gh}$). The kinetic energy is checked to ensure that the total initial energy is correct.

The symmetry condition is at the XZ-plane (Y=0), at which all displacements in the Y-direction are constrained. The soil mat is constrained at the boundaries (X_{max}, X_{min}, Y_{max}, Z_{min}) with a roller condition. The body force is included as an acceleration in the vertical direction (386.4 inches/sec^2).

Filter Frequency

A modal analysis was performed using the ANSYS program on the 100-ton transfer cask to determine the frequency to be used in filtering the acceleration time history data generated by the LS-DYNA program. The 100-ton transfer cask modal analysis finite element model is shown in Figure 11.2.16-5. The x-z plane is the plane of symmetry (at Y=0, Uy=0). The vibration modes of interest for the side-drop are primarily in the lateral direction to the cask body, i.e., the global z-direction. To find the primary vibration mode in the lateral direction, the nodes at the two extreme ends of the cask on the plane of symmetry are pinned in the z-direction (Uz=0 at X_{max}, Y_{min} and X_{min}, Y_{min}). The modal frequency and modal participation factor for the primary mode in the lateral direction is presented in the following table and Figure 11.2.16-6.

Description of Primary Mode of Excitation	Global Direction	Frequency, Hz	Effective Mass, slugs	Sum of Effective Mass, slugs	Percent Mass Participation Factor
Lateral	Z	38.3	82.2	90.7	90.6%

The vibration mode presented is based on the highest percent mass participation factor and is, therefore, called the primary mode of vibration since more than 50% of the mass participates in this mode. As the table shows, the cut-off frequency of the 100-ton transfer cask is 38 Hz. The predicted accelerations are, therefore, obtained by filtering the LS-DYNA acceleration outputs using a filter frequency of 50 Hz.

100-Ton Transfer Cask Side Drop Analysis Results (BWR Canister)

The analysis results are obtained by using the LS-DYNA postprocessor, LS-POST, to display the nodal acceleration time-histories. From the modal analysis, a filter frequency of 50 Hz is used in conjunction with the LS-POST Butterworth filter. For the BWR basket/canister, the maximum filtered acceleration of 20.7g occurs at the basket top support disk location of the canister.

11.2.16.3.3 Dynamic Load Factor

To determine the effect of the rapid application of the inertia loading during the side drop of the 100-ton transfer cask, a dynamic load factor (DLF) is computed using the mode shape of the support disk, the most flexible component of the cask/canister/basket system. The mode shapes corresponding to the in-plane motions of the disk are extracted using ANSYS. However, only the dominant modes with respect to the modal mass participation factor are used in computing the DLF.

PWR Support Disk Modal Analysis

The primary modal frequencies calculated for the PWR support disk and corresponding modal mass participation factors are presented in the following table.

Mode	Frequency (Hz)	Percent Participation (%)
1	109.4	0.8%
2	109.7	85.8%
3	370.1	2.7%
4	371.1	7.2%
5	480.6	0.6%
6	482.0	1.8%
Total		98.9%

BWR Support Disk Modal Analysis

The primary modal frequencies calculated for the BWR support disk and corresponding modal mass participation factors are presented in the following table.

Mode	Frequency (Hz)	Percent Participation (%)
1	79.3	38.4%
2	80.2	54.9%
3	202.9	0.0%
4	210.9	3.4%
5	282.3	0.3%
Total		97.0%

Response Spectrum Analysis Results

The DLFs for the UMS® basket support disks subjected to an impulse are found by performing response spectrum analyses using the results of the modal analysis and the frequency response spectrum analyses. The following table summarizes the DLF and resulting acceleration for each case. The maximum filtered acceleration at the top support disk for the BWR and canister top for the PWR are obtained from the LS-DYNA analyses presented in the main body of this calculation. For the BWR and PWR support disks, the corresponding amplified acceleration is obtained from the response spectrum analysis using the SRSS method. When the SRSS calculated DLF is less than 1.0, the DLF is assumed to be 1.0.

Case	Filtered Acceleration (g)	DLF	Resulting Acceleration (g)
UMS PWR	24.9	1.00	24.9
UMS BWR	20.7	1.38	28.5

11.2.16.4 Analysis of Canister and Basket for 100-Ton Transfer Cask Side Drop

Because the accelerations calculated during the side drop of the 100-ton transfer cask are less than the accelerations calculated during the tip-over event presented in Section 11.2.12, the analyses presented in Section 11.2.12 for the canister, basket, and fuel tubes are bounding.

Figure 11.2.16-1 100-Ton Transfer Cask Side-Drop Model

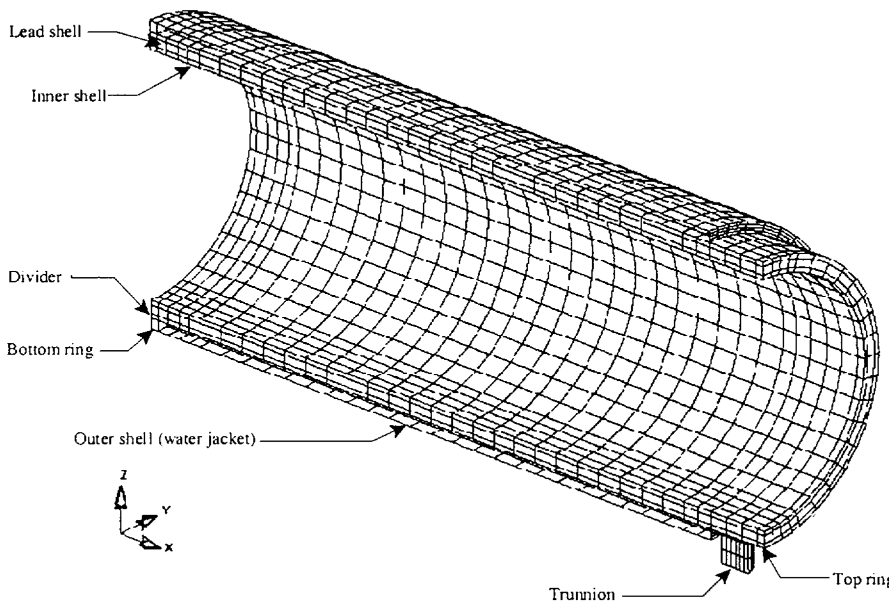


Figure 11.2.16-2 Finite Element Model of the UMS® Transfer Cask Side Impact Analysis

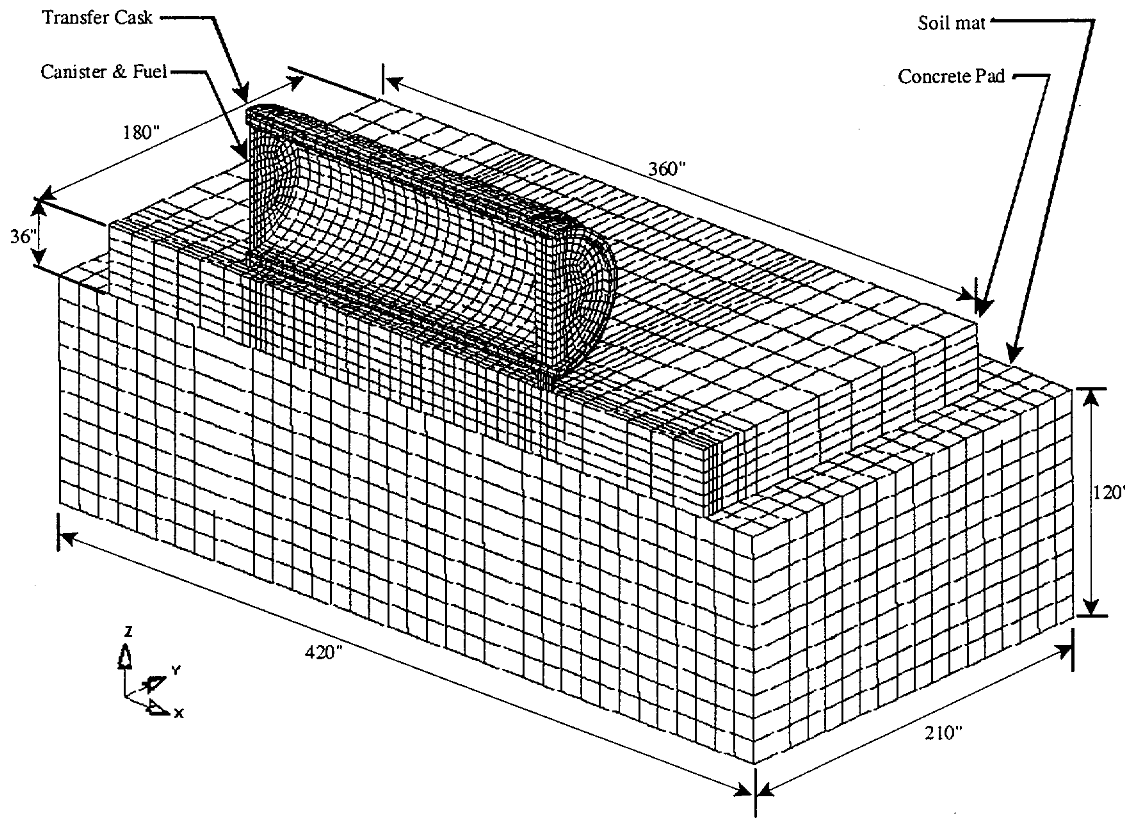


Figure 11.2.16-3 Fuel Canister in the Transfer Cask Model

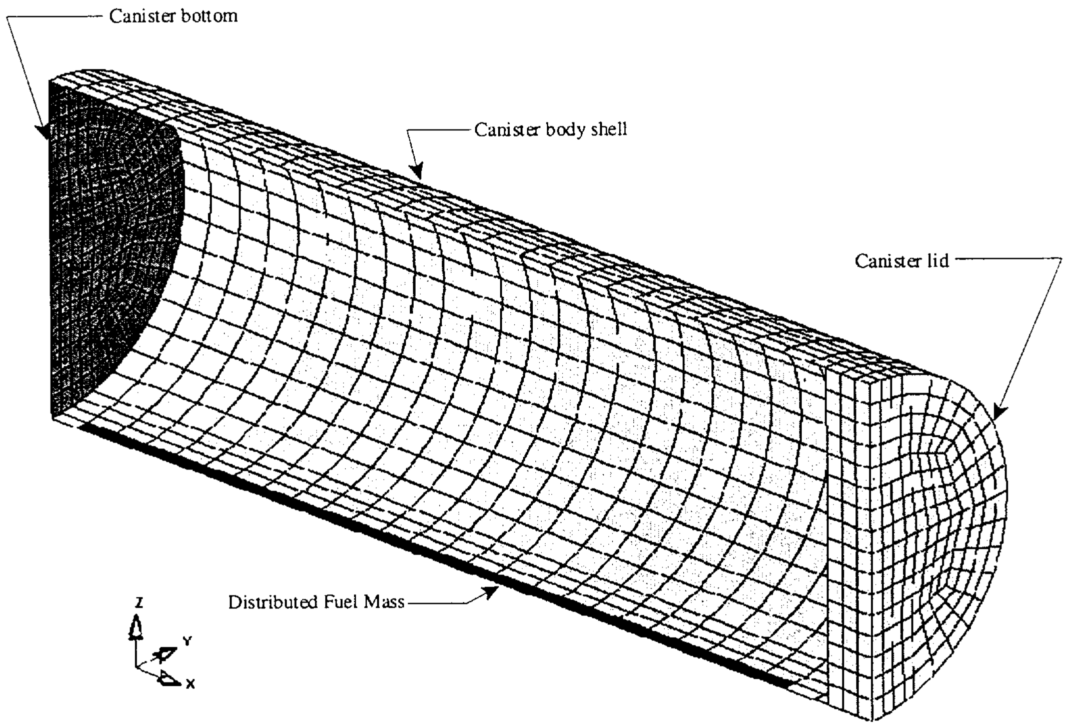


Figure 11.2.16-4 Strain-rate Dependent Stress-Strain Curves for Type 304 Stainless Steel

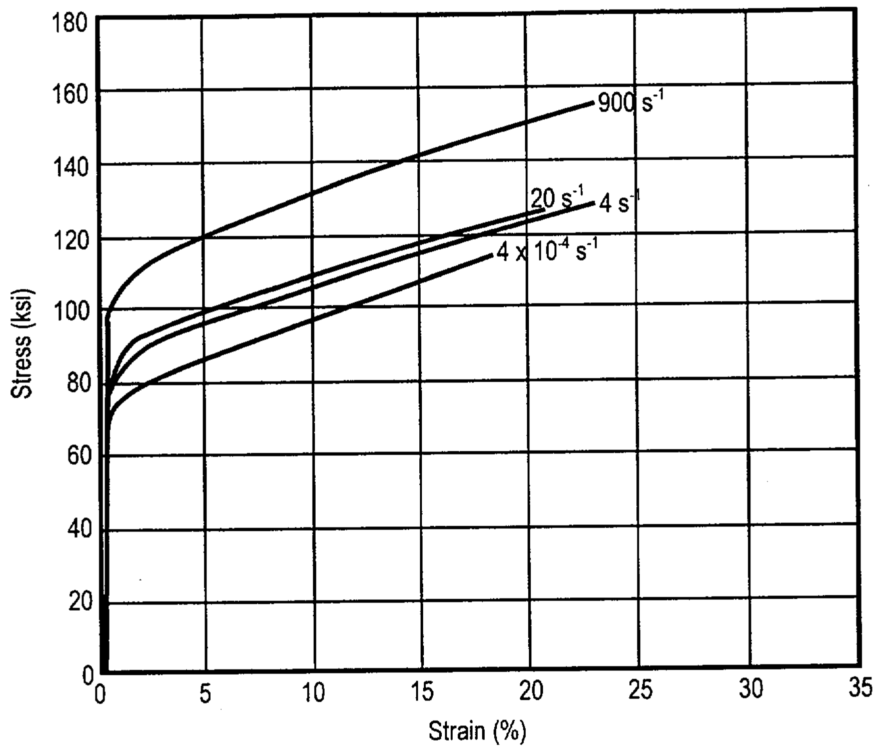


Figure 11.2.16-5 100-Ton Transfer Cask Modal Analysis Finite Element Model

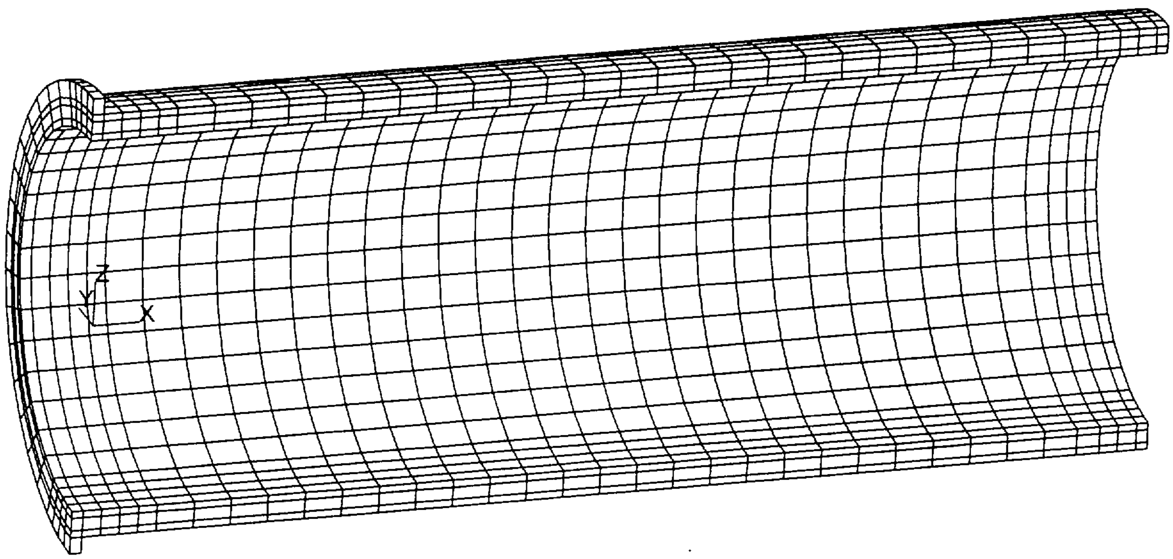
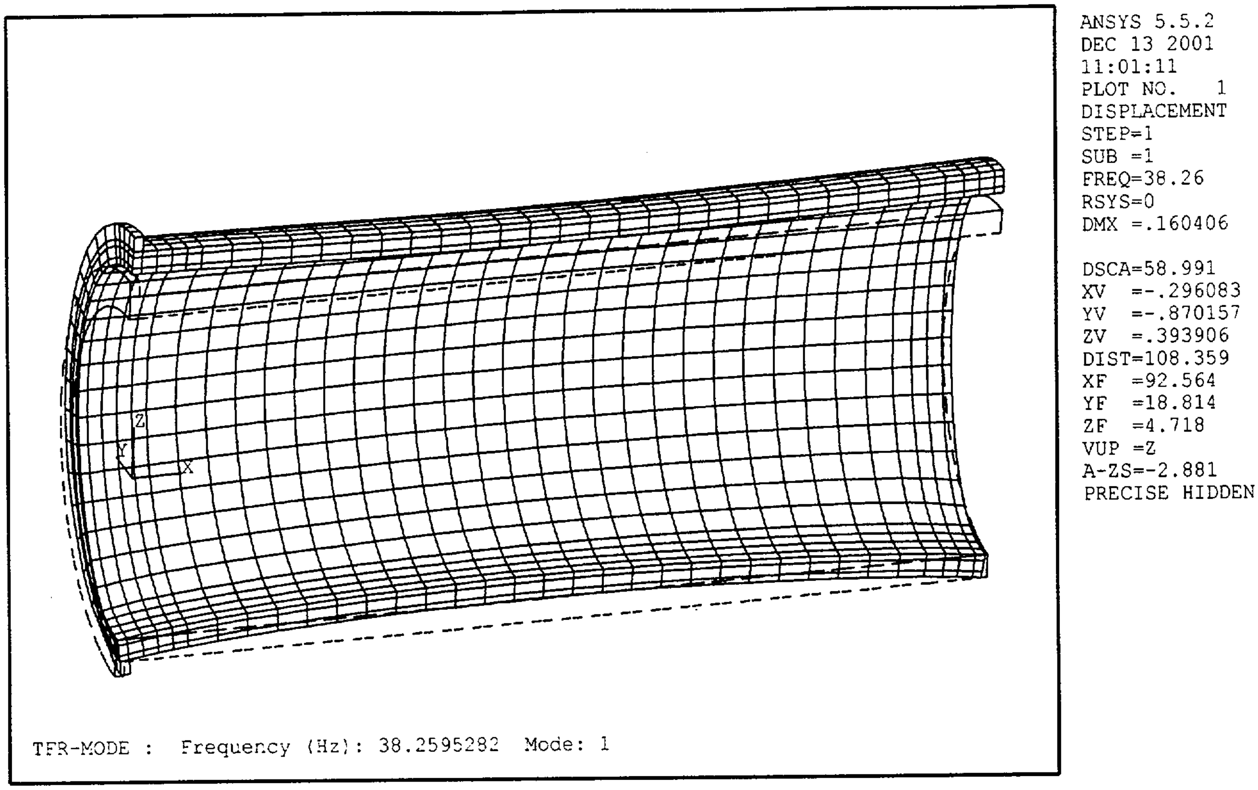


Figure 11.2.16-6 Mode Shape for Excitation in the Lateral (Z) Direction



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Chapter 12

Table of Contents

List of Tables

12.0 OPERATING CONTROLS AND LIMITS

This chapter identifies operating controls and limits, technical parameters and surveillance requirements imposed to ensure the safe operation of the NAC-UMS® System.

Controls used by NAC International (NAC) as part of the NAC-UMS® design and fabrication are provided in the NAC Quality Assurance Manual and Quality Procedure. The NAC Quality Assurance Program is discussed in Chapter 13.0. If procurement and fabrication of the NAC-UMS® System is performed by others, a Quality Assurance Program prepared in accordance with 10 CFR 72 Subpart G shall be implemented. Site specific controls for the organization, administrative system, procedures, record keeping, review, audit and reporting necessary to ensure that the NAC-UMS® storage system installation is operated in a safe manner, are the responsibility of the user of the system.

12.1 Administrative and Operating Controls and Limits for the NAC-UMS® System

The NAC-UMS® Storage System operating controls and limits are summarized in Table 12-1. Appendix 12A provides the proposed Limiting Conditions for Operations (LCO). The Approved Contents and Design Features for the NAC-UMS® System are presented in Technical Specification format. The bases for the specified controls and limits are presented in Appendix 12C.

Section 3.0 Appendix 12B presents Design Features that are important to the safe operation of the NAC-UMS® System, but that are not included as Technical Specifications. These include items which are singular events, those that cannot be readily determined or re-verified at the time of use of the system, or that are easily implemented, verified and corrected, if necessary, at the time the action is undertaken.

12.2 Administrative and Operating Controls and Limits for SITE SPECIFIC FUEL

This section describes the administrative and operating controls and limits placed on the loading of fuel assemblies that are unique to specific reactor sites. SITE SPECIFIC FUEL configurations result from conditions that occurred during reactor operations, participation in research and development programs, testing programs intended to improve reactor operations, from the placement of control components or other items within the fuel assembly and from the disposition of damaged fuel assemblies or fuel rods.

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. Separate evaluation may establish different limits, which are maintained by administrative controls for preferential loading. The preferential loading controls take advantage of design features of the UMS® Storage System to allow the loading of fuel configurations that may have higher burnup or additional hardware material that is not specifically considered in the design basis fuel evaluation.

Unless specifically excepted, SITE SPECIFIC FUEL must meet all of the conditions specified for the design basis fuel presented in Table 12-1.

12.2.1 Operating Controls and Limits for Maine Yankee SITE SPECIFIC FUEL

The fuel design used at Maine Yankee is the Combustion Engineering (CE) 14 × 14 fuel assembly. The CE 14 × 14 fuel assembly is one of those included in the design basis evaluation of the UMS® Storage System as shown in Table 12B2-2. The estimated Maine Yankee SITE SPECIFIC FUEL inventory is shown in Table 12B2-6. Except as noted in this section, the spent fuel in this inventory meets the Fuel Assembly Limits provided in Table 12B2-1.

As shown in Table 12B2-6, certain of the Maine Yankee fuel has characteristics, such as fuel assembly lattice configurations, different from STANDARD FUEL, from PWR INTACT FUEL ASSEMBLIES - including CONSOLIDATED FUEL, DAMAGED FUEL and fuel with higher burnup or enrichment, that differs from the characteristics of the fuel considered in the design basis. As shown in Table 12B2-6, certain fuel configurations must be preferentially loaded in corner or peripheral fuel tube positions in the fuel basket based on the shielding, criticality or thermal evaluation of the fuel configuration.

The corner positions are used for the loading of fuel configurations with missing fuel rods, and for DAMAGED FUEL and CONSOLIDATED FUEL in the MAINE YANKEE FUEL CAN. Specification for placement in the corner fuel tube positions results primarily from shielding or criticality evaluations of the designated fuel configurations.

Spent fuel having a burnup from 45,000 to 50,000 MWD/MTU is assigned to peripheral locations, and based on a cladding oxide layer thickness determination, may require loading in a Maine Yankee fuel can. The interior locations must be loaded with fuel that has lower burnup and/or longer cool times in order to maintain the design basis heat load and component temperature limits for the basket and canister.

The Fuel Assembly Limits for the Maine Yankee SITE SPECIFIC FUEL are shown in Table 12B2-7. Part A of the table lists the STANDARD, INTACT FUEL ASSEMBLY and SITE SPECIFIC FUEL that does not require preferential loading except as required by Section B 2.1.2 to assure that short-term fuel cladding temperature limits are not exceeded.

Part B of the table lists the SITE SPECIFIC FUEL configurations that require preferential loading due to the criticality, shielding or thermal evaluation. The loading pattern for Maine Yankee SITE SPECIFIC FUEL that must be preferentially loaded is presented in Section B 2.1.3. The preferential loading controls take advantage of design features of the UMS® Storage System to allow the loading of fuel configurations that may have higher burnup or additional hardware or fuel source material that is not specifically considered in the design basis fuel evaluation. The preferential loading required by Part B must also consider the preferential loading requirements of Section B 2.1.2 for short-term cladding temperature limits.

Fuel assemblies with a Control Element Assembly (CEA) or a CEA plug inserted are loaded in a Class 2 canister and basket due to the increased length of the assembly with either of these components installed. However, these assemblies are not restricted as to loading position within the basket.

The Transportable Storage Canister loading procedures for Maine Yankee SITE SPECIFIC FUEL will indicate that the loading of a fuel configuration with removed fuel or poison rods, or a MAINE YANKEE FUEL CAN, or fuel with burnup between 45,000 MWD/MTU and 50,000 MWD/MTU, is administratively controlled in accordance with the requirements of Section B 2.1.3.

Table 12-1 NAC-UMS® System Controls and Limits

Control or Limit	Applicable Technical Specification	Condition or Item Controlled
1. Fuel Characteristics	Table 12B2-1	Type and Condition
	Table 12B2-2	Class, Dimensions and Weight for PWR
	Table 12B2-3	Class, Dimensions and Weight for BWR
	Table 12B2-4	Minimum Cooling Time for PWR Fuel
	Table 12B2-5	Minimum Cooling Time for BWR Fuel
	Table 12B2-7	Maine Yankee Site Specific Fuel Limits
	Table 12B2-8	Minimum Cooling Time for Maine Yankee Fuel – No CEA
	Table 12B2-9	Minimum Cooling Time for Maine Yankee Fuel – With CEA
2. Canister	LCO 3.1.4	Time in Transfer Cask (fuel loading)
Fuel Loading	Table 12B2-1	Weight and Number of Assemblies
	Table 12B2-7	Maine Yankee Site Specific Fuel Limits
	Table 12B2-4	Minimum Cooling Time for PWR Fuel
	Table 12B2-5	Minimum Cooling Time for BWR Fuel
Drying	LCO 3.1.2	Vacuum Drying Pressure
Backfilling	LCO 3.1.3	Helium Backfill Pressure
Sealing	LCO 3.1.5	Helium Leak Rate
Vacuum	LCO 3.1.1	Time in Vacuum Drying
External Surface	LCO 3.2.1	Level of Contamination
Unloading	Note 1	Fuel Cooldown Requirement
3. Concrete Cask	LCO 3.2.2	Surface Dose Rates
	Note 1	Cask Spacing
	Note 2	Cask Handling Height
4. Surveillance	LCO 3.1.6	Heat Removal System
5. Transfer Cask	12B 3.4(8)	Minimum Temperature
	LCO 3.1.7	CANISTER Removal from the CONCRETE Cask
6. ISFSI Concrete Pad	B3.4.1(6)	Seismic Event Performance
	B3.4.2(7)	

1. Procedure and/or limits are presented in the Operating Procedures of Chapter 8.
2. Lifting height and handling restrictions are provided in Section A5.6 of Appendix 12A.

APPENDIX 12A

TECHNICAL SPECIFICATIONS FOR THE NAC-UMS® SYSTEM

Table of Contents

Table of Contents (Continued)

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A 1.0 USE AND APPLICATION

A 1.1 Definitions

---NOTE---

The defined terms of this section appear in capitalized type and are applicable throughout this Chapter 12.

Term	Definition
ACTIONS	ACTIONS shall be that part of a Specification that prescribes Required Actions to be taken under designated Conditions within specified Completion Times.
CANISTER	See TRANSPORTABLE STORAGE CANISTER
CANISTER HANDLING FACILITY	The CANISTER HANDLING FACILITY includes the following components and equipment: (1) a canister transfer station that allows the staging of the TRANSFER CASK with the CONCRETE CASK or transport cask to facilitate CANISTER lifts involving spent fuel handling not covered by 10 CFR 50; and (2) either a stationary lift device or mobile lifting device used to lift the TRANSFER CASK and CANISTER.
CONCRETE CASK	See VERTICAL CONCRETE CASK
INDEPENDENT SPENT FUEL STORAGE INSTALLATION (ISFSI)	The facility within the perimeter fence licensed for storage of spent fuel within NAC-UMS® SYSTEMs (see also 10 CFR 72.3).
INTACT FUEL (ASSEMBLY OR ROD) (Undamaged Fuel)	A fuel assembly or fuel rod with no fuel rod cladding defects, or with known or suspected fuel rod cladding defects not greater than pinhole leaks or hairline cracks.

(continued)

LOADING OPERATIONS	LOADING OPERATIONS include all licensed activities on an NAC-UMS® SYSTEM while it is being loaded with fuel assemblies. LOADING OPERATIONS begin when the first fuel assembly is placed in the CANISTER and end when the NAC-UMS® SYSTEM is secured on the transporter. LOADING OPERATIONS does not include post-storage operations, i.e., CANISTER transfer operations between the TRANSFER CASK and the CONCRETE CASK or transport cask after STORAGE OPERATIONS.
INITIAL PEAK PLANAR-AVERAGE ENRICHMENT	THE INITIAL PEAK PLANAR-AVERAGE ENRICHMENT is the maximum planar-average enrichment at any height along the axis of the fuel assembly. The 4.0 wt % ^{235}U enrichment limit for BWR fuel applies along the full axial extent of the assembly. The INITIAL PEAK PLANAR-AVERAGE ENRICHMENT may be higher than the bundle (assembly) average enrichment.
NAC-UMS® SYSTEM	NAC-UMS® SYSTEM includes the components approved for loading and storage of spent fuel assemblies at the ISFSI. The NAC-UMS® SYSTEM consists of a CONCRETE CASK, a TRANSFER CASK, and a CANISTER.
OPERABLE	The CONCRETE CASK heat removal system is OPERABLE if the difference between the ISFSI ambient temperature and the average outlet air temperature is ≤ 102°F for the PWR CANISTER or ≤ 92°F for the BWR CANISTER.

(continued)

STORAGE OPERATIONS	STORAGE OPERATIONS include all licensed activities that are performed at the ISFSI, while an NAC-UMS® SYSTEM containing spent fuel is located on the storage pad within the ISFSI perimeter.
TRANSFER CASK	TRANSFER CASK is a shielded lifting device that holds the CANISTER during LOADING and UNLOADING OPERATIONS and during closure welding, vacuum drying, leak testing, and non-destructive examination of the CANISTER closure welds. The TRANSFER CASK is also used to transfer the CANISTER into and from the CONCRETE CASK and into the transport cask. TRANSFER CASK refers to either the NAC-UMS® standard transfer cask or the 100-ton transfer cask.
TRANSPORT OPERATIONS	TRANSPORT OPERATIONS include all licensed activities involved in moving a loaded NAC-UMS® CONCRETE CASK and CANISTER to and from the ISFSI. TRANSPORT OPERATIONS begin when the NAC-UMS® SYSTEM is first secured on the transporter and end when the NAC-UMS® SYSTEM is at its destination and no longer secured on the transporter.
TRANSPORTABLE STORAGE CANISTER (CANISTER)	TRANSPORTABLE STORAGE CANISTER is the sealed container that consists of a tube and disk fuel basket in a cylindrical canister shell that is welded to a baseplate, shield lid with welded port covers, and structural lid. The CANISTER provides the confinement boundary for the confined spent fuel.
TRANSFER OPERATIONS	TRANSFER OPERATIONS include all licensed activities involved in transferring a loaded CANISTER from a CONCRETE CASK to another CONCRETE CASK or to a TRANSPORT CASK.

(continued)

UNLOADING OPERATIONS	UNLOADING OPERATIONS include all licensed activities on a NAC-UMS® SYSTEM to be unloaded of the contained fuel assemblies. UNLOADING OPERATIONS begin when the NAC-UMS® SYSTEM is no longer secured on the transporter and end when the last fuel assembly is removed from the NAC-UMS® SYSTEM.
VERTICAL CONCRETE CASK (CONCRETE CASK)	VERTICAL CONCRETE CASK is the cask that receives and holds the sealed CANISTER. It provides the gamma and neutron shielding and convective cooling of the spent fuel confined in the CANISTER.
STANDARD FUEL	Irradiated fuel assemblies having the same configuration as when originally fabricated consisting generally of the end fittings, fuel rods, guide tubes, and integral hardware. For PWR fuel, a flow mixer, an in-core instrument thimble or a burnable poison rod insert is considered to be a component of standard fuel. For BWR fuel, the channel is considered to be integral hardware. The design basis fuel characteristics and analysis are based on the STANDARD FUEL configuration.
DAMAGED FUEL	A fuel assembly or fuel rod with known or suspected cladding defects greater than pinhole leaks or hairline cracks. DAMAGED FUEL must be placed in a MAINE YANKEE FUEL CAN.

(continued)

HIGH BURNUP FUEL	A fuel assembly having a burnup between 45,000 and 50,000 MWD/MTU, which must be preferentially loaded in periphery positions of the basket. An intact HIGH BURNUP FUEL assembly in which no more than 1% of the fuel rods in the assembly have a peak cladding oxide thickness greater than 80 microns, and in which no more than 3% of the fuel rods in the assembly have a peak oxide layer thickness greater than 70 microns, as determined by measurement and statistical analysis, may be stored as INTACT FUEL. HIGH BURNUP FUEL assemblies not meeting the cladding oxide thickness criteria for INTACT FUEL or that have an oxide layer that has become detached or spalled from the cladding are stored as DAMAGED FUEL in a MAINE YANKEE FUEL CAN.
FUEL DEBRIS	An intact or a partial fuel rod or an individual intact or partial fuel pellet not contained in a fuel rod. Fuel debris is inserted into a 9 × 9 array of tubes in a lattice that has approximately the same dimensions as a standard fuel assembly. FUEL DEBRIS is stored in a MAINE YANKEE FUEL CAN.
CONSOLIDATED FUEL	A nonstandard fuel configuration in which the individual fuel rods from one or more fuel assemblies are placed in a single container or a lattice structure that is similar to a fuel assembly. CONSOLIDATED FUEL is stored in a MAINE YANKEE FUEL CAN.

(continued)

SITE SPECIFIC FUEL

Spent fuel configurations that are unique to a site or reactor due to the addition of other components or reconfiguration of the fuel assembly at the site. It includes fuel assemblies, which hold nonfuel-bearing components, such as a control element assembly, a burnable poison rod insert, an in-core instrument thimble or a flow mixer, or which are modified as required by expediency in reactor operations, research and development or testing. Modification may consist of individual fuel rod removal, fuel rod replacement of similar or dissimilar material or enrichment, the installation, removal or replacement of burnable poison rods, or containerizing damaged fuel.

Site specific fuel includes irradiated fuel assemblies designed with variable enrichments and/or axial blankets, fuel that is consolidated and fuel that exceeds design basis fuel parameters.

MAINE YANKEE FUEL CAN

A specially designed stainless steel screened can sized to hold INTACT FUEL, CONSOLIDATED FUEL, DAMAGED FUEL or FUEL DEBRIS. The screens preclude the release of gross particulate from the can into the canister cavity. The MAINE YANKEE FUEL CAN may only be loaded in a Class 1 canister.

A 1.0 USE AND APPLICATION

A 1.2 Logical Connectors

PURPOSE

The purpose of this section is to explain the meaning of logical connectors.

Logical connectors are used in Technical Specifications (TS) to discriminate between, and yet connect, discrete Conditions, Required Actions, Completion Times, Surveillances, and Frequencies. The only logical connectors that appear in Technical Specifications are "AND" and "OR." The physical arrangement of these connectors constitutes logical conventions with specific meanings.

BACKGROUND

Several levels of logic may be used to state Required Actions. These levels are identified by the placement (or nesting) of the logical connectors and by the number assigned to each Required Action. The first level of logic is identified by the first digit of the number assigned to a Required Action and the placement of the logical connector in the first level of nesting (i.e., left justified with the number of the Required Action). The successive levels of logic are identified by additional digits of the Required Action number and by successive indentations of the logical connectors.

When logical connectors are used to state a Condition, Completion Time, Surveillance, or Frequency, only the first level of logic is used; the logical connector is left justified with the statement of the Condition, Completion Time, Surveillance, or Frequency.

(continued)

EXAMPLES The following examples illustrate the use of logical connectors.

EXAMPLES <u>EXAMPLE 1.2-1</u>

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. LCO not met	A.1 Verify. . . <u>AND</u> A.2 Restore. . .	

In this example, the logical connector "<u>AND</u>" is used to indicate that when in Condition A, both Required Actions A.1 and A.2 must be completed.

(continued)

EXAMPLES (continued)

EXAMPLE 1.2-2

ACTIONS

CONDITION	REQUIRED ACTION		COMPLETION TIME
A. LCO not met	A.1	Stop. . .	
	OR		
	A.2.1	Verify. . .	
	AND		
	A.2.2		
	A.2.2.1	Reduce. . .	
		OR	
	A.2.2.2	Perform. . .	
	OR		
	A.3	Remove. . .	

This example represents a more complicated use of logical connectors. Required Actions A.1, A.2, and A.3 are alternative choices, only one of which must be performed as indicated by the use of the logical connector "OR" and the left justified placement. Any one of these three Actions may be chosen. If A.2 is chosen, then both A.2.1 and A.2.2 must be performed as indicated by the logical connector "AND." Required Action A.2.2 is met by performing A.2.2.1 or A.2.2.2. The indented position of the logical connector "OR" indicated that A.2.2.1 and A.2.2.2 are alternative choices, only one of which must be performed.

A 1.0 USE AND APPLICATION

A 1.3 Completion Times

PURPOSE

The purpose of this section is to establish the Completion Time convention and to provide guidance for its use.

BACKGROUND

Limiting Conditions for Operations (LCOs) specify the lowest functional capability or performance levels of equipment required for safe operation of the NAC-UMS® SYSTEM. The ACTIONS associated with an LCO state conditions that typically describe the ways in which the requirements of the LCO can fail to be met. Specified with each stated Condition are Required Action(s) and Completion Time(s).

DESCRIPTION

The Completion Time is the amount of time allowed for completing a Required Action. It is referenced to the time of discovery of a situation (e.g., equipment or variable not within limits) that requires entering an ACTIONS Condition, unless otherwise specified, provided that the NAC-UMS® SYSTEM is in a specified Condition stated in the Applicability of the LCO. Prior to the expiration of the specified Completion Time, Required Actions must be completed. An ACTIONS Condition remains in effect and the Required Actions apply until the Condition no longer exists or the NAC-UMS® SYSTEM is not within the LCO Applicability.

Once a Condition has been entered, subsequent subsystems, components, or variables expressed in the Condition, discovered to be not within limits, will not result in separate entry into the Condition, unless specifically stated. The Required Actions of the Condition continue to apply to each additional failure, with Completion Times based on initial entry into the Condition.

(continued)

EXAMPLES

The following examples illustrate the use of Completion Times with different types of Conditions and changing Conditions.

EXAMPLE 1.3-1

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
B. Required Action and associated Completion Time not met	B.1 Perform Action B.1 AND B.2 Perform Action B.2	12 hours 36 hours

Condition B has two Required Actions. Each Required Action has its own Completion Time. Each Completion Time is referenced to the time that Condition B is entered.

The Required Actions of Condition B are to complete action B.1 within 12 hours AND complete action B.2 within 36 hours. A total of 12 hours is allowed for completing action B.1 and a total of 36 hours (not 48 hours) is allowed for completing action B.2 from the time that Condition B was entered. If action B.1 is completed within six hours, the time allowed for completing action B.2 is the next 30 hours because the total time allowed for completing action B.2 is 36 hours.

(continued)

EXAMPLES (continued)

EXAMPLE 1.3-2

ACTIONS

CONDITION	REQUIRED ACTION		COMPLETION TIME
A. One System not within limit	A.1	Restore System to within limit	7 days
B. Required Action and associated Completion Time not met	B.1	Complete action B.1	12 hours
	AND		
	B.2	Complete action B.2	36 hours

When a System is determined not to meet the LCO, Condition A is entered. If the System is not restored within seven days, Condition B is also entered, and the Completion Time clocks for Required Actions B.1 and B.2 start. If the System is restored after Condition B is entered, Conditions A and B are exited; therefore, the Required Actions of Condition B may be terminated.

(continued)

EXAMPLES
(continued)

EXAMPLE 1.3-3

ACTIONS

--NOTE----------------------------------
Separate Condition entry is allowed for each component.

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. LCO not met	A.1 Restore compliance with LCO	4 hours
B. Required Action and associated Completion Time not met	B.1 Complete action B.1 AND B.2 Complete action B.2	6 hours 12 hours

The Note above the ACTIONS table is a method of modifying how the Completion Time is tracked. If this method of modifying how the Completion Time is tracked was applicable only to a specific Condition, the Note would appear in that Condition rather than at the top of the ACTIONS Table.

The Note allows Condition A to be entered separately for each component, and Completion Times to be tracked on a per component basis. When a component is determined to not meet the LCO, Condition A is entered and its Completion Time starts. If subsequent components are determined to not meet the LCO, Condition A is entered for each component and separate Completion Times are tracked for each component.

(continued)

EXAMPLES (continued)	<u>EXAMPLE 1.3-3</u>
IMMEDIATE COMPLETION TIME	When "Immediately" is used as a Completion Time, the Required Action should be pursued without delay and in a controlled manner.

A 1.0 USE AND APPLICATION

A 1.4 Frequency

PURPOSE

The purpose of this section is to define the proper use and application of Frequency requirements.

DESCRIPTION

Each Surveillance Requirement (SR) has a specified Frequency in which the Surveillance must be met in order to meet the associated Limiting Condition for Operation (LCO). An understanding of the correct application of the specified Frequency is necessary for compliance with the SR.

Each "specified Frequency" is referred to throughout this section and each of the Specifications of Section 3.0, Surveillance Requirement (SR) Applicability. The "specified Frequency" consists of requirements of the Frequency column of each SR.

Situations where a Surveillance could be required (i.e., its Frequency could expire), but where it is not possible or not desired that it be performed until sometime after the associated LCO is within its Applicability, represent potential SR 3.0.4 conflicts. To avoid these conflicts, the SR (i.e., the Surveillance or the Frequency) is stated such that it is only "required" when it can be and should be performed. With an SR satisfied, SR 3.0.4 imposes no restriction.

The use of "met" or "performed" in these instances conveys specific meanings. A Surveillance is "met" only after the acceptance criteria are satisfied. Known failure of the requirements of a Surveillance, even without a Surveillance specifically being "performed," constitutes a Surveillance not "met."

(continued)

EXAMPLES The following examples illustrate the various ways that Frequencies are specified.

EXAMPLE 1.4-1

SURVEILLANCE REQUIREMENTS

SURVEILLANCE	FREQUENCY
Verify pressure within limit	12 hours

Example 1.4-1 contains the type of SR most often encountered in the Technical Specifications (TS). The Frequency specifies an interval (12 hours) during which the associated Surveillance must be performed at least one time. Performance of the Surveillance initiates the subsequent interval. Although the Frequency is stated as 12 hours, SR 3.0.2 allows an extension of the time interval to 1.25 times the interval specified in the Frequency for operational flexibility. The measurement of this interval continues at all times, even when the SR is not required to be met per SR 3.0.1 (such as when the equipment or variables are outside specified limits, or the facility is outside the Applicability of the LCO). If the interval specified by SR 3.0.2 is exceeded while the facility is in a condition specified in the Applicability of the LCO, the LCO is not met in accordance with SR 3.0.1.

If the interval as specified by SR 3.0.2 is exceeded while the facility is not in a condition specified in the Applicability of the LCO for which performance of the SR is required, the Surveillance must be performed within the Frequency requirements of SR 3.0.2, prior to entry into the specified condition. Failure to do so would result in a violation of SR 3.0.4.

(continued)

EXAMPLE 1.4-2

SURVEILLANCE REQUIREMENTS

SURVEILLANCE	FREQUENCY
Verify flow is within limits	Once within 12 hours prior to starting activity AND 24 hours thereafter

Example 1.4-2 has two Frequencies. The first is a one time performance Frequency, and the second is of the type shown in Example 1.4-1. The logical connector "AND" indicates that both Frequency requirements must be met. Each time the example activity is to be performed, the Surveillance must be performed within 12 hours prior to starting the activity.

The use of "once" indicates a single performance will satisfy the specified Frequency (assuming no other Frequencies are connected by "AND"). This type of Frequency does not qualify for the 25% extension allowed by SR 3.0.2.

"Thereafter" indicates future performances must be established per SR 3.0.2, but only after a specified condition is first met (i.e., the "once" performance in this example). If the specified activity is canceled or not performed, the measurement of both intervals stops. New intervals start upon preparing to restart the specified activity.

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A 2.0 [Reserved]

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A 3.0 LIMITING CONDITION FOR OPERATION (LCO) APPLICABILITY

LCO 3.0.1	LCOs shall be met during specified conditions in the Applicability, except as provided in LCO 3.0.2.
LCO 3.0.2	Upon failure to meet an LCO, the Required Actions of the associated Conditions shall be met, except as provided in LCO 3.0.5. If the LCO is met or is no longer applicable prior to expiration of the specified Completion Time(s), completion of the Required Action(s) is not required, unless otherwise stated.
LCO 3.0.3	Not applicable to a NAC-UMS® SYSTEM.
LCO 3.0.4	When an LCO is not met, entry into a specified condition in the Applicability shall not be made except when the associated ACTIONS to be entered permit continued operation in the specified condition in the Applicability for an unlimited period of time. This Specification shall not prevent changes in specified conditions in the Applicability that are required to comply with ACTIONS or that are related to the unloading of an NAC-UMS® SYSTEM. Exceptions to this Condition are stated in the individual Specifications. These exceptions allow entry into specified conditions in the Applicability where the associated ACTIONS to be entered allow operation in the specified conditions in the Applicability only for a limited period of time.
LCO 3.0.5	Equipment removed from service or not in service in compliance with ACTIONS may be returned to service under administrative control solely to perform testing required to demonstrate it meets the LCO or that other equipment meets the LCO. This is an exception to LCO 3.0.2 for the System to return to service under administrative control to perform the testing.

A 3.0 SURVEILLANCE REQUIREMENT (SR) APPLICABILITY

SR 3.0.1	SRs shall be met during the specified conditions in the Applicability for individual LCOs, unless otherwise stated in the SR. Failure to meet a Surveillance, whether such failure is experienced during the performance of the Surveillance or between performances of the Surveillance, shall be a failure to meet the LCO. Failure to perform a Surveillance within the specified Frequency shall be a failure to meet the LCO, except as provided in SR 3.0.3. Surveillances do not have to be performed on equipment or variables outside specified limits.
SR 3.0.2	The specified Frequency for each SR is met if the Surveillance is performed within 1.25 times the interval specified in the Frequency, as measured from the previous performance or as measured from the time a specified condition of the Frequency is met. For Frequencies specified as "once," the above interval extension does not apply. If a Completion Time requires periodic performance on a "once per..." basis, the above Frequency extension applies to each performance after the initial performance. Exceptions to this Specification are stated in the individual Specifications.
SR 3.0.3	If it is discovered that a Surveillance was not performed within its specified Frequency, then compliance with the requirement to declare the LCO not met may be delayed from the time of discovery up to 24 hours or up to the limit of the specified Frequency, whichever is less. This delay period is permitted to allow performance of the Surveillance. If the Surveillance is not performed within the delay period, the LCO must immediately be declared not met, and the applicable Condition(s) must be entered.

(continued)

SR 3.0.3 (continued)	When the Surveillance is performed within the delay period and the Surveillance is not met, the LCO must immediately be declared not met, and the applicable Condition(s) must be entered.
SR 3.0.4	Entry into a specified Condition in the Applicability of an LCO shall not be made, unless the LCO's Surveillances have been met within their specified Frequency. This provision shall not prevent entry into specified conditions in the Applicability that are required to comply with Actions or that are related to the unloading of a NAC-UMS® SYSTEM.

A 3.1 NAC-UMS® SYSTEM Integrity

A 3.1.1 CANISTER Maximum Time in Vacuum Drying

LCO 3.1.1 The following limits for vacuum drying time shall be met, as appropriate:

1. The time duration from completion of draining the CANISTER through completion of vacuum dryness testing and the introduction of helium backfill shall not exceed the following time limits:

PWR

Total Heat Load (L) (kW)	Time Limit (Hours)	Total Heat Load (L) (kW)	Time Limit (Hours)
20 < L ≤ 23	32	11 < L ≤ 14	68
17.6 < L ≤ 20	37	8 < L ≤ 11	No Limit
14 < L ≤ 17.6	44	L ≤ 8	No Limit

BWR

Total Heat Load (L) (kW)	Time Limit (Hours)	Total Heat Load (L) (kW)	Time Limit (Hours)
20 < L ≤ 23	25	11 < L ≤ 14	45
17 < L ≤ 20	27	8 < L ≤ 11	72
14 < L ≤ 17	33	L ≤ 8	No Limit

2. The time duration from the end of 24 hours of in-pool cooling or of forced air cooling of the CANISTER through completion of vacuum dryness testing and the introduction of helium backfill shall not exceed the following limits:

PWR Forced Air

Total Heat Load (L) (kW)	Time Limit (Hours)
20 < L ≤ 23	7
17 < L ≤ 20	12
14 < L ≤ 17	19
L ≤ 14	43

PWR In-Pool

Total Heat Load (L) (kW)	Time Limit (Hours)
20 < L ≤ 23	17
17 < L ≤ 20	24
14 < L ≤ 17	31
L ≤ 14	59

BWR Forced Air

Total Heat Load (L) (kW)	Time Limit (Hours)
20 < L ≤ 23	2
17 < L ≤ 20	3
14 < L ≤ 17	8
11 < L ≤ 14	18
8 < L ≤ 11	41

BWR In-Pool

Total Heat Load (L) (kW)	Time Limit (Hours)
20 < L ≤ 23	10
17 < L ≤ 20	11
14 < L ≤ 17	17
11 < L ≤ 14	26
8 < L ≤ 11	52

APPLICABILITY: During LOADING OPERATIONS

(continued)

ACTIONS

-----------------------------------NOTE-----------------------------------

Separate Condition entry is allowed for each NAC-UMS® SYSTEM.

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. LCO time limits not met	A.1.1 Commence filling CANISTER with helium	2 hours
	AND	
	A.1.2 Submerge TRANSFER CASK with helium filled loaded CANISTER in spent fuel pool.	2 hours
	AND	
	A.1.3 Maintain TRANSFER CASK and CANISTER in spent fuel pool for a minimum of 24 hours	Prior to restart of LOADING OPERATIONS
	OR	
	A.2.1 Commence supplying air to the TRANSFER CASK annulus fill/drain lines at a rate of 375 CFM and a maximum temperature of 76°F	2 hours
	AND	
	A.2.2 Maintain airflow for a minimum of 24 hours	Prior to restart of LOADING OPERATIONS

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.1.1.1	Monitor elapsed time from completion of CANISTER draining operations until start of helium backfill	Once within 1 hour of completion of CANISTER draining AND 2 hours thereafter.
SR 3.1.1.2	Monitor elapsed time from the end of in-pool cooling or of forced-air cooling until restart of helium backfill	Once within 1 hour of completion of in-pool cooling or forced-air cooling AND 2 hours thereafter.

A 3.1 NAC-UMS® SYSTEM Integrity

A 3.1.2 CANISTER Vacuum Drying Pressure

LCO 3.1.2 The CANISTER vacuum drying pressure shall be less than or equal to 3 mm of mercury. Pressure shall be held for not less than 30 minutes.

APPLICABILITY: During LOADING OPERATIONS

ACTIONS

---NOTE---

Separate Condition entry is allowed for each NAC-UMS® SYSTEM.

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. CANISTER vacuum drying pressure limit not met	A.1 Establish CANISTER cavity vacuum drying pressure within limit	25 days
B. Required Action and associated Completion Time not met	B.1 Remove all fuel assemblies from the NAC-UMS® SYSTEM	5 days

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.1.2.1	Verify CANISTER cavity vacuum drying pressure is within limits	Prior to TRANSPORT OPERATIONS.

A 3.1 NAC-UMS® SYSTEM Integrity

A 3.1.3 CANISTER Helium Backfill Pressure

LCO 3.1.3 The CANISTER helium backfill pressure shall be 0 (+1, -0) psig.

APPLICABILITY: During LOADING OPERATIONS

ACTIONS

-----NOTE-----
Separate Condition entry is allowed for each NAC-UMS® SYSTEM.

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. CANISTER helium backfill pressure limit not met	A.1 Establish CANISTER helium backfill pressure within limit	25 days
B. Required Action and associated Completion Time not met	B.1 Remove all fuel assemblies from the NAC-UMS® SYSTEM	5 days

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.1.3.1	Verify CANISTER helium backfill pressure is within limit	Prior to TRANSPORT OPERATIONS.

A 3.1 NAC-UMS® SYSTEM Integrity

A 3.1.4 CANISTER Maximum Time in TRANSFER CASK

LCO 3.1.4 The following limits for CANISTER time in TRANSFER CASK shall be met, as appropriate:

1. The time duration from completion of backfilling the CANISTER with helium through completion of the CANISTER transfer operation from the TRANSFER CASK to the CONCRETE CASK shall not exceed the following time limits for BWR fuel. The time duration for PWR fuel is not limited.

Total BWR Heat Load (L) (kW)	Time Limit (Hours)
20 < L ≤ 23	16
17 < L ≤ 20	30
L ≤ 17	Not Limited

2. The time duration from completion of in-pool or external forced air cooling of the CANISTER through completion of the CANISTER transfer operation from the TRANSFER CASK to the CONCRETE CASK shall not exceed the following time limits for BWR fuel after 24 hours of in-pool cooling or forced air cooling. The time duration for PWR fuel is not limited.

Total BWR Heat Load (L) (kW)	Time Limit (Hours)
20 < L ≤ 23	16
17 < L ≤ 20	30
L ≤ 17	Not Limited

APPLICABILITY: During LOADING OPERATIONS

(continued)

ACTIONS

---NOTE---

Separate Condition entry is allowed for each NAC-UMS® SYSTEM.

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. LCO time limits not met	A.1.1 Place TRANSFER CASK with helium filled loaded CANISTER in spent fuel pool	2 hours
	<u>AND</u> A.1.2 Maintain TRANSFER CASK and CANISTER in spent fuel pool for a minimum of 24 hours	Prior to restart of LOADING OPERATIONS
	<u>OR</u>	
	A.2.1 Commence supplying air to the TRANSFER CASK annulus fill/drain lines at a rate of 375 CFM and a maximum temperature of 76°F	2 hours
	<u>AND</u> A.2.2 Maintain airflow for a minimum of 24 hours	Prior to restart of LOADING OPERATIONS

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.1.4.1	Monitor elapsed time from completion of helium backfill until completion of transfer of loaded CANISTER into CONCRETE CASK	Once at completion of helium backfill <u>AND</u> 4 hours thereafter
SR 3.1.4.2	Monitor elapsed time from completion of in-pool or forced-air cooling until completion of transfer of loaded CANISTER into CONCRETE CASK	Once at completion of cooling operations <u>AND</u> 4 hours thereafter

A 3.1 NAC-UMS® SYSTEM Integrity

A 3.1.5 CANISTER Helium Leak Rate

LCO 3.1.5 There shall be no indication of a helium leak at a test sensitivity of 1×10^{-7} cm^3/sec (helium) through the CANISTER shield lid to CANISTER shell confinement weld to demonstrate a helium leak rate equal to or less than 2×10^{-7} cm^3/sec (helium).

APPLICABILITY: During LOADING OPERATIONS

ACTIONS

--NOTE--

Separate Condition entry is allowed for each NAC-UMS® SYSTEM.

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. CANISTER helium leak rate limit not met	A.1 Establish CANISTER helium leak rate within limit	25 days
B. Required Action and associated Completion Time not met	B.1 Remove all fuel assemblies from the NAC-UMS® SYSTEM	5 days

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.1.5.1	Verify CANISTER helium leak rate is within limit	Once prior to TRANSPORT OPERATIONS.

A 3.1 NAC-UMS® SYSTEM

A 3.1.6 CONCRETE CASK Heat Removal System

LCO 3.1.6 The CONCRETE CASK Heat Removal System shall be OPERABLE.

APPLICABILITY: During STORAGE OPERATIONS

ACTIONS

-----NOTE-----

Separate Condition entry is allowed for each NAC-UMS® SYSTEM.

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. CONCRETE CASK Heat Removal System inoperable	A.1 Restore CONCRETE CASK Heat Removal System to OPERABLE status	8 hours
B. Required Action A.1 and associated Completion Time not met	B.1 Perform SR 3.1.6.1	Immediately and every 6 hours thereafter
	AND	
	B.2.1 Restore CONCRETE CASK Heat Removal System to OPERABLE status	12 hours

(continued)

CONDITION	REQUIRED ACTION	COMPLETION TIME

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.1.6.1	Verify the difference between the average CONCRETE CASK air outlet temperature and ISFSI ambient temperature is ≤ 102°F (for the PWR CANISTER) and ≤ 92°F (for the BWR CANISTER)	24 hours

A 3.1 NAC-UMS® SYSTEM Integrity

A 3.1.7 CANISTER Removal from the CONCRETE CASK

LCO 3.1.7 The following limits for TRANSFER OPERATIONS shall be met, as appropriate:

1. The time duration for holding the CANISTER in the TRANSFER CASK shall not exceed the limits defined in LCO 3.1.4(1).
2. The time duration for holding the CANISTER in the TRANSFER CASK using external forced air cooling of the CANISTER is not limited.

APPLICABILITY: During TRANSFER OPERATIONS

ACTIONS

---------------------------------------NOTE---------------------------------------

Separate Condition entry is allowed for each NAC-UMS® SYSTEM.

Separate Condition entry to this LCO is allowed following each 24-hour period of continuous forced air cooling.

(continued)

CONDITION	REQUIRED ACTION		COMPLETION TIME
A. Loaded CANISTER held in TRANSFER CASK	A.1	Load CANISTER into operable CONCRETE CASK	4 hours
	OR A.2	Load CANISTER into TRANSPORT CASK	4 hours
	OR A.3	Perform A.1.1 or A.2.1 following a minimum of 24-hours of forced air cooling	4 hours
B. Required Actions in A and associated Completion Time not met	B.1	Commence supplying air to the TRANSFER CASK annulus fill/drain lines at a rate of 375 CFM and a maximum temperature of 76°F	2 hours
	AND B.2	Maintain forced air cooling. Condition A of this LCO may be re-entered after 24 hours of forced air cooling	24 hours

(continued)

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.1.7.1	Monitor elapsed time from closing of the TRANSFER CASK bottom shield doors until unloading of the CANISTER from the TRANSFER CASK	Once at closing of the TRANSFER CASK bottom shield doors AND 2 hours thereafter
SR 3.1.7.2	Monitor continuous forced air cooling operation until unloading of the CANISTER from the TRANSFER CASK	Once at start of cooling operations AND 6 hours thereafter

A 3.2 NAC-UMS® SYSTEM Radiation Protection

A 3.2.1 <u>CANISTER Surface Contamination</u>

LCO 3.2.1 Removable contamination on the accessible exterior surfaces of the CANISTER or accessible interior surfaces of the TRANSFER CASK shall each not exceed:

a. 10,000 dpm/100 cm^2 from beta and gamma sources; and

b. 100 dpm/100 cm^2 from alpha sources.

APPLICABILITY: During LOADING OPERATIONS

ACTIONS

-----NOTE-----
Separate Condition entry is allowed for each NAC-UMS® SYSTEM.

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. CANISTER or TRANSFER CASK removable surface contamination limits not met	A.1 Restore CANISTER and TRANSFER CASK removable surface contamination to within limits	7 days

(continued)

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.2.1.1	Verify that the removable contamination on the accessible exterior surfaces of the CANISTER is within limits	Once, prior to TRANSPORT OPERATIONS
SR 3.2.1.2	Verify that the removable contamination on the accessible interior surfaces of the TRANSFER CASK does not exceed limits	Once, prior to TRANSPORT OPERATIONS

A 3.2 NAC-UMS® SYSTEM Radiation Protection

A 3.2.2 CONCRETE CASK Average Surface Dose Rates

LCO 3.2.2 The average surface dose rates of each CONCRETE CASK shall not exceed the following limits unless required ACTIONS A.1 and A.2 are met.

a. 50 mrem/hour (neutron + gamma) on the side (on the concrete surfaces);

b. 50 mrem/hour (neutron + gamma) on the top;

c. 100 mrem/hour (neutron + gamma) at air inlets and outlets.

APPLICABILITY: During LOADING OPERATIONS

ACTIONS

-----------------------------------NOTE-----------------------------------

Separate Condition entry is allowed for each NAC-UMS® SYSTEM.

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. CONCRETE CASK average surface dose rate limits not met	A.1 Administratively verify correct fuel loading AND	24 hours

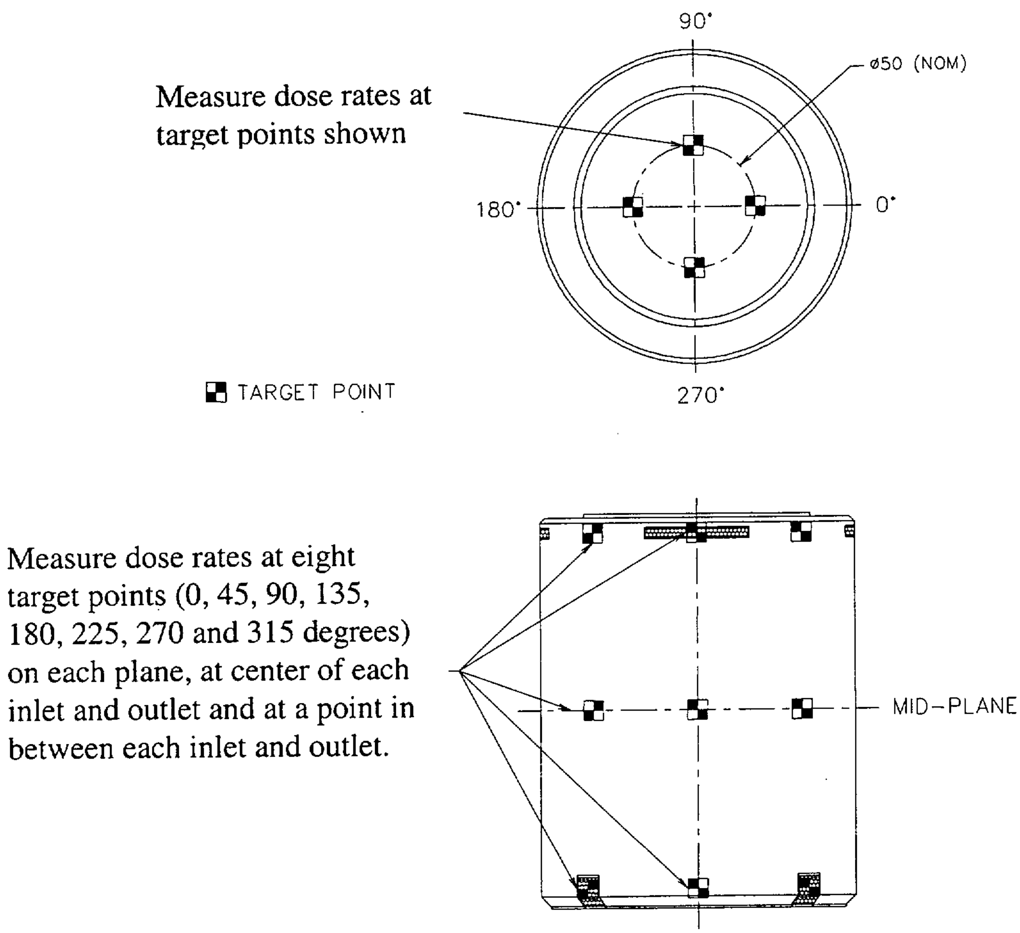
(continued)

CONDITION	REQUIRED ACTION	COMPLETION TIME
	A.2 Perform analysis to verify compliance with the ISFSI offsite radiation protection requirements of 10 CFR 20 and 10 CFR 72	7 days
B. Required Action and associated Completion Time not met.	B.1 Remove all fuel assemblies from the NAC-UMS® SYSTEM	30 days

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.2.2.1	Verify average surface dose rates of CONCRETE CASK loaded with a CANISTER containing fuel assemblies are within limits. Dose rates shall be measured at the locations shown in Figure 12A3-1.	Once after completion of transfer of CANISTER into CONCRETE CASK and prior to beginning STORAGE OPERATIONS.

Figure 12A3-1 CONCRETE CASK Surface Dose Rate Measurement



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A 5.0 ADMINISTRATIVE CONTROLS AND PROGRAMS

A 5.1 Training Program

A training program for the NAC-UMS® Universal Storage System shall be developed under the general licensee's systematic approach to training (SAT). Training modules shall include comprehensive instructions for the operation and maintenance of the NAC-UMS® Universal Storage System and the independent spent fuel storage installation (ISFSI).

A 5.2 Pre-Operational Testing and Training Exercises

A dry run training exercise on loading, closure, handling, unloading, and transfer of the NAC-UMS® Storage System shall be conducted by the licensee prior to the first use of the system to load spent fuel assemblies. The training exercise shall not be conducted with spent fuel in the CANISTER. The dry run may be performed in an alternate step sequence from the actual procedures, but all steps must be performed. The dry run shall include, but is not limited to the following:

a. Moving the CONCRETE CASK into its designated loading area
b. Moving the TRANSFER CASK containing the empty CANISTER into the spent fuel pool
c. Loading one or more dummy fuel assemblies into the CANISTER, including independent verification
d. Selection and verification of fuel assemblies requiring preferential loading
e. Installing the shield lid
f. Removal of the TRANSFER CASK from the spent fuel pool
g. Closing and sealing of the CANISTER to demonstrate pressure testing, vacuum drying, helium backfilling, welding, weld inspection and documentation, and leak testing
h. TRANSFER CASK movement through the designated load path
i. TRANSFER CASK installation on the CONCRETE CASK
j. Transfer of the CANISTER to the CONCRETE CASK

(continued)

A 5.2 Pre-Operational Testing and Training Exercises (continued)

k. CONCRETE CASK shield plug and lid installation
l. Transport of the CONCRETE CASK to the ISFSI
m. CANISTER unloading, including reflooding and weld removal or cutting
n. CANISTER removal from the CONCRETE CASK

Appropriate mockup fixtures may be used to demonstrate and/or to qualify procedures, processes or personnel in welding, weld inspection, vacuum drying, helium backfilling, leak testing and weld removal or cutting.

A 5.3 Special Requirements for the First System Placed in Service

The heat transfer characteristics and performance of the NAC-UMS® SYSTEM will be recorded by air inlet and outlet temperature measurements of the first system placed in service with a heat load equal to or greater than 10 kW. A letter report summarizing the results of the measurements will be submitted to the NRC in accordance with 10 CFR 72.4 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.

A 5.4 Control of Boron Concentration in Pool Water During Loading

The criticality analysis shows that PWR fuel with certain combinations of initial enrichment and fuel content require credit for the presence of at least 1,000 parts per million of boron in solution in the fuel pool water (see Section B3.2.1 for the requirements for the pool soluble boron concentration during loading). This water must be used to flood the canister cavity during underwater PWR fuel loading. The boron in the pool water ensures sufficient thermal neutron absorption to preserve criticality control during fuel loading in the basket. Consequently, if boron credit is required for the fuel being loaded, the canister must be flooded with water that contains boron in the proper concentration. Measurement of pool water boron concentration must be done prior to the submergence of the canister in the pool. The pool boron concentration must be measured or an assessment must be performed to

(continued)

A 5.4 Control of Boron Concentration in Pool Water During Loading (continued)

assure that the boron concentration remains above 1000 ppm any time that the concentration of boron might be diluted by the influx of unborated water.

A 5.5 Surveillance After an Off-Normal, Accident, or Natural Phenomena Event

A Response Surveillance is required following off-normal, accident or natural phenomena events. The NAC-UMS® SYSTEMs in use at an ISFSI shall be inspected within 4 hours after the occurrence of an off-normal, accident or natural phenomena event in the area of the ISFSI. This inspection must specifically verify that all the CONCRETE CASK inlets and outlets are not blocked or obstructed. At least one-half of the inlets and outlets on each CONCRETE CASK must be cleared of blockage or debris within 24 hours to restore air circulation.

The CONCRETE CASK and CANISTER shall be inspected if they experience a drop or a tipover.

A 5.6 Radioactive Effluent Control Program

The program implements the requirements of 10 CFR 72.126.

a. The NAC-UMS® SYSTEM does not create any radioactive materials or have any radioactive waste treatment systems. Therefore, specific operating procedures for the control of radioactive effluents are not required. LCO 3.1.5, CANISTER Helium Leak Rate, provides assurance that there are no radioactive effluents from the NAC-UMS® SYSTEM.

b. This program includes an environmental monitoring program. Each general license user may incorporate NAC-UMS® SYSTEM operations into their environmental monitoring program for 10 CFR Part 50 operations.

(continued)

A 5.7 NAC-UMS® SYSTEM Transport Evaluation Program

This program provides a means for evaluating various transport configurations and transport route conditions to ensure that the design basis drop limits are met. For lifting of the loaded TRANSFER CASK or CONCRETE CASK using devices that are integral to a structure governed by 10 CFR Part 50 regulations, 10 CFR 50 requirements apply. This program is not applicable when the TRANSFER CASK or CONCRETE CASK is in the fuel building or is being handled by a device providing support from underneath (i.e., on a rail car, heavy haul trailer, air pads, etc.).

Pursuant to 10 CFR 72.212, this program shall evaluate the site specific transport route conditions.

a. The lift height above the transport surface prescribed in Section B3.4.6 of Appendix B to Certificate of Compliance (CoC) No. 1015 shall not exceed the limits in Table 12A5-1. Also, the program shall ensure that the transport route conditions (i.e., surface hardness and pad thickness) are equivalent to or less limiting than those prescribed for the reference pad surface which forms the basis for the values cited in the NAC-UMS® FSAR, Sections 11.2.12.3 and 11.2.15.1.1.

b. For site specific transport conditions which are not bounded by the surface characteristics in Section B3.4.6 of Appendix B to CoC No. 1015, the program may evaluate the site specific conditions to ensure that the impact loading due to design basis drop events does not exceed 60g. This alternative analysis shall be commensurate with the drop analyses described in the Safety Analysis Report for the NAC-UMS® SYSTEM. The program shall ensure that these alternative analyses are documented and controlled.

c. The TRANSFER CASK and CONCRETE CASK may be lifted to those heights necessary to perform cask handling operations, including CANISTER transfer, provided the lifts are made with structures and components designed in accordance with the criteria specified in Section B3.5 of Appendix B to CoC No. 1015, as applicable.

(continued)

A 5.8 Verification of Oxide Layer Thickness on High Burnup Fuel

A verification program is required to determine the oxide layer thickness on high burnup fuel by measurement or by statistical analysis. A fuel assembly having a burnup between 45,000 MWD/MTU and 50,000 MWD/MTU is classified as high burnup. The verification program shall be capable of classifying high burnup fuel as INTACT FUEL or DAMAGED FUEL based on the following criteria:

1. A HIGH BURNUP FUEL assembly may be stored as INTACT FUEL provided that no more than 1% of the fuel rods in the assembly have a peak cladding oxide thickness greater than 80 microns, and that no more than 3% of the fuel rods in the assembly have a peak oxide layer thickness greater than 70 microns, and that the fuel assembly is otherwise INTACT FUEL.

2. A HIGH BURNUP FUEL assembly not meeting the cladding oxide thickness criteria for INTACT FUEL or that has an oxide layer that is detached or spalled from the cladding is classified as DAMAGED FUEL.

A fuel assembly, having a burnup between 45,000 and 50,000 MWD/MTU, must be preferentially loaded in periphery positions of the basket.

Table 12A5-1 TRANSFER CASK and CONCRETE CASK Lifting Requirements

Item	Orientation	Lifting Height Limit
TRANSFER CASK	Horizontal	None Established
TRANSFER CASK	Vertical	None Established[1]
CONCRETE CASK	Horizontal	Not Permitted
CONCRETE CASK	Vertical	< 24 inches

Note:

1. See Technical Specification A5.7(c).

APPENDIX 12B

APPROVED CONTENTS AND DESIGN FEATURES FOR THE NAC-UMS® SYSTEM

Appendix 12B
Table of Contents

Appendix 12B
Table of Contents (continued)

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B 2.0 APPROVED CONTENTS

B 2.1 Fuel Specifications and Loading Conditions

The NAC-UMS® System is designed to provide passive dry storage of canistered PWR and BWR spent fuel. The system requires few operating controls. The principal controls and limits for the NAC-UMS® SYSTEM are satisfied by the selection of fuel for storage that meets the Approved Contents presented in this section and in Tables 12B2-1 through 12B2-5 for the standard NAC-UMS® SYSTEM design basis spent fuels.

This section also permits the loading of fuel assemblies that are unique to specific reactor sites. SITE SPECIFIC FUEL assembly configurations are either shown to be bounded by the analysis of the standard NAC-UMS® System 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.

The separate specific evaluation may establish different limits, which are maintained by administrative controls for preferential loading. The preferential loading controls allow the loading of fuel configurations that may have higher burnup, additional hardware material or unique configurations as compared to the standard NAC-UMS® System design basis spent fuels.

Unless specifically excepted, SITE SPECIFIC FUEL must meet all of the controls and limits specified for the NAC-UMS® System, as presented in Table 12-1.

If any Fuel Specification or Loading Conditions of this section are violated, the following actions shall be completed:

- The affected fuel assemblies shall be placed in a safe condition.
- Within 24 hours, notify the NRC Operations Center.
- Within 30 days, submit a special report that describes the cause of the violation and actions taken to restore or demonstrate compliance and prevent recurrence.

(continued)

B 2.1.1 Fuel to be Stored in the NAC-UMS® SYSTEM

INTACT FUEL ASSEMBLIES meeting the limits specified in Tables 12B2-1 through 12B2-5 may be stored in the NAC-UMS® SYSTEM.

B 2.1.2 Preferential Fuel Loading

The normal temperature distribution in the loaded TRANSPORTABLE STORAGE CANISTER results in the basket having the highest temperature at its center and lowest temperature at the outer edge. Considering this temperature distribution, spent fuel with the shortest cooling time (and, therefore, having a higher allowable cladding temperature) is placed in the center of the basket. Fuel with the longest cooling time (and, therefore, having a lower allowable cladding temperature) is placed in the periphery of the basket.

Using a similar argument, fuel assemblies with cooling times between the highest and lowest cooling times of the designated fuel, are placed in intermediate fuel positions.

Loading of the fuel assemblies designated for a given TRANSPORTABLE STORAGE CANISTER must be administratively controlled to ensure that the dry storage fuel cladding temperature limits are not exceeded for any fuel assembly, unless all of the designated fuel assemblies have a cooling time of 7 years of more.

CANISTERS containing fuel assemblies, all of which have a cooling time of 7 years, or more, do not require preferential loading, because analyses have shown that the fuel cladding temperature limits will always be met for those CANISTERS.

CANISTERS containing fuel assemblies with cooling times from 5 to 7 years must be preferentially loaded based on cooling time. By controlling the placement of the fuel assemblies with the shortest cooling time (thermally hottest), preferential loading ensures that the allowable fuel cladding temperature for a given fuel assembly is not exceeded. The preferential loading of fuel into the CANISTER based on cooling time is described as follows.

(continued)

For the PWR fuel basket configuration, shown in Figure 12B2-1, fuel positions are numbered using the drain line as the reference point. Fuel positions 9, 10, 15 and 16 are considered to be basket center positions for the purpose of meeting the preferential loading requirement. The fuel with the shortest cooling times from among the fuel designated for loading in the CANISTER will be placed in the center positions. A single fuel assembly having the shortest cooling time may be loaded in any of these four positions. Fuel positions 1, 2, 3, 6, 7, 12, 13, 18, 19, 22, 23 and 24 are periphery positions, where fuel with the longest cooling times will be placed. Fuel with the longest cooling times may be loaded in any of these 12 positions. Similarly, designated fuel assemblies with cooling times in the midrange of the shortest and longest cooling times will be loaded in the intermediate fuel positions – 4, 5, 8, 11, 14, 17, 20 and 21.

For the BWR fuel basket configuration, shown in Figure 12B2-2, fuel positions are also numbered using the drain line as the reference point. Fuel positions 23, 24, 25, 32, 33 and 34 are considered to be basket center positions for the purpose of meeting the preferential loading requirement. The fuel with the shortest cooling times from among the fuel designated for loading in the CANISTER will be placed in the center positions. However, the single fuel assembly having the shortest cooling time will be loaded in either position 24 or position 33. Fuel positions 1, 2, 3, 4, 5, 6, 12, 13, 19, 20, 28, 29, 37, 38, 44, 45, 51, 52, 53, 54, 55 and 56 are periphery positions, where fuel with the longest cooling times will be placed. Fuel with the longest cooling times may be loaded in any of these 22 positions. Designated fuel assemblies with cooling times in the midrange of the shortest and longest cooling times will be divided into two tiers. The fuel assemblies with the shorter cooling times in the midrange will be loaded in the inner intermediate fuel positions - 15, 16, 17, 22, 26, 31, 35, 40, 41, and 42. Fuel assemblies with the longer cooling times in the midrange will be loaded in the outer intermediate fuel positions - 7, 8, 9, 10, 11, 14, 18, 21, 27, 30, 36, 39, 43, 46, 47, 48, 49 and 50. These loading patterns result in the placement of fuel such that the shortest-cooled fuel is in the center of the basket and the longest-cooled fuel is on the periphery. Based on engineering evaluations, this loading pattern ensures that fuel assembly allowable cladding temperatures are satisfied.

(continued)

B 2.1.3 Maine Yankee SITE SPECIFIC FUEL Preferential Loading

The estimated Maine Yankee SITE SPECIFIC FUEL inventory is shown in Table 12B2-6. As shown in this table, certain of the Maine Yankee fuel configurations must be preferentially loaded in specific basket fuel tube positions.

Corner positions are used for CONSOLIDATED FUEL, certain HIGH BURNUP FUEL and DAMAGED FUEL or FUEL DEBRIS loaded in a MAINE YANKEE FUEL CAN, for fuel assemblies with missing fuel rods, burnable poison rods or fuel assemblies with fuel rods that have been replaced by hollow Zircaloy rods. Designation for placement in corner positions results primarily from shielding or criticality evaluations of these fuel configurations. CONSOLIDATED FUEL is conservatively designated for a corner position, even though analysis shows that these lattices could be loaded in any basket position. Corner positions are positions 3, 6, 19, and 22 in Figure 12B2-1.

Preferential loading is also used for HIGH BURNUP fuel not loaded in the MAINE YANKEE FUEL CAN. This fuel is assigned to peripheral locations, positions 1, 2, 3, 6, 7, 12, 13, 18, 19, 22, 23, and 24 in Figure 12B2-1. The interior locations must be loaded with fuel that has lower burnup and/or longer cool times to maintain the design basis heat load and component temperature limits for the basket and canister, and the spent fuel short-term temperature limits, as described in Section B 2.1.2.

One of the three loading patterns (Standard, 1.05 kW (periphery), or 0.958 kW [periphery]) shown in Table 12B2-8 must be used to load each canister. Once selected, all of the spent fuel in that canister must be loaded in accordance with that pattern. Within a pattern, mixing of enrichment and cool time is allowed, but no mixing of loading patterns is permitted. For example, choosing a Perf (1.05) pattern restricts the interior fuel to the cool times shown in the Perf (1.05i) column, and the peripheral fuel to the cool times shown in the Perf (1.05p) column.

Fuel assemblies with a control element assembly (CEA) inserted will be loaded in a Class 2 canister and basket due to the increased length of the assembly with the CEA installed. However, these assemblies are not restricted as to loading position within the basket. Fuel assemblies with non-fuel items installed in corner guide tubes of the fuel assembly must also have a flow mixer installed and must be loaded in a basket corner fuel position in a Class 2 canister.

(continued)

The Transportable Storage Canister loading procedures indicates that loading of a fuel configuration with removed fuel or poison rods, CONSOLIDATED FUEL, or a MAINE YANKEE FUEL CAN with DAMAGED FUEL, FUEL DEBRIS or HIGH BURNUP FUEL, is administratively controlled in accordance with Section B 2.1.

Figure 12B2-1 PWR Basket Fuel Loading Positions

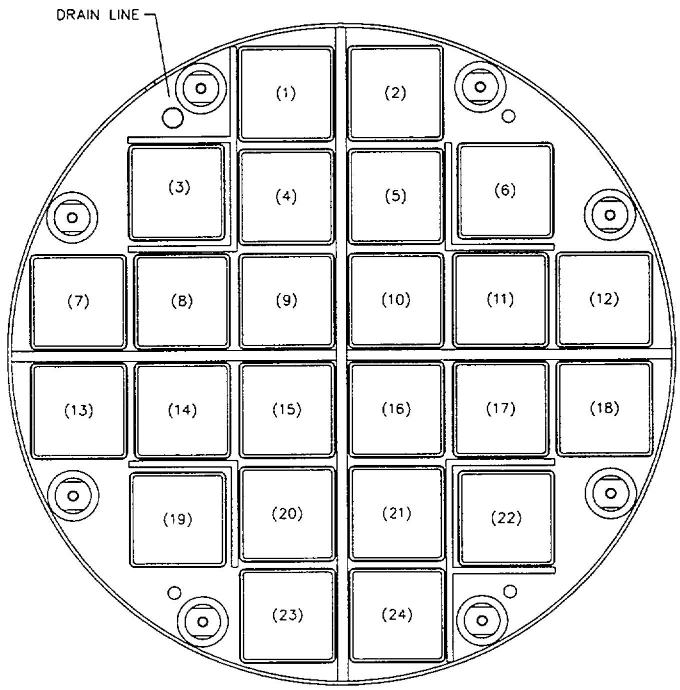

Figure 12B2-2 BWR Basket Fuel Loading Positions

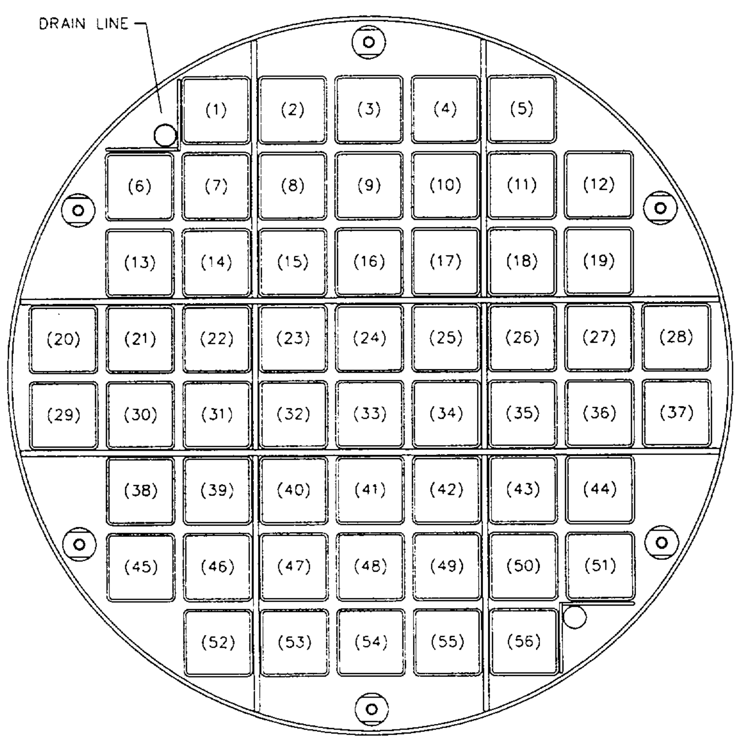

Table 12B2-1
Fuel Assembly Limits

I. NAC-UMS® CANISTER: PWR FUEL

A. Allowable Contents

1. Uranium oxide PWR INTACT FUEL ASSEMBLIES listed in Table 12B2-2 and meeting the following specifications:

a. Cladding Type:	Zircaloy with thickness as specified in Table 12B2-2 for the applicable fuel assembly class.
b. Enrichment, Post-irradiation Cooling Time and Average Burnup Per Assembly:	Maximum enrichment limits are shown in Table 12B2-2. For variable enrichment fuel assemblies, maximum enrichments represent peak rod enrichments. Combined minimum enrichment, maximum burnup and minimum cool time limits are shown in Table 12B2-4.
c. Decay Heat Per Assembly:	$\leq$ 958.3 watts †
d. Nominal Fresh Fuel Assembly Length (in.):	$\leq$ 178.3
e. Nominal Fresh Fuel Assembly Width (in.):	$\leq$ 8.54
f. Fuel Assembly Weight (lbs.):	$\leq$ 1,602 ‡

† Decay heat may be higher for site-specific configurations, which control fuel loading position.

‡ Includes the weight of nonfuel-bearing components.

B. Quantity per CANISTER: Up to 24 PWR INTACT FUEL ASSEMBLIES.

C. PWR INTACT FUEL ASSEMBLIES may contain a flow mixer, an in-core instrument thimble or a burnable poison rod insert (Class 1 and Class 2 contents) consistent with Table 12B2-2.

D. PWR INTACT FUEL ASSEMBLIES shall not contain a control element assembly, except as permitted for site-specific fuel.

E. Stainless steel spacers may be used in CANISTERS to axially position PWR INTACT FUEL ASSEMBLIES that are shorter than the available cavity length to facilitate handling.

F. Unenriched fuel assemblies are not authorized for loading.

G. The minimum length of the PWR INTACT FUEL ASSEMBLY internal structure and bottom end fitting and/or spacers shall ensure that the minimum distance to the fuel region from the base of the CANISTER is 3.2 inches.

H. PWR INTACT FUEL ASSEMBLIES with one or more grid spacers missing or damaged such that the unsupported length of the fuel rods does not exceed 60 inches. End fitting damage including damaged or missing hold-down springs is allowed, as long as the assembly can be handled safely by normal means.

Table 12B2-1
Fuel Assembly Limits (continued)

II. NAC-UMS® CANISTER: BWR FUEL

A. Allowable Contents

1. Uranium oxide BWR INTACT FUEL ASSEMBLIES listed in Table 12B2-3 and meeting the following specifications:

a. Cladding Type:	Zircaloy with thickness as specified in Table 12B2-3 for the applicable fuel assembly class.
b. Enrichment:	Maximum and minimum INITIAL PEAK PLANAR-AVERAGE ENRICHMENTS are 4.0 and 1.9 wt % ^{235}U, respectively. Fuel enrichment, burnup and cooling time are related as shown in Table 12B2-5.
c. Decay Heat per Assembly:	≤ 410.7 watts
d. Post-irradiation Cooling Time and Average Burnup Per Assembly:	As specified in Table 12B2-5 and for the applicable fuel assembly class.
e. Nominal Fresh Fuel Design Assembly Length (in.):	≤ 176.1
f. Nominal Fresh Fuel Design Assembly Width (in.):	≤ 5.51
g. Fuel Assembly Weight (lbs):	≤ 702, including channels

Table 12B2-1
Fuel Assembly Limits (continued)

B. Quantity per CANISTER: Up to 56 BWR INTACT FUEL ASSEMBLIES

C. BWR INTACT FUEL ASSEMBLIES can be unchanneled or channeled with Zircaloy channels.

D. BWR INTACT FUEL ASSEMBLIES with stainless steel channels shall not be loaded.

E. Stainless steel fuel spacers may be used in CANISTERS to axially position BWR INTACT FUEL ASSEMBLIES that are shorter than the available cavity length to facilitate handling.

F. Unenriched fuel assemblies are not authorized for loading.

G. The minimum length of the BWR INTACT FUEL ASSEMBLY internal structure and bottom end fitting and/or spacers shall ensure that the minimum distance to the fuel region from the base of the CANISTER is 6.2 inches.

Table 12B2-2 PWR Fuel Assembly Characteristics

Fuel Class	Vendor[1]	Array	Max. MTU	Max. wt % ^{235}U [4]	Max. wt % ^{235}U [5]	No of Fuel Rods	No of Water Holes	Max. Pitch (in)	Min. Rod Dia. (in)	Min. Clad Thick (in)	Max. Pellet Dia.(in)	Max. Active Length (in)	Min. Guide Tube Thick (in)
1	CE	14×14	0.404	5.0	5.0	176	5	0.590	0.438	0.024	0.380	137.0	0.034
1	Ex/ANF	14×14	0.369	5.0	5.0	179	17	0.556	0.424	0.030	0.351	142.0	0.034
1	WE	14×14	0.362	5.0	5.0	179	17	0.556	0.400	0.024	0.345	144.0	0.034
1	WE	14×14	0.415	5.0	5.0	179	17	0.556	0.422	0.022	0.368	145.2	0.034
1	WE, Ex/ANF	15×15	0.465	4.6	5.0	204	21	0.563	0.422	0.024	0.366	144.0	0.015
1	Ex/ANF	17×17	0.413	4.3	5.0	264	25	0.496	0.360	0.025	0.303	144.0	0.016
1	WE	17×17	0.468	4.3	5.0	264	25	0.496	0.374	0.022	0.323	144.0	0.016
1	WE	17×17	0.429	4.3	5.0	264	25	0.496	0.360	0.022	0.309	144.0	0.016
2	B&W	15×15	0.481	4.4	5.0	208	17	0.568	0.430	0.026	0.369	144.0	0.016
2	B&W	17×17	0.466	4.3	5.0	264	25	0.502	0.379	0.024	0.324	143.0	0.017
3	CE	16×16	0.442	4.8	5.0	236[3]	5	0.506	0.382	0.023	0.3255	150.0	0.035
1	Ex/ANF[2]	14×14	0.375	5.0	5.0	179	17	0.556	0.417	0.030	0.351	144.0	0.036
1	CE[2]	15×15	0.432	4.2	5.0	216	9[6]	0.550	0.418	0.026	0.358	132.0	----
1	Ex/ANF[3]	15×15	0.431	4.2	5.0	216	9[6]	0.550	0.417	0.030	0.358	131.8	----
1	CE[2]	16×16	0.403	4.8	5.0	236	5	0.506	0.382	0.023	0.3255	136.7	0.035

Note: Parameters shown are nominal pre-irradiation values.

1. Vendor ID indicates the source of assembly base parameters, which are nominal, pre-irradiation values. Loading of assemblies meeting above limits is not restricted to the vendor(s) listed.
2. 14×14, 15×15 and 16×16 fuel manufactured for Prairie Island, Palisades and St. Lucie 2 cores, respectively. These are not generic fuel assemblies provided to multiple reactors.
3. Fuel rod positions may be occupied by burnable poison rods or solid filler rods.
4. Maximum initial enrichment without boron credit. Assemblies meeting this limit may contain a flow mixer, an ICI thimble or a burnable poison rod insert.
5. Maximum initial enrichment with taking credit for a minimum soluble boron concentration of 1000-ppm in the spent fuel pool water. Assemblies meeting this limit may contain a flow mixer.
6. 9 non-fuel locations, which may be filled by solid non-fuel rods.

Table 12B2-3 BWR Fuel Assembly Characteristics

Fuel Class[1,5]	Vendor[4]	Array	Max. MTU	No of Fuel Rods	Max. Pitch (in)	Min. Rod Dia. (in)	Min. Clad Thick (in)	Max. Pellet Dia.(in)	Max. Active Length (in)[2]
4[5]	Ex/ANF	7 × 7	0.196	48	0.738	0.570	0.036	0.490	144.0
4	Ex/ANF	8 × 8	0.177	63	0.641	0.484	0.036	0.405	145.2
4	Ex/ANF	9 × 9	0.173	79	0.572	0.424	0.030	0.357	145.2
4	GE	7 × 7	0.199	49	0.738	0.570	0.036	0.488	144.0
4	GE	7 × 7	0.198	49	0.738	0.563	0.032	0.487	144.0
4	GE	8 × 8	0.173	60	0.640	0.484	0.032	0.410	145.2
4	GE	8 × 8	0.179	62	0.640	0.483	0.032	0.410	145.2
4	GE	8 × 8	0.186	63	0.640	0.493	0.034	0.416	144.0
5	Ex/ANF	8 × 8	0.180	62	0.641	0.484	0.036	0.405	150.0
5	Ex/ANF	9 × 9	0.167	74[3]	0.572	0.424	0.030	0.357	150.0
5[6]	Ex/ANF	9 × 9	0.178	79[3]	0.572	0.424	0.030	0.357	150.0
5	GE	7 × 7	0.198	49	0.738	0.563	0.032	0.487	144.0
5	GE	8 × 8	0.179	60	0.640	0.484	0.032	0.410	150.0
5	GE	8 × 8	0.185	62	0.640	0.483	0.032	0.410	150.0
5	GE	8 × 8	0.188	63	0.640	0.493	0.034	0.416	146.0
5	GE	9 × 9	0.186	74[3]	0.566	0.441	0.028	0.376	150.0
5	GE	9 × 9	0.198	79[3]	0.566	0.441	0.028	0.376	150.0

Note: Parameters shown are nominal pre-irradiation values.

1. Maximum Initial Peak Planar Average Enrichment 4.0 wt % ^{235}U. All fuel rods are Zircaloy clad.
2. 150 inch active fuel length assemblies contain 6" natural uranium blankets on top and bottom.
3. Shortened active fuel length in some rods.
4. Vendor ID indicates the source of assembly base parameters, which are nominal, pre-irradiation values. Loading of assemblies meeting above limits is not restricted to the vendor(s) listed.
5. UMS Class 4 and 5 for BWR 2/3 fuel.
6. Assembly width including channel. Unchanneled or channeled assemblies may be loaded based on a maximum channel thickness of 120 mil.

Table 12B2-4 Minimum Cooling Time Versus Burnup/Initial Enrichment for PWR Fuel

Minimum Initial Enrichment	Burnup ≤30 GWD/MTU Minimum Cooling Time [years]				30< Burnup ≤35 GWD/MTU Minimum Cooling Time [years]			
wt % ^{235}U (E)	14×14	15×15	16×16	17×17	14×14	15×15	16×16	17×17
1.9 ≤ E < 2.1	5	5	5	5	7	7	5	7
2.1 ≤ E < 2.3	5	5	5	5	7	6	5	6
2.3 ≤ E < 2.5	5	5	5	5	6	6	5	6
2.5 ≤ E < 2.7	5	5	5	5	6	6	5	6
2.7 ≤ E < 2.9	5	5	5	5	6	5	5	5
2.9 ≤ E < 3.1	5	5	5	5	5	5	5	5
3.1 ≤ E < 3.3	5	5	5	5	5	5	5	5
3.3 ≤ E < 3.5	5	5	5	5	5	5	5	5
3.5 ≤ E < 3.7	5	5	5	5	5	5	5	5
3.7 ≤ E ≤ 4.9	5	5	5	5	5	5	5	5
E ≥ 4.9	5	5	5	5	5	5	5	5
Minimum Initial Enrichment	**35< Burnup ≤40 GWD/MTU Minimum Cooling Time [years]**				**40< Burnup ≤45 GWD/MTU Minimum Cooling Time [years]**			
wt % ^{235}U (E)	**14×14**	**15×15**	**16×16**	**17×17**	**14×14**	**15×15**	**16×16**	**17×17**
1.9 ≤ E < 2.1	10	10	7	10	15	15	11	15
2.1 ≤ E < 2.3	9	9	7	9	14	13	10	13
2.3 ≤ E < 2.5	8	8	6	8	12	13	10	12
2.5 ≤ E < 2.7	8	8	6	8	11	13	10	12
2.7 ≤ E < 2.9	7	8	6	8	10	12	9	12
2.9 ≤ E < 3.1	7	8	6	8	9	12	9	11
3.1 ≤ E < 3.3	6	8	6	7	8	12	9	10
3.3 ≤ E < 3.5	6	8	6	7	8	12	9	10
3.5 ≤ E < 3.7	6	8	6	6	8	11	9	10
3.7 ≤ E ≤3.9	6	7	6	6	8	10	9	10
3.9 ≤ E ≤4.1	6	6	6	6	8	10	9	10
4.1 ≤ E ≤4.3	5	6	6	6	8	10	9	10
4.3 ≤ E ≤4.7	5	6	6	6	7	10	8	9
4.7 ≤ E ≤4.9	5	6	5	6	6	10	8	9
E ≥ 4.9	5	6	5	6	6	10	8	9

Approved Contents
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Table 12B2-5 Minimum Cooling Time Versus Burnup/Initial Enrichment for BWR Fuel

Minimum Initial Enrichment wt % ^{235}U (E)	Burnup ≤30 GWD/MTU Minimum Cooling Time [years]			30< Burnup ≤35 GWD/MTU Minimum Cooling Time [years]		
	7×7	8×8	9×9	7×7	8×8	9×9
1.9 ≤ E < 2.1	5	5	5	8	7	7
2.1 ≤ E < 2.3	5	5	5	6	6	6
2.3 ≤ E < 2.5	5	5	5	5	5	5
2.5 ≤ E < 2.7	5	5	5	5	5	5
2.7 ≤ E < 2.9	5	5	5	5	5	5
2.9 ≤ E < 3.1	5	5	5	5	5	5
3.1 ≤ E < 3.3	5	5	5	5	5	5
3.3 ≤ E < 3.5	5	5	5	5	5	5
3.5 ≤ E < 3.7	5	5	5	5	5	5
3.7 ≤ E ≤ 4.9	5	5	5	5	5	5
E ≥ 4.9	5	5	5	5	5	5
Minimum Initial Enrichment wt % ^{235}U (E)	**35< Burnup ≤40 GWD/MTU Minimum Cooling Time [years]**			**40< Burnup ≤45 GWD/MTU Minimum Cooling Time [years]**		
	7×7	8×8	9×9	7×7	8×8	9×9
1.9 ≤ E < 2.1	16	14	15	26	24	25
2.1 ≤ E < 2.3	13	12	12	23	21	22
2.3 ≤ E < 2.5	9	8	8	18	16	17
2.5 ≤ E < 2.7	8	7	7	15	14	14
2.7 ≤ E < 2.9	7	6	6	13	11	12
2.9 ≤ E < 3.1	6	6	6	11	10	10
3.1 ≤ E < 3.3	6	5	6	9	8	9
3.3 ≤ E < 3.5	6	5	6	8	7	8
3.5 ≤ E < 3.7	6	5	6	7	7	7
3.7 ≤ E ≤ 3.9	6	5	5	7	6	7
3.9 ≤ E ≤ 4.3	5	5	5	7	6	7
4.3 ≤ E ≤ 4.5	5	5	5	7	6	6
4.5 ≤ E ≤ 4.9	5	5	5	6	6	6
E ≥ 4.9	5	5	5	6	6	6

Table 12B2-6 Maine Yankee Site Specific Fuel Canister Loading Position Summary

Site Specific Spent Fuel Configurations[1]	**Est. Number of Assemblies**[2]	**Canister Loading Position**
Total Number of Fuel Assemblies[3]	1,434	Any
Inserted Control Element Assembly (CEA)	168	Any
Inserted In-Core Instrument (ICI) Thimble	138	Any
Consolidated Fuel	2	Corner[4]
Fuel Rod Replaced by Rod Enriched to 1.95 wt %	3	Any
Fuel Rod Replaced by Stainless Steel Rod or Zircaloy Rod	18	Any
Fuel Rods Removed	10	Corner[4]
Variable Enrichment[6]	72	Any
Variable Enrichment and Axial Blanket[6]	68	Any
Burnable Poison Rod Replaced by Hollow Zircaloy Rod	80	Corner[4]
Damaged Fuel in MAINE YANKEE FUEL CAN	12	Corner[4]
Burnup between 45,000 and 50,000 MWD/MTU	90	Periphery[5]
MAINE YANKEE FUEL CAN	As Required	Corner[4]
Inserted Start-up Source	4	Corner[4]
Inserted CEA Finger Tip or ICI String Segment	1	Corner[4]

1. All spent fuel, including that held in a Maine Yankee fuel can, must conform to the loading limits presented in Tables 12B2-8 and 12B2-9 for cool time.
2. The number of fuel assemblies in some categories may vary depending on future fuel inspections.
3. Includes these site specific spent fuel configurations and standard fuel assemblies. Standard fuel assemblies may be loaded in any canister position.
4. Basket corner positions are positions 3, 6, 19, and 22 in Figure 12B2-1. Corner positions are also periphery positions.
5. Basket periphery positions are positions 1, 2, 3, 6, 7, 12, 13, 18, 19, 22, 23, and 24 in Figure 12B2-1. Periphery positions include the corner positions.
6. Variably enriched fuel assemblies have a maximum burnup of less than 30,000 MWD/MTU and enrichments greater than 1.9 wt %. The minimum required cool time for these assemblies is 5 years.

Table 12B2-7 Maine Yankee Site Specific Fuel Limits

A. Allowable Contents
   1. Combustion Engineering 14 × 14 PWR INTACT FUEL ASSEMBLIES meeting the specifications presented in Tables 12B2-1, 12B2-2 and 12B2-4.
   2. PWR INTACT FUEL ASSEMBLIES may contain inserted Control Element Assemblies (CEA), In-Core Instrument (ICI) Thimbles or Flow Mixers. CEAs or Flow Mixers may not be inserted in damaged fuel assemblies, consolidated fuel assemblies or assemblies with irradiated stainless steel replacement rods. Fuel assemblies with a CEA or Flow Mixer inserted must be loaded in a Class 2 CANISTER and cannot be loaded in a Class 1 CANISTER. Fuel assemblies without an inserted CEA or CEA Plug, including those with inserted ICI Thimbles, must be loaded in a Class 1 CANISTER.
   3. PWR INTACT FUEL ASSEMBLIES with fuel rods replaced with stainless steel or Zircaloy rods or with Uranium oxide rods nominally enriched up to 1.95 wt %.
   4. PWR INTACT FUEL ASSEMBLIES with fuel rods having variable enrichments with a maximum fuel rod enrichment up to 4.21 wt % ^{235}U and that also have a maximum planar average enrichment up to 3.99 wt % ^{235}U.
   5. PWR INTACT FUEL ASSEMBLIES with annular axial end blankets. The axial end blanket enrichment may be up to 2.6 wt % ^{235}U.
   6. PWR INTACT FUEL ASSEMBLIES with solid filler rods or burnable poison rods occupying up to 16 of 176 fuel rod positions.
   7. PWR INTACT FUEL ASSEMBLIES with one or more grid spacers missing or damaged such that the unsupported length of the fuel rods does not exceed 60 inches or with end fitting damage, including damaged or missing hold-down springs, as long as the assembly can be handled safely by normal means.

B. Allowable Contents requiring preferential loading based on shielding, criticality or thermal constraints. The preferential loading requirement for these fuel configurations is as described in Table 12B2-6.
   1. PWR INTACT FUEL ASSEMBLIES with up to 176 fuel rods missing from the fuel assembly lattice.
   2. PWR INTACT FUEL ASSEMBLIES with a burnup between 45,000 and 50,000 MWD/MTU meeting the requirements of Section A 5.7(1).
   3. PWR INTACT FUEL ASSEMBLIES with a burnable poison rod replaced by a hollow Zircaloy rod.

Table 12B2-7 Maine Yankee Site Specific Fuel Limits (continued)

4. INTACT FUEL ASSEMBLIES with a start-up source in a center guide tube. The assembly must be loaded in a basket corner position and must be loaded in a Class 1 CANISTER. Only one (1) start-up source may be loaded in any fuel assembly or any CANISTER.
5. PWR INTACT FUEL ASSEMBLIES with CEA ends (finger tips) and/or ICI segment inserted in corner guide tube positions. The assembly must also have a CEA plug installed. The assembly must be loaded in a basket corner position and must be loaded in a Class 2 CANISTER.
6. INTACT FUEL ASSEMBLIES may be loaded in a MAINE YANKEE FUEL CAN.
7. FUEL enclosed in a MAINE YANKEE FUEL CAN. The MAINE YANKEE FUEL CAN can only be loaded in a Class 1 CANISTER. The contents that must be loaded in the MAINE YANKEE FUEL CAN are:
   a) PWR fuel assemblies with up to two INTACT or DAMAGED FUEL rods inserted in each fuel assembly guide tube or with up to two burnable poison rods inserted in each guide tube. The rods inserted in the guide tubes cannot be from a different fuel assembly. The maximum number of rods in the fuel assembly (fuel rods plus inserted rods, including burnable poison rods) is 176.
   b) A DAMAGED FUEL ASSEMBLY with up to 100% of the fuel rods classified as damaged and/or damaged or missing assembly hardware components. A DAMAGED FUEL ASSEMBLY cannot have an inserted CEA or other non-fuel component.
   c) Individual INTACT or DAMAGED FUEL rods in a rod type structure, which may be a guide tube, to maintain configuration control.
   d) FUEL DEBRIS consisting of fuel rods with exposed fuel pellets or individual intact or partial fuel pellets not contained in fuel rods.

Table 12B2-7 Maine Yankee Site Specific Fuel Limits (continued)

e) CONSOLIDATED FUEL lattice structure with a 17 × 17 array formed by grids and top and bottom end fittings connected by four solid stainless steel rods. Maximum contents are 289 fuel rods having a total lattice weight ≤ 2,100 pounds. A CONSOLIDATED FUEL lattice cannot have an inserted CEA or other non-fuel component. Only one CONSOLIDATED FUEL lattice may be stored in any CANISTER.

f) HIGH BURNUP FUEL assemblies not meeting the criteria of Section A 5.7(1).

C. Unenriched fuel assemblies are not authorized for loading.

D. A canister preferentially loaded in accordance with Table 12B2-8 may only contain fuel assemblies selected from the same loading pattern.

Table 12B2-8 Loading Table for Maine Yankee CE 14 × 14 Fuel with No Non-Fuel Material – Required Cool Time in Years Before Assembly is Acceptable

Enrichment	Burnup ≤ 30 GWD/MTU - Minimum Cool Time [years] for[1]				
	Standard[2]	Pref (0.958i)	Pref (0.958p)	Pref (1.05i)	Pref (1.05p)
1.9 ≤ E < 2.1	5	5	5	5	5
2.1 ≤ E < 2.3	5	5	5	5	5
2.3 ≤ E < 2.5	5	5	5	5	5
2.5 ≤ E < 2.7	5	5	5	5	5
2.7 ≤ E < 2.9	5	5	5	5	5
2.9 ≤ E < 3.1	5	5	5	5	5
3.1 ≤ E < 3.3	5	5	5	5	5
3.3 ≤ E < 3.5	5	5	5	5	5
3.5 ≤ E < 3.7	5	5	5	5	5
3.7 ≤ E ≤ 4.2	5	5	5	5	5
Enrichment	30 < Burnup ≤ 35 GWD/MTU - Minimum Cool Time [years] for				
	Standard[2]	Pref (0.958i)	Pref (0.958p)	Pref (1.05i)	Pref (1.05p)
1.9 ≤ E < 2.1	5	5	5	5	5
2.1 ≤ E < 2.3	5	5	5	5	5
2.3 ≤ E < 2.5	5	5	5	5	5
2.5 ≤ E < 2.7	5	5	5	5	5
2.7 ≤ E < 2.9	5	5	5	5	5
2.9 ≤ E < 3.1	5	5	5	5	5
3.1 ≤ E < 3.3	5	5	5	5	5
3.3 ≤ E < 3.5	5	5	5	5	5
3.5 ≤ E < 3.7	5	5	5	5	5
3.7 ≤ E ≤ 4.2	5	5	5	5	5
Enrichment	35 < Burnup ≤ 40 GWD/MTU - Minimum Cool Time [years] for				
	Standard[2]	Pref (0.958i)	Pref (0.958p)	Pref (1.05i)	Pref (1.05p)
1.9 ≤ E < 2.1	7	7	6	15	5
2.1 ≤ E < 2.3	6	6	6	15	5
2.3 ≤ E < 2.5	6	6	5	14	5
2.5 ≤ E < 2.7	5	5	5	14	5
2.7 ≤ E < 2.9	5	5	5	14	5
2.9 ≤ E < 3.1	5	5	5	6	5
3.1 ≤ E < 3.3	5	5	5	6	5
3.3 ≤ E < 3.5	5	5	5	6	5
3.5 ≤ E < 3.7	5	5	5	6	5
3.7 ≤ E ≤ 4.2	5	5	5	6	5

1. Cool times for preferential loading of fuel assemblies with a decay heat of either 0.958 or 1.05 kw per assembly, loaded in either interior (i) or periphery (p) basket positions. All of the fuel assemblies in a canister must be selected using the same preferential loading pattern (Standard, 0.958 kW or 1.05 kW).
2. Fuel assemblies with cool times from 5 to 7 years must be preferentially loaded based on cool time, with fuel with the shortest cool time in the basket interior, in accordance with Section B2.1.2.

Table 12B2-8 Loading Table for Maine Yankee CE 14 × 14 Fuel with No Non-Fuel Material – Required Cool Time in Years Before Assembly is Acceptable (continued)

	40 < Burnup ≤ 45 GWD/MTU - Minimum Cool Time [years] for[1]				
Enrichment	Standard[2]	Pref(0.958i)	Pref(0.958p)	Pref(1.05i)	Pref(1.05p)
1.9 ≤ E < 2.1	11	20	7	Not Allowed	6
2.1 ≤ E < 2.3	9	15	7	Not Allowed	6
2.3 ≤ E < 2.5	8	15	6	Not Allowed	6
2.5 ≤ E < 2.7	8	15	6	Not Allowed	6
2.7 ≤ E < 2.9	8	14	6	Not Allowed	6
2.9 ≤ E < 3.1	8	14	6	Not Allowed	6
3.1 ≤ E < 3.3	7	14	6	Not Allowed	5
3.3 ≤ E < 3.5	6	14	6	Not Allowed	5
3.5 ≤ E < 3.7	6	13	6	Not Allowed	5
3.7 ≤ E ≤ 4.2	6	13	6	Not Allowed	5
	45 < Burnup ≤ 50 GWD/MTU - Minimum Cool Time [years] for				
Enrichment	Standard	Pref(0.958i)	Pref(0.958p)	Pref(1.05i)	Pref(1.05p)
1.9 ≤ E < 2.1	Not Allowed	Not Allowed	8	Not Allowed	7
2.1 ≤ E < 2.3	Not Allowed	Not Allowed	8	Not Allowed	7
2.3 ≤ E < 2.5	Not Allowed	Not Allowed	8	Not Allowed	7
2.5 ≤ E < 2.7	Not Allowed	Not Allowed	8	Not Allowed	7
2.7 ≤ E < 2.9	Not Allowed	Not Allowed	8	Not Allowed	7
2.9 ≤ E < 3.1	Not Allowed	Not Allowed	8	Not Allowed	7
3.1 ≤ E < 3.3	Not Allowed	Not Allowed	7	Not Allowed	7
3.3 ≤ E < 3.5	Not Allowed	Not Allowed	7	Not Allowed	6
3.5 ≤ E < 3.7	Not Allowed	Not Allowed	7	Not Allowed	6
3.7 ≤ E ≤ 4.2	Not Allowed	Not Allowed	7	Not Allowed	6

1. Cool times for preferential loading of fuel assemblies with a decay heat of either 0.958 or 1.05 kw per assembly, loaded in either interior (i) or periphery (p) basket positions. All of the fuel assemblies in a canister must be selected using the same preferential loading pattern.

2. Fuel assemblies with cool times from 5 to 7 years must be preferentially loaded based on cool time, with fuel with the shortest cool time in the basket interior, in accordance with Section B2.1.2.

Table 12B2-9 Loading Table for Maine Yankee CE 14×14 Fuel Containing CEA Cooled to Indicated Time

Enrichment	≤ 30 GWD/MTU Burnup - Minimum Cool Time in Years for				
	No CEA (Class 1)	5 Year CEA	10 Year CEA	15 Year CEA	20 Year CEA
1.9 ≤ E < 2.1	5	5	5	5	5
2.1 ≤ E < 2.3	5	5	5	5	5
2.3 ≤ E < 2.5	5	5	5	5	5
2.5 ≤ E < 2.7	5	5	5	5	5
2.7 ≤ E < 2.9	5	5	5	5	5
2.9 ≤ E < 3.1	5	5	5	5	5
3.1 ≤ E < 3.3	5	5	5	5	5
3.3 ≤ E < 3.5	5	5	5	5	5
3.5 ≤ E < 3.7	5	5	5	5	5
3.7 ≤ E ≤ 4.2	5	5	5	5	5
Enrichment	30 < Burnup ≤ 35 GWD/MTU - Minimum Cool Time in Years for				
	No CEA (Class 1)	5 Year CEA	10 Year CEA	15 Year CEA	20 Year CEA
1.9 ≤ E < 2.1	5	5	5	5	5
2.1 ≤ E < 2.3	5	5	5	5	5
2.3 ≤ E < 2.5	5	5	5	5	5
2.5 ≤ E < 2.7	5	5	5	5	5
2.7 ≤ E < 2.9	5	5	5	5	5
2.9 ≤ E < 3.1	5	5	5	5	5
3.1 ≤ E < 3.3	5	5	5	5	5
3.3 ≤ E < 3.5	5	5	5	5	5
3.5 ≤ E < 3.7	5	5	5	5	5
3.7 ≤ E ≤ 4.2	5	5	5	5	5
Enrichment	35 < Burnup ≤ 40 GWD/MTU - Minimum Cool Time in Years for				
	No CEA (Class 1)	5 Year CEA	10 Year CEA	15 Year CEA	20 Year CEA
1.9 ≤ E < 2.1	7	7	7	7	7
2.1 ≤ E < 2.3	6	6	6	6	6
2.3 ≤ E < 2.5	6	6	6	6	6
2.5 ≤ E < 2.7	5	5	5	5	5
2.7 ≤ E < 2.9	5	5	5	5	5
2.9 ≤ E < 3.1	5	5	5	5	5
3.1 ≤ E < 3.3	5	5	5	5	5
3.3 ≤ E < 3.5	5	5	5	5	5
3.5 ≤ E < 3.7	5	5	5	5	5
3.7 ≤ E ≤ 4.2	5	5	5	5	5
Enrichment	40 < Burnup ≤ 45 GWD/MTU - Minimum Cool Time in Years for				
	No CEA (Class 1)	5 Year CEA	10 Year CEA	15 Year CEA	20 Year CEA
1.9 ≤ E < 2.1	11	11	11	11	11
2.1 ≤ E < 2.3	9	9	9	9	9
2.3 ≤ E < 2.5	8	8	8	8	8
2.5 ≤ E < 2.7	8	8	8	8	8
2.7 ≤ E < 2.9	8	8	8	8	8
2.9 ≤ E < 3.1	8	8	8	8	8
3.1 ≤ E < 3.3	7	7	8	8	8
3.3 ≤ E < 3.5	6	6	7	7	7
3.5 ≤ E < 3.7	6	6	6	6	6
3.7 ≤ E ≤ 4.2	6	6	6	6	6

B 3.0 DESIGN FEATURES

B 3.1 Site

B 3.1.1 Site Location

The NAC-UMS® SYSTEM is authorized for general use by 10 CFR 50 license holders at various site locations under the provisions of 10 CFR 72, Subpart K.

B 3.2 Design Features Important for Criticality Control

B 3.2.1 CANISTER-INTACT FUEL ASSEMBLIES

a) Minimum ^{10}B loading in the BORAL neutron absorbers:
   1. PWR – 0.025g/cm^2
   2. BWR – 0.011g/cm^2

b) Minimum length of INTACT FUEL ASSEMBLY internal structure and bottom end fitting and/or spacers shall ensure the minimum distance to the fuel region from the base of the CANISTER is:
   1. PWR – 3.2 inches
   2. BWR – 6.2 inches

c) Soluble boron concentration in the PWR spent fuel pool water:
   1. Fuel meeting the 1st set of enrichment limits in Table 12B2–2 — 0 ppm
   2. Fuel meeting the 2nd set of enrichment limits in Table 12B2–2 ≥1000 ppm

d) Minimum PWR spent fuel pool water temperature to ensure boron is soluble:
   1. Temperature should be 5 - 10°F higher than the minimum needed to ensure solubility.

B 3.3 Codes and Standards

The American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), 1995 Edition with Addenda through 1995, is the governing Code for the NAC-UMS® CANISTER.

The American Concrete Institute Specifications ACI-349 (1985) and ACI-318 (1995) govern the NAC-UMS® CONCRETE CASK design and construction, respectively.

The American National Standards Institute ANSI N14.6 (1993) and NUREG-0612 govern the NAC-UMS® TRANSFER CASK design, operation, fabrication, testing, inspection and maintenance.

(continued)

B 3.3.1 Exceptions to Codes, Standards, and Criteria

Table 12B3-1 lists exceptions to the ASME Code for the design of the NAC-UMS® SYSTEM.

B 3.3.2 Construction/Fabrication Exceptions to Codes, Standards, and Criteria

Proposed alternatives to ASME Code, Section III, 1995 Edition with Addenda, through 1995, including exceptions listed in Specification B3.3.1, may be used when authorized by the Director of the Office of Nuclear Material Safety and Safeguards or designee. The request for such alternatives should demonstrate that:

1. The proposed alternatives would provide an acceptable level of quality and safety, or
2. Compliance with the specified requirements of ASME Code, Section III, 1995 Edition with Addenda through 1995, would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

Requests for exceptions shall be submitted in accordance with 10 CFR 72.4.

Table 12B3-1 List of ASME Code Exceptions for the NAC-UMS® SYSTEM

Component	Reference ASME Code Section/Article	Code Requirement	Exception, Justification and Compensatory Measures
CANISTER	NB-1100	Statement of requirements for Code stamping of components.	CANISTER is designed and will be fabricated in accordance with ASME Code, Section III, Subsection NB to the maximum practical extent, but Code stamping is not required. The completion of an ASME Design Specification, Design Report and Overpressure Protection Report are not required.
CANISTER	NB-2000	Requirements to be supplied by ASME-approved material supplier.	Materials will be supplied by NAC-approved suppliers with Certified Material Test Reports (CMTRs) in accordance to NB-2000 requirements.
CANISTER Shield Lid and Structural Lid Welds	NB-4243	Full penetration welds required for Category C joints (flat head to main shell per NB-3352.3).	Shield lid and structural lid to CANISTER shell welds are not full penetration welds. These field welds are performed independently to provide a redundant closure. Leaktightness of the CANISTER is verified by testing.
CANISTER Structural Lid Weld	NB-4421	Requires removal of backing ring.	Structural lid to CANISTER shell weld uses a backing ring that is not removed. The backing ring permits completion of the groove weld; it is not considered in any analyses; and it has no detrimental effect on the CANISTER's function.
CANISTER Vent Port Cover and Drain Port Cover to Shield Lid Welds; Shield Lid to Canister Shell Weld	NB-5230	Radiographic (RT) or ultrasonic (UT) examination required.	Root and final surface liquid penetrant examination to be performed per ASME Code Section V, Article 6, with acceptance in accordance with ASME Code, Section III, NB-5350.

Table 12B3-1 List of ASME Code Exceptions for the NAC-UMS® SYSTEM (continued)

Component	Reference ASME Code Section/Article	Code Requirement	Exception, Justification and Compensatory Measures
CANISTER Structural Lid to Shell Weld	NB-5230	Radiographic (RT) or ultrasonic (UT) examination required.	The CANISTER structural lid to CANISTER shell closure weld is performed in the field following fuel assembly loading. The structural lid-to-shell weld will be verified by either ultrasonic (UT) or progressive liquid penetrant (PT) examination. If progressive PT examination is used, at a minimum, it must include the root and final layers and each approximately 3/8 inch of weld depth. If UT examination is used, it will be followed by a final surface PT examination. For either UT or PT examination, the maximum, undetectable flaw size is demonstrated to be smaller than the critical flaw size. The critical flaw size is determined in accordance with ASME Code, Section XI methods. The examination of the weld will be performed by qualified personnel per ASME Code Section V, Articles 5 (UT) and 6 (PT) with acceptance per ASME Code Section III, NB-5332 (UT) per 1997 Addenda, and NB-5350 for (PT).

Table 12B3-1 List of ASME Code Exceptions for the NAC-UMS® SYSTEM (continued)

Component	Reference ASME Code Section/Article	Code Requirement	Exception, Justification and Compensatory Measures
CANISTER Vessel and Shield Lid	NB-6111	All completed pressure retaining systems shall be pressure tested.	The CANISTER shield lid to shell weld is performed in the field following fuel assembly loading. The CANISTER is then pneumatically (air-over-water) pressure tested as defined in Chapter 9 and described in Chapter 8. Accessibility for leakage inspections precludes a Code compliant hydrostatic test. The shield lid-to-shell weld is also leak tested to the leak-tight criteria of ANSI N14.5. The vent port and drain port cover welds are examined by root and final PT examination. The structural lid enclosure weld is examined by progressive PT or UT and final surface PT.
CANISTER Vessel	NB-7000	Vessels are required to have overpressure protection.	No overpressure protection is provided. The function of the CANISTER is to confine radioactive contents under normal, off-normal, and accident conditions of storage. The CANISTER vessel is designed to withstand a maximum internal pressure considering 100% fuel rod failure and maximum accident temperatures.

Table 12B3-1 List of ASME Code Exceptions for the NAC-UMS® SYSTEM (continued)

Component	Reference ASME Code Section/Article	Code Requirement	Exception, Justification and Compensatory Measures
CANISTER Vessel	NB-8000	States requirements for nameplates, stamping and reports per NCA-8000.	The NAC-UMS® SYSTEM is marked and identified in accordance with 10 CFR 72 requirements. Code stamping is not required. The QA data package will be in accordance with NAC's approved QA program. The completion of an ASME Design Specification, Design Report and Overpressure Protection Report are not required.
CANISTER Basket Assembly	NG-2000	Requires materials to be supplied by ASME approved material supplier.	Materials to be supplied by NAC-approved suppliers with CMTRs in accordance with NG-2000 requirements.
CANISTER Basket Assembly	NG-8000	States requirements for nameplates, stamping and reports per NCA-8000.	The NAC-UMS® SYSTEM will be marked and identified in accordance with 10 CFR 72 requirements. No Code stamping is required. The CANISTER basket data package will be in accordance with NAC's approved QA program.
CANISTER Vessel and Basket Assembly Material	NB-2130/ NG-2130	States requirements for certification of material organizations and materials to NCA-3861 and NCA-3862, respectively.	The NAC-UMS® CANISTER and Basket Assembly component materials are procured in accordance with the specifications for materials in ASME Code Section II with Certified Material Test Reports. The component materials will be obtained from NAC approved Suppliers in accordance with NAC's approved QA program.

B 3.4 Site Specific Parameters and Analyses

This section presents site-specific parameters and analytical bases that must be verified by the NAC-UMS® SYSTEM user. The parameters and bases presented in Section B.3.4.1 are those applied in the design basis analysis. The parameters and bases used in the evaluation of SITE SPECIFIC FUEL are presented in the appropriate sections below.

B 3.4.1 Design Basis Site Specific Parameters and Analyses

The design basis site-specific parameters and analyses that require verification by the NAC-UMS® SYSTEM user are:

1. The temperature of 76°F is the maximum average yearly temperature. The 3-day average ambient temperature shall be 106°F or less.

2. The allowed temperature extremes, averaged over a 3-day period, shall be greater than –40°F and less than 133°F.

3. The design basis earthquake horizontal and vertical seismic acceleration levels at the top surface of the ISFSI pad are bounded by the values shown:

Configuration	Coefficient of Friction	Horizontal g-level in each of Two Orthogonal Directions[1]	Corresponding Vertical g-level (upward)
Standard	0.35	0.26	0.26 × 0.667 = 0.173g
Standard	0.40	0.30	0.30 × 0.667 = 0.200g

1. Earthquake loads are applied to the center of gravity of the concrete cask on the ISFSI pad.

4. The analyzed flood condition of 15 fps water velocity and a height of 50 feet of water (full submergence of the loaded cask) are not exceeded.

5. The potential for fire and explosion shall be addressed, based on site-specific considerations. This includes the condition that the fuel tank of the cask handling equipment used to move the loaded CONCRETE CASK onto or from the ISFSI site contains no more than 50 gallons of fuel.

(continued)

B 3.4.2 Maine Yankee Site Specific Parameters and Analyses

The design basis site-specific parameters and analyses that require verification by Maine Yankee are:

1. The temperature of 76°F is the maximum average yearly temperature. The 3-day average ambient temperature shall be 106°F or less.

2. The allowed temperature extremes, averaged over a 3-day period, shall be greater than –40°F and less than 133°F.

3. The design basis earthquake horizontal and vertical seismic acceleration levels at the top surface of the ISFSI pad are bounded by the values shown:

Configuration	Coefficient of Friction	Horizontal g-level in each of Two Orthogonal Directions[1]	Corresponding Vertical g-level (upward)
Maine Yankee	0.50	0.38	$0.38 \times 0.667 = 0.253$g

1. Earthquake loads are applied to the center of gravity of the concrete cask on the ISFSI pad.

4. The analyzed flood condition of 15 fps water velocity and a height of 50 feet of water (full submergence of the loaded cask) are not exceeded.

5. The potential for fire and explosion shall be addressed, based on site-specific considerations. This includes the condition that the fuel tank of the cask handling equipment used to move the loaded CONCRETE CASK onto or from the ISFSI site contains no more than 50 gallons of fuel.

6. Physical testing shall be conducted to demonstrate that the coefficient of friction between the concrete cask and ISFSI pad surface is at least 0.5.

(continued)

B 3.4.2 Maine Yankee Site Specific Parameters and Analyses

The design basis site-specific parameters and analyses that require verification by Maine Yankee are:

1. The temperature of 76°F is the maximum average yearly temperature. The 3-day average ambient temperature shall be 106°F or less.

2. The allowed temperature extremes, averaged over a 3-day period, shall be greater than –40°F and less than 133°F.

3. The design basis earthquake horizontal and vertical seismic acceleration levels at the top surface of the ISFSI pad are bounded by the values shown:

Configuration	Coeffiecient of Friction	Horizontal g-level in each of Two Orthogonal Directions[1]	Corresponding Vertical g-level (upward)
Maine Yankee	0.50	0.38	$0.38 \times 0.667 = 0.253$g

1. Earthquake loads are applied to the center of gravity of the concrete cask on the ISFSI pad.

4. The analyzed flood condition of 15 fps water velocity and a height of 50 feet of water (full submergence of the loaded cask) are not exceeded.

5. The potential for fire and explosion shall be addressed, based on site-specific considerations. This includes the condition that the fuel tank of the cask handling equipment used to move the loaded CONCRETE CASK onto or from the ISFSI site contains no more than 50 gallons of fuel.

6. Physical testing shall be conducted to demonstrate that the coefficient of friction between the concrete cask and ISFSI pad surface is at least 0.5.

(continued)

B 3.4.2 Maine Yankee Site Specific Parameters and Analyses (continued)

7. In addition to the requirements of 10 CFR 72.212(b)(2)(ii), the ISFSI pad(s) and foundation shall meet the design basis earthquake horizontal and vertical seismic acceleration levels at the top surface of the ISFSI pad as specified in B 3.4.2 (3).

   The surface of the ISFSI pad shall have a broom finish or brushed surface as defined in ACI 116R-90 and described in Sections 7.12 and 7.13.4 of ACI 302.1R.

8. In cases where engineered features (i.e., berms, shield walls) are used to ensure that requirements of 10 CFR 72.104(a) are met, such features are to be considered important to safety and must be evaluated to determine the applicable Quality Assurance Category on a site specific basis.

9. TRANSFER CASK OPERATIONS shall only be conducted with surrounding air temperatures ≥ 0°F.

B 3.5 CANISTER HANDLING FACILITY (CHF)

B 3.5.1 TRANSFER CASK and CANISTER Lifting Devices

Movements of the TRANSFER CASK and CANISTER outside of the 10 CFR 50 licensed facilities, when loaded with spent fuel are not permitted unless the movements are made with a CANISTER HANDLING FACILITY designed, operated, fabricated, tested, inspected and maintained in accordance with the guidelines of NUREG-0612, "Control of Heavy Loads at Nuclear Power Plants" and the below clarifications. This Technical Specification does not apply to handling heavy loads under a 10 CFR 50 license.

B 3.5.2 CANISTER HANDLING FACILITY Structure Requirements

B 3.5.2.1 CANISTER Station and Stationary Lifting Devices

1. The weldment structure of the CANISTER HANDLING FACILITY shall be designed to comply with the stress limits of ASME Code, Section III, Subsection NF, Class 3 for linear structures. The applicable loads, load combinations, and associated service condition definitions are provided in Table 12B3-2. All compression loaded members shall satisfy the buckling criteria of ASME Code, Section III, Subsection NF.

2. If a portion of the CANISTER HANDLING FACILITY structure is constructed of reinforced concrete, then the factored load combinations set forth in ACI-318 (1995) for the loads defined in Table 12B3-2 shall apply.

3. The TRANSFER CASK and CANISTER lifting device used with the CANISTER HANDLING FACILITY shall be designed, fabricated, operated, tested, inspected and maintained in accordance with NUREG-0612, Section 5.1.

(continued)

B 3.5.2.1 CANISTER HANDLING Station and Stationary Lifting Devices (continued)

4. The CHF design shall incorporate an impact limiter for CANISTER lifting and movement if a qualified single failure proof crane is not used. The impact limiter must be designed and fabricated to ensure that, if a CANISTER is dropped, the confinement boundary of the CANISTER would not be breached.

B 3.5.2.2 Mobile Lifting Devices

If a mobile lifting device is used as the lifting device, in lieu of a stationary lifting device, it shall meet the guidelines of NUREG-0612, Section 5.1, with the following clarifications:

1. Mobile lifting devices shall have a minimum safety factor of two over the allowable load table for the lifting device in accordance with the guidance of NUREG-0612, Section 5.1.6(1)(a) and shall be capable of stopping and holding the load during a Design Basis Earthquake (DBE) event.
2. Mobile lifting devices shall conform to the requirements of ANSI B30.5, "Mobile and Locomotive Cranes," in lieu of the requirements of ANSI B30.2, "Overhead and Gantry Cranes."
3. Mobile cranes are not required to meet the requirements of NUREG-0612, Section 5.1.6(2) for new cranes.

Table 12B3-2 Load Combinations and Service Condition Definitions for the CANISTER HANDLING FACILITY (CHF) Structure

Load Combination	ASME Section III Service Condition for Definition of Allowable Stress	Comment
D* D + S	Level A	All primary load bearing members must satisfy Level A stress limits
D + M + W'[1] D + F D + E D + Y	Level D	Factor of safety against overturning shall be ≥ 1.1

D = Crane hook dead load
D* = Apparent crane hook dead load
S = Snow and ice load for the CHF site
M = Tornado missile load of the CHF site[1]
W' = Tornado wind load for the CHF site[1]
F = Flood load for the CHF site
E = Seismic load for the CHF site
Y = Tsunami load for the CHF site

Note:

1. Tornado missile load may be reduced or eliminated based on a PRA for the CHF site.

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APPENDIX 12C

TECHNICAL SPECIFICATION BASES FOR THE NAC-UMS® SYSTEM

Appendix 12C
Table of Contents

C 1.0 Introduction

This Appendix presents the design or operational condition, or regulatory requirement, which establishes the bases for the Technical Specifications provided in Appendix 12A.

The section and paragraph numbering used in this Appendix is consistent to the numbering used in Appendix 12A, Technical Specifications for the NAC-UMS® SYSTEM, and Appendix 12B, Approved Contents and Design Features for the NAC-UMS® System.

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C 2.0 APPROVED CONTENTS

C 2.1 Fuel to be Stored in the NAC-UMS® SYSTEM

BASES

BACKGROUND	The NAC-UMS® SYSTEM design requires specifications for the spent fuel to be stored, such as the type of spent fuel, minimum and maximum allowable enrichment prior to irradiation, maximum burnup, minimum acceptable post-irradiation cooling time prior to storage, maximum decay heat, and condition of the spent fuel (i.e., INTACT FUEL). Other important limitations are the dimensions and weight of the fuel assemblies. The approved contents, which can be loaded into the NAC-UMS® SYSTEM are specified in Section B2.0 of Appendix 12B. Specific limitations for the NAC-UMS® SYSTEM are specified in Table 12B2-1 of Appendix 12B. These limitations support the assumptions and inputs used in the thermal, structural, shielding, and criticality evaluations performed for the NAC-UMS® SYSTEM.
APPLICABLE SAFETY ANALYSES	To ensure that the shield lid is not placed on a CANISTER containing an unauthorized fuel assembly, facility procedures require verification of the loaded fuel assemblies to ensure that the correct fuel assemblies have been loaded in the canister.
APPROVED CONTENTS	C 2.1.1 Approved Contents Section B2.0 refers to Table 12B2-1 in Appendix 12B for the specific fuel assembly characteristics for the PWR or BWR fuel assemblies authorized for loading into the NAC-UMS® SYSTEM. These fuel assembly characteristics include parameters such as cladding material, minimum and maximum enrichment, decay heat generation, post-irradiation cooling time, burnup, and fuel assembly length, width, and weight. Tables 12B2-2 through 12B2-5 are referenced from Table 12B2-1 and provide additional specific fuel characteristic limits for the fuel assemblies based on the fuel assembly class type, enrichment, burnup and cooling time.

(continued)

APPROVED CONTENTS (continued)

The fuel assembly characteristic limits of Tables 12B2-1 through 12B2-5 must be met to ensure that the thermal, structural, shielding, and criticality analyses supporting the NAC-UMS® SYSTEM Safety Analysis Report are bounding.

C 2.1.2

Approved Contents Section B2.0 in Appendix 12B requires preferential loading of fuel assemblies with significantly different post-irradiation cooling times. This preferential loading is required to prevent a cooler assembly from heating up due to being surrounded by hotter fuel assemblies. For the purposes of complying with this Approved Contents limit, only fuel assemblies with post-irradiation cooling times differing by one year or greater need to be loaded preferentially. This is based on the fact that the heat-up phenomenon can only occur with significant differences in decay heat generation characteristics between adjacent fuel assemblies having different post-irradiation cooling times.

APPROVED CONTENT LIMITS AND VIOLATIONS

C 2.2.1

If any Approved Contents limit of B2.1.1 or B2.1.2 in Appendix 12B is violated, the limitations on fuel assemblies to be loaded are not met. Action must be taken to place the affected fuel assembly(s) in a safe condition. This safe condition may be established by returning the affected fuel assembly(s) to the spent fuel pool. However, it is acceptable for the affected fuel assemblies to temporarily remain in the NAC-UMS® SYSTEM, in a wet or dry condition, if that is determined to be a safe condition.

C 2.2.2 and C 2.2.3

NRC notification of the Approved Contents limit violation is required within 24 hours. A written report on the violation must be submitted to the NRC within 30 days. This notification and written report are independent of any reports and notification that may be required by 10 CFR 72.216.

REFERENCES

1. SAR, Sections 2.1, 4.4; Chapters 5 and 6.

C 3.0 LIMITING CONDITION FOR OPERATION (LCO) APPLICABILITY

BASES

LCOs	LCO 3.0.1, 3.0.2, 3.0.4, and 3.0.5 establish the general requirements applicable to all Specifications and apply at all times, unless otherwise stated.
LCO 3.0.1	LCO 3.0.1 establishes the Applicability statement within each individual Specification as the requirement for when the LCO is required to be met (i.e., when the NAC-UMS® SYSTEM is in the specified conditions of the Applicability statement of each Specification).

LCO 3.0.2

LCO 3.0.2 establishes that upon discovery of a failure to meet an LCO, the associated ACTIONS shall be met. The Completion Time of each Required Action for an ACTIONS Condition is applicable from the point in time that an ACTIONS Condition is entered. The Required Actions establish those remedial measures that must be taken within the specified Completion Times when the requirements of an LCO are not met. This Specification establishes that:

a. Completion of the Required Actions within the specified Completion Times constitutes compliance with a Specification; and,

b. Completion of the Required Actions is not required when an LCO is meet within the specified Completion Time, unless otherwise specified.

There are two basic Required Action types. The first Required Action type specifies a time limit, the Completion Time to restore a system or component or to restore variables to within specified limits, in which the LCO must be met. Whether stated as a Required Action or not, correction of the entered Condition is an action that may always be considered upon entering ACTIONS. The second Required Action type specifies the remedial measures that permit continued activities that are not further restricted by the Completion Time. In this case, compliance with the Required Actions provides an acceptable level of safety for continued operation.

(continued)

LCO 3.0.2 (continued)	Completing the Required Actions is not required when an LCO is met or is no longer applicable, unless otherwise stated in the individual Specifications. The Completion Times of the Required Actions are also applicable when a system or component is removed from service intentionally. The reasons for intentionally relying on the ACTIONS include, but are not limited to, performance of Surveillance, preventive maintenance, corrective maintenance, or investigation of operational problems. Entering ACTIONS for these reasons must be done in a manner that does not compromise safety. Intentional entry into ACTIONS should not be made for operational convenience.
LCO 3.0.3	This specification is not applicable to the NAC-UMS® SYSTEM because it describes conditions under which a power reactor must be shut down when an LCO is not met and an associated ACTION is not met or provided. The placeholder is retained for consistency with the power reactor technical specifications.
LCO 3.0.4	LCO 3.0.4 establishes limitations on changes in specified conditions in the Applicability when an LCO is not met. It precludes placing the facility in a specified condition stated in that Applicability (e.g., Applicability desired to be entered) when the following exist: a. NAC-UMS® SYSTEM conditions are such that the requirements of the LCO would not be met in the Applicability desired to be entered; and b. Continued noncompliance with the LCO requirements, if the Applicability were entered, would result in NAC-UMS® SYSTEM activities being required to exit the Applicability desired to be entered to comply with the Required Actions. Compliance with Required Actions that permit continued operation for an unlimited period of time in a specified condition provides an acceptable level of safety for continued operation. This is without regard to the status of the NAC-UMS® SYSTEM. Therefore, in such cases, entry into a specified condition in the Applicability may be made in accordance with the provisions of the Required Actions.

(continued)

LCO 3.0.4 (continued)	The provisions of this Specification should not be interpreted as endorsing the failure to exercise the good practice of restoring systems or components before entering an associated specified condition in the Applicability. The provisions of LCO 3.0.4 shall not prevent changes in specified conditions in the Applicability that are required to comply with ACTIONS. In addition, the provisions of LCO 3.0.4 shall not prevent changes in specified conditions in the Applicability that are related to the unloading of the NAC-UMS® SYSTEM. Exceptions to LCO 3.0.4 are stated in the individual Specifications. Exceptions may apply to all the ACTIONS or to a specific Required Action of a Specification.
LCO 3.0.5	LCO 3.0.5 establishes the allowance for restoring equipment to service under administrative controls when it has been removed from service or determined to not meet the LCO to comply with the ACTIONS. The sole purpose of the Specification is to provide an exception to LCO 3.0.2 (e.g. to not comply with the applicable Required Action[s]) to allow the performance of testing to demonstrate: a. The equipment being returned to service meets the LCO; or b. Other equipment meets the applicable LCOs. The administrative controls ensure the time the equipment is returned to service in conflict with the requirements of the ACTIONS is limited to the time absolutely necessary to perform the allowed testing. This Specification does not provide time to perform any other preventive or corrective maintenance.

C 3.0 SURVEILLANCE REQUIREMENT (SR) APPLICABILITY

BASES

Surveillance Requirements (SRs)	SR 3.0.1 through SR 3.0.4 establish the general requirements applicable to all Specifications and apply at all times, unless otherwise stated.

SR 3.0.1

SR 3.0.1 establishes the requirement that SRs must be met during the specified conditions in the Applicability for which the requirements of the LCO apply, unless otherwise specified in the individual SRs. This Specification is to ensure that Surveillance is performed to verify that systems and components meet the LCO and variables are within specified limits. Failure to meet Surveillance within the specified Frequency, in accordance with SR 3.0.2, constitutes a failure to meet an LCO.

Systems and components are assumed to meet the LCO when the associated SRs have been met. Nothing in this Specification, however, is to be construed as implying that systems or components meet the associated LCO when:

a. The systems or components are known to not meet the LCO, although still meeting the SRs; or,

b. The requirements of the Surveillance(s) are known to be not met between required Surveillance performances.

Surveillances do not have to be performed when the NAC-UMS® SYSTEM is in a specified condition for which the requirements of the associated LCO are not applicable, unless otherwise specified.

Surveillances, including those invoked by Required Actions, do not have to be performed on equipment that has been determined to not meet the LCO because the ACTIONS define the remedial measures that apply. Surveillances have to be met and performed in accordance with SR 3.0.2, prior to returning equipment to service. Upon completion of maintenance, appropriate post maintenance testing is required. This includes ensuring applicable Surveillances are not failed and their most recent performance is in accordance with SR 3.0.2. Post maintenance

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SR 3.0.1 (continued)	testing may not be possible in the current specified conditions in the Applicability, due to the necessary NAC-UMS® SYSTEM parameters not having been established. In these situations, the equipment may be considered to meet the LCO provided testing has been satisfactorily completed to the extent possible and the equipment is not otherwise believed to be incapable of performing its function. This will allow operation to proceed to a specified condition where other necessary post maintenance tests can be completed.
SR 3.0.2	SR 3.0.2 establishes the requirements for meeting the specified Frequency for Surveillances and any Required Action with a Completion Time that requires the periodic performance of the Required Action on a "once per…" interval. This extension facilitates Surveillance scheduling and considers facility conditions that may not be suitable for conducting the Surveillance (e.g., transient conditions or other ongoing Surveillance or maintenance activities). The 25% extension does not significantly degrade the reliability that results from performing the Surveillance at its specified Frequency. This is based on the recognition that the most probable result of any particular Surveillance being performed is the verification of conformance with the SRs. The exceptions to SR 3.0.2 are those Surveillances for which the 25% extension of the interval specified in the Frequency does not apply. These exceptions are stated in the individual Specifications as a Note in the Frequency stating, "SR 3.0.2 is not applicable." As stated in SR 3.0.2, the 25% extension also does not apply to the initial portion of a periodic Completion Time that requires performance on a "once per…" basis. The 25% extension applies to each performance after the initial performance. The initial performance of the Required Action, whether it is a particular Surveillance or some other remedial action, is considered a single action with a single Completion time. One reason for not allowing the 25% extension to this Completion Time is that such an action usually verifies that no loss of function has occurred by checking the status of redundant or diverse components or accomplishes the function of the affected equipment in an alternative manner.

(continued)

SR 3.0.2 (continued)	The provisions of SR 3.0.2 are not intended to be used repeatedly, merely as an operational convenience to extend Surveillance intervals or periodic Completion Time intervals beyond those specified.

SR 3.0.3

SR 3.0.3 establishes the flexibility to defer declaring affected equipment as not meeting the LCO or an affected variable outside the specified limits when a Surveillance has not been completed within the specified Frequency. A delay period of up to 24 hours or up to the limit of the specified Frequency, whichever is less, applies from the point in time that it is discovered that the Surveillance has not been performed in accordance with SR 3.0.2, and not at the time that the specified Frequency was not met.

This delay period provides adequate time to complete Surveillances that have been missed. This delay period permits the completion of a Surveillance before complying with Required Actions or other remedial measures that might preclude completion of the Surveillance.

The basis for this delay period includes: consideration of facility conditions, adequate planning, availability of personnel, the time required to perform the Surveillance, the safety significance of the delay in completing the required Surveillance, and the recognition that the most probable result of any particular Surveillance being performed is the verification of conformance with the requirements. When a Surveillance with a Frequency, based not on time intervals, but upon specified NAC-UMS® SYSTEM conditions, is discovered not to have been performed when specified, SR 3.0.3 allows the full delay period of 24 hours to perform the Surveillance.

SR 3.0.3 also provides a time limit for completion of Surveillances that become applicable as a consequence of changes in the specified conditions in the Applicability imposed by the Required Actions.

Failure to comply with specified Frequencies for SRs is expected to be an infrequent occurrence. Use of the delay period established by SR 3.0.3 is a flexibility, which is not intended to be used as an operational convenience to extend Surveillance intervals.

(continued)

SR 3.0.3 (continued)

If a Surveillance is not completed within the allowed delay period, then the equipment is considered to not meet the LCO or the variable is considered outside the specified limits and the Completion Times of the Required Actions for the applicable LCO Conditions begin immediately upon expiration of the delay period. If a Surveillance is failed within the delay period, then the equipment does not meet the LCO, or the variable is outside the specified limits and the Completion Times of the Required Actions for the applicable LCO Conditions begin immediately upon the failure of the Surveillance.

Completion of the Surveillance within the delay period allowed by this Specification, or within the Completion Time of the ACTIONS, restores compliance with SR 3.0.1.

SR 3.0.4

SR 3.0.4 establishes the requirement that all applicable SRs must be met before entry into a specified condition in the Applicability.

This Specification ensures that system and component requirements and variable limits are met before entry into specified conditions in the Applicability for which these systems and components ensure safe operation of NAC-UMS® SYSTEM activities.

The provisions of this Specification should not be interpreted as endorsing the failure to exercise the good practice of restoring systems or components before entering an associated specified condition in the Applicability.

However, in certain circumstances, failing to meet an SR will not result in SR 3.0.4 restricting a change in specified condition. When a system, subsystem, division, component, device, or variable is outside its specified limits, the associated SR(s) are not required to be performed per SR 3.0.1, which states that Surveillances do not have to be performed on equipment that has been determined to not meet the LCO.

(continued)

SR 3.0.4 (continued)

When equipment does not meet the LCO, SR 3.0.4 does not apply to the associated SR(s), since the requirement for the SR(s) to be performed is removed. Therefore, failing to perform the Surveillance(s) within the specified Frequency does not result in a SR 3.0.4 restriction to changing specified conditions of the Applicability. However, since the LCO is not in this situation, LCO 3.0.4 will govern any restrictions that may be (or may not) apply to specified condition changes.

The provisions of SR 3.0.4 shall not prevent changes in specified conditions in the Applicability that are required to comply with ACTIONS. In addition, the provisions of LCO 3.0.4 shall not prevent changes in specified conditions in the Applicability that are related to the unloading of the NAC-UMS® SYSTEM.

The precise requirements for performance of SRs are specified such that exceptions to SR 3.0.4 are not necessary. The specific time frames and conditions necessary for meeting the SRs are specified in the Frequency, in the Surveillance, or both. This allows performance of Surveillances, when the prerequisite condition(s) specified in a Surveillance procedure require entry into the specified condition in the Applicability of the associated LCO, prior to the performance or completion of a Surveillance. A Surveillance that could not be performed until after entering LCO Applicability, would have its Frequency specified such that is not "due" until the specific conditions needed are met.

Alternately, the Surveillance may be stated in the form of a Note as not required (to be met or to be performed) until a particular event, condition, or time has been reached. Further discussion of the specific formats of SRs' annotation is found in Section 1.4, Frequency.

C 3.1 NAC-UMS® SYSTEM Integrity

C 3.1.1 CANISTER Maximum Time in Vacuum Drying

BASES

BACKGROUND	A TRANSFER CASK with an empty CANISTER is placed into the spent fuel pool and loaded with fuel assemblies meeting the requirements of the Approved Contents limits. A shield lid is then placed on the CANISTER. The TRANSFER CASK and CANISTER are raised out of the spent fuel pool. The TRANSFER CASK and CANISTER are then moved into the cask decontamination area, where dose rates are measured and the CANISTER shield lid is welded to the CANISTER shell and the lid weld is examined, pressure tested, and leak tested. The water is drained from the CANISTER, and CANISTER cavity vacuum drying is performed. The CANISTER cavity is then backfilled with helium. Additional dose rates are measured, and the CANISTER vent port and drain port covers and structural lid are installed and welded. Non-destructive examinations are performed on the welds. Contamination measurements are completed prior to moving the TRANSFER CASK and CANISTER in position to transfer the CANISTER to the CONCRETE CASK. After the CANISTER is transferred, the CONCRETE CASK is then moved to the ISFSI. Average CONCRETE CASK dose rates are measured at the ISFSI pad. Limiting the elapsed time from the end of CANISTER draining operations through dryness verification testing and subsequent backfilling of the CANISTER with helium ensures that the short-term temperature limits established in the Safety Analyses Report for the spent fuel cladding and CANISTER materials are not exceeded.
APPLICABLE SAFETY ANALYSIS	Limiting the total time for loaded CANISTER vacuum drying operations ensures that the short-term temperature limits for the fuel cladding and CANISTER materials are not exceeded. If vacuum drying operations are not completed in the required time period, the CANISTER is backfilled with helium, the TRANSFER CASK and loaded CANISTER are submerged in the spent fuel pool, and the TRANSFER CASK and loaded CANISTER are kept in the pool for a minimum of 24 hours.

(continued)

APPLICABLE SAFETY ANALYSIS (continued)	Analyses reported in the Safety Analysis Report conclude that spent fuel cladding and CANISTER material short-term temperature limits will not be exceeded for total elapsed time in the vacuum drying operation and in the TRANSFER CASK with the CANISTER filled with helium. Since the rate of heat up is slower for lower total heat loads, the time required to reach component limits is longer than for the design basis heat load. Consequently, longer time limits are specified for heat loads below the design basis for the PWR and BWR fuel configurations as shown in LCO 3.1.1. As shown in the LCO, for total heat loads not specified, the time limit for the next higher specified heat load is conservatively applied. Analysis also shows that the fuel cladding and CANISTER component temperatures are well below the allowable temperatures for the time durations specified from the end of in-pool cooling, or end of forced air cooling, of the CANISTER through the completion of the vacuum drying and for the time specified in LCO 3.1.4 for the CANISTER in the TRANSFER CASK when backfilled with helium.
LCO	Limiting the length of time for vacuum drying operations for the CANISTER ensures that the spent fuel cladding and CANISTER material temperatures remain below the short-term temperature limits for the NAC-UMS® SYSTEM.
APPLICABILITY	The elapsed time restrictions for vacuum drying operations on a loaded CANISTER apply during LOADING OPERATIONS from the completion point of CANISTER draining operations through the completion point of the CANISTER dryness verification testing. The LCO is not applicable to TRANSPORT OPERATIONS or STORAGE OPERATIONS.
ACTIONS	A note has been added to the ACTIONS, which states that, for this LCO, separate Condition entry is allowed for each NAC-UMS® SYSTEM. This is acceptable, since the Required Actions for each Condition provide appropriate compensatory measures for each NAC-UMS® SYSTEM not meeting the LCO. Subsequent NAC-UMS® SYSTEMS that do not meet the LCO are governed by subsequent Condition entry and application of associated Required Actions.

(continued)

ACTIONS (continued)

A.1.1
If the LCO time limit is exceeded, the CANISTER will be backfilled with helium to a pressure of 0 psig (+1,-0).

AND

A.2.1
The TRANSFER CASK and loaded CANISTER shall be submerged in the spent fuel pool for in-pool cooling operations.

AND

A.2.2
The TRANSFER CASK and loaded CANISTER shall be maintained submerged in the spent fuel pool for a minimum of 24 hours prior to the restart of LOADING OPERATIONS.

OR

A.3.1
A cooling air flow of 375 CFM at a maximum temperature of 76°F shall be initiated. The airflow will be routed to the annulus fill/drain lines of the TRANSFER CASK and will flow through the annulus and cool the CANISTER.

AND

A.3.2
The cooling air flow shall be maintained for a minimum of 24 hours prior to restart of LOADING OPERATIONS.

(continued)

SURVEILLANCE REQUIREMENTS

SR 3.1.1.1

The elapsed time shall be monitored from completion of CANISTER draining through completion of the CANISTER vacuum dryness verification testing. Monitoring the elapsed time ensures that helium backfill and in-pool cooling operations can be initiated in a timely manner during LOADING OPERATIONS to prevent fuel cladding and CANISTER materials from exceeding short-term temperature limits.

SR 3.1.1.2

The elapsed time shall be monitored from the end of in-pool cooling through completion of the CANISTER vacuum dryness verification testing. Monitoring the elapsed time ensures that helium backfill and in-pool cooling operations can be initiated in a timely manner during LOADING OPERATIONS to prevents fuel cladding and CANISTER materials from exceeding short-term temperature limits.

REFERENCES

1. SAR Sections 4.4 and 8.1.

C 3.1 NAC-UMS® SYSTEM Integrity

C 3.1.2 CANISTER Vacuum Drying Pressure

BASES

BACKGROUND

A TRANSFER CASK with an empty CANISTER is placed into the spent fuel pool and loaded with fuel assemblies meeting the requirements of the Approved Contents Limits. A shield lid is then placed on the CANISTER. The TRANSFER CASK and CANISTER are raised out of the spent fuel pool. The TRANSFER CASK and CANISTER are then moved into the cask decontamination area, where dose rates are measured and the CANISTER shield lid is welded to the CANISTER shell and the lid weld is examined, pressure tested, and leak tested. The water is drained from the CANISTER, and CANISTER cavity vacuum drying is performed. The CANISTER cavity is then backfilled with helium. Additional dose rates are measured, and the CANISTER vent port and drain port covers and structural lid are installed and welded. Non-destructive examinations are performed on the welds. Contamination measurements are completed prior to moving the TRANSFER CASK and CANISTER in position to transfer the CANISTER to the CONCRETE CASK. After the CANISTER is transferred, the CONCRETE CASK is then moved to the ISFSI. Average CONCRETE CASK dose rates are measured at the ISFSI pad.

CANISTER cavity vacuum drying is utilized to remove residual moisture from the CANISTER cavity after the water is drained from the CANISTER. Any water not drained from the CANISTER cavity evaporates due to the vacuum. This is aided by the temperature increase, due to the heat generation of the fuel.

APPLICABLE SAFETY ANALYSIS

The confinement of radioactivity (including fission product gases, fuel fines, volatiles, and crud) during the storage of design basis spent fuel in the CANISTER is ensured by the multiple confinement boundaries and systems. The barriers relied on are: the fuel pellet matrix, the metallic fuel cladding tubes where the fuel pellets are contained, and the CANISTER where the fuel assemblies are stored. Long-term integrity of the fuel and cladding depends on storage in an inert atmosphere. This is accomplished by removing water from the CANISTER and backfilling the cavity with helium. The thermal analysis assumes that the CANISTER cavity is dried and filled with helium.

(continued)

APPLICABLE SAFETY ANALYSIS (continued)	The heat-up of the CANISTER and contents will occur during CANISTER vacuum drying, but is controlled by LCO 3.1.1.
LCO	A vacuum pressure, meeting the limit specified in Table 12A3-1, indicates that liquid water has evaporated and been removed from the CANISTER cavity. Removing water from the CANISTER cavity helps to ensure the long-term maintenance of fuel cladding integrity.
APPLICABILITY	Cavity vacuum drying is performed during LOADING OPERATIONS before the TRANSFER CASK holding the CANISTER is moved to transfer the CANISTER into the CONCRETE CASK. Therefore, the vacuum requirements do not apply after the CANISTER is backfilled with helium and leak tested prior to TRANSPORT OPERATIONS and STORAGE OPERATIONS.
ACTIONS	A note has been added to the ACTIONS, which states that, for this LCO, separate Condition entry is allowed for each CANISTER. This is acceptable, since the Required Actions for each Condition provide appropriate compensatory measures for each CANISTER not meeting the LCO. Subsequent CANISTERs that do not meet the LCO are governed by subsequent Condition entry and application of associated Required Actions.

<u>A.1</u>

If the CANISTER cavity vacuum drying pressure limit cannot be met, actions must be taken to meet the LCO. Failure to successfully complete cavity vacuum drying could have many causes, such as failure of the vacuum drying system, inadequate draining, ice clogging of the drain lines, or leaking CANISTER welds. The Completion Time is sufficient to determine and correct most failure mechanisms. Excessive heat-up of the CANISTER and contents is precluded by LCO 3.1.1.

<u>B.1</u>

If the CANISTER fuel cavity cannot be successfully vacuum dried, the fuel must be placed in a safe condition. Corrective actions may be taken after the fuel is placed in a safe condition to perform the A.1 action provided that the initial conditions for performing A.1 are met.

(continued)

ACTIONS (continued)	A.1 may be repeated as necessary prior to performing B.1. The time frame for completing B.1 can not be extended by re-performing A.1. The Completion Time is reasonable, based on the time required to reflood the CANISTER, perform fuel cooldown operations, cut the shield lid weld, move the TRANSFER CASK into the spent fuel pool, and remove the CANISTER shield lid in an orderly manner and without challenging personnel.
SURVEILLANCE REQUIREMENTS	SR 3.1.2.1 The long-term integrity of the stored fuel is dependent on storage in a dry, inert environment. Cavity dryness is demonstrated by evacuating the cavity to a very low absolute pressure and verifying that the pressure is held over a specified period of time. A low vacuum pressure is an indication that the cavity is dry. The surveillance must verify that the CANISTER cavity vacuum drying pressure is within the specified limit prior to backfilling the CANISTER with helium.
REFERENCES	1. SAR Sections 4.4, 7.1 and 8.1.

C 3.1 NAC-UMS® SYSTEM Integrity

C 3.1.3 CANISTER Helium Backfill Pressure

BASES

BACKGROUND

A TRANSFER CASK with an empty CANISTER is placed into the spent fuel pool and loaded with fuel assemblies meeting the requirements of the Approved Contents limits. A shield lid is then placed on the CANISTER. The TRANSFER CASK and CANISTER are raised out of the spent fuel pool. The TRANSFER CASK and CANISTER are then moved into the cask decontamination area, where dose rates are measured and the CANISTER shield lid is welded to the CANISTER shell and the lid weld is examined, pressure tested, and leak tested. The water is drained from the CANISTER, and CANISTER cavity vacuum drying is performed. The CANISTER cavity is then backfilled with helium. Additional dose rates are measured, and the CANISTER vent port and drain port covers and structural lid are installed and welded. Non-destructive examinations are performed on the welds. Contamination measurements are completed prior to moving TRANSFER CASK and CANISTER in position to transfer the CANISTER to the CONCRETE CASK. After the CANISTER is transferred, the CONCRETE CASK is then moved to the ISFSI. Average CONCRETE CASK dose rates are measured at the ISFSI pad.

Backfilling of the CANISTER cavity with helium promotes heat transfer from the spent fuel to the CANISTER structure and the inert atmosphere protects the fuel cladding. Providing a helium pressure equal to atmospheric pressure ensures that there will be no in-leakage of air over the life of the CANISTER, which might be harmful to the heat transfer features of the NAC-UMS® SYSTEM and harmful to the fuel.

APPLICABLE SAFETY ANALYSIS

The confinement of radioactivity (including fission product gases, fuel fines, volatiles, and crud) during the storage of spent fuel in the CANISTER is ensured by the multiple confinement boundaries and systems. The barriers relied on are: the fuel pellet matrix, the metallic fuel cladding tubes where the fuel pellets are contained, and the CANISTER where the fuel assemblies are stored. Long-term integrity of the fuel and cladding depends on the ability of the NAC-UMS® SYSTEM to remove heat from the CANISTER and reject it to the

(continued)

APPLICABLE SAFETY ANALYSIS (continued)

environment. This is accomplished by removing water from the CANISTER cavity and backfilling the cavity with an inert gas. The heat-up of the CANISTER and contents will continue following backfilling with helium, but is controlled by LCO 3.1.4.

The thermal analyses of the CANISTER assume that the CANISTER cavity is dried and filled with dry helium.

LCO

Backfilling the CANISTER cavity with helium at a pressure equal to atmospheric pressure ensures that there is no air in-leakage into the CANISTER, which could decrease the heat transfer properties and result in increased cladding temperatures and damage to the fuel cladding over the storage period. The helium backfill pressure specified in Table 12A3-1 was selected based on a minimum helium purity of 99.9% to ensure that the CANISTER internal pressure and heat transfer from the CANISTER to the environment are maintained consistent with the design and analysis basis of the CANISTER.

APPLICABILITY

Helium backfill is performed during LOADING OPERATIONS, before the TRANSFER CASK and CANISTER are moved to the CONCRETE CASK for transfer of the CANISTER. Therefore, the backfill pressure requirements do not apply after the CANISTER is backfilled with helium and leak tested prior to TRANSPORT OPERATIONS and STORAGE OPERATIONS.

ACTIONS

A note has been added to the ACTIONS, which states that, for this LCO, separate Condition entry is allowed for each CANISTER. This is acceptable, since the Required Actions for each Condition provide appropriate compensatory measures for each CANISTER not meeting the LCO. Subsequent CANISTERs that do not meet the LCO are governed by subsequent condition entry and application of associated Required Actions.

A.1

If the backfill pressure cannot be established within limits, actions must be taken to meet the LCO. The Completion Time is sufficient to determine and correct most failures, which would prevent backfilling of the CANISTER cavity with helium. These actions include identification and repair of helium leak paths or replacement of the helium backfill equipment.

(continued)

ACTIONS (continued)

B.1

If the CANISTER cavity cannot be backfilled with helium to the specified pressure, the fuel must be placed in a safe condition. Corrective actions may be taken after the fuel is placed in a safe condition to perform the A.1 action provided that the initial conditions for performing A.1 are met. A.1 may be repeated as necessary prior to performing B.1. The time frame for completing B.1 cannot be extended by reperforming A.1. The Completion Time is reasonable based on the time required to re-flood the CANISTER, perform cooldown operations, cut the CANISTER shield lid weld, move the TRANSFER CASK and CANISTER into the spent fuel pool, remove the CANISTER shield lid, and remove the spent fuel assemblies in an orderly manner and without challenging personnel.

SURVEILLANCE REQUIREMENTS

SR 3.1.3.1

The long-term integrity of the stored fuel is dependent on storage in a dry, inert atmosphere and maintenance of adequate heat transfer mechanisms. Filling the CANISTER cavity with helium at a pressure within the range specified in Table 12A3-1 will ensure that there will be no air in-leakage, which could potentially damage the fuel. This pressure of helium gas is sufficient to maintain fuel cladding temperatures within acceptable levels.

Backfilling of the CANISTER cavity must be performed successfully on each CANISTER before placing it in storage. The surveillance must verify that the CANISTER helium backfill pressure is within the limit specified prior to installation of the structural lid.

REFERENCES

1. SAR Sections 4.4, 7.1 and 8.1.

C 3.1 NAC-UMS® SYSTEM Integrity

C 3.1.4 CANISTER Maximum Time in the TRANSFER CASK

BASES

BACKGROUND

A TRANSFER CASK with an empty CANISTER is placed into the spent fuel pool and loaded with fuel assemblies meeting the requirements of the Approved Contents limits. A shield lid is then placed on the CANISTER. The TRANSFER CASK and CANISTER are raised out of the spent fuel pool. The TRANSFER CASK and CANISTER are then moved into the cask decontamination area, where dose rates are measured and the CANISTER shield lid is welded to the CANISTER shell and the lid weld is examined, pressure tested, and leak tested. The water is drained from the CANISTER, and CANISTER cavity vacuum drying is performed. The CANISTER cavity is then backfilled with helium. Additional dose rates are measured, and the CANISTER vent port and drain port covers and structural lid are installed and welded. Non-destructive examinations are performed on the welds. Contamination measurements are completed prior to moving TRANSFER CASK and CANISTER in position to transfer the CANISTER to the CONCRETE CASK. After the CANISTER is transferred, the CONCRETE CASK is then moved to the ISFSI. Average CONCRETE CASK dose rates are measured at the ISFSI pad.

Backfilling the CANISTER cavity with helium promotes heat transfer from the fuel and the inert atmosphere protects the fuel cladding. Limiting the total time the loaded CANISTER is in the TRANSFER CASK, prior to its placement in the CONCRETE CASK, ensures that the short-term temperature limits established in the Safety Analysis Report for the spent fuel cladding and CANISTER materials are not exceeded.

APPLICABLE SAFETY ANALYSIS

Limiting the total time that a loaded CANISTER backfilled with helium may be in the TRANSFER CASK, prior to placement in the CONCRETE CASK, ensures that the short-term temperature limits for the spent fuel cladding and CANISTER materials are not exceeded. Upon placement of the loaded CANISTER in the CONCRETE CASK, the temperatures of the CANISTER and stored spent fuel will return to normal storage condition values due to the more efficient passive heat transfer characteristics of the CONCRETE CASK. Ensuring temperatures are maintained below short-term limits

(continued)

APPLICABLE SAFETY ANALYSIS (continued)	for a limited time period and returning them to values below long-term limits will prevent damage to the spent fuel cladding and the CANISTER materials. Analyses reported in the Safety Analysis Report conclude that spent fuel cladding and CANISTER material short-term temperature limits will not be exceeded for the total elapsed times specified in LCO 3.1.4, in the TRANSFER CASK. Since the rate of heat up is slower for lower total heat loads, the time required to reach component limits is longer than for the design basis heat load. Consequently, longer time limits are specified for heat loads below the design basis for the PWR fuel configurations as shown in LCO 3.1.4. As shown in the LCO, for total heat loads not specified, the time limit for the next higher specified heat load is conservatively applied. Analysis also shows that the fuel cladding and CANISTER component temperatures are below their allowable temperatures for the time durations specified with the CANISTER in the TRANSFER CASK and backfilled with helium when the CANISTER is cooled in-pool or using forced air. The basis for forced air cooling is an inlet maximum air temperature of 76°F which is the maximum normal ambient air temperature in the thermal analysis. The specified 375 CFM air flow rate exceeds the CONCRETE CASK natural convective cooling flow rate by a minimum of 10 percent. This comparative analysis conservatively excludes the higher flow velocity resulting from the smaller annulus between the TRANSFER CASK and CANISTER, which would result in improved heat transfer from the CANISTER. Since initiation of cooling air flow begins to lower CANISTER component temperatures, LOADING OPERATIONS may resume after cooling air flow is initiated and may continue while cooling air flow is maintained.
LCO	Limiting the length of time that the loaded CANISTER backfilled with helium is allowed to remain in the TRANSFER CASK ensures that the spent fuel cladding and CANISTER material temperatures remain below the short-term temperature limits established in the SAR for the NAC-UMS® SYSTEM. The time duration is a function of the design of the TRANSFER CASK and the NAC-UMS® SYSTEM.
APPLICABILITY	The elapsed time restrictions on the loaded CANISTER apply during LOADING OPERATIONS from the completion point of the CANISTER vacuum dryness verification through completion of the transfer from the TRANSFER CASK to the CONCRETE CASK.

(continued)

ACTIONS

A note has been added to the ACTIONS, which states that, for this LCO, separate Condition entry is allowed for each NAC-UMS® SYSTEM. This is acceptable, since the Required Actions for each Condition provide appropriate compensatory measures for each NAC-UMS® SYSTEM not meeting the LCO. Subsequent NAC-UMS® SYSTEMS that do not meet the LCO are governed by subsequent Condition entry and application of associated Required Actions.

A.1.1

If either LCO time limit is exceeded, the TRANSFER CASK containing the loaded CANISTER backfilled with helium will be returned to the spent fuel pool to allow the cooler spent fuel pool water to reduce the TRANSFER CASK, CANISTER, and spent fuel cladding temperatures to below long-term temperature limits.

AND

A.1.2

The TRANSFER CASK and loaded CANISTER shall be kept in the spent fuel pool for a minimum of 24 hours prior to restart of LOADING OPERATIONS.

OR

A.2.1

A cooling air flow of 375 CFM at a maximum temperature of 76°F shall be initiated. The airflow will be routed to the annulus fill/drain lines in the TRANSFER CASK and will flow through the annulus and cool the CANISTER.

AND

A.2.2

The cooling air flow shall be maintained for a minimum of 24 hours prior to restart of LOADING OPERATIONS.

(continued)

SURVEILLANCE REQUIREMENTS	SR 3.1.4.1 The elapsed time from completion of CANISTER dryness verification until CANISTER transfer operations into the CONCRETE CASK are completed shall be monitored. The SR ensures that CANISTER material and fuel cladding short-term temperature limits are not exceeded. SR 3.1.4.2 The elapsed time from the completion of in-pool or forced air cooling until CANISTER transfer operations into the CONCRETE CASK are completed shall be monitored. This SR ensures that CANISTER materials and fuel cladding short-term temperature limits are not exceeded. This SR is also applicable to the maximum time the CANISTER backfilled with helium can be loaded in the TRANSFER CASK if forced air or in-pool cooling operations were performed during vacuum drying operations under LCO 3.1.1.

REFERENCES	1. SAR Sections 4.4 and 8.1.

C 3.1 NAC-UMS® SYSTEM Integrity

C 3.1.5 CANISTER Helium Leak Rate

BASES

BACKGROUND	A TRANSFER CASK with an empty CANISTER is placed into the spent fuel pool and loaded with fuel assemblies meeting the requirements of the Approved Contents limits. A shield lid is then placed on the CANISTER. The TRANSFER CASK and CANISTER are raised out of the spent fuel pool. The TRANSFER CASK and CANISTER are then moved into the cask decontamination area, where dose rates are measured and the CANISTER shield lid is welded to the CANISTER shell and the lid weld is examined, pressure tested, and leak tested. The water is drained from the CANISTER, and CANISTER cavity vacuum drying is performed. The CANISTER cavity is then backfilled with helium. Additional dose rates are measured, and the CANISTER vent port and drain port covers and structural lid are installed and welded. Non-destructive examinations are performed on the welds. Contamination measurements are completed prior to moving TRANSFER CASK and CANISTER in position to transfer the CANISTER to the CONCRETE CASK. After the CANISTER is transferred, the CONCRETE CASK is then moved to the ISFSI. Average CONCRETE CASK dose rates are measured at the ISFSI pad. Backfilling the CANISTER cavity with helium promotes heat transfer from the fuel to the CANISTER shell. The inert atmosphere protects the fuel cladding. Prior to transferring the CANISTER to the CONCRETE CASK, the CANISTER helium leak rate is verified to meet leaktight requirements to ensure that the fuel and helium backfill gas is confined.
APPLICABLE SAFETY ANALYSIS	The confinement of radioactivity (including fission product gases, fuel fines, volatiles, and crud) during the storage of spent fuel in the CANISTER is ensured by the multiple confinement boundaries and systems. The barriers relied on are: the fuel pellet matrix, the metallic fuel cladding tubes where the fuel pellets are contained, and the CANISTER where the fuel assemblies are stored. Long-term integrity of the fuel and cladding depends on maintaining an inert atmosphere, and maintaining the cladding temperatures below established long-term limits. This is accomplished by removing water from the CANISTER and backfilling the cavity with helium. The heat-up of the CANISTER and contents will continue following backfilling the cavity and leak testing the shield lid-to-shell weld, but is controlled by LCO 3.1.4.

(continued)

LCO

Verifying that the CANISTER cavity helium leak rate is below the leaktight limit specified in Table 12A3-1 ensures that the CANISTER shield lid is sealed. Verifying that the helium leak rate is below leaktight levels will also ensure that the assumptions in the accident analyses and radiological evaluations are maintained.

APPLICABILITY

The leaktight helium leak rate verification is performed during LOADING OPERATIONS before the TRANSFER CASK and integral CANISTER are moved for transfer operations to the CONCRETE CASK. TRANSPORT OPERATIONS would not commence if the CANISTER helium leak rate was not below the test sensitivity. Therefore, CANISTER leak rate testing is not required during TRANSPORT OPERATIONS or STORAGE OPERATIONS.

ACTIONS

A note has been added to the ACTIONS, which states that, for this LCO, separate Condition entry is allowed for each CANISTER. This is acceptable, since the Required Actions for each Condition provide appropriate compensatory measures for each CANISTER not meeting the LCO. Subsequent CANISTERs that do not meet the LCO are governed by subsequent Condition entry and application of associated Required Actions.

A.1

If the helium leak rate limit is not met, actions must be taken to meet the LCO. The Completion Time is sufficient to determine and correct most failures, which could cause a helium leak rate in excess of the limit. Actions to correct a failure to meet the helium leak rate limit would include, in ascending order of performance, 1) verification of helium leak test system performance; 2) inspection of weld surfaces to locate helium leakage paths using a helium sniffer probe; and 3) weld repairs, as required, to eliminate the helium leakage. Following corrective actions, the helium leak rate verification shall be reperformed.

(continued)

ACTIONS (continued)

B.1

If the CANISTER leak rate cannot be brought within the limit, the fuel must be placed in a safe condition. Corrective actions may be taken after the fuel is placed in a safe condition to perform the A.1 action provided that the initial conditions for performing A.1 are met. A.1 may be repeated as necessary prior to performing B.1. The time frame for completing B.1 can not be extended by re-performing A.1. The Completion Time is reasonable based on the time required to re-flood the CANISTER, perform fuel cooldown operations, cut the CANISTER shield lid weld, move the TRANSFER CASK into the spent fuel pool, remove the CANISTER shield lid, and remove the spent fuel assemblies in an orderly manner and without challenging personnel.

SURVEILLANCE REQUIREMENTS

SR 3.1.5.1

The primary design consideration of the CANISTER is that it is leaktight to ensure that off-site dose limits are not exceeded and to ensure that the helium remains in the CANISTER during long-term storage. Long-term integrity of the stored fuel is dependent on storage in a dry, inert environment.

Verifying that the helium leak rate meets leaktight requirements must be performed successfully on each CANISTER prior to TRANSPORT OPERATIONS. The Surveillance Frequency allows sufficient time to backfill the CANISTER cavity with helium and performs the leak test, while minimizing the time the fuel is in the CANISTER and loaded in the TRANSFER CASK.

REFERENCES

1. SAR Sections 7.1 and 8.1.

C 3.1 NAC-UMS® SYSTEM Integrity

C 3.1.6 CONCRETE CASK Heat Removal System

BASES

BACKGROUND	The CONCRETE CASK Heat Removal System is a passive, air-cooled convective heat transfer system, which ensures that heat from the CANISTER is transferred to the environment by the upward flow of air through the CONCRETE CASK. Relatively cool air is drawn into the annulus between the CONCRETE CASK and the CANISTER through the four air inlets at the bottom of the CONCRETE CASK. The CANISTER transfers its heat from the CANISTER surface to the air via natural convection. The buoyancy created by the heating of the air creates a chimney effect and the air flows back into the environment through the four air outlets at the top of the CONCRETE CASK.
APPLICABLE SAFETY ANALYSIS	The thermal analyses of the CONCRETE CASK take credit for the decay heat from the spent fuel assemblies being ultimately transferred to the ambient environment surrounding the CONCRETE CASK. Transfer of heat away from the fuel assemblies ensures that the fuel cladding and CANISTER component temperatures do not exceed applicable limits. Under normal storage conditions, the four air inlets and four air outlets are unobstructed and full air flow (i.e., maximum heat transfer for the given ambient temperature) occurs. Analyses have been performed for the complete obstruction of all of the air inlets and outlets. The complete blockage of all air inlets and outlets stops air cooling of the CANISTER. The CANISTER will continue to radiate heat to the relatively cooler inner shell of the CONCRETE CASK. With the loss of air cooling, the CANISTER component temperatures will increase toward their respective short-term temperature limits. The limiting component is the CANISTER basket support and heat transfer disks, which, by analysis, approach their temperature limits in 24 hours, if no action is taken to restore air flow to the heat removal system.
LCO	The CONCRETE CASK Heat Removal System must be verified to be OPERABLE to preserve the assumptions of the thermal analyses.

(continued)

LCO (continued)	Operability of the heat removal system ensures that the decay heat generated by the stored fuel assemblies is transferred to the environment at a sufficient rate to maintain fuel cladding and CANISTER component temperatures within design limits.
APPLICABILITY	The LCO is applicable during STORAGE OPERATIONS. Once a CONCRETE CASK containing a CANISTER loaded with spent fuel has been placed in storage, the heat removal system must be OPERABLE to ensure adequate heat transfer of the decay heat away from the fuel assemblies.
ACTIONS	A note has been added to ACTIONS which states that, for this LCO, separate Condition entry is allowed for each CONCRETE CASK. This is acceptable since the Required Actions for each Condition provide appropriate compensatory measures for each CONCRETE CASK not meeting the LCO. Subsequent CONCRETE CASKs that do not meet the LCO are governed by subsequent Condition entry and application of associated Required Actions. <u>A.1</u> If the heat removal system has been determined to be inoperable, it must be restored to OPERABLE status within 8 hours. Eight hours is reasonable based on the accident analysis which shows that the limiting CONCRETE CASK component temperatures will not reach their temperature limits for 24 hours after a complete blockage of all inlet air ducts. <u>B.1</u> SR 3.1.6.1 is performed to document the continuing status of the operability of the CONCRETE CASK Heat Removal System. <u>B.2.1</u> Efforts must continue to restore the heat removal system to OPERABLE status by removing the air flow obstruction(s) unless optional Required Action B.2.2 is being implemented.

(continued)

ACTIONS
(continued)

B.2.1 (continued)

This Required Action must be completed in 12 hours. The Completion Time reflects a conservative total time period without any cooling of 24 hours. The results of the thermal analysis of this accident show that the fuel cladding temperature does not reach its short-term temperature limit for more than 24 hours. It is also unlikely that an unforeseen event could cause complete blockage of all four air inlets and outlets immediately after the last successful Surveillance.

SURVEILLANCE
REQUIREMENTS

SR 3.1.6.1

The long-term integrity of the stored fuel is dependent on the ability of the CONCRETE CASK to reject heat from the CANISTER to the environment. The temperature rise between ambient and the CONCRETE CASK air outlets shall be monitored to verify operability of the heat removal system. Blocked air inlets or outlets will reduce air flow and increase the temperature rise experienced by the air as it removes heat from the CANISTER. Based on the analyses, provided the air temperature rise is less than the limits stated in the SR, adequate air flow and, therefore, adequate heat transfer is occurring to provide assurance of long-term fuel cladding integrity. The reference ambient temperature used to perform this Surveillance shall be measured at the ISFSI facility.

The Frequency of 24 hours is reasonable based on the time necessary for CONCRETE CASK components to heat up to unacceptable temperatures assuming design basis heat loads, and allowing for corrective actions to take place upon discovery of the blockage of the air inlets and outlets.

(continued)

REFERENCES 1. SAR Chapter 4 and Chapter 11, Section 11.2.13.

C 3.1 NAC-UMS® SYSTEM Integrity

C 3.1.7 CANISTER Removal from the CONCRETE CASK

BASES

BACKGROUND

A loaded CANISTER is removed from a CONCRETE CASK using the TRANSFER CASK, so that the CANISTER may be transferred to another CONCRETE CASK or transferred to a TRANSPORT CASK for purposes of transport. The CANISTER is removed from the CONCRETE CASK using the procedure provided in Section 8.2. Once in the TRANSFER CASK, the CANISTER begins to heat up due to the decay heat of the contents and the reduced heat transfer provided by the TRANSFER CASK compared to the CONCRETE CASK.

The CANISTER time in the TRANSFER CASK is limited when forced air cooling is not used to ensure that the short-term temperature limits established in the Safety Analysis Report for the spent fuel cladding and CANISTER materials are not exceeded.

If forced air cooling is maintained, then the CANISTER time in the TRANSFER CASK is not limited, since the short-term temperature limits of the spent fuel cladding and of the CANISTER components are not exceeded.

APPLICABLE SAFETY ANALYSIS

Limiting the total time that a loaded CANISTER backfilled with helium may be in the TRANSFER CASK, prior to unloading the CANISTER from the TRANSFER CASK, ensures that the short-term temperature limits for the spent fuel cladding and CANISTER materials are not exceeded. Upon placement of the loaded CANISTER in the CONCRETE CASK or TRANSPORT CASK, the temperatures of the

(continued)

APPLICABLE SAFETY ANALYSIS (continued)

CANISTER and stored spent fuel will return to normal storage or transport condition values due to the more efficient passive heat transfer characteristics of the CONCRETE CASK or TRANSPORT CASK.

This ensures that temperatures are maintained below short-term limits for a limited time period. Returning these temperatures to values below long-term limits will prevent damage to the spent fuel cladding and the CANISTER materials.

From calculated temperatures reported in the Safety Analysis Report, it can be concluded that spent fuel cladding and CANISTER material short-term temperature limits will not be exceeded for a total elapsed time of greater than 6 hours (PWR or BWR configurations), if the loaded CANISTER backfilled with helium is in the TRANSFER CASK. After 4 hours, forced airflow cooling is used to ensure cooling of the CANISTER. The analysis provided in the Safety Analysis Report shows that the spent fuel cladding and CANISTER temperatures will be at or below their long-term limits, as long as the cooling airflow is maintained. This forced airflow provides a similar rate of cooling to that provided by the passive airflow cooling provided by the CONCRETE CASK. Consequently, there is no time limit associated with the continued forced air cooling of the CANISTER while it is in the TRANSFER CASK. The basis for forced air cooling is an inlet maximum air temperature of 76°F, which is the maximum normal ambient air temperature in the thermal analysis. The specified 375 CFM air flow rate exceeds the CONCRETE CASK natural

(continued)

APPLICABLE SAFETY ANALYSIS (continued)

convective cooling flow rate by a minimum of 10 percent. This comparative analysis conservatively excludes the higher flow velocity resulting from the smaller annulus between the TRANSFER CASK and CANISTER, which would result in improved heat transfer from the CANISTER.

If forced air flow is continuously maintained for a period of 24 hours, or longer, then the temperatures of the spent fuel cladding and CANISTER components are at the values calculated for the CONCRETE CASK normal conditions. Consequently, forced air cooling may be ended, allowing a new entry into Condition A. This provides a new minimum 4-hour period in which continuation of the TRANSFER OPERATIONS may occur.

LCO

Limiting the length of time that the loaded CANISTER backfilled with helium is allowed to remain in the TRANSFER CASK without forced air cooling ensures that the spent fuel cladding and CANISTER material temperatures remain below the short-term temperature limits established in the SAR for the NAC-UMS® SYSTEM. Once forced air cooling is established, the amount of time the CANISTER resides in the TRANSFER CASK is not limited since the cooling provided by the forced air is equivalent to the passive cooling that is provided by the CONCRETE CASK or TRANSPORT CASK.

If forced air flow is continuously maintained for a period of 24 hours, or longer, then the temperatures of the spent fuel cladding and CANISTER components are at, or below, the values calculated for the CONCRETE CASK normal conditions. Therefore, forced air cooling

(continued)

LCO (continued)

may be ended, allowing a new entry into Condition A of this LCO. This provides a new minimum 4-hour period in which continuation of TRANSFER OPERATIONS may occur.

APPLICABILITY

The elapsed time restrictions on the loaded CANISTER apply during TRANSFER OPERATIONS from the completion point of the closing of the TRANSFER CASK shield doors through completion of the unloading of the CANISTER from the TRANSFER CASK.

ACTIONS

A note has been added to the ACTIONS, which states that, for this LCO, separate Condition entry is allowed for each NAC-UMS® SYSTEM. This is acceptable, since the Required Actions for each Condition provide appropriate compensatory measures for each NAC-UMS® SYSTEM not meeting the LCO. Subsequent NAC-UMS® SYSTEMS that do not meet the LCO are governed by subsequent Condition entry and application of associated Required Actions.

Separate Condition A re-entry is also permitted after 24-hours of continuous forced air cooling in accordance with this LCO.

A.1.1

If the CANISTER can be loaded into an operable CONCRETE CASK without the LCO time limit being exceeded, then no further action is required since the spent fuel cladding and CANISTER component short-term temperature limits are not exceeded.

(continued)

ACTIONS (continued)

OR

A.2.1

If the CANISTER can be loaded into a TRANSPORT CASK without the LCO time limit being exceeded, then no further action is required since the spent fuel cladding and CANISTER component short-term temperature limits are not exceeded.

OR

A.3.1

If forced air flow is continuously maintained for a period of 24 hours, or longer, then the temperatures of the spent fuel cladding and CANISTER components are at, or below, the values calculated for the CONCRETE CASK normal conditions. Consequently, forced air cooling may be ended, allowing a new entry into Condition A of this LCO. This provides a new minimum 4-hour period in which continuation or completion of TRANSFER OPERATIONS may occur.

B.1.1

Commence supplying air to the TRANSFER CASK annulus using the fill/drain lines at a rate of 375 CFM and a maximum temperature of 76°F. This action provides the equivalent cooling that would be provided by the passive heat removal systems of the CONCRETE CASK or TRANSPORT CASK in normal operations. Consequently, no short-term spent fuel cladding or CANISTER component temperature limits are exceeded.

AND

B.2.1

Maintain the airflow established by B.1.1 for the time period that the CANISTER remains in the TRANSFER CASK. This action provides the equivalent cooling that would be provided by the passive heat removal systems of the CONCRETE CASK or TRANSPORT CASK in normal operations. Consequently, no short-term spent fuel cladding or CANISTER component temperature limits are exceeded.

SURVEILLANCE REQUIREMENTS

SR 3.1.7.1

This SR ensures that the time that the CANISTER is in the TRANSFER CASK does not exceed the 4-hour limit without the use of forced air cooling of the CANISTER. This ensures that the short-term temperature limits of the spent fuel cladding and CANISTER components is not exceeded.

SR 3.1.7.2

This SR ensures that short-term temperature limits of the spent fuel cladding and CANISTER components are not exceeded by initiating and maintaining forced air cooling of the CANISTER in the TRANSFER CASK if the time limits established by Condition A are not met. Forced air cooling is maintained until unloading of the CANISTER from the TRANSFER CASK.

REFERENCES

1. SAR Sections 4.4 and 8.2.

C 3.2 NAC-UMS® SYSTEM Radiation Protection

C 3.2.1 CANISTER Surface Contamination

BASES

BACKGROUND

A TRANSFER CASK containing an empty CANISTER is immersed in the spent fuel pool in order to load the spent fuel assemblies. The external surfaces of the CANISTER are maintained clean by the application of clean water to the annulus of the TRANSFER CASK. However, there is potential for the surface of the CANISTER to become contaminated with the radioactive material in the spent fuel pool water. This contamination is removed prior to moving the CONCRETE CASK containing the CANISTER to the ISFSI in order to minimize the radioactive contamination to personnel or the environment. This allows the ISFSI to be entered without additional radiological controls to prevent the spread of contamination and reduces personnel dose due to the spread of loose contamination or airborne contamination. This is consistent with ALARA practices.

APPLICABLE SAFETY ANALYSIS

The radiation protection measures implemented at the ISFSI are based on the assumption that the exterior surfaces of the CANISTER are not contaminated. Failure to decontaminate the surfaces of the CANISTER could lead to higher-than-projected occupational dose and potential site contamination.

LCO

Removable surface contamination on accessible exterior surfaces of the CANISTER and accessible interior surfaces of the TRANSFER CASK are limited to 10,000 dpm/100 cm^2 from beta and gamma sources and 100 dpm/100 cm^2 from alpha sources. Only loose contamination is controlled, as fixed contamination will not result from the CANISTER loading process. Experience has shown that these limits are low enough to prevent the spread of contamination to clean areas and are significantly less than the levels, which would cause significant personnel skin dose.

(continued)

LCO (continued)

LCO 3.2.1 requires removable contamination to be within the specified limits for the accessible exterior surfaces of the CANISTER and accessible interior surfaces of the TRANSFER CASK. The location and number of CANISTER and TRANSFER CASK surface swipes used to determine compliance with this LCO are determined based on standard industry practice and the user's plant-specific contamination measurement program for objects of this size. Accessible portions of the CANISTER are the upper portion of the CANISTER external shell wall accessible after draining of the TRANSFER CASK annulus and the top surface of the structural lid. The user shall determine a reasonable number and location of swipes for the accessible portion of the CANISTER. The objective is to determine a removable contamination value representative of the entire upper circumference of the CANISTER and the structural lid, while implementing sound ALARA practices.

Verification swipes and measurements of removable surface contamination levels on the accessible interior surfaces of the TRANSFER CASK shall be performed following transfer of the CANISTER to the CONCRETE CASK. These measurements will provide indirect evidence that the inaccessible surfaces of the CANISTER do not have removable contamination levels exceeding the limit.

APPLICABILITY

Verification that the accessible exterior surface contamination of the CANISTER and accessible interior surface contamination of the TRANSFER CASK are less than the LCO limits is performed during LOADING OPERATIONS. This occurs before TRANSPORT OPERATIONS and STORAGE OPERATIONS. Measurement of the CANISTER and TRANSFER CASK surface contamination is unnecessary during UNLOADING OPERATIONS as surface contamination would have been measured prior to moving the subject CANISTER to the ISFSI.

(continued)

ACTIONS

A note has been added to the ACTIONS, which states that, for this LCO, separate Condition entry is allowed for each CANISTER LOADING OPERATION. This is acceptable, since the Required Actions for each Condition provide appropriate compensatory measures for each CANISTER and TRANSFER CASK not meeting the LCO. Subsequent CANISTERs that do not meet the LCO are governed by subsequent Condition entry and application of associated Required Actions.

A.1

If the removable surface contamination of the CANISTER that has been loaded with spent fuel or the TRANSFER CASK is not within the LCO limits, action must be initiated to decontaminate the CANISTER and TRANSFER CASK, and bring the removable surface contamination to within limits. The Completion Time of 7 days is appropriate, given that the time needed to complete the decontamination is indeterminate and surface contamination does not affect the safe storage of the spent fuel assemblies.

SURVEILLANCE REQUIREMENTS

SR 3.2.1.1

This SR verifies that the removable surface contamination on the accessible exterior surfaces of the CANISTER is less than the limits in the LCO. The Surveillance is performed using smear surveys to detect removable surface contamination. The Frequency requires performing the verification prior to initiating TRANSPORT OPERATIONS in order to confirm that the CANISTER can be moved to the ISFSI without spreading loose contamination.

(continued)

SURVEILLANCE REQUIREMENTS (continued)

SR 3.2.1.2

This SR verifies that the removable surface contamination on the accessible interior surfaces of the TRANSFER CASK is less than the limits, thereby providing indirect confirmation that the removable surface contamination on the inaccessible surfaces of the CANISTER are within the limits. It also confirms the proper functioning of the annulus clean water fill system. The Surveillance is performed using smear surveys to detect removable surface contamination. The Frequency requires performing the verification prior to TRANSPORT OPERATIONS, which ensures a potentially contaminated CANISTER is not placed at the ISFSI.

REFERENCES

1. SAR Section 8.1.
2. NRC IE Circular 81-07.

C 3.2 NAC-UMS® SYSTEM Radiation Protection

C 3.2.2 CONCRETE CASK Average Surface Dose Rates

BASES

BACKGROUND	The regulations governing the operation of an ISFSI set limits on the control of occupational radiation exposure and radiation doses to the general public (Ref. 1). Occupational radiation exposure should be kept as low as reasonably achievable (ALARA) and within the limits of 10 CFR Part 20. Radiation doses to the public are limited for both normal and accident conditions in accordance with 10 CFR 72.
APPLICABLE SAFETY ANALYSIS	The CONCRETE CASK average surface dose rates are not an assumption in any accident analysis, but are used to ensure compliance with regulatory limits on occupational dose and dose to the public.
LCO	The limits on CONCRETE CASK average surface dose rates are based on the Safety Analysis Report shielding analysis of the NAC-UMS® SYSTEM (Ref. 2). The limits are selected to minimize radiation exposure to the public and to maintain occupational dose ALARA to personnel working in the vicinity of the NAC-UMS® SYSTEM. The LCO specifies sufficient locations for taking dose rate measurements to ensure the dose rates measured are indicative of the effectiveness of the shielding materials.
APPLICABILITY	The CONCRETE CASK average surface dose rates apply during STORAGE OPERATIONS. These limits ensure that the CONCRETE CASK average surface dose rates during STORAGE OPERATIONS are bounded by the shielding safety analyses. Radiation doses during STORAGE OPERATIONS are monitored by the NAC-UMS® SYSTEM user in accordance with the plant-specific radiation protection program as required by 10 CFR 72.212(b)(6) and 10 CFR 20 (Reference 1).
ACTIONS	A note has been added to the ACTIONS, which states that, for this LCO, separate Condition entry is allowed for each loaded CONCRETE CASK. This is acceptable, since the Required Actions for each Condition provide appropriate compensatory measures for each CONCRETE CASK not meeting the LCO. Subsequent NAC-UMS®

(continued)

ACTIONS (continued)

SYSTEMs that do not meet the LCO are governed by subsequent Condition entry and application of associated Required Actions.

A.1

If the CONCRETE CASK average surface dose rates are not within limits, it could be an indication that a fuel assembly that did not meet the Approved Contents Limits in Section B2.0 of Appendix 12B was inadvertently loaded into the CANISTER. Administrative verification of the CANISTER fuel loading, by means such as review of video recordings and records of the loaded fuel assembly serial numbers, can establish whether a misloaded fuel assembly is the cause of the out-of-limit condition. The Completion time is based on the time required to perform such a verification.

A.2

If the CONCRETE CASK average surface dose rates are not within limits and it is determined that the CONCRETE CASK was loaded with the correct fuel assemblies, an analysis may be performed. This analysis will determine if the CONCRETE CASK would result in the ISFSI offsite or occupational calculated doses exceeding regulatory limits in 10 CFR Part 72 or 10 CFR Part 20, respectively. If it is determined that the measured average surface dose rates do not result in the regulatory limits being exceeded, STORAGE OPERATIONS may continue.

B.1

If it is verified that the fuel was misloaded, or that the ISFSI offsite radiation protection requirements of 10 CFR Part 20 or 10 CFR Part 72 will not be met with the CONCRETE CASK average surface dose rates above the LCO limit, the fuel assemblies must be placed in a safe condition in the spent fuel pool. The Completion Time is reasonable, based on the time required to transport the CONCRETE CASK, transfer the CANISTER to the TRANSFER CASK, remove the structural lid and vent and drain port cover welds, perform fuel cooldown operations, cut the shield lid weld, move the TRANSFER CASK and CANISTER into the spent fuel pool, remove the shield lid, and remove the spent fuel assemblies in an orderly manner and without challenging personnel.

(continued)

SURVEILLANCE REQUIREMENTS

SR 3.2.2.1

This SR ensures that the CONCRETE CASK average surface dose rates are within the LCO limits after transfer of the CANISTER into the CONCRETE CASK and prior to the beginning of STORAGE OPERATIONS. This Frequency is acceptable as corrective actions can be taken before off-site dose limits are compromised. The surface dose rates are measured approximately at the locations indicated on Figure 12A3-1, following standard industry practices for determining average surface dose rates for large containers.

REFERENCES

1. 10 CFR Parts 20 and 72.
2. SAR Sections 5.1 and 8.2.

Chapter 13

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13.0 QUALITY ASSURANCE

13.1 Introduction

The NAC International (NAC) Quality Assurance (QA) Program is designed and administered to meet all Quality Assurance criteria of 10 CFR 72, Subpart G [1], 10 CFR 50, Appendix B [2], 10 CFR 71, Subpart H [3], and NQA-1 (Basic and Supplemental Requirements) [4]. The program is defined in a QA Program description document that has been reviewed and approved by the Nuclear Regulatory Commission (Approval No. 0018).

The NAC Quality Assurance Program is described in a Quality Assurance Manual. This Quality Assurance Manual, as approved by the company's President and Chief Executive Officer, contains policy as to how NAC intends to comply with the applicable regulatory QA criteria. Detailed implementing quality procedures are used to provide the procedural direction to comply with the policy of the QA Manual.

Employing a graded methodology, as described in USNRC Regulatory Guide 7.10 [5], NAC applies quality controls to items and activities consistent with their safety significance. Table 13.1-1 identifies the NAC Quality Assurance Manual sections, which address the applicable quality criteria.

A synopsis of the NAC Quality Assurance Program is presented in Section 13.2.

Table 13.1-1 Correlation of Regulatory Quality Assurance Criteria to NAC Quality Assurance Program

Regulatory Quality Assurance Criteria*		Corresponding NAC QA Manual Section Number
I.	Organization	1
II.	Quality Assurance Program	2
III.	Design Control	3
IV.	Procurement Document Control	4
V.	Procedures, Instructions, and Drawings	5
VI.	Document Control	6
VII.	Control of Purchased Items and Services	7
VIII.	Identification and Control of Material, Parts and Components	8
IX.	Control of Special Processes	9
X.	Inspection	10
XI.	Test Control	11
XII.	Control of Measuring and Test Equipment	12
XIII.	Handling, Storage and Shipping	13
XIV.	Inspection, Test and Operating Status	14
XV.	Control of Nonconforming Items	15
XVI.	Corrective Action	16
XVII.	Records	17
XVIII.	Audits	18

*The criteria are obtained from 10 CFR 50 Appendix B; 10 CFR 71 Subpart H; and 10 CFR 72 Subpart G.

13.2 NAC Quality Assurance Program Synopsis

Eighteen applicable Quality Assurance criteria are identified in 10 CFR 72, Subpart G; 10 CFR 50, Appendix B; 10 CFR 71, Subpart H; and ASME NQA-1 (Basic and Supplemental Requirements). NAC compliance with each of these criteria is addressed below.

13.2.1 Organization

The President and Chief Executive Officer of NAC has the ultimate authority and responsibility over all organizations and their functions within the corporation. However, the President delegates and empowers qualified personnel with the authority and responsibility over selected key areas, as identified in the NAC Organization Chart, Figure 13.2-1.

The Vice President, Quality, is responsible for definition, development, implementation and administration of the NAC Quality Assurance Program. The Quality Assurance organization is independent from other organizations within NAC and has complete authority to assure adequate and effective program execution, including problem identification, satisfactory corrective action implementation and the authority to stop work, if necessary. The Vice President, Quality, reports directly to the President and Chief Executive Officer of NAC. The Vice President, Quality, has sufficient expertise in the field of quality to direct the quality function and will be capable of qualifying as a lead auditor.

Strategic Business Unit (SBU) Vice Presidents direct operations, utilizing project teams as appropriate for a particular work scope. SBU Vice Presidents are responsible to the President and Chief Executive Officer for the proper implementation of the NAC Quality Assurance Program.

13.2.2 Quality Assurance Program

NAC has established a Quality Assurance Program that meets the requirements of 10 CFR 72, Subpart G, 10 CFR 50 Appendix B, 10 CFR 71, Subpart H, and NQA-1. Employing a grading methodology consistent with U.S. NRC Regulatory Guide 7.10, the Quality Assurance Program provides control over activities affecting quality from the design to fabrication, operation, and maintenance of nuclear products and services for nuclear applications. The Quality Assurance Program is documented in the Quality Assurance Manual and implemented via Quality Procedures. These documents are approved by the Vice President, Quality, and the President and

Chief Executive Officer, as well as the Vice President from each SBU performing activities within the scope of the NAC Quality Assurance Manual.

Personnel assigned responsibilities by the Quality Assurance Program may delegate performance of activities associated with that responsibility to other personnel in their group when those individuals are qualified to perform those activities by virtue of their education, experience and training. Such delegations need not be in writing. The person assigned responsibility by the Quality Assurance Program retains full accountability for the activities.

13.2.3 Design Control

The established Quality Procedures covering design control assure that the design activity is planned, controlled, verified and documented so that applicable regulatory and design basis requirements are correctly translated into specifications, drawings, and procedures with appropriate acceptance criteria for inspection and test delineated.

When computer software is utilized to perform engineering calculations, verifications of the computational accuracy are performed, and error tracking of the software is controlled in accordance with approved Quality Procedures.

Design interface control is established and adequate to assure that the review, approval, release, distribution and revision of design documents involving interfaces are performed by appropriately trained, cognizant design personnel using approved procedures.

Design verification is performed by individuals other than those who performed the original design. These verifications may include design reviews, alternate calculations or qualification tests. Selection of the design verification method is based on regulatory, contractual or design complexity requirements. When qualification testing is selected, the "worst case" scenario will be utilized. The verification may be performed by the originator's supervisor, provided the supervisor did not specify a singular design approach, rule out certain design considerations, or establish the design inputs used in the design, unless the supervisor is the only individual in the organization competent to perform the verification. When verification is provided by the supervisor, the need shall be so documented in advance and evaluated after performance by internal audit.
Design changes are controlled and require the same review and approvals as the original design.

13.2.4 Procurement Document Control

Procurement documents and their authorized changes are generated, reviewed and approved in accordance with the Quality Procedures. These procedures assure that all purchased material, components, equipment and services adhere to design specification, regulatory and contractual requirements including Quality Assurance Program and documentation requirements.

NAC Quality Assurance personnel review and approve all purchase orders invoking compliance with the Quality Assurance Program for inclusion of quality related requirements in the procurement documents.

13.2.5 Procedures, Instructions, and Drawings

All activities affecting quality are delineated in the Quality Procedures, Specifications, Inspection/Verification Plans or on appropriate drawings. These documents are developed via approved Quality Procedures and include appropriate quantitative and qualitative acceptance criteria. These documents are reviewed and approved by Quality Assurance personnel prior to use.

13.2.6 Document Control

All documents affecting quality, including revisions thereto, are reviewed and approved by authorized personnel, and are issued and controlled in accordance with Quality Procedures by those persons or groups assigned responsibility for the document to be controlled. Transmittal forms, with provisions for receipt acknowledgment, are utilized and controlled document distribution logs are maintained.

All required support documentation for prescribed activities is available at the work location prior to initiation of the work effort.

13.2.7 Control of Purchased Items and Services

Items and services affecting quality are procured from qualified and approved suppliers. These suppliers have been evaluated and selected in accordance with the Quality Procedures based upon their capability to comply with applicable regulatory and contractual requirements.

Objective evidence attesting to the quality of items and services furnished by NAC suppliers is provided with the delivered item or service, and is based on contract requirements and item or service complexity. This vendor documentation requirement is delineated in the procurement documents.

Source inspection, receipt inspection, vendor audits and vendor surveillance are performed as required to assure product quality, documentation integrity, and supplier compliance to the procurement, regulatory and contractual requirements.

13.2.8 Identification and Control of Material, Parts, and Components

Identification is maintained either on the item or in quality records traceable to the item throughout fabrication and construction to prevent the use of incorrect or defective items.

Identification, in accordance with drawings and inspection plans, is verified by Quality Assurance personnel prior to releasing the item for further processing or delivery.

13.2.9 Control of Special Processes

Special processes, such as welding, heat treating and nondestructive testing, are performed in accordance with applicable codes, standards, specifications and contract requirements by qualified personnel. NAC and NAC suppliers' special process procedures and personnel certifications are reviewed and approved by NAC Quality Assurance prior to their use.

13.2.10 Inspection

NAC has an established and documented inspection program that identifies activities affecting quality and verifies their conformance with documented instructions, plans, procedures and drawings.

Inspections are performed by individuals other than those who performed the activity being inspected. Inspection personnel report directly to the Vice President, Quality.

Process monitoring may also be used in conjunction with identified inspections, if beneficial to achieve required quality.

Mandatory inspection hold points are used to assure verification of critical characteristics. Such hold points are delineated in appropriate process control documents.

13.2.11 Test Control

NAC testing requirements are developed and applied in order to demonstrate satisfactory performance of the tested items to design/contract requirements.

The NAC test program is established to assure that preoperational or operational tests are performed in accordance with written test procedures. Test procedures developed in accordance with approved Quality Procedures identify test prerequisites, test equipment and instrumentation and suitable environmental test conditions. Test procedures are reviewed and approved by NAC Quality Assurance personnel.

Test results are documented, evaluated and accepted by qualified personnel as required by the Quality Assurance inspection instructions prepared for the test, as approved by cognizant quality personnel.

13.2.12 Control of Measuring and Testing Equipment

Control of measuring and testing equipment/instrumentation is established to assure that devices used in activities affecting quality are calibrated and properly adjusted at specified time intervals to maintain their accuracy.

Calibrated equipment is identified and traceable to calibration records, which are maintained. Calibration accuracy is traceable to national standards when such standards exist. The basis of calibration shall always be documented.

Whenever measuring and testing equipment is found to be out of calibration, an evaluation shall be made and documented of the validity of inspection or test results performed and of the acceptability of items inspected or tested since the previous calibration.

13.2.13 Handling, Storage and Shipping

Requirements for handling, storage and shipping are documented in specifications and applicable procedures or instructions. These requirements are designed to prevent damage or deterioration to items and materials.

Information pertaining to shelf life, environment, packaging, temperature, cleaning and preservation are also delineated as required.

Quality Assurance Surveillance/Inspection personnel are responsible for verifying that approved handling, storage, and shipping requirements are met.

13.2.14 Inspection, Test and Operating Status

Procedures are established to indicate the means of identifying inspection and test status on the item and/or on records traceable to the item. These procedures assure identification of items that have satisfactorily passed required inspections and/or tests, to preclude inadvertent bypassing of inspection/test.

Inspection, test, and operating status indicators may only be applied or modified by Quality Assurance personnel or with formal Quality Assurance concurrence.

13.2.15 Control of Nonconforming Items

NAC has established and implemented procedures that assure appropriate identification, segregation, documentation, notification and disposition of items that do not conform to specified requirements. These measures prevent inadvertent usage of the item and assure appropriate authorization or approval of the item's disposition.

All nonconformances are reviewed and accepted, rejected, repaired or reworked in accordance with documented approved procedures. If necessary, a Review Board is convened, consisting of engineering, licensing, quality, operations and testing personnel to provide disposition of nonconforming conditions.

NAC procurement documents provide for control, review and approval of nonconformances noted on NAC items, including associated dispositions.

13.2.16 Corrective Action

Conditions adverse to quality, such as failures, malfunctions, deficiencies, defective material/ equipment, and nonconformances are promptly identified, documented and corrected.

Significant conditions adverse to quality will have their cause determined and sufficient corrective action taken to preclude recurrence. These conditions are documented and reported to the Vice President, Quality, who assures awareness by the President and Chief Executive Officer.

13.2.17 Records

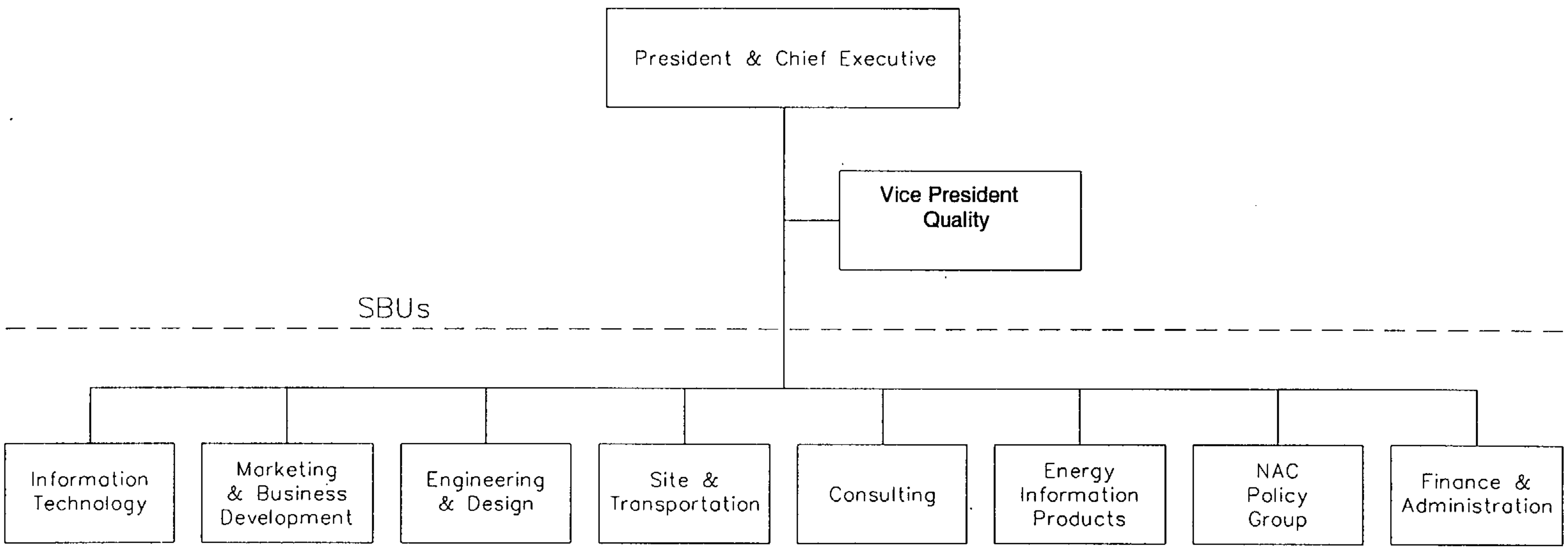
NAC maintains a records system in accordance with approved procedures to assure that documented objective evidence pertaining to quality related activities is identifiable, retrievable and retained to meet regulatory and contract requirements, including retention duration, location and responsibility.

Quality records include, but are not limited to, inspection and test reports, audit reports, quality personnel qualifications, design documents, purchase orders, supplier evaluations, fabrication documents, nonconformance reports, drawings, specifications, etc. Quality Assurance maintains a complete list of records and provides for record storage and disposition to meet regulatory and contractual requirements.

13.2.18 Audits

Approved Quality Procedures provide for a comprehensive system of planned and periodic audits performed by qualified personnel, independent of activities being audited. These audits are performed in accordance with written procedures and are intended to verify program adequacy and its effective implementation and compliance, both internally and at approved-supplier locations. Internal audits are conducted annually, and approved suppliers are audited on a triennial basis, as a minimum.

Figure 13.2-1 NAC Organization Chart



13.3 References

1. U.S. Code of Federal Regulations, "Quality Assurance," Part 71, Title 10, Subpart H.

2. U.S. Code of Federal Regulations, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," Part 50, Title 10, Appendix B.

3. U.S. Code of Federal Regulations, "Quality Assurance Requirements," Part 72, Title 10, Subpart G.

4. ASME NQA-1-1994, Part 1, Basic and Supplemental Requirements (as referenced by the ASME Code, including latest accepted addenda), Quality Assurance Program Requirements for Nuclear Facility Applications.

5. U.S. Nuclear Regulatory Commission, "Establishing Quality Assurance Program for Packaging Used in the Transport of Radioactive Material," Regulatory Guide 7.10, Revision 1, June 1986.

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